SPECIES STATUS REPORT

Western Bumble Bee, Yellow-banded Bumble Bee, and Gypsy Cuckoo Bumble Bee

(Bombus occidentalis, Bombus terricola, Bombus bohemicus)

Bourdon de l'ouest, Bourdon terricole, Psithyre bohémien (French)

DRAFT – FOR REVIEW

August 2018

NORTHWEST TERRITORIES SPECIES AT RISK COMMITTEE

Status of Western Bumble Bee, Yellow-banded Bumble Bee, and Gypsy Cuckoo Bumble Bee in the NWT

Species at Risk Committee status reports are working documents used in assigning the status of species suspected of being at risk in the Northwest Territories (NWT).

Suggested citation:

Species at Risk Committee. 2018. **Draft** Species Status Report for Western Bumble Bee, Yellow-banded Bumble Bee, and Gypsy Cuckoo Bumble Bee (*Bombus occidentalis, Bombus terricola, Bombus bohemicus*) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.

ISBN: To be added once report is approved and finalized.

Production note:

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ABOUT THE SPECIES AT RISK COMMITTEE

The Species at Risk Committee was established under the *Species at Risk (NWT) Act*. It is an independent committee of experts responsible for assessing the biological status of species at risk in the NWT. The Committee uses the assessments to make recommendations on the listing of species at risk. The Committee uses objective biological criteria in its assessments and does not consider socio-economic factors. Assessments are based on species status reports that include the best available Aboriginal traditional knowledge, community knowledge and scientific knowledge of the species. The status report is approved by the Committee before a species is assessed.

ABOUT THIS REPORT

This species status report is a comprehensive report that compiles and analyzes the best available information on the biological status of the western bumble bee, yellow-banded bumble bee, and gypsy cuckoo bumble bee in the NWT, as well as existing and potential threats and positive influences. Full guidelines for the preparation of species status reports, including a description of the review process, may be found at www.nwtspeciesatrisk.ca.

Northwest Territories Environment and Natural Resources

Environment and Natural Resources, Government of the Northwest Territories, provides full administrative and financial support to the Species at Risk Committee.

Cover illustration photo credit: Yellow-banded bumble bee (credit: Lief Richardson)

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Executive Summary

Description

The western bumble bee (*Bombus occidentalis*), has two subspecies in North America, *Bombus occidentalis occidentalis*, and *Bombus occidentalis mckayi*. Only the *mckayi* subspecies is found in the Northwest Territories (NWT). It is a medium-sized bee (0.9-2.1 centimetres (cm)) with a short, dark head, a short tongue, a band of yellow hairs in front of the wings, and highly variable colours and abdominal banding patterns. All individuals in the NWT have banded abdominal patterns, whereas the southern subspecies also has non-banded forms.

The yellow-banded bumble bee (*Bombus terricola*) closely resembles *B. occidentalis mckayi* in size, shape, colour, and banding patterns. The second and third abdominal sections are usually predominantly yellow (some workers have a dark fringe on the second segment), and segments four and five are usually black or yellow-brown.

The gypsy cuckoo bumble bee (*Bombus bohemicus*) is a nest parasite of other bumble bees. A medium-sized bee (1.7-1.9 cm), it also has variable colours and patterns, but always has a dark head and a yellow band in front of the wings. Because they are parasitic, females lack the ability to collect pollen on their hind legs.

Distribution

The western bumble bee and yellow-banded bumble bee are only known to occur in North America. The northern *mckayi* subspecies of western bumble bee occurrs in northern Alberta, northern British Columbia, the NWT, Yukon, and Alaska. The yellow-banded bumble bee occurs widely throughout Canada (except Nunavut) and the northeastern and central United States.

The gypsy cuckoo bumble bee has one of the largest ranges of all bumble bee species in Canada. It occurs in Europe, the Far East of Asia, south into many parts of China, as well as the central and eastern United States, and Canada.

In the NWT, the western bumble bee has only been collected from four sites along the Nahanni River in the Nahanni National Park Reserve; however, it could conceivably be present throughout much of the southwestern NWT. The yellow-banded bumble bee has been collected primarily in the south-central and southwestern NWT. The most recent observations of this species were from 2017, near Norman Wells, Fort Simpson, and Yellowknife. The gypsy cuckoo bumble bee has been collected at various sites along the length of the Mackenzie River valley, and south of Great Slave Lake. The most recent observation of this species in the NWT is from

2017 near Norman Wells.

Biology and Behaviour

All three species have an annual life cycle. The western bumble bee and yellow-banded bumble bee have three castes in their colonies: a single queen, female workers, and males. Young mated queens emerge from overwintering sites in the spring, locate and modify nest sites, and eventually lay eggs to produce a brood of workers. Workers then assume responsibility for foraging (pollen and nectar) and care of subsequent broods. Males and reproductive females (new queens) are produced in late summer. At the onset of winter, males, old queens, and workers die. The mated new queens hibernate until the following spring.

Gypsy cuckoo bumble bees are obligate nest parasites of other bumble bees. They emerge later in the spring than the other two species. Rather than develop nests of their own, females (there are no queen or worker castes) invade established colonies of their hosts (the yellow-banded bumble bee in the NWT, and possibly also the western bumble bee and the cryptic bumble bee, *B. cryptarum*), and the workers of the host colony care for their young. Females and males emerge to mate in late July, and mated females overwinter. Males and the original egg-laying female die before the onset of winter.

Population

Only four specimens of the *mckayi* western bumble bee have been collected in the NWT, in 2011. It is currently only known from the Nahanni National Park Reserve in the southwest part of the territory, in the Boreal Cordillera ecoregion.

The yellow-banded bumble bee has been recorded in the NWT since the 1920s, and as recently as 2017. It is the most commonly encountered bumble bee of the three in this report: 90 specimens have been collected in the NWT so far. In “high collection” years prior to the 2010s, its relative abundance was about 6-9 percent (%) of all *Bombus* records, so it was probably fairly common. However, during the present decade it accounted for fewer than 1% of all bumble bees collected in the NWT. It is found throughout the central Taiga Plains and Taiga Shield ecoregions, and has been collected along the South Nahanni River, in foothills east of the main mountain ranges.

The gypsy cuckoo bumble bee has been recorded sporadically in the NWT since the 1940s (total number of records = 41). Most occurrences were recorded between 1940-1979. There were no new records in the territory until recently, when a single individual was found in Norman Wells in 2017.

Habitat

All three species require consistent access to floral resources, nesting sites, and overwintering sites. Nesting sites are below ground, usually in the abandoned burrows of small mammals. Overwintering sites are unknown. There are generalist pollinators, and use a wide variety of flowering plants as food. They are considered habitat generalists, but all three may have an affinity for open sites near forests and water. The yellow-banded bumble bee and gypsy cuckoo bumble bee have been recorded in urban centers in addition to natural habitats.

Threats and limiting factors

The main threats to these species in the NWT are climate change, invasive species/pathogens, and habitat modifications caused by natural (fire) and human activities (i.e., the presence and construction of roads and utility lines). Climate change is threatening bumble bees worldwide, but species in northern/arctic regions are particularly vulnerable. Average temperatures are rising faster in the NWT than in southern parts of Canada; heat waves, drought, forest fires, and floods are becoming more common and weather patterns are generally becoming more unpredictable. Introduced plant species could affect food availability, and exotic diseases could be spread by non-native, managed bees.

Bumble bees are cold tolerant species, which makes them well-suited for life in the far north. However, cold adaptations also make it harder for them to thrive during long periods of hot weather. Hotter summer temperatures and more heat waves in the NWT could affect their ability to forage and grow their colonies. The gypsy cuckoo bumble bee might be even more susceptible to threats than the other two species because it needs hosts to reproduce: if its hosts' populations decline, the impacts of other threats are probably compounded.

Positive influences

These bumble bees can use a wide range of food plants and habitats. Western and yellow-banded bumble bees can use even more plants as food than other short-tongued bees as they have learned to "rob" flowers with long petals of their nectar. Small mammal populations are healthy in the NWT, which means that these bumble bees should have plenty of nesting sites. Their nesting habits and long active seasons make them more resistant to fires and land use changes.

New initiatives by the Government of the Northwest Territories are expected to help preserve bumble bee habitat, including more monitoring for invasive species and the development of new protected areas.

Technical Summary

Population trends	
Generation time (average age of parents in the population) (indicate years, months, days, etc.).	1 year[1].
Number of mature individuals in the NWT (or give a range of estimates).	Unknown.
Percent change in total number of mature individuals over the **last** 10 years or 3 generations, whichever is longer.	**Western bumble bee/yellow-banded bumble bee:** Rate of decline of bumble bee species in the NWT is unknown. Anecdotal information from northern Canada and Alaska suggests populations may be stable. **Gypsy cuckoo bumble bee:** Rate of decline of bumble bee species in the NWT is unknown. Anecdoctal information suggests populations may be stable.
Percent change in total number of mature individuals over the **next** 10 years or 3 generations, whichever is longer.	Unknown.
Percent change in total number of mature individuals over any 10 year or 3 generation period which includes **both the past and the future.**	Unknown.
If there is a decline in the number of mature individuals,	Unknown.

[1] Where a species isn't specified, the answer applies to all three species.

is the decline likely to continue if nothing is done?	
If there is a decline, are the causes of the decline reversible?	Unknown.
If there is a decline, are the causes of the decline clearly understood?	Unknown.
If there is a decline, have the causes of the decline been removed?	Unknown.
If there are fluctuations or declines, are they within, or outside of, natural cycles?	Unknown.
Are there ‘extreme fluctuations’ (>1 order of magnitude) in the number of mature individuals?	Unknown.
Distribution trends	
Estimated extent of occurrence in the NWT (in km^2).	**Western bumble bee**: Known extent of occurrence is 18,806 km^2 but is probably much larger; a plausible estimate is around 55,000 km^2. **Yellow-banded bumble bee**: Known extent of occurrence is 226,321 km^2 but is probably larger; a plausible estimate is around 284,373 km^2. **Gypsy cuckoo bumble bee**: Known extent of occurrence is 148,085 km^2 but is probably much larger; a plausible estimate is around 480,652 km^2.
Index of area of occupancy	**Western bumble bee**: Known index of area of occupancy is 16

(IAO) in the NWT (in km^2; based on 2 × 2 grid).	km^2 (4 grid cells) but probably much larger; a plausible estimate is 110 km^2 or more. **Yellow-banded bumble bee**: Known index of area of occupancy is 112 km^2 (28 grid cells) but is probably larger; a plausible estimate is 140 km^2 or more. **Gypsy cuckoo bumble bee**: Known index of area of occupancy is 36 km^2 (9 grid cells) but probably much larger; a plausible estimate is 116 km^2 or more.
Number of extant locations[2] in the NWT.	**Western bumble bee** (*mckayi*): 2 locations, assuming climate change as the most serious plausible threat and using Level III ecoregions as a proxy for climatic zones (Boreal Cordillera - High Boreal and Mid-Boreal). **Yellow-banded bumble bee**: 5 locations, assuming climate change as the most serious plausible threat and using Level III ecoregions as a proxy for climatic zones (Boreal Cordillera – High Boreal, Taiga Plains – Central Great Bear Plains Low Subarctic, Great Slave Uplands High Boreal, and Mackenzie and Slave Lowlands Mid-Boreal, and Taiga Shield – High Boreal). **Gypsy cuckoo bumble bee**: 4 locations. Although decline in host species is the most serious plausible threat, because climate change is the most serious plausible threat to those host species in the NWT, locations were determined in the same manner as above; that is, using Level III ecoregions as a proxy for climatic zones (Taiga Plains – Northern Great Bear Plains High Subarctic, Central Great Bear Plains Low Subarctic, Great Slave Uplands High

[2] Extant location – The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the species present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a species is affected by more than one threatening event, location should be defined by considering the most serious plausible threat.

	Boreal, and Mackenzie and Slave Lowlands Mid-Boreal).
Is there a **continuing decline** in area, extent and/or quality of habitat?	Large expanses of natural habitat are available in the NWT, but the quality and extent are changing due to climate warming.
Is there a **continuing decline** in number of locations, number of populations, extent of occupancy and/or IAO?	**Western bumble bee**: Uncertain. Data are sparse and locations have not been systematically or routinely sampled. This species has only been collected in 2011. **Yellow-banded bumble bee/gypsy cuckoo bumble bee**: Uncertain. Data are sparse and locations have not been systematically or routinely sampled. The relative abundance of these two species has declined in recent years (2007-2017) compared to historical (pre-2007) records.
Are there extreme fluctuations (>1 order of magnitude) in number of locations, extent of occupancy and/or IAO?	Unknown.
Is the total population severely fragmented (most individuals found within small and isolated populations)?	Locations of individual collected specimens are disjunct, but the degree of isolation between populations in the NWT, if any, is unknown.
Immigration from populations elsewhere	
Does the species exist elsewhere?	**Western bumble bee**: Yes. This species is found elsewhere in Canada and the United States. **Yellow-banded bumble bee**: Yes. The species is found elsewhere in Canada (including adjacent British Columbia, Alberta, and Saskatchewan) and in the United States. **Gypsy cuckoo bumble bee**: Yes. The species is known from elsewhere in Canada (including adjacent Yukon, British Columbia, Alberta, and Saskatchewan), and in the United States. It is also widespread in Europe, part of the Far East of Asia, and China.

Status of the outside population(s)?	**Western bumble bee**: May be stable in northern British Columbia, Yukon, and Alaska. The southern subspecies is in dramatic decline across North America. **Yellow-banded bumble bee**: This species may be stable in northern British Columbia. Populations are in dramatic decline in the United States and elsewhere in Canada, south of the NWT. **Gypsy cuckoo bumble bee**: The species has been infrequently encountered in Yukon in the past decade. It is known to be in dramatic decline in the United States. It has not been detected anywhere else in Canada since 2008.
Is immigration known or possible?	**Western bumble bee**: Uncertain but possible. Physical barriers (mountain ranges) could make immigration difficult. The *mckayi* subspecies is limited to regions north of 55 degrees latitude. **Yellow-banded bumble bee**: Uncertain but possible. Declining populations in regions south of the NWT, and geographic barriers (mountain ranges) could make immigration difficult. **Gypsy cuckoo bumble bee**: Uncertain but unlikely. Declining populations in other regions, and geographic barriers (mountain ranges), could make immigration difficult. Immigration is also dependent on the availability of suitable hosts, and its only known host in western North America (yellow-banded bumble bee) is in decline.
Would immigrants be adapted to survive and reproduce in the NWT?	Yes.
Is there enough good habitat for immigrants in the NWT?	Yes.
Is the NWT population self-sustaining or does it depend on immigration for long-term survival?	Uncertain.

Threats and limiting factors	
Briefly summarize negative influences and indicate the magnitude and imminence for each.	Climate change: A significant, large-scale threat in all parts of the NWT (though extreme changes/events will be more localized in the short term). Ongoing and intensifying. Invasive and problematic species, pathogens, and genes: Currently a low threat, as invasives are uncommon in the NWT. Novel diseases and pathogen spillover are unlikely to be significant threats in the short term. Transportation and utility corridors: Corridors fragment habitat, and new construction can cause significant local habitat modification. Some large corridors are in development or planned for the short term, but overall threat impact is low. Natural systems and modifications: Fires cause large-scale habitat loss/damage and are becoming more common in the NWT; however, overall threat impact is low. An additional threat to gypsy cuckoo bumble bee is: Declines in host populations: The only known host (yellow-banded bumble bee) is still present in the NWT and has been collected as recently as 2007. However, its recent relative abundance (2007-2017) is only 5.5%, down from 7.6% in historical records. A possible (but unconfirmed) host, cryptic bumble bee (*B. cryptarum*) has stable populations in North America, and is widespread in the NWT.
Positive influences	
Briefly summarize positive influences and indicate the magnitude and imminence for each.	Life history traits: May be more resilient to land use changes, fire, and agricultural intensification, because of their nesting habits and longer active seasons. This species uses many habitats, is a generalist forager, and can exploit nectar sources that short-tongued bees cannot. Mammal burrows, on which they are dependent for nesting sites, are likely very abundant. Regulatory actions: Over 9% of the NWT is in a protected area;

	these preserve natural bumble bee habitats. More protected areas are being planned. Better efforts to monitor invasive species are helping detect problematic exotics. Regulations for import of live bees into the territory is advisable.

SPECIES OVERVIEW

Names and classification

Over 20,000 bee species are found worldwide (Ascher and Pickering 2018), roughly 260 of which belong to the genus *Bombus*, commonly called "bumble bees" (Cameron *et al.* 2007; Williams *et al*. 2014). Approximately 47 *Bombus* species have been described in North America, 45 of which are found in Canada (Williams *et al*. 2014; Williams *et al*. 2016). Recent DNA barcoding efforts suggest that other additional cryptic (visually and morphologically identical, but genetically distinct) species may be present in Arctic regions (Williams *et al*. 2016; Sheffield *et al*. 2017). Specimen records show that 24 recognized species of bumble bees are known in the Northwest Territories (NWT).

Bombus contains approximately 48 recognized subgenera. The western bumble bee, *Bombus occidentalis* Greene 1858, and the yellow-banded bumble bee, *B. terricola* Kirby 1837, are contained in the subgenus *Bombus sensu stricto*, along with three others in North America (*B. affinis* Cresson 1863, *B. cryptarum* Fabricus 1775 (=*B. moderatus* Cresson 1863; also found in the NWT), and *B. franklini* Frison 1921) (Bertsch *et al*. 2010). The gypsy cuckoo bumble bee, *B. bohemicus* Seidl 1837, is one of six cuckoo bumble bees (subgenus *Psithyrus*) in North America. Three other cuckoo bumble bees have been recorded from the NWT: *B. insularis* Smith 1861, *B. suckleyi* Greene 1860, and *B. flavidus* Eversmann 1852 (Williams *et al*. 2014).

Systematic/taxonomic clarifications

Greene published his description of *B. occidentalis* (western bumble bee) in 1858, and *B. terricola* (yellow-banded bumble bee) was first described by Kirby in 1937. Their status as distinct species, or "designatable units", has been the subject of considerable debate since the earliest revision of North American *Bombus* by Franklin (1913). Franklin tentatively listed them as separate species, but expressed uncertainty about the decision given their morphological similarities and geographic co-occurrence in some parts of western Canada. Some authors supported the separate designations (Stephen 1957; Thorp et al. 1983), while other authors suggested that *B. occidentalis* (western bumble bee) was either a conspecific or a subspecies of *B. terricola* (yellow-banded bumble bee) (Handlirsch 1888; Milliron 1961; Hobbs 1967; Milliron 1971; Cameron *et al*. 2007).

Table 1. Names and synonymies of the western bumble bee, yellow-banded bumble bee, and gypsy cuckoo bumble bee.

Common Name	Western bumble bee	Yellow-banded bumble bee	Gypsy cuckoo bumble bee
Subgenus	*Bombus* Latreille *sensu stricto*	*Bombus* Latreille *sensu stricto*	*Psithyrus* Lepeletier

Scientific Name	*Bombus (Bombus) occidentalis* Greene 1858	*Bombus (Bombus) terricola* Kirby 1837	*Bombus (Psithyrus) bohemicus* Seidl 1837
Common Name (French)	Bourdon de l'ouest	Bourdon terricole	Psithyre bohémien
(Sub)species	*Bombus o. occidentalis* *Bombus o. mckayi*[3]	None	None
Synonym(s)	*Bombus mckayi* Ashmead 1902 *Bombus proximus* Cresson 1863 *Bombus occidentalis nigroscutatus* Franklin 1913	None	*Bombus ashtoni* Cresson 1864[4]
Class	Insecta (insects)	Insecta (insects)	Insecta (insects)
Order	Hymenoptera (sawflies, ants, bees, and wasps)	Hymenoptera (sawflies, ants, bees, and wasps)	Hymenoptera (sawflies, ants, bees, and wasps)
Family	Apidae (bees) – includes, but is not limited to bumble bees, honey bees and stingless bees	Apidae (bees) – includes, but is not limited to bumble bees, honey bees and stingless bees	Apidae (bees) – includes, but is not limited to bumble bees, honey bees and stingless bees
Life Form	Animal, invertebrate, insect, bumble bee	Animal, invertebrate, insect, bumble bee	Animal, invertebrate, insect, cuckoo bumble bee

Recent gene sequencing and morphological studies support the status of *B. occidentalis* (western bumble bee) and *B. terricola* (yellow-banded bumble bee) as discrete, separable species (Williams *et al*. 2012; Owen and Whidden 2013; Sheffield *et al*. 2016), and also resulted in the discovery of distinct northern and southern subpopulations of *B. occidentalis*, with monophyletic CO1 barcode haplotype groups[5] (Williams *et al.* 2012; Sheffield *et al.* 2016; Williams *et al.* 2016). Thus, *B. occidentalis* (western bumble bee) is now recognized to consist of two

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[3] *Bombus occidentalis mckayi* is the subspecies found in the NWT.
[4] Common name for gypsy cuckoo bumble bee was formerly Ashton's cuckoo bumble bee.
[5] CO1 is an abbreviation of "Cytochrome c Oxidase subunit 1". CO1 is a gene used by geneticists to distinguish between individuals from closely related species or subspecies, such as the northern and southern subspecies of *B. occidentalis*. Organisms with the same CO1 are considered to have the same haplotype: the same group of inherited genes that makes them distinct from all other (sub)species. When we compare the CO1 haplotypes of individuals of *B. o. occidentalis* against the CO1 haplotypes of individuals of *B. o. mckayi*, we find that all the *occidentalis* haplotypes are more closely related to each other than to any of the *mckayi* haplotypes. This means that all *B. o. occidentalis* individuals have the same common ancestor, and all *B. o. mckayi* individuals have a different common ancestor. Since no other bees have the same ancestor as either *B. o. occidentalis* or *B. o. mckayi*, geneticists use the term monophyletic (mono = "one", phyletic = "ancestor") to describe the two CO1 haplotype groups.

subspecies: *B. o. occidentalis* and *B. o. mckayi*. These subspecies are distinct not only genetically and morphologically, but also geographically: only *B. o. mckayi* is found in the NWT. Since the two subspecies designations are relatively new, life history and other data pertaining uniquely to either one is sparse. Throughout this report, the information presented for *B. occidentalis* (western bumble bee) should be interpreted as pertaining to both subspecies, unless expressly stated otherwise.

In recognition of their distinct morphology and parasitic behaviour, cuckoo bumble bees were widely treated as a separate genus (*Psithyrus*). However, the taxon is now considered a monophyletic subspecies of *Bombus* (Cameron *et al.* 2007). The gypsy cuckoo bumble bee was first described by Seidl in 1837, as a European/Old World species, *Psithyrus bohemicus*. Cresson described a North American species of cuckoo bumble bee, *Apathus ashtoni*, in 1864, though "Ashton's cuckoo bumblee bee" was later re-assigned to the genus *Bombus*. Genetic analyses (DNA sequences and CO1 barcodes) now strongly suggest that *B. (Psithyrus) bohemicus* and *B. (Psithyrus) ashtoni* are conspecific, leading to the synonymization of the North American *B. ashtoni* under *B. bohemicus* as a single, Holarctic species (Williams *et al*. 2012; Williams *et al*. 2014).

Description

Morphological species descriptions are largely drawn from Williams *et al.* (2014) and supplemented by other sources as indicated. Generalized illustrations of bumble bee anatomy, and of the numbering scheme used for abdominal segments (the tergites), are provided in Figure 1. Microscopic characteristics are described and illustrated in Williams *et al.* (2014).

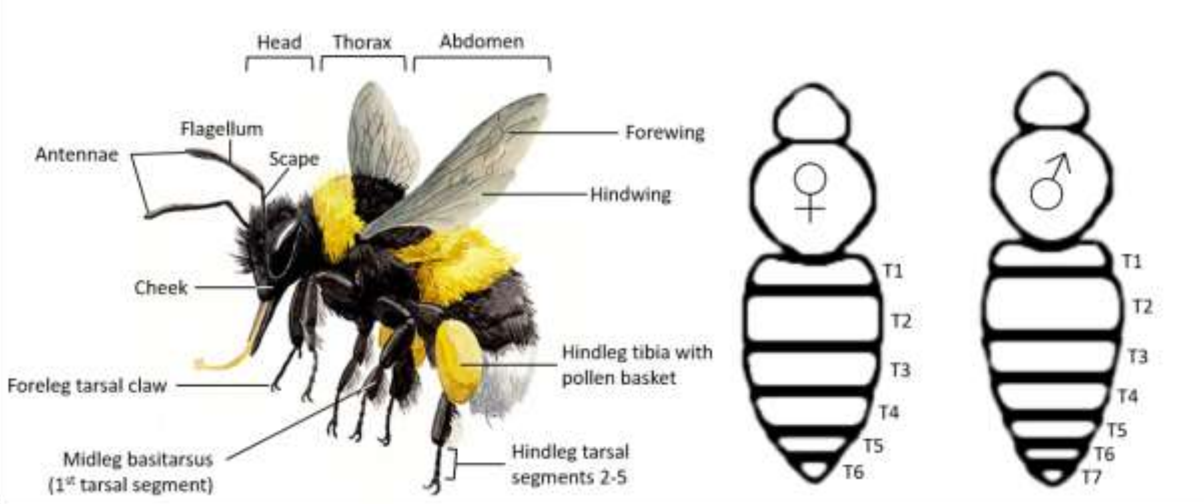

Figure 1. Generalized illustration of key bumble bee anatomy mentioned in this report. *Left*: A lateral (side) view of a female worker. *Center*: The numbering system used for the abdominal segments (tergites) in female bees, including queens (T1-T6). *Right*: The numbering system for male tergites (T1-T7). Worker bee illustration courtesy of the Blooms for Bees website: www.BloomsForBees.co.uk, which is funded by the Heritage Lottery Fund and Coventry University, used and modified by C. Ernst with permission. Line drawings produced by C. Ernst, after

illustrations in Williams *et al.* (2014), used and modified with permission.

Western bumble bee

The western bumble bee is a medium-sized bee (queen: 2.0-2.1 centimeters (cm); workers: 0.9-1.5 cm; males: 1.2-1.6 cm). The pile (the soft, fuzzy hairs covering the entire body) is moderately short and of a uniform length; the pile of *B. o. mckayi* (the subspecies found in the NWT) is longer than that of the southern subspecies. The head is short, with a cheek (oculo-malar region) slightly shorter than broad. The first tarsal segment (basitarsus) of the female midleg is rounded at the back far corner (as opposed to coming to a sharp point, as in other species). The outer surface of the female hind tibia is flat and lacks long hairs but has long fringes at the margins that form a pollen basket. The male antennae are short, with the flagellum slightly more than twice as long as the scape.

Figure 2. Female worker of *B. o. mckayi*, the subspecies found in the NWT, clearly displaying a "banded" abdominal pattern typical of this subspecies. Western bumble bees in the NWT are all banded to some degree, though the shade and extent of the light-coloured regions in T2-4 vary between individuals. Photograph courtesy of Cory Sheffield, used with permission.

Females (both queens and workers) (Figs. 2 and 4) and males (Figs. 3 and 4) have similar colouration and patterns. The head is usually dark to black, with at least some greyish to yellow hairs on the face between the eyes, and on the upper surface of the head. Hairs on the dorsal surface of the thorax (the mid-body section between the head and abdomen) form a yellow band in front of the wings, and between the wings, there is at a minimum, a large black central spot that often forms a full black band between the wings.

The western bumble bee has a wide range of abdominal colours and patterns (Fig. 4). The dorsal surface of the first abdominal segment (tergum 1, or T1, which is closest to the thorax) is black. The second (T2) is usually black at the front, and if it is predominantly yellow then the head is similarly mostly yellow. Tergum 3 (T3) can be fully yellow, fully black, or partly black with scattered yellow hairs.

Figure 3. Male specimen of *B. o. mckayi*, the subspecies found in the NWT. Specimen collected along the Dempster Highway in Yukon Territory in July 1991. Photograph courtesy of Laurence Packer, www.discoverlife.org, used

with permission.

The diverse abdominal colour patterns of the western bumble bee can be categorized as banded (the "typical" form first described by Greene (1862)) or non-banded. Banded individuals always have at least some yellow pubescence on T3, and T4 is at least partially black (Figs. 2-4). Individuals with non-banded abdomens are entirely black on *both* T2 and T3, with the terminal segments broadly and extensively white to yellow (Figs. 4 and 5).

Recent genetic and morphological analyses concluded that nearly 100 percent (%) of *B. o. mckayi* found at latitudes of 60°N are of the banded type (Sheffield *et al.* 2016). Therefore, western bumble bee workers in the NWT should consistently have banded abdominal patterns (Williams *et al*. 2012; Sheffield *et al.* 2016). *B. o. occidentalis*, the southern subspecies (Fig. 5), displays both banded and non-banded colour patterns (though the latter is the most common). The southern banded form is more variable with respect to the banding pattern and is geographically disjunct from the northern subspecies (Koch and Strange 2012; Sheffield *et al*. 2016). In the NWT, western bumble bee is most likely to be mistaken for the yellow-banded bumble bee (*B. terricola*) or the cryptic bumble bee (*B. cryptarum*), both of which have similar banding patterns (Williams *et al*. 2014; Environment and Natural Resources [ENR] 2017b).

The immature stages (egg, larva, pupa) of the western bumble bee have not been formally described in the literature. In general, bumble bee eggs are small (about 3 millimeters (mm)), elongate-oval, and pale yellow or whitish in colour (Alford 1975). Bumble bee larvae are grublike and pale, with 13 body segments, a head capsule, no eyes, and no legs (Alford 1975). Mature larvae enclose themselves in silk cocoons in which they become pupae. The pupae have all the same body parts as adult bees (eyes, antennae, thorax with legs and wings, abdominal segments, etc.), but they are pale coloured and hairless until they mature into adults.

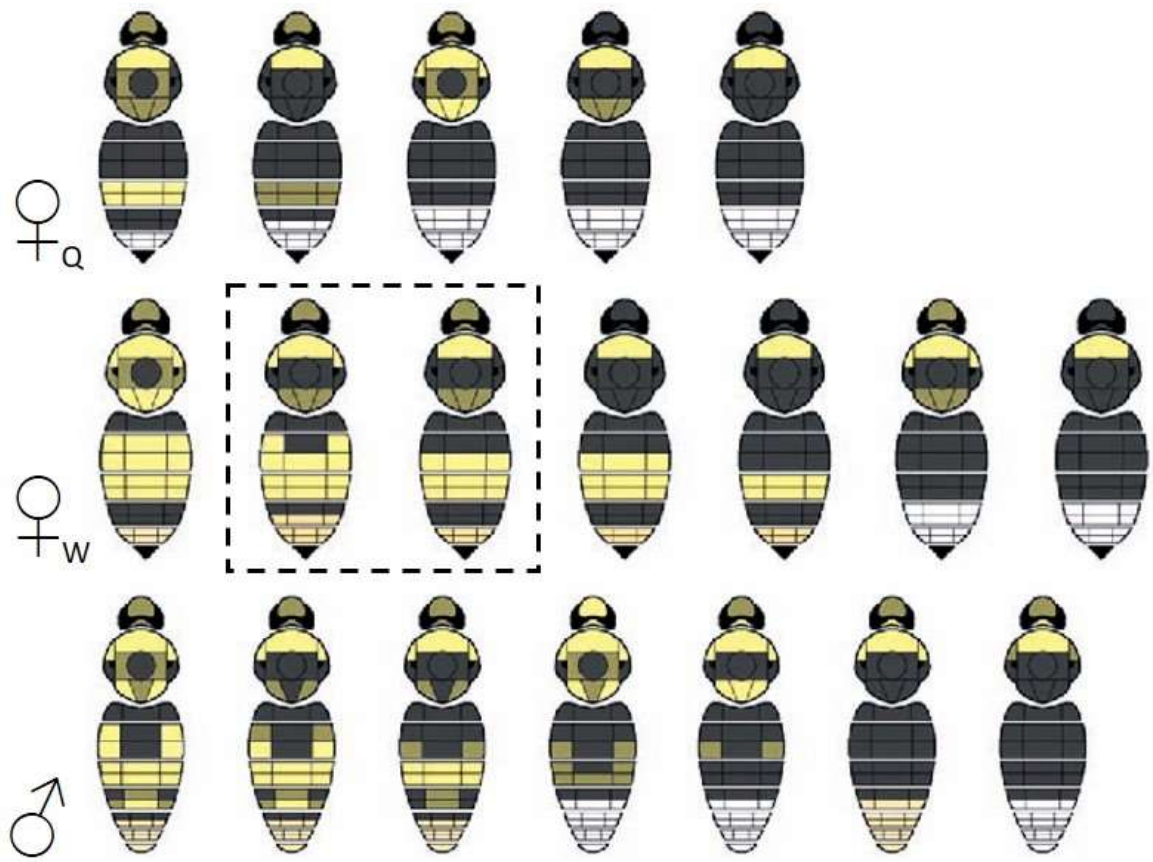

Figure 4. Colours and patterns in the western bumble bee, *B. occidentalis*. Top row: female queens. Middle row: female workers. Bottom row: males. Workers enclosed in dashed box display known banding patterns of *B. o. mckayi*, the subspecies found in the NWT.

Figure 5. A non-banded female worker (L) and male (R) of the southern subspecies of western bumble bee, *Bombus occidentalis occidentalis*. Female specimen collected from unknown location in 1888; male collected from Departure Bay, British Columbia, in August 1928. Photographs courtesy of Margarita Miklasevskaja at (Lawrence) Packer Collection of York University (PCYU) with funding from NSERC-CANPOLIN, used with permission.

See *Life Cycle and Reproduction* for more information about the life cycle of bumble bees.

Yellow-banded bumble bee

The yellow-banded bumble bee is a medium-sized bee, with reproductive individuals slightly smaller than those of the western bumble bee (queen: 1.9-2.1 cm; workers: 1.0-1.5 cm; males: 1.3-1.5 cm). The hairs are short and even. The head, cheek, basitarsus, hind tibia, and male antennae are the same as in the western bumble bee.

Females (both queens and workers) (Figs. 6 and 7) and males (Figs. 6 and 8) have similar colouration and patterns. Wings are slightly brown. Hair on the head is black, but it may be intermixed with some short pale hairs. Males may have more yellow hairs on the head than females. The second abdominal segment (T2) is usually yellow with no black at the front, or with only a narrow black fringe along the front margin. Tergum 2 can less commonly be more extensively black, in which case T4 and T5 are also mostly black. Tergum 3 is usually yellow. Tergum 5 is usually black or yellow-brown. In the NWT, the yellow-banded bumble bee is most likely to be confused with the western or the white-tailed bumble bee.

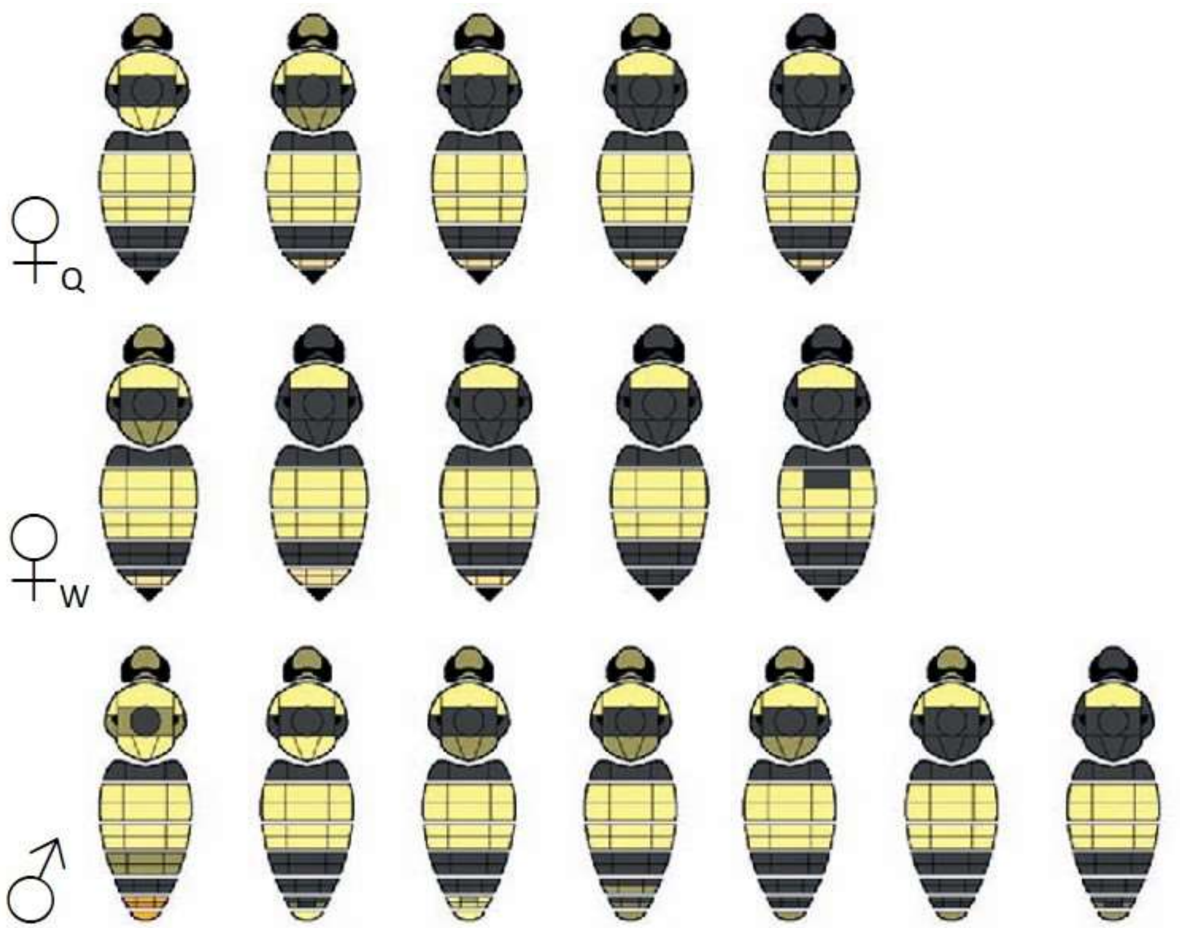

Figure 6. Colours and patterns of the yellow-banded bumble bee, *Bombus terricola*. Top row: female queens. Middle row: female workers. Bottom row: males. Illustrations from Williams *et al.* (2014), used and modified by C. Ernst with permission.

Figure 7. Female yellow-banded bumble bee, *Bombus terricola*. Specimen collected in Caledon, Ontario, in September 2002. Image courtesy of Margarita Miklasevskaja at PCYU with funding from NSERC-CANPOLIN.

Figure 8. Male yellow-banded bumble bee, *Bombus terricola*. Specimen collected in Caledon, Ontario, in August 2013. Image courtesy of Margarita Miklasevskaja at PCYU with funding from NSERC-CANPOLIN.

The appearances of yellow-banded bumble bee eggs, larvae, and pupae are not described in the literature, but they are probably similar to most other immature bumble bees (see the description above). In one study, yellow-banded bumble bee eggs averaged 3.06 mm in length, and .94 mm in width (based on 44 eggs) (Fisher and Sampson 1992). It can be difficult to measure bumble bee larvae without fatally disturbing them, but one study of two yellow-banded bumble bee colonies found that mature larvae of workers weighed about 90-300 milligrams (mg), while the mature larvae of queens were much larger and ranged from about 600-800 mg (Plowright and Jay 1968).

Gypsy cuckoo bumble bee

The gypsy cuckoo bumble bee is a medium-sized bee, smaller than either the western or yellow-banded bumble bee. There are no workers. Reproductive females (Fig. 9) are 1.7-1.9 cm and males (Fig. 10) are 1.1-1.7 cm. The hairs are of a medium length. The outer surface of the female hind tibia is convex, densely covered in hairs, and lacks a pollen basket (corbicula); this characteristic is unique to females of the subgenus Psithyrus (i.e., cuckoo bumble bees). The top of the female's abdomen is curved strongly downward (Fig. 9) and the underside of the abdomen has a strong carina (ridge) on either side near the tip.

Figure 9. Female gypsy cuckoo bumblee bee, *Bombus bohemicus*. Specimen collected in Palmer, Alaska, in May 2009. Image courtesy of Margarita Miklasevskaja at PCYU with funding from NSERC-CANPOLIN, used with permission.

Figure 10. Male gypsy cuckoo bumble bee, *Bombus bohemicus*. Specimen collected at Invern, Nova Scotia, in August 2001. Image courtesy of Margarita Miklasevskaja at PCYU with funding from NSERC-CANPOLIN, used with permission.

Colour and patterns differ between the two sexes (Figs. 9-11). On females, the hairs of the face and upper surface of the head are black, occasionally with some yellow hairs at the rear of the head. Head colour is a useful diagnostic field character: other cuckoo bumble bees in the NWT have predominantly pale hairs on the head. The sides of the thorax are predominantly black. Hairs on the third and fourth tergites are variably yellowish-white, but T4 usually has white at least in the middle, and at the back.

On males (Fig. 10), the fringe of hairs on the first tarsal segment of the hindleg is predominantly black. The sides of the male thorax are extensively black, T2 is entirely black, T4 is yellow with a little black, and T7 is black. Male antennae are of a medium length, with a flagellum about three times longer than the scape.

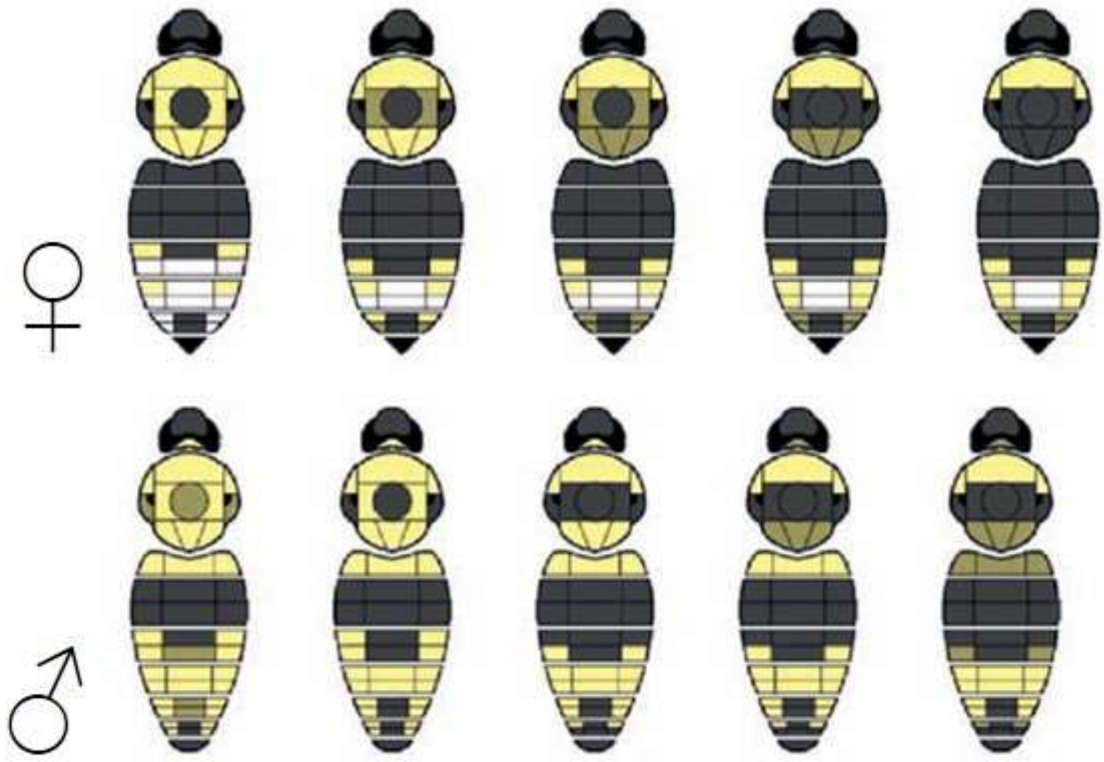

Figure 11. Colours and patterns of the gypsy cuckoo bumble bee, *Bombus bohemicus*. Top row: females (reproductive females only; cuckoo bumble bees do not have a worker caste). Bottom row: males. Illustrations from Williams *et al.* (2014), used and modified by C. Ernst with permission.

In the NWT, the gypsy cuckoo bumble bee is most similar in appearance to the other three cuckoo bumble bees found in the territory: the yellow cuckoo bumble bee (*B. flavidus*), Suckley's cuckoo bumble bee (*B. suckleyi*), and the indiscriminate cuckoo bumble bee (*B. insularis*).

Gypsy cuckoo bumble bee eggs are smaller than those of its hosts (around 2.5-2.6 mm long and 0.6-0.7 mm wide), and are narrowed toward the middle (Fisher and Sampson 1992). Egg cells into which eggs are placed are rougher in shape than those of the hosts, and are constructed from wax collected from destroyed host egg cells and nectar pots (Fisher 1988). The larval and pupal stages of this species have not been described in the literature, but they are likely similar to those of other bumble bees, as described above.

Distribution

The distribution data for all three bumble bee species are based on occurrence and/or collection records for individual specimens at specific locations, rather than populations. Occurrence records are displayed on NWT maps as single points (one point per specimen record). For North American range maps, only one record per locality is displayed per species. GPS coordinates were not available for some records in the original datasets (see *Search Effort* for more information about the data sources), so locality descriptions were used to estimate the coordinates when possible.

World distribution

Western bumble bee

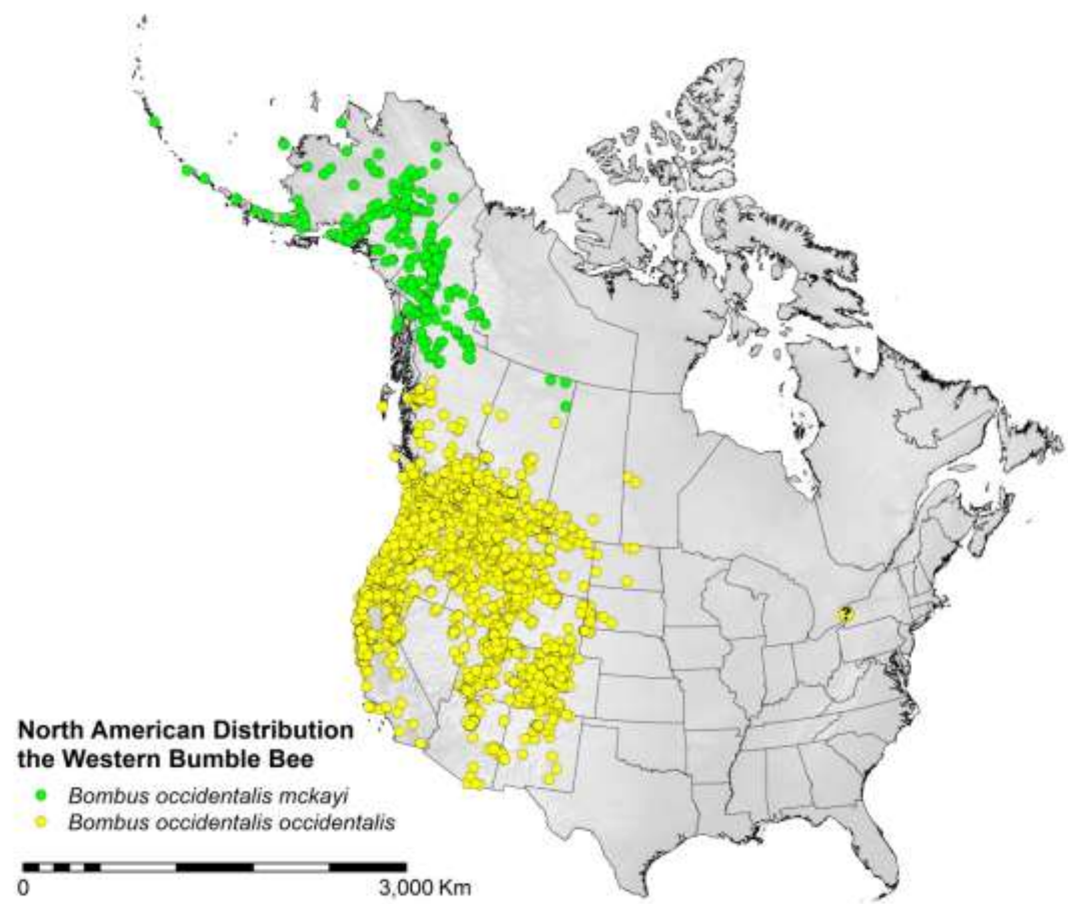

Figure 12. North American distribution of the western bumble bee, *Bombus occidentalis*, including the northern *mckayi* subspecies found in the NWT (green) and the southern *occidentalis* subspecies (yellow). See *Search Effort* for full list of sources from which points were derived. Map courtesy of C. Ernst.

The western bumble bee resides only in North America (although it has historically been imported to Europe and bred commercially there). It has been recorded from the west coast and mountain west regions of North America, from Arizona, New Mexico, and California, north through the Pacific northwest and the tundra/taiga region up to Alaska (Williams *et al.* 2014;

Hatfield *et al.* 2015b) (Fig. 12). Its range eastward includes the northwestern Great Plains and southeast Saskatchewan. A single specimen whose identity was confirmed via genetic (mitochondrial DNA) analysis was recently documented in Ontario, Canada (Hatfield *et al*. 2015b). Since this is well outside the species' known range, its presence in eastern Canada must be considered uncertain (perhaps introduced). The two subspecies' populations are distinct, and geographically disjunct.

List of jurisdictions:

- *Bombus o. mckayi*: Canada, at latitudes of 55°N or higher (northern British Columbia, western NWT, Yukon); United States (Alaska).
- *Bombus o. occidentalis*: Canada, at latitudes below 55°N (southern/central British Columbia, Alberta, Saskatchewan, Ontario (uncertain)); United States (Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, Wyoming).

Yellow-banded bumble bee

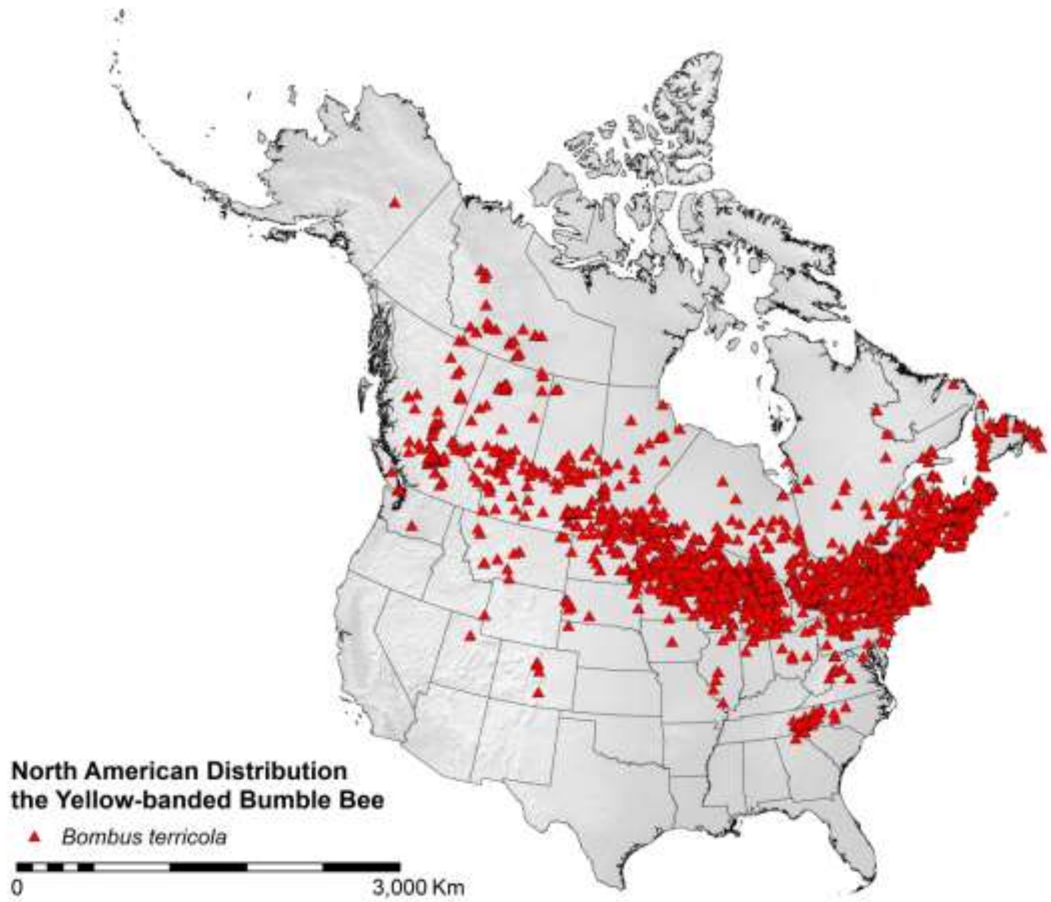

Figure 13. North American distribution of the yellow-banded bumble bee, *Bombus terricola*. See *Search Effort* for full list of sources from which points were derived. Map courtesy of C. Ernst.

The yellow-banded bumble bee is found only in North America (Fig. 13). It has a large range that includes Newfoundland and Labrador, the eastern temperate and boreal forest regions, south along high-elevation regions of the Appalacians, west through North Dakota and the Canadian Great Plains, to the tundra and taiga of Canada, and the mountain west (Williams *et al*. 2014). Approximately 50-60% of its North American range is within Canada (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2015).

List of jurisdictions:

- Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, NWT, Nova Scotia, Prince Edward Island, Quebec, Saskatchewan, Yukon); United States (Alaska, Arizona, Colorado, Connecticut, Georgia, Idaho, Illinois (possibly extirpated), Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Montana, Nevada, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Tennessee, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming) (Hatfield *et al*. 2015a).

Gypsy cuckoo bumble bee

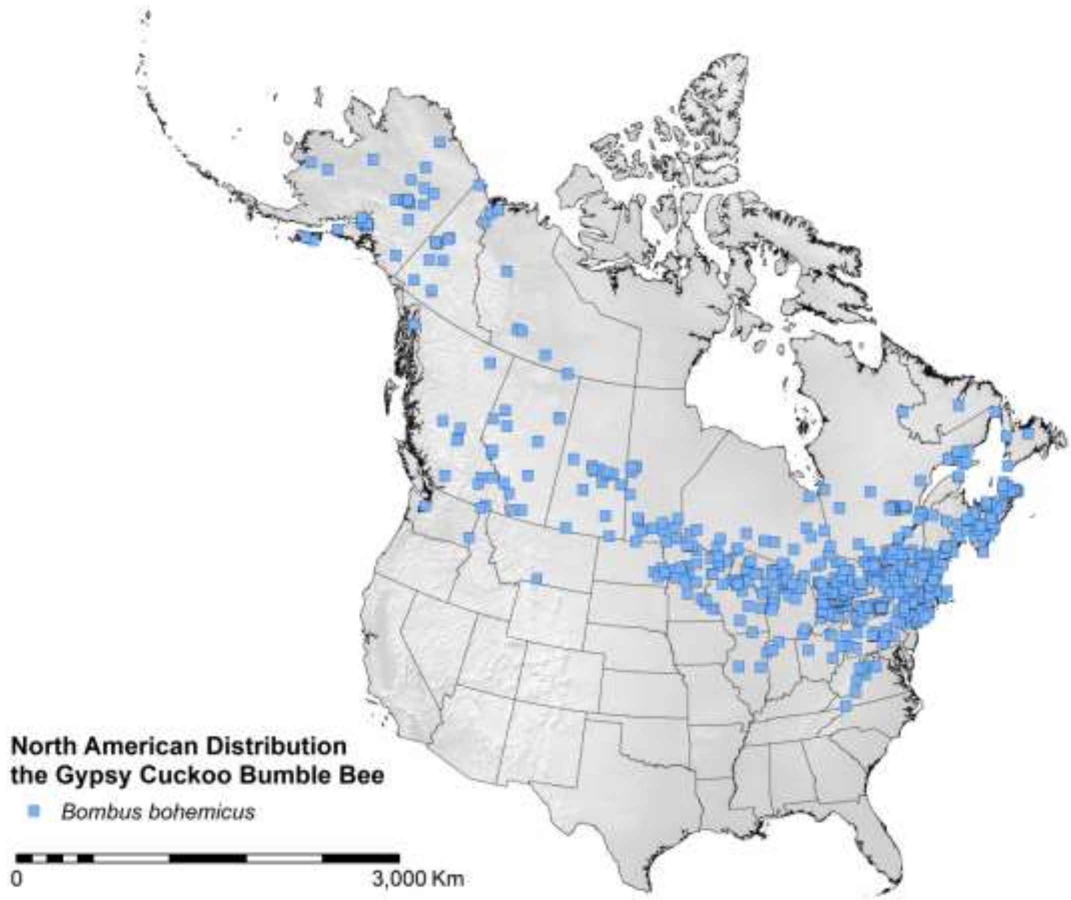

Figure 14. North American distribution of the gypsy cuckoo bumble bee, *Bombus bohemicus*. See *Search Effort* for full list of sources from which points were derived. Map courtesy of C. Ernst.

The gypsy cuckoo bumble bee is a Holarctic species. In the Old World, it is found throughout most of Europe (other than Iceland and the extreme southwest): from the north of Spain, the south of Italy and the Balkans in the south, to beyond the Arctic Circle in the north. Its range extends to the Far East of Asia, and south into many parts of China (Hatfield *et al.* 2016).

In North America (Fig. 14), the gypsy cuckoo bumble bee is found in the midwestern United States and Canada, eastern temperate and boreal forest regions, south along the Appalacians and northwest through the Great Plains, the mountain west, and in the tundra/taiga to Alaska (Williams *et al*. 2014; Hatfield *et al*. 2016). This species has one of the largest ranges of all bumble bee species in Canada (COSEWIC 2014a).

List of jurisdictions:

- Andorra; Austria; Belarus; Belgium; Bulgaria; Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, NWT, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan, Yukon); China; Czech Republic; Denmark; Estonia; Finland; France (mainland); Germany; Hungary; Ireland; Italy (mainland); Latvia; Lithuania; Luxembourg; Macedonia; the former Yugoslav Republic; Montenegro; Netherlands; Norway; Poland; Romania; Russian Federation; Serbia; Slovakia; Slovenia; Spain (mainland); Sweden; Switzerland; Ukraine; United Kingdom (Great Britain, northern Ireland); United States (Alaska, Connecticut, Idaho, Illinois, Indiana, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin) (Williams *et al*. 2014; Hatfield *et al*. 2016; Richardson 2018).

NWT distribution and locations

Given the scarcity of surveys and occurrence data in the NWT, any comments regarding the fragmentation or continuity of these bumble bees' distributions are purely speculative. The lack of records between know occurrence points (positive data) cannot be presumed to indicate that the species are necessarily absent from those areas since surveys were likely not conducted, and appropriate habitat and/or hosts may be present. Similarly, if a species of interest has not been recorded from locations where other bumble bee species were collected, this does not necessarily imply that the species is absent from those locations (i.e., negative data). Depending on a species' commonness, hundreds of bees might have to be collected at a single location before it would be reasonable to draw conclusions about the species' presence/absence (Colla and Packer 2008). Exhaustive searches for all bumble bee species have not been made at any known location in the NWT; rather, collection events were opportunistic and usually yielded small numbers of individual specimens.

A species' extent of occurrence (EO) is the area contained within the shortest continuous boundary drawn to encompass all the known, inferred, or projected sites of present occurrence of the species, excluding cases of vagrancy. Extent of occurrence was estimated for all three species using the minimum bounding tool in ArcGIS 10.3: this calculates the area within the minimum convex hull circumscribing all sites from which occurrence data (recent and historical) have been obtained for one species. An equal-area map projection (World Cylindrical Equal Area) was used during these calculations to avoid possible bias or distortions (Budic et al. 2016).

The area of occupancy (AO) is defined as the area within the EO that is occupied by a species; precise area of occupancy for these three species could not be determined from the available data. However, and index of area of occupancy (IAO) was calculated for each species. An IAO is defined as the surface area of grid cells that intersect that area occupied by the species (in km^2). In this report, the IAO for each species was determined by overlaying a 2x2 km grid over the species' extent of occurrence, determining the number of grid cells that contained occurrence records, and multiplying that by the area of each cell (4 km^2). IAOs are presented with a caveat: estimated values are likely grossly underestimated because the records are scattered and widespread. They should be viewed as rough approximations at best. In addition to calculating EO and IAO from available data, plausible maximums have also been estimated for each species, based on distribution models and other data.

Western bumble bee

In the NWT, the northern subspecies of the western bumble bee (*B. o. mckayi*) has only been collected from four sites along the Nahanni River in the Nahanni National Park Reserve (Stotyn and Tate 2012) in the Boreal Cordillera ecoregion (Ecosystem Classification Group [ECG] 2010) (Fig. 15). There is apparently one additional record of the species in the NWT dated August 4, 1944, but the location where this specimen was collected is unknown (COSEWIC 2014b) (See *Appendix A* for occurrence record details).

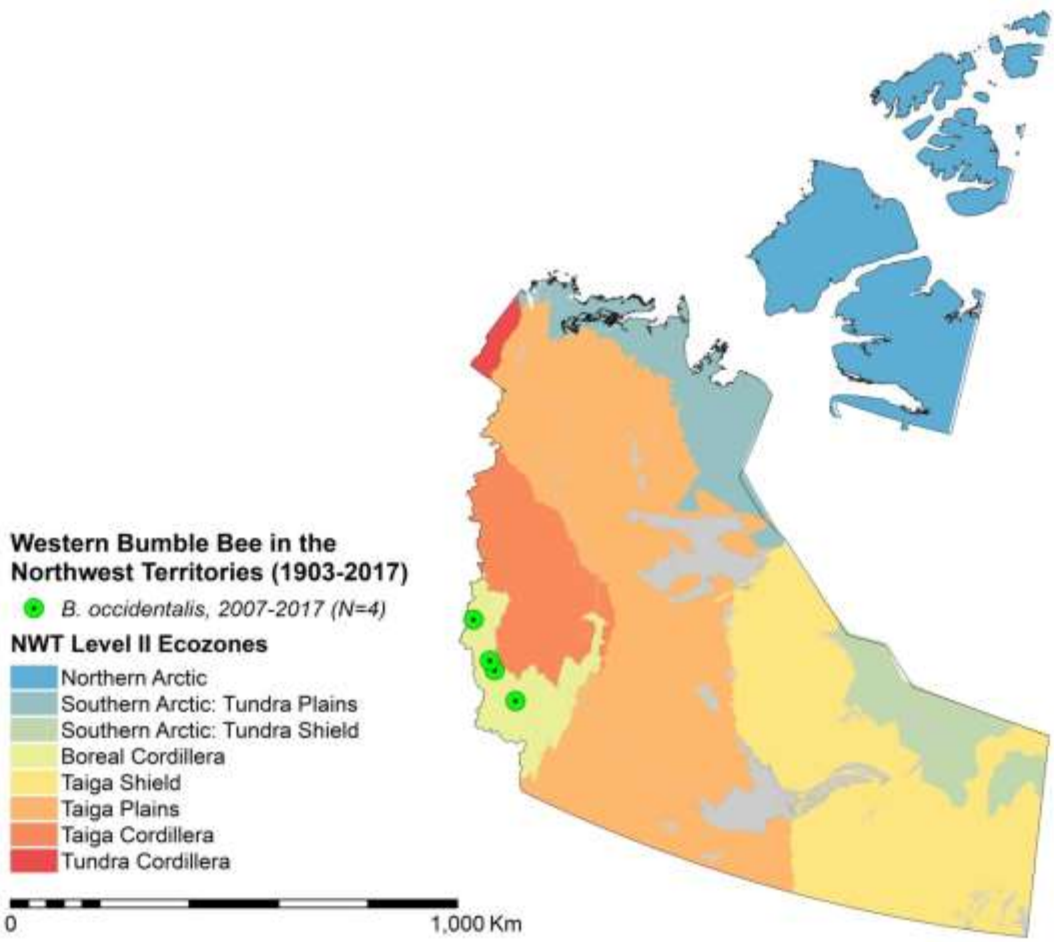

Figure 15. Occurrence records of the northern subspecies of the western bumble bee (*Bombus o. mckayi*) in the NWT (green circles). There are no historical records of this species in the NWT (i.e., prior to 2007). Points are

derived from 4 records, from a dataset compiled by Lief Richardson (2018). Map courtesy of C. Ernst.

Based on available data, the EO of the western bumble bee (*mckayi* subspecies only) in the NWT is approximately 18,809 km^2, and its IAO is 16 km^2. North American occurrence records indicate it is rarely found at latitudes north of 65 degrees, while recent distribution models (COSEWIC 2014b; Sheffield *et al*. 2016) suggest it could be found throughout much of the Boreal Cordillera, and small portions of the Taiga Cordillera (the southernmost reaches) and the Taiga Plains (only in the extreme southwest) (ECG 2010). Based on these lines of evidence, the maximum EO for this species in the NWT could plausibly be around 55,500 km^2. Assuming that the species' distribution pattern in the NWT is similar to its distribution in the Yukon and Alaska (i.e., scattered and widespread over a relatively large area), a plausible maximum IAO for the western bumble bee in the NWT is about 110 km^2 or more.

The southern *occidentalis* subspecies is not expected to be found in the NWT.

"Location" refers to a distinct area in which a single threatened event could rapidly affect all individuals of the species present. As noted in *Threats and Limiting Factors*, climate change is considered the most serious threat for western bumble bees in the NWT. Using Level III ecoregions as a proxy for NWT climatic zones in which western bumble bees are known to occur, there are two locations for western bumble bee in the NWT (Boreal Cordillera – High Boreal and Mid-Boreal Level III ecoregions) (ECG 2010).

Yellow-banded bumble bee

The yellow-banded bumble bee has been collected primarily in the Taiga Plains ecoregion of the NWT (ECG 2009), with a few records taken in the extreme southwest of the Taiga Shield (ECG 2008), and more recently in the Boreal Cordillera (ECG 2010) along the South Nahanni River (Fig. 16). The species was most recently collected in 2017, at three sites: a beach off the Mackenzie River at Norman Wells; in the town of Fort Simpson; and 40 km northwest of Fort Simpson, at km 581 on the Mackenzie Highway (Heron 2018). Another recent sighting was in downtown Yellowknife, in July 2016, and was contributed by a citizen scientist to Bumble Bee Watch (The Xerces Society *et al*. 2017) (see *Appendix A* for occurrence record details).

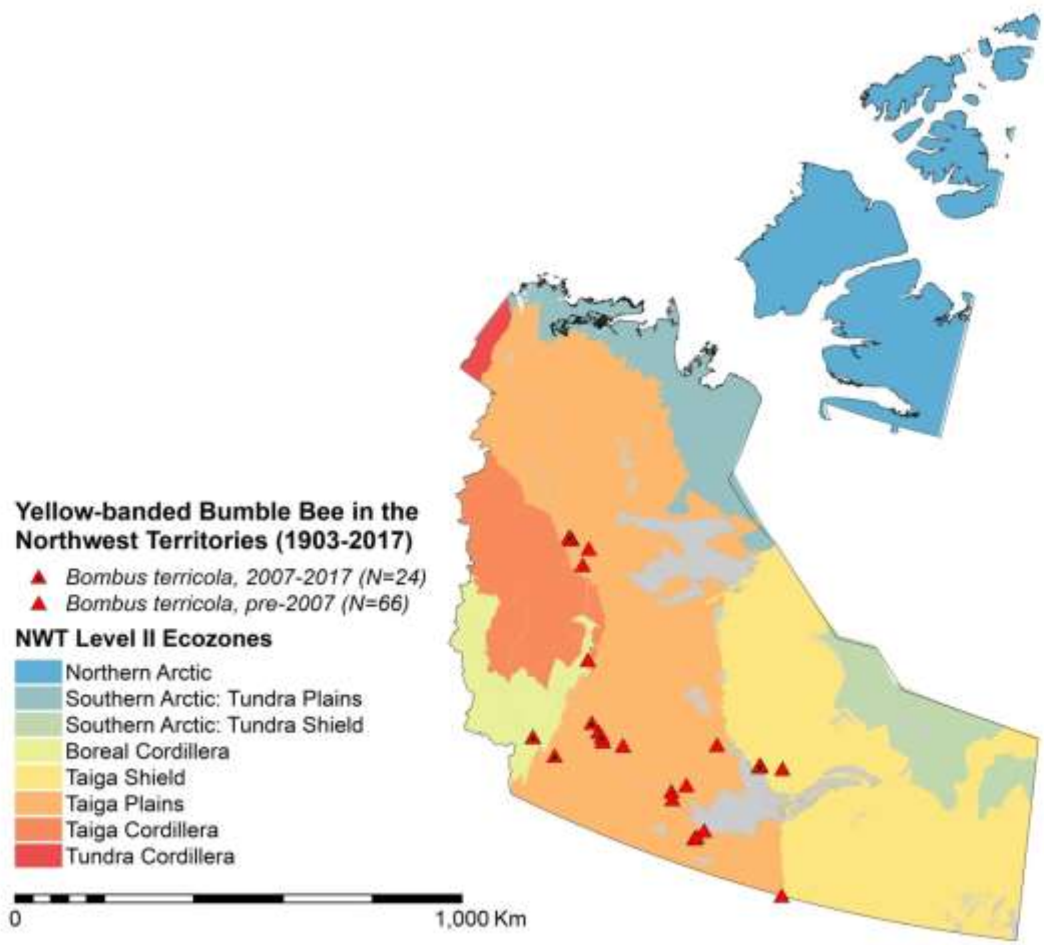

Figure 16. Current (2007-2017) and historical (1903-2006) occurrence records of the yellow-banded bumble bee (*Bombus terricola*) in the NWT (red triangles). Points are derived from: a dataset compiled by Leif Richardson (2018); a 2017 collection effort contributed by Jennifer Heron (2018); and verified sightings or collection events contributed by C. Ernst, using data sourced from www.bumblebeewatch.org. Map courtesy C. Ernst.

The EO for the yellow-banded bumble bee in the NWT is estimated to be 226,321 km^2, and its IAO is approximately 112 km^2 (28 grid cells), based on occurrence records. This species could be found throughout the south/central regions of the Taiga Plains, and more narrowly to the south in adjacent areas of the Boreal Cordillera and Taiga Shield, with a plausible maximum EO of about 284,373 km^2, and an IAO of 140 km^2 or more.

“Location” refers to a distinct area in which a single threatened event could rapidly affect all individuals of the species present. As noted in *Threats and Limiting Factors*, climate change is considered the most serious threat for yellow-banded bumble bees in the NWT. Using Level III ecoregions as a proxy for NWT climatic zones in which yellow-banded bumble bees are known to occur, there are five locations for yellow-banded bumble bee in the NWT (Boreal Cordillera – High Boreal Level III ecoregion; Taiga Plains – Central Great Bear Plains Low Subarctic, Great Slave Uplands High Boreal, and Mackenzie and Slave Lowlands Mid-Boreal Level III ecoregions; and Taiga Shield – High Boreal Level III ecoregion) (ECG 2008, 2009, 2010).

Gypsy cuckoo bumble bee

This cuckoo bumble bee has been collected at sites along the Mackenzie River in the NWT and along the entire latitudinal reach of the Taiga Plains ecoregion (ECG 2009) (Fig. 17). The most recent record of this species is a single individual from Norman Wells, in July 2017 (Heron 2018); the most recent record prior to this was from 1972, southeast of Fort Smith (see *Appendix A* for occurrence record details).

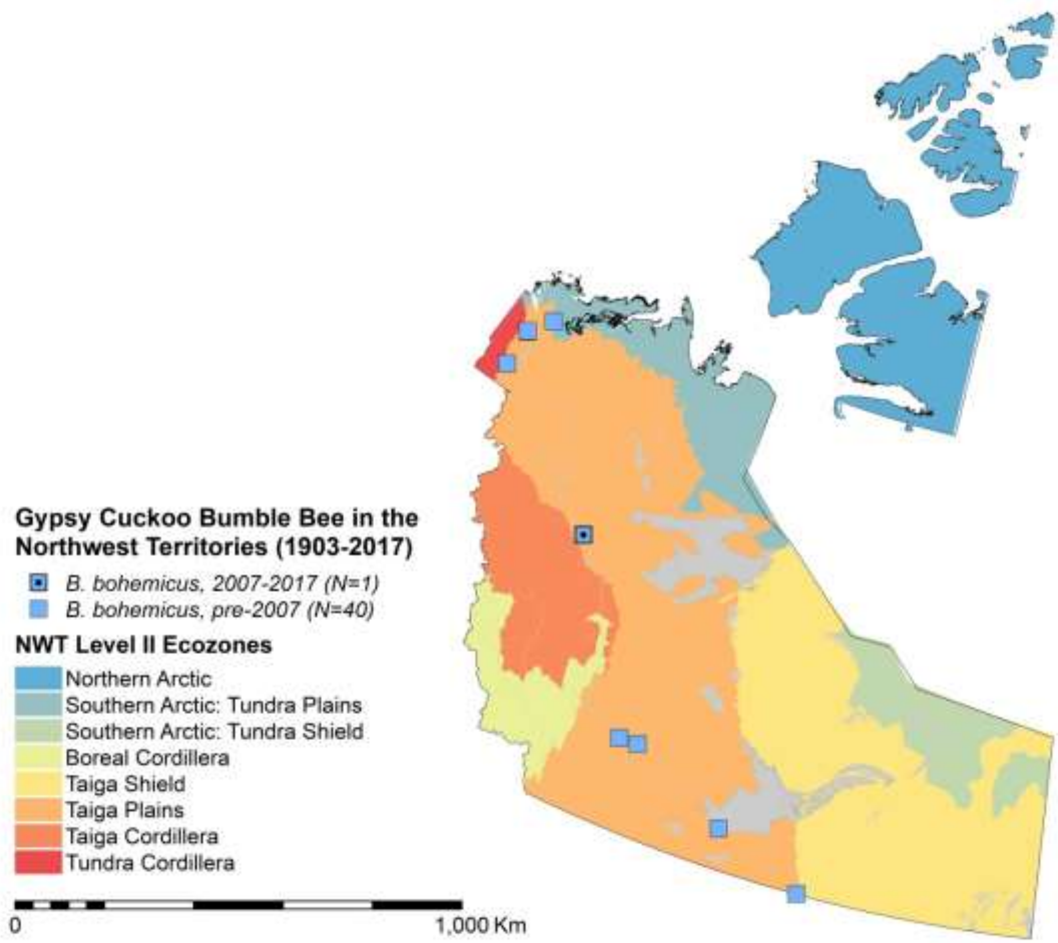

Figure 17. Current (2007-2017) and historical (1903-2006) occurrence records of the gypsy cuckoo bumble bee (*Bombus bohemicus*) in the NWT (blue squares). Points are derived from: a dataset compiled by Leif Richardson (2018), a 2017 collection effort contributed by Jennifer Heron (2018); and verified sightings or collection events contributed by C. Ernst, using data sourced from www.bumblebeewatch.org. Map courtesy of C. Ernst.

Based on available data, the EO for the gypsy cuckoo bumble bee in the NWT is estimated at 148,085 km^2, with an IAO of 36 km^2 (9 grid cells). This species could plausibly be found throughout the Taiga Plains, with a maximum EO of around 480,652 km^2, and an IAO of about 116 km^2 or greater.

“Location” refers to a distinct area in which a single threatened event could rapidly affect all individuals of the species present. As noted in *Threats and Limiting Factors*, decline in host species is the most serious plausible threat to gypsy cuckoo bumble bees in the NWT; however, because climate change is the most serious threat for its hosts, locations were determined using Level III ecoregions as a proxy for the climatic zones in which gypsy cuckoo bumble bee is known to occur. There are four such locations for gypsy cuckoo bumble bee in the NWT (Taiga Plains – Northern Great Bear Plains High Subarctic, Central Great Bear Plains Low Subarctic, Great Slave Uplands High Boreal, and Mackenzie and Slave Lowlands Mid-boreal Level III ecoregions) (ECG 2009).

Search effort

With mounting global concern over the health and resilience of wild pollinators, considerable effort has been invested in surveys of bumble bees in North America and elsewhere. Extensive occurrence data are available for wild *Bombus* species compared to many other insect taxa. A compilation of museum and other collection records (see list of all contributors at www.leifrichardson.org/bbna.html) by Leif Richardson (2018) contains over 275,000 North American specimens identified to the species level, including approximately 933 records from the NWT (included in this report). If GPS coordinates for a record were not included in the original dataset, reasonable coordinates were approximated, based on location data (e.g., name of town, landmark, water body, etc.). If a locality could not be reasonably approximated based on available information, the record was excluded from this report (Fig. 18). GPS coordinates were similarly approximated as required for all records of the three species of interest outside of the NWT (i.e., in Canada and the United States) in order to produce North American distribution maps.

According to communications with entomologists and others working in northern Canada, only a single new field survey for bumble bees has taken place in the NWT since 2014 (i.e., since the COSEWIC reports were compiled) (see *Contacts*). Sites included in this recent survey, part of a larger NWT BioBlitz event in 2017[6], were Tuktoyaktuk, Inuvik, Norman Wells, Yellowknife, and Fort Simpson (Heron 2018). Over 330 specimens were collected during the survey, including several series of the yellow-banded bumble bee and a single male gypsy cuckoo bumble bee, and are therefore a very significant contribution to data on NWT bumble bees (Heron 2018). No western bumble bees have been observed in the territory since 2011. Other bumble bee surveys have been conducted in adjacent northern British Columbia and Yukon (Hatten *et al.* 2015; Sheffield *et al.* 2016). Additional field surveys were not conducted specifically for this report.

Citizen science initiatives can provide an alternative and scientifically sound source of open-access occurrence data, provided that the identifications are validated by individuals with appropriate taxonomic expertise (Theobald *et al.* 2015; Lukyanenko *et al.* 2016; Sullivan *et al.* 2017). Citizen science may be particularly valuable for recording species over large spatial scales

[6] http://inaturalist.ca/projects/nwt-tno-bioblitz-canada-2017

or in locations that are visited infrequently. Citizen science contributions to NWT bee occurrence data are generally scarce, and primarily originate from heavily populated areas such as Yellowknife. Twenty-eight additional records of bumble bee sightings in the NWT were found (either non-target species, or specimens that were not conclusively expert-identified to species), made to citizen science programs[7] between 2012-2017 (Ernst 2018).

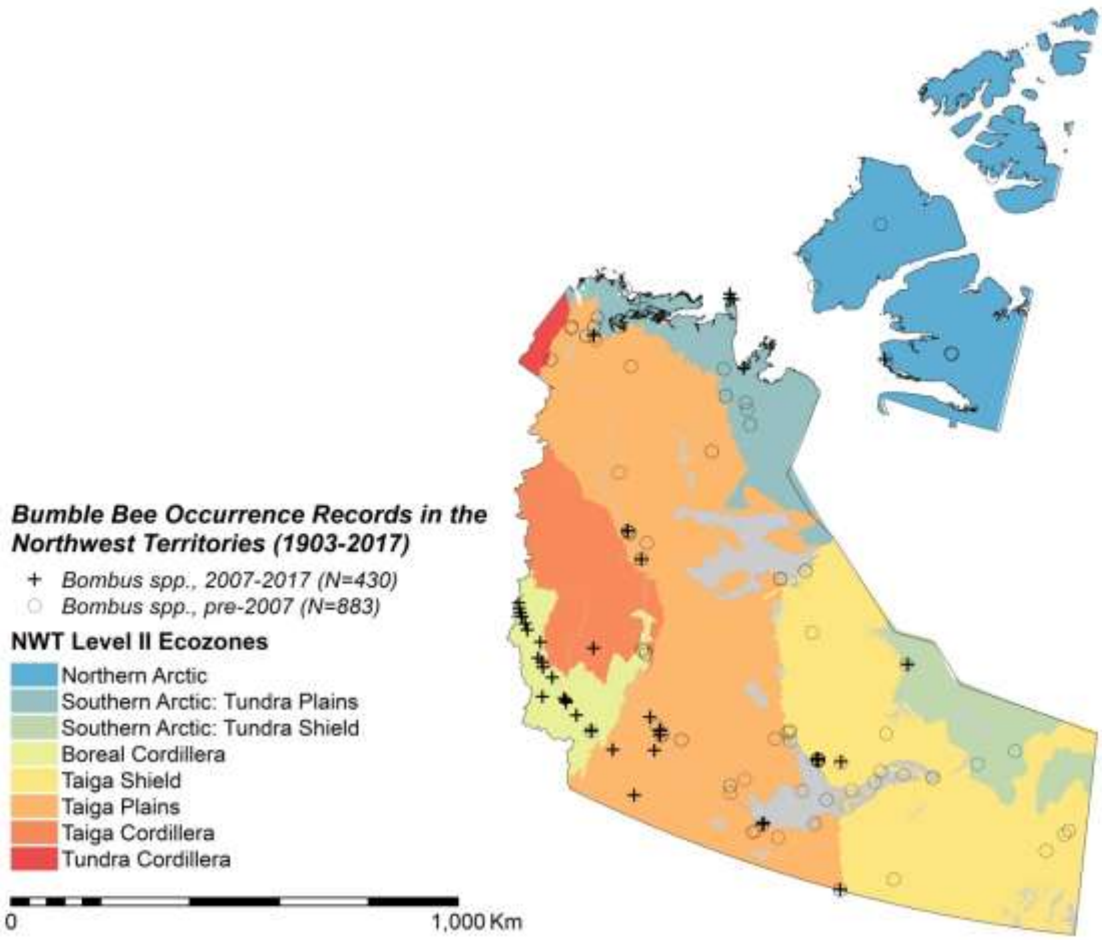

Figure 18. Map of all bumble bee (*Bombus* spp.) occurrence records in the NWT from 1903-2017. Black crosses: current records (2007-2017); black circles: historical records (1903-2006). Two records with uncertain dates were excluded from this figure (total N for all records = 1,285). Points are derived from: a dataset compiled by Leif Richardson (2018), a 2017 collection effort by Jennifer Heron (2018); and verified sightings or collection events contributed by C. Ernst (2018).

DNA barcode databases can also be a source of “new” records, when the barcode sequences of older, mis-, or unidentified specimens are clustered within an expected Barcode Index Number (BIN; a grouping with high concordance with species identities) (Ratnasingham and Hebert 2013). A search of DNA barcoded specimens in the Barcode of Life database (Ratnasingham and Hebert 2007) failed to turn up any new reassigned (e.g., cryptic/erroneously identfied specimens) records of the species of interest from the NWT.

[7] Bug Guide or Bumble Bee Watch.

Status of Western Bumble Bee, Yellow-banded Bumble Bee, and Gypsy Cuckoo Bumble Bee in the NWT

Approximately 1,285 specimens, representing 24 bumble bee species, have been collected or observed in the NWT between 1903-2017 (Ernst 2018; Heron 2018; Richardson 2018). Table 2 lists the number of occurrence records for the three species of interest from every decade since 1900, as well as the number of all other bumble bee records combined. For each decade, these data were also used to calculate the relative abundance[8] (RA) of the three species, compared to all other bumble bees recorded in the NWT. One record of the yellow-banded bumble bee and one other bumble bee record are not included in these calculations, as the years during which the specimens were collected are uncertain.

About 40% of all NWT bumble bee records were from 1940-1960, and may originate from the Northern Insect Survey conducted by the Government of Canada between 1947-1957 (Freeman 2009). No bumble bees were recorded from the NWT between 1980-1999, but this is certainly due to a lack of surveys, rather than the absence of bees. Specimens from the 2017 survey (Heron 2018) represent over 25% of all NWT bumble bee records.

Table 2. Number of occurrence records and RA (in parentheses) of the western bumble bee (*Bombus occidentalis*), yellow-banded bumble bee (*B. terricola*), gypsy cuckoo bumble bee (*B. bohemicus*), and other bumble bee (*Bombus*) species recorded from the NWT by dedade, from 1900-2017 (total N = 1,285).

Decade	**Western bumble bee**	**Yellow-banded bumble bee**	**Gypsy cuckoo bumble bee**	**Other *Bombus* spp.**	**Total**
1900-1909	0	0	0	11 (1.000)	11
1910-1919	0	0	0	3 (1.000)	3
1920-1929	0	9 (0.474)	0	10 (0.526)	19
1930-1939	0	0	0	69 (1.000)	69
1940-1949	0	1 (0.004)	13 (0.055)	224 (0.041)	238
1950-1959	0	25 (0.093)	24 (0.089)	221 (0.819)	270
1960-1969	0	2 (0.012)	2 (0.012)	161 (0.976)	165
1970-1979	0	6 (0.150)	1 (0.025)	33 (0.825)	40
1980-1989	0	0	0	0	0
1990-1999	0	0	0	0	0
2000-2009	0	22 (0.579)	0	16 (0.421)	38
2010-2017	4 (0.009)	24 (0.056)	1 (0.002)	401 (0.933)	430
Uncertain	*0*	*1*	*0*	*1*	*2*

[8] A species' relative abundance (RA) can tell us how rare or common it is compared to all the members of its community. Here, it measures the proportion of one bumble bee species out of the total number of all bumble bees. For example, in the 1920s, 19 bumble bees were collected and 9 of them were yellow-banded bumble bees. By dividing 9/19, we find that the RA of yellow-banded bumble bees in that decade was 0.474; in other words, 47.4% of all bumble bees were yellow-banded bumble bees. In the 1940s, only one yellow-banded bumble bee was collected out of 238 bees, so its RA was only 0.004, or less than 1%.

Total	4	90	41	1150	1285

Compared to other parts of Canada, large expanses of land in northern boreal and arctic regions have been insufficiently sampled for bumble bees in general; most efforts have focsed on populated, easily accessible areas (Dennis and Thomas 2000; Funk *et al.* 2005). As a result, we have very little knowledge about historic or current abundances or distributions of any bumble bee species in northern Canada, including the NWT. It is therefore possible that the western bumble bee, yellow-banded bumble bee, and gypsy cuckoo bumble bee have ranges different from those inferred from the sparse data currently available (see estimates in *NWT Distribution*).

BIOLOGY AND BEHAVIOUR

Information in this section is largely drawn from general references on bumble bees (Morse 1982; Benton 2009; Goulson 2010; Williams *et al.* 2014). Other information, including data pertaining specifically to the species of interest where available, is supported by additional citations.

Habitat requirements

Bumble bee habitat must include access to flowing plants throughout the active season, suitable overwintering sites, and for non-parasitic species, suitable nesting sites. Parasitic species like the gypsy cuckoo bumble bee require established colonies of their host species.

Western bumble bee

The western bumble bee is a habitat generalist. Across western North America it can be found at altitudes from sea level to above 2,000 meters, and has been collected from many habitat types: mixed, deciduous, and coniferous forests; open, grassy areas; urban parks and gardens; chaparral and shrub areas; and mountain meadows (Williams *et al*. 2014). The species could reasonably be expected to use many different types of habitats in the NWT.

Records of the northern subspecies (*B. o. mckayi*) in the NWT are located along the South Nahanni River, in the western half of the Boreal Cordillera Ecoregion (Level II) (ECG 2010). This ecoregion covers an area of roughly 57,018 km^2 and has some of the tallest and most rugged mountains in the NWT, but there is highly variable topography (ECG 2010). Three records are found in the Mid-Boreal (MB) (Level III), an ecoregion with short and cool summers, very cold winters, high levels of precipitation, and a mean annual temperature of -4 to -6°C (ECG 2010). The northernmost record is from the southern half of the Natla Plateau MB (Level IV), where lower-elevation plateaus and sloping valleys are dominated by open subalpine spruce-lichen woodlands (ECG 2010). The other two MB records are further south in the Ragged Range Valley MB (Level IV); there, the glacial valleys of the South Nahanni are characterized by blankets of till, lodgepole pine (*Pinus contorta*) and trembling aspen (*Populus tremuloides*) amidst mixed-wood and spruce (*Picea* spp.) forests, plus rich wetlands and meadows (ECG 2010). The fourth specimen was collected in the High Boreal (HB) (Level III), in the Liard Plateau HB (Level IV), where rolling hills and ridges are typically covered with open spruce woodlands and forests (ECG 2010).

Climatic suitability models show that temperature and precipitation are strong drivers of the subspecies' distribution in northern Canada (Sheffield *et al*. 2016). These models have suggested there may be very little suitable habitat for B. *o. mckayi* in the NWT (they identify a small area in south-central NWT). However, the models are heavily influenced by the much greater number of records from southern provinces, Yukon, and Alaska, and therefore are probably not accurate for the NWT. New models with more NWT specimens would generate a clearer understanding of the habitat and climatic requirements for this species. It is likely that the species is found throughout much of the Boreal Cordillera, at least at latitudes below 65 degrees.

The western bumble bee has been observed from, or could be expected to use the following species as food plants: thistle (*Cirsium* spp.), Richardson geranium (*Geranium richardsonii*), Arctic lupine (*Lupinus arcticus*), raspberry (*Rubus* spp.), and goldenrod (*Solidago* spp.) (Williams *et al*. 2014). Other flowering plant species are probably visited as well.

This species prefers to establish colonies in holes underground, on open slopes bordered by trees, with west-southwest facing entrances and downward-sloping tunnels connecting the belowground chamber to the surface (Hobbs 1967; Richards 1978; Thorp *et al*. 1983; Laverty and Harder 1988). Nest tunnels up to 2.1 meters long have been reported for this species (Macfarlane *et al.* 1994). Western bumble bees do not construct nest chambers themselves. Instead, they use the abandoned burrows of small mammals (squirrels, mice, etc.), or natural cavities such as those formed in rocks (Plath 1927; Hobbs 1967). The western bumble bee will occasionally establish colonies at or above the ground surface: some queens will use artificial "bee houses" attached to tree trunks several feet above the ground as nesting sites (Richards 1978), while another nest was found in logs among railroad ties (Hobbs 1967). In Richards' study (1978), 45% of western bumble bee queens chose nesting sites positioned where open meadows transitioned into aspen groves, 38% opted to nest in forested habitat, and open meadows were selected only 17% of the time.

Western bumble bee hibernacula sites are unknown. Hobbs (1967) described a single western bumble bee hibernaculum found two inches below the ground surface on a steep west-facing hill.

Yellow-banded bumble bee

The yellow-banded bumble bee is also a habitat generalist. Throughout North America, it has been collected in open coniferous, deciduous, and mixed-wood forests; wet and dry meadows;

prairie grasslands; meadows near riparian zones; along roadsides; in taiga adjacent to wooded areas; urban parks; gardens and agricultural areas; subalpine habitats; and others (Williams *et al*. 2014). It has also been recorded in some high-elevation, montane habitats (Tucker and Rehan 2017). The species could reasonably be expected to use a wide variety of habitats in the NWT.

In the NWT, the yellow-banded bumble bee is recorded from the central/southern Taiga Plains Ecoregion (Level II), adjacent western Taiga Shield HB (Level III) ecoregions, and recently also from the south Nahanni River in the Boreal Cordillera (ECG 2008, 2009, 2010). The Taiga Plains have many waterbodies and extensive peatlands; the Mackenzie River delta occurs mainly in this region (ECG 2009). In the southern third of the Taiga Plains, the climate is quite mild (mean annual temperatures of -1 to -4.5°C) with warm, moist summers, and there are species-rich, dense, mixed-wood forests (ECG 2009). The western lower-elevation Taiga Shield HB similarly experiences milder climates, and has discontinuous but vigorous mixed-wood forests and richly vegetated shorelines around its many ponds and lakes (ECG 2008). The yellow-banded bumble bee is not found in the northern High Subarctic (HS) regions of the NWT, nor is it known from high elevations/mountain ranges (COSEWIC 2015). Maxent habitat suitability models using the yellow-banded bumble bee's North American distribution suggest there is very little suitable habitat for the species in the NWT (Sheffield *et al*. 2016). However, the models are strongly influenced by the huge number of records from southeastern regions. Refined models using NWT occurrence records would produce different results and possibly provide more insight as to their habitat requirements in the territory.

Like the western bumble bee, the yellow-banded bumble bee nests belowground in abandoned mammal burrows with downward sloping entrances, at depths of 15-45 cm (Plath 1927; Hobbs 1967).

The yellow-banded bumble bee is a generalist floral visitor. In Ontario, it has been recorded from about 90 different flowering plant species, including many introduced species (Colla and Dumesh 2010). Similar food plant diversity was recorded for the species in the northeastern United States (Jacobson *et al.* 2018). In the NWT, the yellow-banded bumble bee is known or expected to visit asters (*Asteraceae* spp.), gooseberry (*Ribes* spp.), roses (*Rosa* spp.), raspberry (*Rubus* spp.), lowbush cranberry (*Vaccinium vitis-idaea*), and blueberry (*Vaccinium* spp.) (ENR 2017b).

Yellow-banded bumble bee queens overwinter in burrows they construct in loose soil or rotting trees (Benton 2009).

Gypsy cuckoo bumble bee

The habitat of gypsy cuckoo bumble bee is not well documented. In Ontario, it may prefer to reside and forage close to wooded areas (Colla and Dumesh 2010). In the NWT, the gypsy cuckoo bumble bee has been collected in the western half of the territory, in the Taiga Plains, including in the High Subarctic (HS) (unlike the yellow-banded bumble bee, which does not appear so far to the north). The HS region in the north is generally drier and colder than in south/central areas (mean annual temperatures of -5 to -11°C) (ECG 2009). White spruce (*Picea glauca*)-dominant forests are most common in the Taiga Plains HS; these become more open and shorter at higher latitudes, ultimately transitioning to shrub-dominated tundra (ECG 2009). The gypsy cuckoo bumble bee has only been found in the Mackenzie Delta HS Ecoregion (Level IV), which is distinguished from the rest of the Taiga Plains HS Level III Ecoregion by its deep permafrost layer and forests with tall, dense, closed, spruce stands and robust understories (ECG 2009). Forested areas appear to be an important component of gypsy cuckoo bumble bee habitat in the NWT.

As a social parasite, the gypsy cuckoo bumble bee does not require nesting habitat per se, but it does need the nests of suitable bumble bee hosts to reproduce. Most cuckoo bumble bee species are quire specialized and parasitize only one bumble bee host; more rarely, they can have as many as five hosts (Williams 2008). While the gypsy cuckoo bumble bee is one of these rare generalists at a global scale, its only confirmed host in the NWT is the yellow-banded bumble bee. However, since the gypsy cuckoo bumble bee is known from locations where this particular host seems to be absent, this indicates that it must have other host species in the NWT. Other psosible hosts in the NWT include the western bumble bee and the cryptic bumble bee.

Floral visitation records from other provinces suggest that the gypsy cuckoo bumble bee is a generalist forager, but it may be more selective about its nectar sources than western and yellow-banded bumble bees, as it tends to be associated with plants that flower close to wooded areas (Colla and Dumesh 2010). In the NWT, the gypsy cuckoo bumble bee is thought to visit thistle, raspberry, goldenrod, blueberry, cranberry, and Nahanni aster (*Symphyotrichum nahanniense*) (ENR 2017b).

The gypsy cuckoo bumble bee's overwintering sites are unknown, but it most likely uses hibernacula situated below the soil surface or in decomposing plant matter, as is the general habit of bumble bees.

Movements

Bumble bees are capable of flying distances of at least several kilometers (Rau 1924; Heinrich 2004; Hagen *et al.* 2011). Males of the buff-tailed bumble bee (*B. terrestris* Linnaeus 1758) can fly up to 9.9 km from their colony (Kraus *et al.* 2009). New queens disperse to establish new colonies after emerging from their hibernacula in the spring. Dispersal capabilities for the three species of interest are not known. Queens of other bumble bee species have been observed to establish new nests at distances ranging from 400 meters to 9.9 km from their hibernacula (see Owen *et al.* 2011 and references therein). Estimates of different species' dispersal rates vary from 0.3 km to 10 km per generation (i.e., per year) (Stout and Goulson 2000; Owen *et al*. 2011). Potential geographic barriers for dispersal include mountain ranges and large water bodies, although individual species vary considerably in their ability to overcome such barriers (Benton

2009).

Female workers are generally thought to forage close to their nests, perhaps within 300-600 meters, likely because the time and energetic costs of the flight are high (see review by Dramstad 1996). Mark-recapture studies suggest that workers faithfully use the same forage patch throughout their lifetime. Assuming a maximum foraging distance of 600 meters, a forage patch could be as large as 1.13 km^2 (Dramstad 1996). Bumble bees will forage much further from their nests (up to 1,750 meters in one case) if there is a particularly abundant food source, but these instances are generally known only from agricultural systems with dense monocultures of flowering crops and high nectar rewards (e.g., Walther-Hellwig and Frankl 2000), and these are uncommon in the NWT.

Gypsy cuckoo bumble bee dispersal must be contingent upon and limited by the movements of its host(s).

Bumble bees are cold-adapted and are non-migratory animals.

Life cycle and reproduction

Bumble bees are eusocial[9] insects that live in nests, or colonies, usually consisting of a single queen and female workers. Colonies are annual, with a single generation produced per year, and consist of three adult castes (specialized groups with different behaviours and roles): a queen (the reproductive female), workers (typically the non-reproductive female offspring of the queen), and males (reproductive). Cuckoo bumble bees are the exception; as parasites, they have only reproductive females and males, with no queen or worker castes (more information about the cuckoo bumble bee life cycle is provided later in this section.

New bumble bee colonies are established by the surviving young queens each spring. Queens seeking new nesting sites will fly low over the ground, inspecting different objects and landscape features that might serve as an adequate location. When a suitable site is located, western bumble bee queens will drag dead grass or soil into and around the tunnel entrances, apparently to disguise or reduce the size of the entrances (Hobbs 1967). Queens will also generally rearrange any nesting materials (grass, leaves, hair, etc.) already present in the cavity before starting to produce egg cells and storage pots for honey production, using slivers of wax she produces from glands on her abdomen. She will then forage for nectar and pollen before laying eggs, which hatch in about four days. The larvae have four instars[10], and take roughly two weeks to fully develop. The larvae initially feed on pollen, and may also be directly fed honey by the queen, a

[9] Eusocial animals live in groups and have highly advanced social structures. Individuals cooperate and take care of the young, they have overlapping generations of adults (in bumble bee colonies, new queens and males live with the original queen when they are young), and different groups of individuals (called "castes") have different behaviours and roles in the colonies.

[10] An instar is a growth stage of a larva. Between each growth stage, the larva sheds its skin (this is called "molting"), revealing the larger instar beneath. This is how the larva grows and gets bigger over time.

role later assumed by workers. The western bumble bee is a "pollen-storing" species, meaning that each larva is fed pollen individually ("pocket-making" species distribute food rather unevenly across clumps of egg cells) (Hobbs 1967). Pollen-storers may need more pollen than pocket-making bumble bees to initiate worker production. Mature larvae spin cocoons and pupate[11], and develop for an additional two weeks, making the total development time approximately 5 weeks. The new adult female workers emerge from the pupae and begin foraging and feeding for the queen and subsequent broods.

In temperate and arctic environments, the maximum size a bumble bee colony can reach is largely limited by food availability, which is closely tied to the length of the active season and weather conditions. Despite challenging climatic conditions, northern bumble bees develop relatively large colonies, perhaps because they tend to establish early in spring and produce reproductives[12] quite late in the fall (Hobbs 1967). Established western bumble bee colonies can contain up to 1,685 workers and produce up to 360 new queens (Macfarlane *et al*. 1994). In the NWT, active western bumble bee workers were observed in mid-July, while yellow-banded bumble bee workers have been encountered from early June until early September (Fig. 19). Assuming that it takes about five weeks for the first worker brood to develop and begin foraging, some yellow-banded bumble bee queens must be active by late April/early May, and western bumble bee queens must be active by early June. More data are required from the NWT to fully understand the timing of emergence and development of these species.

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[11] When a larva pupates, it has its final molt (skin shed) and becomes a pupa. While the larva feeds and is active, the pupa is an inactive form. It is the final stage before becoming an adult.

[12] "Reproductive" or "reproductives" refers to female and/or male individuals capable of producing offspring.

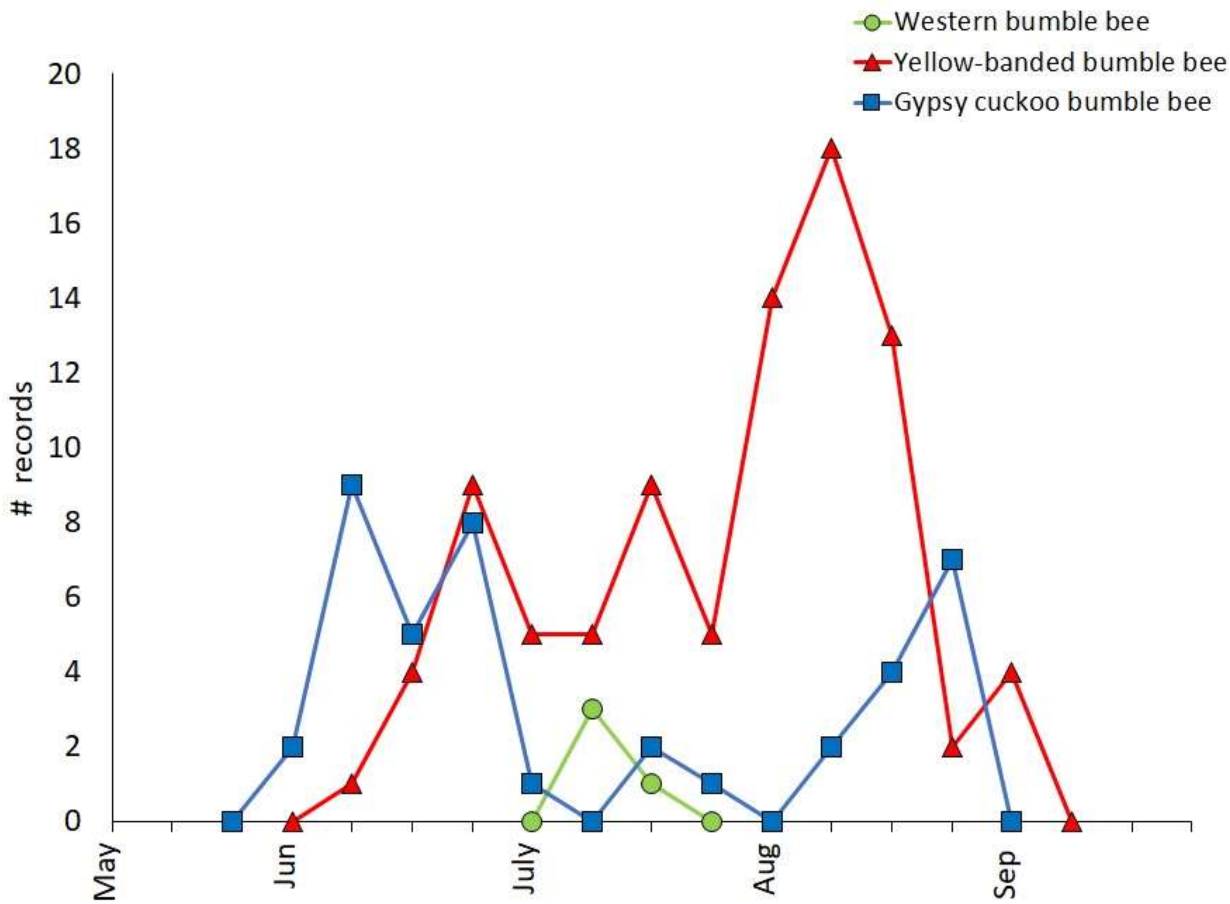

Figure 19. Seasonal activity patterns from May to September of the western bumble bee (*Bombus occidentalis*), yellow-banded bumble bee (*B. terricola*), and gypsy cuckoo bumble bee (*B. bohemicus*) in the NWT. Reported values are the total number of specimens (all castes) collected during each quarter of each month (all years combined). The observation date for one record of the yellow-banded bumble bee was not available, so it was omitted from this analysis. In instances where observation dates were recorded as a date range (i.e., when passive traps were deployed for multiple days), the median day was used as an approximation. Data are derived from: a dataset compiled by Leif Richardson (2018), a 2017 collection effort contributed by Jennifer Heron (2018), and verified sightings or collection events from www.bumblebeewatch.org (Ernst 2018). Figure courtesy of C. Ernst.

The queen produces reproductive males and new reproductive females are at the end of the active season. Males patrol established territorial circuits daily in search of mates, depositing species-specific pheromone scent-markers at what have been variously termed “stopping places” or “buzzing places” along the route. It is assumed that females are attracted to these marked sites, and that mating occurs when males revisit them the following day (Hobbs 1967), but there is little evidence to support this assumption.

All workers die at the onset of winter, along with the old queen and males. Only the young, mated females survive the cold winter temperatures by hibernating in sheltered overwintering sites (hibernacula). Mated young females may begin constructing their hibernacula as early as the same day as copulation.

Because cuckoo bumble bees have no pollen baskets on their legs, they cannot collect pollen.

They gypsy cuckoo bumble bee is thus an obligate social parasite, and has a different reproductive strategy than non-cuckoo bumble bees. Like the birds of the same name, cuckoo bumble bees do not construct nests or rear workers on their own. Rather, they invade and deposit their eggs in the nests of other bumble bees and rely on the hosts' workers to rear their young (Fisher 1984). The gypsy cuckoo bumble bee is a parasitic generalist, and uses many different species of bumble bees as hosts across its global range (Benton 2009; Bunk *et al.* 2010). Its confirmed hosts in North America are the rusty-patched bumble bee (*B. affinis*; not found in the NWT) and the yellow-banded bumble bee. Possible hosts also include the western bumble bee and cryptic bumble bee (the gypsy cuckoo bumble bee parasitizes the latter species in Europe and it is also present in the NWT) (Bunk *et al.* 2010; Williams *et al*. 2014). Compared to other cuckoo bees that take over or kill the host queen, the gypsy cuckoo bumble bee takes a relatively passive approach to invasion, avoiding conflict with the host queen or antagonizing the workers: a gypsy cuckoo bumble bee female can often be found "peacefully" incubating cocoons alongside the host queen within minutes of the parasite's arrival in the nest (Fisher 1984).

Female cuckoo bumble bees emerge later in the spring than their host species (Suhonen *et al.* 2015), then seek colonies to invade. Gypsy cuckoo bumble bees in the NWT have been observed in late May – earlier in the active season than their known host, the yellow-banded bumble bee (Fig. 19). This is a good indication that gypsy cuckoo bumble bees probably use at least one other early-emerging species as a host. Several NWT species have been observed in later April and early May, including the cryptic bumble bee. Female cuckoo bumble bees detect host colonies by species-specific scent marks deposited by host workers at the nest entrance (Foster and Gamboa 1989; Fisher *et al.* 1993; Bunk *et al*. 2010; Martin *et al*. 2010). Upon entry in a host nest, the female gypsy cuckoo bumble bee is typically met by attacking workers attempting to bite and sting the intruder bee; the cuckoo bee will in turn remain motionless, move slowly to the outer edges of the comb, or hide under the comb or host queen (Fisher 1984). Female gypsy cuckoo bumble bees rarely retaliate with stringing, opting instead to threaten workers by grabbing and positioning them as if to sting before releasing them, and very few host workers are killed in these interactions (Fisher 1984). The intensity and duration of the host worker attacks increase with the size of the colony (in large colonies the female cuckoo bumble bee may be entirely engulfed in a ball of attacking workers), and the likelihood of a successful invasion correspondingly decreases with host colony size (Fisher 1984, 1987). It is perhaps unsurprising that female gypsy cuckoo bumble bees are generally more likely to try invading small colonies rather than large ones. If she is not attacked, the invading female will groom herself for several minutes, then follow the host queen and/or rub her own body against the comb (this probably reduces or masks scents that make it obvious she is an intruder) (Fisher 1984; Kreuter *et al.* 2012).

The female cuckoo bumble bee deposits her eggs in egg cells made of wax salvaged from damaged host egg cells. She helps the host workers care for her brood by defending them from attacks, as well as by feeding and incubating them (Fisher 1988). Like the western bumble bee and yellow-banded bumble bee, gypsy cuckoo bumble bee reproductives are produced at the end of the active season. Male gypsy cuckoo bumble bees also patrol scent-marked routes to locate female mates. Interestingly, the pheromones they leave on stopping places seem to cause males to gather together (Kullenberg 1956 *in* Goulson 2010), possibly to give females a better opportunity to select a high quality mate among multiple candidates.

Physiology and adaptability

Many insects, especially smaller species, are obligately ectothermic: they cannot create their own metabolic (body) heat so they must get it from external sources like the sun or warm surfaces, and they have body temperatures close to that of their environment. Bumble bees must reach internal temperatures of at least 30°C before they are able to fly (Goulson 2010). This would be a problem for bumble bees in colder regions, except for the fact that they *can* generate their own metabolic heat (Heinrich 2004). By shivering the muscles in its thorax, a bumble bee can make itself much warmer than its surrounding environment. Northern bumble bee species tend to have larger bodies, shorter legs, and longer hair, all of which help them preserve heat and prevent heat loss (Peat *et al*. 2005). The northern *mckayi* subspecies of the western bumble bee has longer hair than the southern subspecies.

Female gypsy cuckoo bumble bees have adaptations that may help them successfully invade a host colony and defend against attacks by host workers. They have large, well-muscled mandibles (jaws); bodies with extra-thick exoskeletons[13]; and long, broad, and strongly curved stingers through which large amounts of venom can be pumped (Fisher and Sampson 1992). Additionally, female gypsy cuckoo bumble bees have twice as many ovarioles[14] as at least one of their hosts (the yellow-banded bumble bee), and their eggs are much smaller (Fisher and Sampson 1992). These differences might allow gypsy cuckoo bumble bee females to produce more offspring than their hosts, and increase the chances that their offspring will receive a greater share of the colony's resources (food, protection) and improve their chances of survival.

As short-tongued species, western and yellow-banded bumble bees forage at open flowers with short corollas (the part of the flower where petals are fused into a tube that leads to the nectar). While reaching its tongue into a flower's corolla to collect nectar, a bumble bee gathers or deposits pollen: short-tongued bees are therefore pollinators of flowers with short corollas. However, both western and yellow-banded bumble bees are known to be primary nectar-robbers, meaning that they can avoid the obstacle of long corollas by chewing holes at the base of the tube to access the nectar ("robbed" flowers are not pollinated by the bees as a result) (Miller 1978; Laverty and Harder 1988; Goulson 2010). The western bumble bee is one of only two

[13] The exoskeleton is the hard outer body covering that provides protection and support. Bees and other insects have no bones or internal skeletons.
[14] Ovarioles in bees are like ovaries in mammals: this is where eggs are produced in females.

bumble bee species that have mandibles with distinct teeth (Goulson 2010); this rather unique adaptation makes nectar-robbing even more efficient.

Interactions

Pollination ecology

Bumble bees depend on a wide variety of flower species for nectar and pollen and are important generalist pollinators of flowering plants. Plants in the NWT either known or assumed to be visited and pollinated by the three bumble bee species of interest are listed previously (see *Habitat Requirements*). The two nectar-robbing species may have a negative effect on the reproductive success of some flowering plants with long corollas, but the effects of nectar-robbing on fruit and seed production probably varies by plant species (Ledbetter 2017). The yellow-banded bumble bee is an important pollinator of commercially-grown lowbush blueberry and cranberry (Evans *et al.* 2008). Neither blueberries nor cranberries have been commercialized in the NWT, but wild blueberry and cranberry (*Vaccinium*) species are widely harvested for personal consumption (Murray and Boxall 2002; Wohlgemuth 2012). Wild *Vaccinium* are likely pollinated by all three species. The gypsy cuckoo bumble bee has been recorded on the Nahanni aster (NWT Species at Risk [NWT SAR] 2018), a rare endemic plant known only from the Nahanni National Park Reserve in the NWT (Working Group on General Status of NWT Species [WG-GSNWTS] 2016). It is unknown how much, if at all, this rare species depends on the gypsy cuckoo bumble bee for pollination. All three bumble bee species likely forage alongside each other where their distributions overlap (perhaps competitively), and they would also compete for pollen and nectar resources with many types of bees, flies, beetles, and other insect pollinators.

Interactions with parasitoids and parasites

Parasitoids are insects that lay eggs inside the bodies of other insects, ultimately killing the hosts. Known insect parasitoids are flies in the families Conopidae and Phoridae, and wasps in the familiar Brachonidae. Conipids do parasitize western bumble bees and other species in some parts of North America (James and Li 2012), but conopids are absent north of 50° of latitude and are not a concern in the NWT (Burt 2015). Brachonids (Stahlhurt *et al*. 2013) and phorids are unusually abundant and diverse in the north, including in the high arctic. Species lists for the latter two families are not available for the NWT, but it is reasonable to assume that bumble bee parasitoids are present among the territory's fly and wasp fauna.

Cuckoo bumble bees are obligate social parasites of other bumble bees. Western bumble bees and yellow-banded bumble bees are known to be parasitized by Suckley's cuckoo bumble bee, and they are probably also hosts for the indiscriminate cuckoo bumble bee and the Fernald cuckoo bumble bee (*B. flavidus*). The gypsy cuckoo bumble bee is known to parasitize the yellow-banded bumble bee and one species not found in the NWT (the rusty-patched bumble bee); it may also parasitize western bumble bees and cryptic bumble bees.

Interactions with predators

Foraging worker bumble bees are thought to have few "true predators", and as such, their activities may not be greatly affected by predation (Goulson 2010). The bright yellow/white/orange and black stripe patterns displayed by all three species are classic examples of warning colouration[15] (Williams 2007), but some animals are apparently willing to overlook the implied threat. Spiders, robber flies (family Asilidae), and songbirds are probably the main true predators of bumble bees worldwide (Goulson 2010). Crab spiders are ambush hunters that wait on flowers for prey. Large crab spiders are capable of catching bumble bees (Plath 1934), and do so more effectively than web-spinning spiders. In the NWT, there are approximately 15 species of crab spider large enough to prey on bees, including the widespread goldenrob crab spider (*Misumena vatia*), and numerous *Xysticus* species (WG-GSNWTS 2016). At least seven species of robber flies are known from the NWT (Cannings 1994). Robber flies snatch bees out of the air while in flight, as do birds. Robins (*Turdus migratorius*, Turdidae), flycatchers (Tyrannidae) including the olive-sided flycatcher (*Contopus cooperi*), northern shrikes (*Lanius exubitor*, Laniidae), and summer tanagers (*Piranga rubra*, Cardinalidae) are birds present in the NWT known to prey on bumble bees elsewhere.

Bumble bee nests may also be predated by mammals, including foxes, skunks, mink, bears, shrews, voles, and mice, but none of these animals specialize in bumble bee predation. Since they all nest below the ground, the three bee species are likely protected from most mammal predators most of the time.

STATE AND TRENDS

Population

Abundance

The absolute abundance of any bee species cannot easily be determined. Most bumble bee records result from opportunistic collections or observations instead of from repeatable, standardized sampling regimes: sampling efforts cannot be quantified. Any estimates of absolute abundance, either historical or recent, would be excessively speculative. Established colonies can produce hundreds of workers and dozens of queens per year, so an individual specimen collection event is probably indicative that at least hundreds of other individuals (from the same

[15] Warning colouration tells predators an animal is dangerous to eat: it may be venomous, poisonous, or otherwise toxic or painful.

colony) are present in approximately the same location (see *Movements* for discussion on foraging and dispersal ranges) during the year the specimen was collected.

While absolute abundances cannot be determined, proxies can be used to assess trends over time. The relative abundance (RA) of one bumble bee species is one such proxy, and it can be calculated by dividing the number of records for that species by the total number of bumble bees collected (Colla and Packer 2008). The RA of western bumble bees, yellow-banded bumble bees, and gypsy cuckoo bumble bees in the NWT are shown for each decade since 1900 in Table 2.

Trends and fluctuations

Information from residents of Fort Good Hope and Red River suggests that bumble bee numbers have generally remained stable, or perhaps increased slightly (Pierre Benoit *in* Benson 2012). Other reports from residents of Inuvik indicate that "bumble bee numbers have dropped drastically" (John Jerome *in* Benson 2012).

Only four western bumble bees have been collected in the NWT, all from the same year. During the most recent decade (2010s), it has had an RA of about 1%. It is impossible to comment on changes in the species' absolute abundance or the stability of the NWT population over time.

Some researchers suggest the southern subspecies (*B. o. occidentalis*) is suffering the most significant declines in the western bumble bee's North American range (Sheffield *et al.* 2016). Evidence from northern British Columbia, Yukon, and Alaska suggests that *B. o. mckayi* has comparatively stable populations in the north (Koch and Strange 2012; COSEWIC 2014b; Pampell *et al*. 2015; Sheffield *et al.* 2016), while populations of *B. o. occidentalis* in southern British Columbia are declining (Colla and Ratti 2010).

An examination of changes in the RA of the yellow-banded bumble bee in the NWT reveals no obvious temporal trends. Its maximum RA was about 59% (22 out of 38 NWT bumble bee observations) in the 2000s, less than 1% (1 out of 238 observations) in the 1940s, and recent records place its RA at about 5.6% during the current decade, when about 430 specimens were collected (Table 2).

The gypsy cuckoo bumble bee's RA in the NWT was 0% from 1900 until the 1940s, when it first appeared in collection records with an RA of about 5.5%. Its RA during the last decade is less than 1%, and reached a maximum of 8.9% in the 1950s when 24 individuals were noted out of 270 NWT bumble bee observations. Only one specimen was collected between 1970-2009. Populations of the gypsy cuckoo bumble bee in the Yukon may be declining: only two individuals have been detected in that territory in the last 5 years (Heron and Sheffield 2018). Those two specimens, and the one collected in the NWT in 2017 (Heron 2018) are the only recent detections of the species in North America (Heron and Sheffield 2018).

It is difficult to draw sound conclusions about temporal changes in RA for the yellow-banded bumble bee and the gypsy cuckoo bumble bee, because the total number of bumble bee specimens records in the NWT is quite low and varies considerably from decade to decade (N = 0 to 430 individuals). Decades during which larger numbers were recorded (N > 150) might be more meaningful (i.e., more likely to reflect something close to the "true" RA). However, RAs are highly variable even in these "high collection" decades: the yellow-banded bumble bee's RA ranges from 0.9-9.3%, while that of the gypsy cuckoo bumble bee's is between 0.2 and 8.9% (Table 2).

Given the low number of observations year-to-year, longer-term trends in RA might be evident by treating records as either "recent" (2007-2017) or "historical" (2006 or earlier), and pooling the data accordingly before calculating each species' RA (Fig. 20). It is impossible to comment meaningfully on long-term changes in the western bumble bee's RA since it has only been recorded from one location in one year. Yellow-banded and gypsy cuckoo bumble bees appear to have recently declined in RA, by -26.8% and -95.1%, respectively (Fig. 20). Even with pooled data, the RAs are based on very small sample sizes and should be interpreted conservatively. There are insufficient data to determine whether these apparent differences in RA are statistically significant.

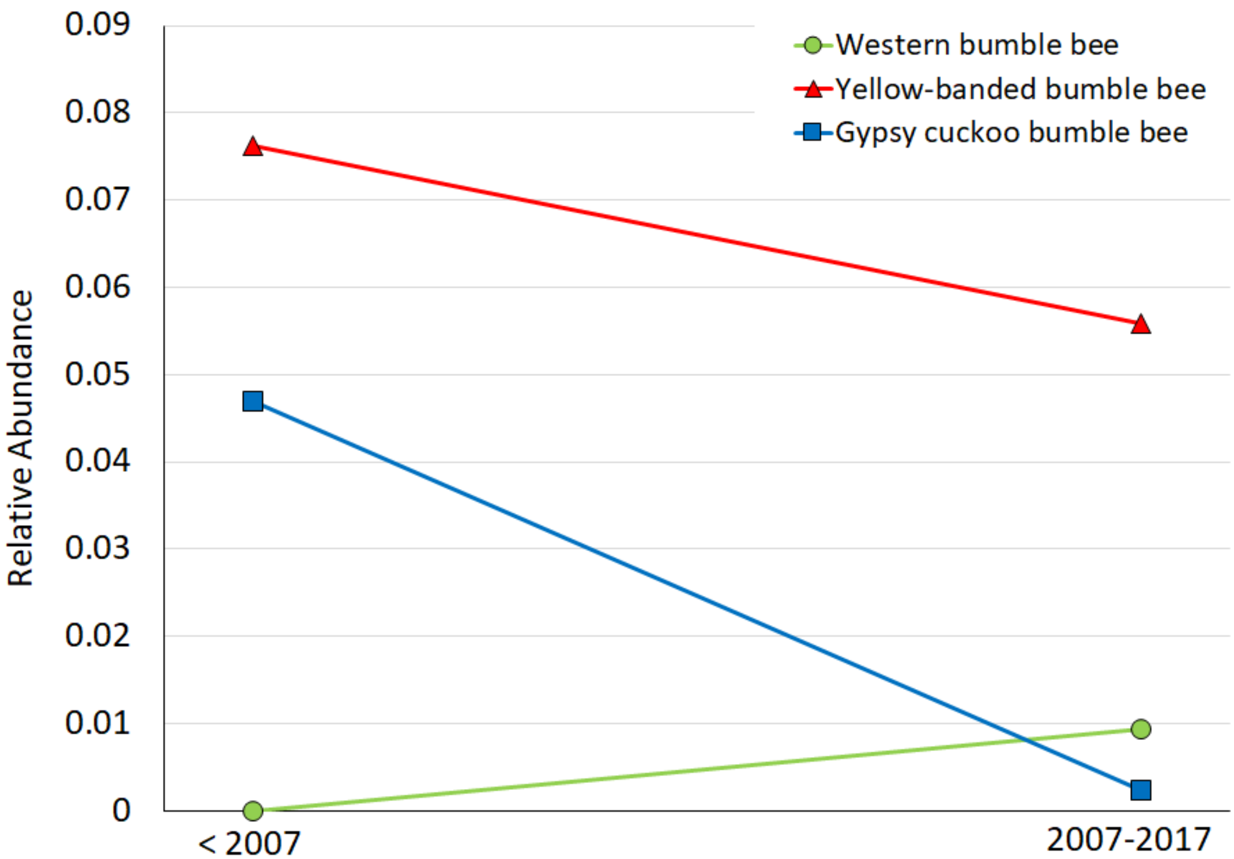

Figure 20. Relative abundance (RA) of the western bumble bee (*Bombus occidentalis mckayi*), yellow-banded bumble bee (*B. terricola*), and gypsy cuckoo bumble bee (*B. bohemicus*) in the NWT in the last decade (2007-2017; total number of *Bombus* collected = 430), compared to historical NWT records (2006 and earlier; total number of *Bombus* collected = 853). Records for which dates were uncertain (N = 2) were not included in this analysis. Data

were derived from: a dataset compiled by Leif Richardson (2018), a 2017 collection effort contributed by Jennifer Heron (2018), and verified sightings or collection events contributed by C. Ernst, using data sourced from www.bumblebeewatch.org (Ernst 2018). Figure courtesy of C. Ernst.

Population dynamics

Information on the population dynamics of these species (birth and death rates, immigration and emigration rates, demographic trends) is not available for these three bumble bee species.

Possibility of rescue

The western bumble bee (*mckayi* subspecies) is present in northern British Columbia and the Yukon, and populations in those regions appear to be stable. However, large mountain ranges in the southwest of the NWT could impede the dispersal of rescuers into the territory. More sampling is required to determine if the species is present in other areas of the NWT, and if so, whether emigration is possible or more likely from the pool of rescuers.

The yellow-banded bumble bee is known from adjacent areas of northern Alberta, northern Saskatchewan, and northern British Columbia. Once very common throughout North America, this species is in serious decline throughout southern and central Canada, but it may be more stable in northern British Columbia (Hatfield *et al*. 2015a). Immigration from this small potential pool of rescuers in British Columbia may be impeded by large mountain ranges in southwestern NWT.

The gypsy cuckoo bumble bee is also recorded from adjacent areas of northern British Columbia, northern Alberta, and from the Yukon. However, the only new records of the species in Canada since 2008 are from the Yukon, where it is still encountered infrequently; small and declining populations are unlikely to provide significant rescue effects. Additionally, the species can only disperse from areas outside the NWT if there are sufficient hosts available along the way. Its known host, the yellow-banded bumble bee, is known from adjacent areas of northern British Columbia, northern Alberta, and northern Saskatchewan, but populations are probably only stable in British Columbia. The yellow-banded bumble bee has not been recorded from the Yukon, but the cuckoo bumble bee's presence in the territory indicates that a suitable host must be present. The cryptic bumble bee is a potential host, and it remains very common with stable populations throughout North America, including in the NWT (Hatfield *et al.* 2014).

Habitat

Habitat availability

In the south, all three species face considerable habitat loss and fragmentation due to agricultural intensification, and land use changes associated with natural resource exploitation (logging and hydroelectricity), recreation, and human habitation (Javorek 2011).

Although certain site characteristics are preferred to an extent, they all display considerable habitat plasticity. Underground nesting sites are preferred by these species, and by many other bumble bees in the NWT. Niche overlap, or competition for suitable nesting sites from other species, is a potential stressor for these bumble bees (Richards 1978), but the distribution or number of nesting sites are unknown.

Habitat fragmentation

Habitat fragmentation can potentially restrict the movement of foraging bumble bees. Foraging, nesting, and overwintering sites need to be relatively close to each other, although bumble bees can travel long distances if needed. Their capacity for flight aids with dispersal between habitat fragments, even if unsuitable habitat or physical barriers (e.g., water bodies) are present.

Habitat trends

Information on the smaller-scale habitat requirements (e.g., at the local or microhabitat level) of the three species in the NWT specifically is not available. The large-scale habitats from which the species have been recorded in the NWT (i.e., Level III and IV ecozones) have been described in *Description* and *Habitat Requirements*. All three species are found in natural habitats that vary considerably in terms of topography, precipitation, forest/vegetation types, etc. Yellow-banded and gypsy cuckoo bumble bees are also known to occupy many habitat types in urbanized or otherwise heavily modified landscapes in the NWT (see *Habitat*), as does the western bumble bee elsewhere in North America, suggesting that all three species may be able to persist even if some or many types of their natural habitats were fragmented or destroyed.

These species' natural (non-urban/unmodified) habitats are still extensive in the NWT, since human populations, developments, and activities are all quite low. However, natural habitats are expected to change considerably in the next 50 years, due to changes in temperature and precipitation regimes (see detailed discussion on climate-related change in *Threats and Limiting Factors*). It is unknown if these changes will have positive or negative effects on the three bumble bee species.

Distribution trends

Distribution trends for the three bumble bee species cannot be meaningfully assessed from the sparse and temporally disparate occurrence data available.

THREATS AND LIMITING FACTORS

Across the entire North American extent of the three species' known distributions, multiple factors are likely working in concert to directly threaten their persistence or increase their susceptibility to risk. Threats at the continental scale include pathogens, land use changes, and resulting losses of habitat and food sources, agricultural chemicals including pesticides, invasive species, pollution, and climate change (International Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2016).

Large expanses of the NWT have not been surveyed for bumble bees: waterways and locations in and around city centers are overrepresented in the records, but this is almost certainly just an artifact of selective sampling (many parts of the NWT are extremely difficult to access). As such, threats should be assessed for areas where the species have recently been recorded, but not exclusively: threats should probably also be assessed or considered in areas where they *may* exist. The area contained within the extent of occupancy is probably the best proxy for this at present. However, the scope and severity of the majority of threats are unknown, as very little baseline or current data are available in the NWT. Rather than omit potential threats from this review, they have been retained and examined in the hopes that they will be useful for identifying threats worth monitoring in the NWT.

An International Union for Conservation of Nature (IUCN) and Conservation Measures Partnership (CMP) threats calculator (Salafsky *et al.* 2008; Master *et al*. 2009; NatureServe 2014; CMP 2018) was used to identify and evaluate 11 categories of possible threats to the three species. With this tool, the impact level (Very High, High, Medium, Low, or Negligible) of each threat is determined by cumulatively considering the scope[16], severity[17], and timing[18] of different aspects of the threat. For example, a threat rated Very High is one that is already destroying or reducing most of a species' population, or is likely to do so in the very near future. A Negligible threat is one that currently has very little to no impact on the species and is unlikely to impact the species in anything other than the distant future. An overall threat impact level for each species is determined by considering the impacts of all 11 threats. All 11 threat categories are listed and examined in *Appendix A*. Any threats determined to have a Low, Medium, High, or Very High impact on the three bumble bee species are discussed below.

The four main threats identified for the three bumble bee species in the NWT are as follows, in order of their importance.

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[16] The proportion (%) of the population or occurrence likely to be affected by the threat over the next 10 years.
[17] How likely the threat is to destroy, degrade, or reduce the number of occurrences or habitat, or how much the threat will reduce the population.
[18] Considers if the threat is ongoing/current, likely to happen in the future, or has only happened in the past.

Climate change and severe weather – threat level High (but uncertain)

This section considers threats from long-term climate change that may be linked to global warming, and weather events more severe than what is typical for the region.

Arctic temperatures are rising twice as fast as the global average, with associated shifts in vegetation zones, habitat, and species range (Arctic Climate Impact Assessment [ACIA] 2004; International Panel on Climate Change [IPCC] 2014; ENR 2016b). Temperatures are rising in the NWT, and generally have been warmer in the past 15 years compared to all years recorded prior to 1990, both in winter and summer (ENR 2016b). The entirety of the NWT is expected to be affected by climate change, although some regions (for example, the Mackenzie River valley) may be warming even more quickly than others (ENR 2008). With climate warming, summers begin earlier and end later, extending the length of the active season for bees. A longer active season could be positive for bumble bees if food resources are available when queens emerge to establish new colonies in spring, but if there is a timing mismatch with floral resources, the effects could be devastating.

Bees are cold-adapted species; such species are likely to show population declines with increased annual temperatures, especially in northern latitudes (Goulson *et al*. 2015; Kerr *et al*. 2015). Habitat suitability models for the yellow-banded bumble bee and the western bumble bee show that temperature is a key determinant of the species' distributions in northern Canada (Sheffield *et al*. 2016). Bumble bees are intolerant of prolonged high heat exposure; it can render them immobile, or result in death (discussed in more detail in *Other Limitations and Considerations*) (Martinet *et al*. 2015). There have been a number of extended heat waves in the NWT in the past decade, and temperature fluctuations are generally less predictable than in the past (ENR 2008, 2016b). Heat waves usually affect some parts of the NWT more than others, so individual heat wave events are not expected to be a threat to all bumble bees within their entire distribution. Bumble bees whose active seasons end in early or mid-summer are most likely to escape the negative effects of heat waves (since heat waves are most likely to occur in July/August). However, yellow-banded and gypsy cuckoo bumble bees are both active at least until the end of August, so they are not protected from heat waves by their phenology. The western bumble bee is likely active during the same period.

Climate change can affect bumble bees by altering or shifting their habitats. Climate warming in northwestern Canada has caused permafrost to degrade; permafrost in one study area in the Hay River Lowlands shrank by about 38% between 1947 and 2008 (Quinton *et al*. 2011). Permafrost thaw can increase the frequency of active layer slides, change water storage in lakes and soils, alter surface water and groundwater connectivity, and shift vegetation cover (Bring *et al*. 2016). Loss of permafrost in the southern Taiga Plains watershed of the NWT has changed soil drainage and groundwater storage, causing bogs and fens to experience drought conditions (Chasmer and Hopkinson 2017). As a result, these wetlands are losing ground-cover plants, while tree canopies are increasing (Chasmer and Hopkinson 2017). Active layer thickening caused by permafrost thaw has caused drought stress in other high-latitude spruce forests, reducing tree growth rates (Sniderhan and Baltzer 2016). As the temperatures have warmed in the NWT, low shrub cover above the treeline has expanded and become more robust (ENR 2016b). Generally in the arctic, woody vegetation is expected to increase by 52% by the 2050s (Pearson *et al*. 2013). Since the three bumble bee species of interest appear to have affinities for habitat adjacent to forests, changes to forest habitat will likely have an impact on them. These effects may be positive or negative, depending on whether forests expand or contract, create or reduce forest edge habitat, and whether they enhance or displace flowering plant communities. Encroachment is likely occurring fairly rapidly and effects are expected to continue in the next 10 years.

The amount and timing of precipitation events in the NWT are becoming increasingly variable between seasons and communities (ENR 2008, 2016b). Drought conditions have been a problem in parts of the NWT in recent years, leading to dropping river and lake water levels (e.g., Great Slave Lake), and low water tables generally (CBC News 2015). This (as well as the effects of permafrost thaw discussed earlier) could have an impact on bumble bees' water availability and floral resources (Rasmont and Iserbyt 2012; Thomson 2016).

Dought is also associated with increased forest fires, and forest fires are expected to increase in duration and intensity in the NWT (Flannigan *et al*. 2008; ENR 2016b). Dry weather can also affect soil moisture and other properties, which could affect quality or availability of nesting and hibernacula sites. Some NWT residents in the Gwich'in Settlement Area report that the soil used to be softer in some areas in the spring, when they usually noted bumble bees emerging (Benson 2012).

There are no baseline data available for flooding in the NWT, but it is now being monitored, at least in part, as a component of forest health monitoring plans, due to rising concerns about climate-change induced flooding (Olesinski and Brett 2017). Flooding could have a direct negative impact on ground-nesting bees in floodplains or other low-elevation areas. Newly established nests of ground-nesting bumble bees display higher rates of failure in flood conditions, either from immersion or increased susceptibility to mold (Harder 1986). Floral resources could also be affected by flooding. Some large-scale flooding has taken place in the Mackenzie River valley, Aklavik, and Fort Good Hope (ENR 2012), as well as near Fort Providence and in the Slave River delta in the last 5 years (Olesinski and Brett 2017).

Invasive and problematic species, pathogens, and genes – threat level Low

This section includes threats related to non-native (alien) and native plants, animals, and diseases that could have a negative effect on the species if introduced to the NWT, whether by human activities or natural range expansions.

Non-native plants might be displacing some native plants in the NWT, potentially affecting bees' floral resources. In 2010, 116 alien plant species were known from the NWT, none of which were considered highly invasive, and only 12 were shown to successfully invade natural habitats (ENR 2016b). It is not currently known whether or to what extent the three bees' floral resources or habitats are being affected by these, or other, alien plants. There has been little initiative at the government level to develop plans to prevent and control non-native plants until the last decade or so (Carrière 2009).

Non-native honey bees (*Apis mellifera*) are present in the NWT (WG-GSNWTS 2016). Honey bees are managed throughout North America and worldwide for pollination services, and the production of honey, wax, and related products (National Research Council 2007). They have been imported into the NWT by businesses and hobbyists, but the total number of colonies in the territory, their origins, and their current distribution is unknown. No formal surveys of beekeepers or colonies in the NWT have been performed. Some level of beekeeping is currently taking place in Yellowknife and Fort Simpson (Carrière pers. comm. 2018), colonies are probably currently present in Norman Wells (ITI 2017b), and citizen science platforms show one honey bee record in Fort Smith (www.bugguide.net) and one in Gamètì (www.inaturalist.org), indicating the presence of colonies in those regions. Other locations are probable. Increased media coverage of declining bee populations worldwide has probably generated public interest in beekeeping as a hobby. Additionally, the GNWT has named honey as a potential commercial opportunity (ITI 2017a). While the desire to increase pollinator populations is admirable, importing non-native bees into the NWT could be problematic. Honey bees are known to compete directly with native bumble bees including the western bumble bee (Thomson 2004), reducing the foraging and reproductive success of the native species. Generally, managed bee colonies have the potential to create problems for native species: they can compete with native species for nesting and floral resources, alter plant communities, and spread diseases to native species (Mallinger *et al*. 2017).

No native plants or animals are known to be problematic (e.g., as predators, disease vectors, parasites, competitors, etc.) for bumble bees in the NWT. There is little evidence that predators are responsible for bumble bee population declines (Williams and Osborne 2009).

A potentially problematic species is the common eastern bumble bee (*Bombus impatiens* Cresson 1863). This species is widely used elsewhere in greenhouses and field crops for pollination services (National Research Council 2007). If they escape and establish populations, they can out-compete native bumble bees for habitat, or act as disease vectors (Mallinger *et al*. 2017; Jacobson *et al*. 2018). According to the COSEWIC status report on yellow-banded bumble bee, the common eastern bumble bee may already be used in the NWT for commercial pollination services (COSEWIC 2015), but no documentation to support this claim was available when this report was prepared.

Pathogens (fungi, bacteria, viruses, and other microorganisms that cause disease) are widely implicated in the decline of North American bumble bees, and it is presumed that "pathogen spillover" is to blame (Power and Mitchell 2004). Pathogen spillover is when pathogens spread from a heavily infected bee population to unaffected populations, and is strongly associated with commercially reared honey and bumble bee colonies (Colla *et al.* 2006; Cameron *et al.* 2011; Szabo *et al*. 2012; Murray *et al.* 2013; Goulson *et al*. 2015; McArt *et al*. 2017).

Nosema bombi is a fungal pathogen that can infect and harm tissues throughout a bumble bee's body (James and Li 2012). An aggressive and virulent strain of this fungus is found in many declining bumble bee species, including wild and commercially-reared colonies of yellow-banded and western bumble bees (Whittington and Winston 2003; Cameron *et al*. 2016; Arbetman *et al*. 2017). It has long been assumed that this problematic strain was introduced to North America via reared colonies imported from Europe, and that it subsequently spread to wild populations (Cameron *et al.* 2016). However, recent genetic analyses suggest that the strain of *N. bombi* wreaking havoc in North America was present and established before the commercial colony trade (Cameron *et al.* 2016). Although its origins may not be exotic, the fungus' high rate of transmission and impacts are nevertheless likely significant. Commercially-reared bumble bee colonies of several species have been found to harbour other parasites, including *Crithidia bombi* (a single-celled gut parasite) and *Locustacarus buchneri* (a mite that lives in the airways of bumble bees) (James and Li 2012). There are no studies to confirm if these pathogens are present in the NWT.

Declining bumble bee populations are more commonly affected by pathogens than those that are stable (Cameron *et al.* 2011). Interestingly, we see a different trend in western bumble bees: both subspecies of the western bumble bee have similar levels of parasitism (about 40%) (Koch and Strange 2012; Pampell *et al*. 2015; Sheffield *et al.* 2016), but *B. o. mckayi* populations are probably more stable than those of *B. o. occidentalis*. Since commercial bumble bee colonies are not widely used in the north, these relatively high levels of infection may be natural and not caused by pathogen spillover (McHugh and Sikes 2016). If these infection levels are indeed natural, *N. bombi* and other pathogens may not have the same effect on northern bumble bee populations as they do in the south, perhaps because other factors that increase the susceptibily to infections are not concurrent or as prevalent in the north. It is also possible that some pathogens are less likely to survive in cold climates; a close relative of *N. bombi* (*N. ceranae*, which affects honey bees), is known to be more cold-sensitive and more commonly found in warmer climates (James and Li 2012).

Many other bee pathogens exist worldwide, and the potential of these to cause additional disease epidemics in bumble bees is uncertain (James and Li 2012; Brown 2017). Small, isolated bumble bee populations with lower genetic diversity could be more affected by new diseases than large populations with high genetic diversity (Brown 2017). The genetic diversity and isolation of bumble bee populations in the NWT is uncertain at this time.

High rates of fungal infections in bumble bees are associated with large-scale agricultural or commercial fungicide use (McArt *et al.* 2017); this is not a significant factor in the NWT

(Statistics Canada 2016). Additionally, since commercial beekeeping and bee rearing is probably currently uncommon in the NWT, it is unlikely that pathogens or spillovers pose a serious threat to bumble bees in the NWT, at least in the short term (< 10 years). Commercial use of bees is unlikely to be widespread or to increase significantly in the NWT in the next 10 years.

Transportation and service corridors – threat level Low

Among other things, this category includes different types of surface transport corridors (e.g., highways, logging roads, and railroads), as well as corridors through which electrical and phone lines are run. The construction of roads and utility lines could fragment and modify bumble bee habitat (Forman and Alexander 1998), and roadways increase the risk of bees being killed by vehicles while in flight (Baxter-Gilbert *et al.* 2015).

In the NWT, there are large areas of natural habitat where transportation and service corridors are not present. Only one third of the territory's land area is within 100 km of an all-weather road (total of 2,200 km of roadway) so the total extent of existing roads in the NWT is not significant (Department of Transportation [DOT] 2014). The Government of Canada recently announced significant infrastructure funding for the NWT, including for roads and utility lines (Infrastructure Canada 2018). The GNWT is pursuing the development of three major infrastructure corridors (Department of Infrastructure [DOI] 2018a). The Mackenzie Valley Highway Expansion Project is underway, adding 321 km of all-season roadway from Wrigley to Norman Wells (DOT 2013). The Tłı̨chǫ All-Season Road was recently approved for federal funding and will add 94 km of roadway (DOT 2016). These projects lie within the Taiga Plains, in areas from which yellow-banded and gypsy cuckoo bumble bees have been recorded or are expected to be found (Figs. 16 and 17). The Slave Geological Province Access Corridor would add 413 km of all-weather road between Highway 4 to the Nunavut border, passing through the Taiga Shield ecoregion (DOI 2018b). Very few bumble bees have been collected near the proposed corridor route, but this is almost certainly due to a lack of surveys rather than a lack of bees. The western bumble bee is known only from a protected area where corridor development is not expected. It could plausibly be found in a small southwest portion of the Taiga Plains, where some of the Mackenzie Valley Highway Extension Project is being constructed.

These (and any other) corridor expansion activities could potentially disturb or fragment bumble bee habitat, and bees generally tend to be less abundant in disturbed habitats (Williams *et al.* 2010). However, the disturbances caused by corridors will be fairly localized and the amount of undisturbed land nearby will remain significant. Some land clearing for roads and utility lines would potentially create some new usable bumble bee habitat, such as open areas or forest edges; some yellow-banded and gypsy cuckoo bumble bees have been recorded along existing infrastructure corridors. Some projects, the Slave Geological Province Access Corridor in particular, may facilitate future bee surveys in undersampled regions that have historically been difficult to access. Roadways will also increase the risk of bees being killed by moving vehicles, but traffic volumes are expected to be low (DOT 2011, 2016), and it is uncertain what impact road kills might have on bumble bee populations.

Natural systems and modifications – threat level Low

This threat pertains to activities undertaken by humans to manage natural processes for the sake of improving human welfare, such as fire regimes and water cycles, that degrade natural habitats. Over- and under-management is also considered.

Great expanses of the NWT are covered in forests, and fires caused by natural processes such as lightening are extremely widespread and common. Based on data from 1988-2008, there has been an average of 274 forest fires per year in the NWT, with 600,000 hectares affected annually (ENR 2015c). Eighty-eight percent of fires are caused by lightening (the remainder are caused by people and industry) (ENR 2018).

All three species are known to nest near forests, and open areas by forest edges may be particularly valuable habitat (see *Habitat Requirements*). Ground-nesting bees, such as western and yellow-banded bumble bees, may be negatively affected by fires 20 years or more after they took place; fires often lead to dense regrowth of shrubs and grasses, reducing the amount of unvegetated (open) nesting habitat (Williams *et al*. 2010). Gypsy cuckoo bumble bees would be similarly negatively affected, due to the loss of nesting habitat for their hosts. Wildland fire suppression in the NWT is usually prioritized in commerically valuable forests, recreational sites, and residential areas; fires in wilderness parks and remote forests with low economic value are uncommonly managed (ENR 2018). As such, unmanaged fires could be an ongoing and potentially escalating threat for all three bumble bee species, since fire frequency and intensity is expected to increase over time (Flannigan *et al.* 2008). The western bumble bee, known only from a wilderness area to date, may be particularly threatened by unmanaged fire. However, all three species are also known to display considerable flexibility in choosing nesting and foraging habitats and are able to travel considerable distances; they could therefore reasonably be expected to adapt to the use of alternate habitats after a fire in a particular locality.

Overall threat impact

With three Low level threats and one High level threat, the overall threat impact for the three bumble bee species is estimated to be High (NatureServe 2014).

Other limitations and considerations

Host availability

The most serious threat to the gypsy cuckoo bumble bee in the NWT is the potential loss or decline of its hosts. While the *rate* of decline of parasitic bumble bees seems to be about the same as for nonparasitic species (Bartomeus *et al.* 2013), the *risk* of decline is probably higher because they are so dependent on their hosts. Stressors such as climate change or habitat loss directly affect gypsy cuckoo bumble bees, and those effects could be amplified if their hosts are also threatened by the same stressors (Koh *et al*. 2004; Suhonen *et al*. 2015). All three bumble bee species are likely to be affected by many of the same stressors.

The known host of the gypsy cuckoo bumble bee, the yellow-banded bumble bee, is in decline in North America, but its populations appear to be relatively stable in northern provinces (and presumably also in the NWT). Of 331 specimens collected during the most recent NWT bumble bee survey, 17 (5%) were yellow-banded bumble bees (Heron 2018), which is higher than or close to the RA for this species in other decades in which 150 or more bumble bees were recorded from the territory. The historical RA of yellow-banded bumble bees in the NWT (all records prior to 2006) was about 7.6%, while its RA in the past decade is 5.5%, which is a decline of about 27%, but uneven sample sizes year-to-year might be affecting this pattern. The yellow-banded bumble bee has historically been present throughout the south/central aspects of the gypsy cuckoo bumble bee's extent of occurrence, but it has not been found in the High Subarctic (Fig. 21).

The cryptic bumble bee is probably a host of the gypsy cuckoo bumble bee in the NWT, at least in the High Subarctic (since yellow-banded bumble bees are not known from that ecoregion). The cryptic bumble bee is present in the Mackenzie River valley in the north and coincides with gypsy cuckoo bumble bee records in that area (Fig. 21). The cryptic bumble bee has been assigned a general status rank of Secure (not at risk nor sensitive) in the NWT (Hatfield *et al.* 2014; WG-GSNWTS 2016).

The western bumble bee may also be a suitable host, but no gypsy cuckoo bumble bees have been collected in locations from which *B. o. mckayi* has been recorded (Fig. 21). The western bumble bee is also in decline in North America.

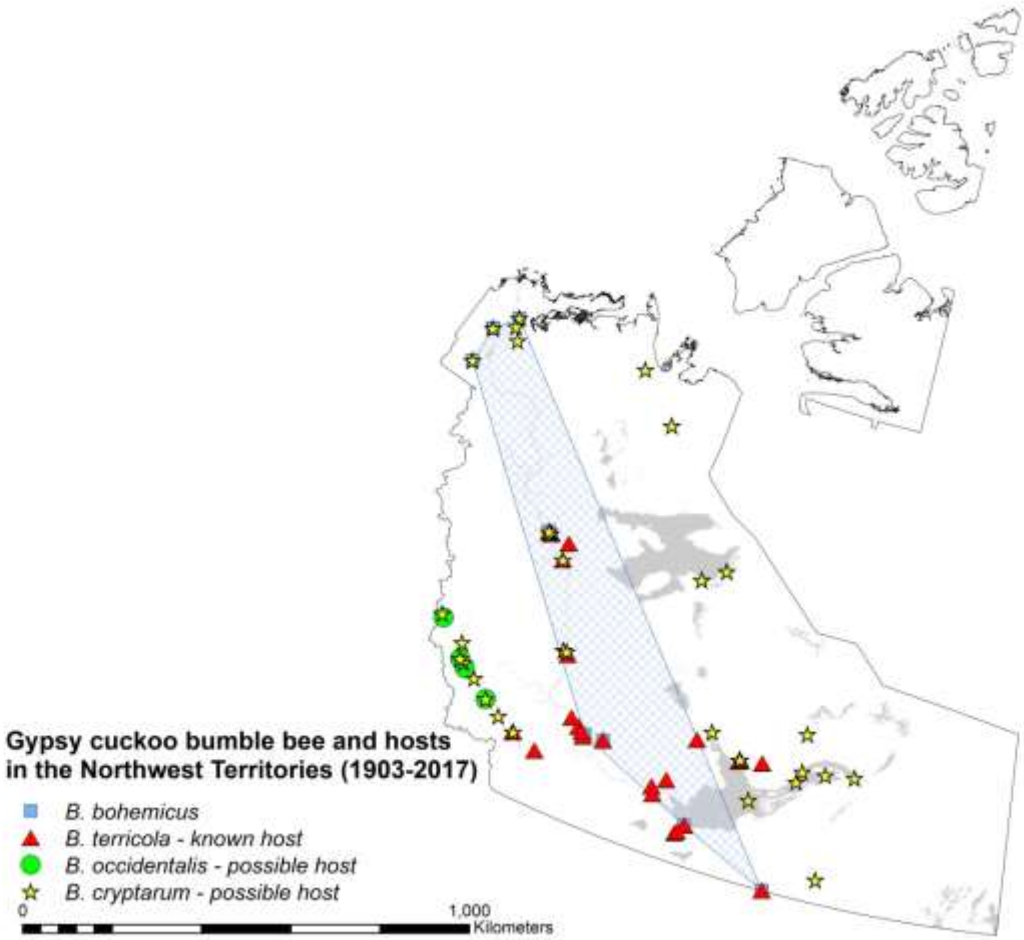

Figure 21. Occurrence records of the gypsy cuckoo bumble bee (*Bombus bohemicus*; blue), its known host the yellow-banded bumble bee (*B. terricola*; red) and two potential hosts, the cryptic bumble bee (*B. cryptarum*; yellow) and the western bumble bee (*B. occidentalis*; green), in the NWT from 1903-2017. Shaded region enclosing gypsy cuckoo bumble bee records illustrates the extent of occurrence for this species, based on historical and recent records. Points are derived from: a dataset compiled by Leif Richardson (2018), a 2017 collection effort contributed by Jennifer Heron (2018), and verified sightings or collection events contributed by C. Ernst (2018). Map courtesy of C. Ernst.

Temperature in(tolerance)

Bumble bees are adapted for living in cold climates: they have large and densely hairy bodies (both reduce heat loss), dark heat-absorbing colours, and the ability to generate body heat (Goulson 2010). However, while their cold adaptations permit bumble bees to thrive in colder climates, they also prohibit them from thriving in warm climates. Most bumble bee species are found in cool climates (Williams *et al.* 2014). The maximum thoracic temperature bumble bees can tolerate is roughly 44°C; anything higher is probably fatal for most bees (Goulson 2010). In natural conditions, bumble bees can cool themselves by ceasing flight, staying in shade, and/or going underground, but these behavioural changes are energetically costly (Sunday *et al.* 2014), as they prevent bees from foraging. High temperatures and heat waves therefore pose a threat to bumble nees, and have been implicated in local bumble bee population extirpations in Europe (Rasmont and Iserbyt 2012). The frequency of extreme summer temperatures (> 30°C) is expected to increase across the NWT (ENR 2016a), and heat waves are becoming more frequent and more intense (ENR 2016a, b).

Extended exposure to high ambient temperatures can result in a phenomenon called "heat stupor", where the bumble bee falls on its back, becomes immobilized, and loses its normal reflexes; heat stupor is often followed by death shortly after (Martinet *et al*. 2015). The time it takes for a bumble bee to experience heat stupor is probably species-specific. Heat tolerances have not been assessed in the western, yellow-banded, or gypsy cuckoo bumble bees. Martinet *et al.* (2015) assessed the time it took six European bumble bee species to reach heat stupor (time before heat stupor; THS) after being placed in an incubator at 40°C. The white-tailed bumble bee (*Bombus lucorum*) is a close relative of western and yellow-banded bumble bees (it is also in the subgenus *Bombus*). The median THS for the white-tailed bumble bee was higher than all other species in the study (242 minutes), but only 26% of them survived the experience (Martinet *et al*. 2015). On the other hand, yellow cuckoo bumble bees in the same study had a median THS of only 82 minutes, but 48% of them survived (Martinet *et al.* 2015). In the study, the lowest THS (31 minutes) was associated with two true arctic species of the subgenus *Alpinobombus*; their survival rates were between 52 and 56% (Martinet *et al.* 2015). The two *Alpinobombus* species also had the largest body sizes out of the six species in the study (the largest bumble bee species are typically found in the far north) (Peat *et al.* 2005).

Animals with large bodies have small surface area to volume ratios, which makes them lose heat more slowly (this is why larger animals are common in the far north) (Blackburn *et al.* 1999). The few bumble bees found in the tropics are, unexpectedly, the largest, but they also have long extremities and short hair, which must adequately permit them to thermoregulate even in hot ambient temperatures (Peat *et al.* 2005). Large-bodied bees in North America are more likely to have declined in abundance in the last 140 years (Bartomeus *et al.* 2013). There are some reports by residents of the NWT that bumble bee body size has changed during their lifetime; that they are now "much bigger than years ago" (Ellen Firth *in* Benson 2012).

Because of their heat intolerance, northern bumble bees are expected to be particularly vulnerable to the effects of climate change. The southern limits of their distributions are shifting northward in response to warming, but the northern limits are not similarly increasing (Kerr *et al*. 2015). Bumble bee species with small range sizes (and thus narrow habitable climatic niches) likely face additional risks as temperatures continue to increase (Williams *et al*. 2009; Williams and Osborne 2009; Kerr *et al.* 2015; Rasmont *et al.* 2015; Arbetman *et al.* 2017). The northern *mckayi* subspecies of the western bumble bee is limited to latitudes above 55°N. As temperatures warm in the NWT, we can probably expect to see the distribution of *B. o. mckayi* decline. However, some bumble bees with small ranges in mountainous areas are moving to high elevations in response to warming climates (Kerr *et al*. 2015). Yellow-banded and gypsy cuckoo bumble bees have widespread distributions in North America that extend down into the north/central east coast of the United States (Williams *et al.* 2014). Presumably, these two species are more likely to tolerate periods of heat and wider temperature ranges than the western bumble bee, which is the largest of the three species and the only one with a truly northern distribution.

POSITIVE INFLUENCES

Life history traits

Bumble bees with late-season colony initiation and development are associated with greater susceptibility to land use changes (Williams and Osborne 2009). All three species emerge and begin to establish colonies shortly after spring thaw, so they should be less susceptible. Bees that nest below ground are less affected by agricultural intensification and recent fires (Williams *et al.* 2009; Williams and Osborne 2009; Williams *et al.* 2010).

Pollinators that are specialist floral visitors may be more susceptible to decline (Williams *et al.* 2010). All three bumble bee species of interest are generalist foragers. Despite having short tongues, western and yellow-banded bumble bees use a nectar-robbing strategy to exploit additional sources. Arbetman *et al*. (2017) found that tongue length is not significantly related to declines in bumble bee species, suggesting that changes in floral resources might not be a major driver for at least some species.

Yellow-banded bumble bee larvae can survive short periods without eating, and temporary shortages of food have little effect on their adult size, although it can influence their development time (Plowright and Pendrel 1977). This trait would be beneficial if normal foraging activities were disrupted (e.g., by extreme weather, or sudden loss of floral resources from part of their foraging territory).

Because these bumble bees are largely reliant on existing mammal burrows for nest sites, the composition and habits of rodent fauna can influence the relative and absolute abundance of bumble bees (Harder 1986). Existing mammal burrows are not common in intensively modified habitats (Williams *et al.* 2010), but modified habitats make up a small proportion of the total land area of the NWT. Mice, voles, lemmings, and shrews are considered Secure under the general status ranking program throughout the NWT, in forested areas and on the tundra (WG-GSNWTS 2016). Their populations experience natural cycles of high- and low-density years but their abundances are stable when this is taken into consideration (ENR 2016b). Underground nesting sites should be widely available for bees in the foreseeable future.

Regulatory actions

Approximately 9.2% of the NWT's land falls within one of 14 established terrestrial protected areas, and more areas have been identified for the establishment of additional protected areas

(ENR 2016a). Existing protected areas already provide safe havens for the three bumble bee species (e.g., Nahanni National Park Reserve harbours *B. o. mckayi*), and additional protected land will likely help conserve bumble bee habitat.

The GNWT has recently increased efforts to curate historical records of alien invasive plants, and baseline surveys were performed in 2006 along major roadways and in larger communities (Oldman 2007). Understanding changes in the plant community will help identify and manage threats to bumble bee habitat and floral resources.

The Canadian Food Inspection Agency has regulations in place to prevent the introduction and spread of bee pathogens into the country via the import of bee products and live bees (CFIA 2011). Many provinces similarly regulate the import of live bees from other provinces and territories. The NWT does not currently have any regulations or restrictions on live bees brought into the territory.

Acknowledgements

The Species at Risk Committee thanks Dr. Christopher M. Ernst for his work preparing the drafts of this status report. This report benefited from the many comments received during the review process and we thank all of those who contributed their views to the content and structure of this report.

The preparer is deeply grateful for the NWT *Bombus* data generously provided by Leif Richardson. The entire dataset includes over 275,000 records of bumble bees collected in North America since 1805, and represents the collective contributions of over 70 individuals and institutions, and over 125 collections worldwide: a complete list of all contributors can be found at https://www.leifrichardson.org/bbna.html. Many thanks also to Jennifer Heron for sharing unpublised data from her 2017 collection efforts in the NWT, and to John Williams for permission to reproduce illustrations from his 2014 book, *Bumble Bees of North America: An Identification Guide*. This report has benefitted greatly from the tremendous efforts of the preparers of recent COSEWIC reports for the three species discussed herein. The preparer is thankful for useful discussions with many individuals (see *Authorities Contacted*); in particular, Jennifer Heron, Lawrence Packer, Cory Sheffield, and John Williams.

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Status of Western Bumble Bee, Yellow-banded Bumble Bee, and Gypsy Cuckoo Bumble Bee in the NWT

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Biography of preparer

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Status and ranks

Western bumble bee (*Bombus occidentalis mckayi*)

Region	Coarse filter (Ranks) To prioritize	Fine filter (Status) To provide advice	Legal listings (Status) To protect under species at risk legislation
Global	T4 – Apparently secure	G4T4	No legal tools exist.
Canada	NNR	Special Concern (2014)	
Northwest Territories	**Sensitive (2016)**	**To be determined**	**To be determined**
Adjacent Jurisdictions			
United States			
Alberta			
British Columbia	SNR – NatureServe		
Yukon Territory	S3S4 – NatureServe		

Yellow-banded bumble bee (*Bombus terricola*)

Region	Coarse filter (Ranks) To prioritize	Fine filter (Status) To provide advice	Legal listings (Status) To protect under species at risk legislation
Global	G3 – Vulnerable	G3G4	No legal tools exist
Canada	N5	Special Concern (2015)	
Northwest Territories	**Sensitive (2016)**	**To be determined**	**To be determined**
Adjacent Jurisdictions			
United States	NU		
Alberta	S5		
British Columbia	S3S4		
Yukon Territory			

Gypsy cuckoo bumble bee (*Bombus bohemicus*)

Region	Coarse filter (Ranks) To prioritize	Fine filter (Status) To provide advice	Legal listings (Status) To protect under species at risk legislation
Global	G4 – Apparently secure	**G4**	No legal tools exist
Canada	N1	Endangered (2014)	
Northwest Territories	**At Risk (2016)**	**To be determined**	**To be determined**
Adjacent Jurisdictions			
United States	NU		
Alberta	SH		
British Columbia	SH		
Yukon Territory	SU		

Collections examined

No collections were examined firsthand. See *Search Effort* for information about the sources of the data.

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Appendix A

NWT RECORDS

This table includes all records of the species of interest from the NWT used in this report. Records are listed in alphabetical order by species, and then by year of collection (oldest to newest). Records with entries in the "code" field starting with BBNA were provided by L. Richardson (2018). For some entries in the Richardson dataset, the dates were not completed and/or GPS coordinates were not provided. An effort was made to search other online databases (e.g., museum holding records, etc.) to complete missing data when possible, and generic locality (latitude/longitude) was used when precise records were not available (primarily for older specimens). Records with entries in the "code" field starting with JH were provided by Jennifer Heron for this report (Heron 2018).

Code	Data Source	Species	Collector	Location	Latitude	Longitude	Date	Notes
BBNA 165453	CNC[19]	*B. bohemicus*	J.R.Vockeroth	Reindeer Depot, Mackenzie Delta	68.7	-134.1333	8/10/1948	
BBNA 165454	CNC	*B. bohemicus*	J.R.Vockeroth	Reindeer Depot, Mackenzie Delta	68.7	-134.1333	8/13/1948	
BBNA 165455	CNC	*B. bohemicus*	J.R.Vockeroth	Reindeer Depot, Mackenzie Delta	68.7	-134.1333	8/19/1948	
BBNA 165456	CNC	*B. bohemicus*	J.R.Vockeroth	Reindeer Depot, Mackenzie Delta	68.7	-134.1333	8/17/1948	
BBNA 163416	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/9/1949	
BBNA 163417	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/30/1949	
BBNA 163418	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/12/1949	
BBNA 163419	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/12/1949	
BBNA 163420	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/29/1949	
BBNA 163421	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/9/1949	
BBNA 163422	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/14/1949	

[19] Canadian National Collection

BBNA 163423	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/9/1949	
BBNA 163424	CNC	*B. bohemicus*	W.R.M.Mason	Norman Wells	65.2833	-126.8333	6/20/1949	
BBNA 157318	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/20/1950	
BBNA 157319	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/7/1950	
BBNA 157320	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/19/1950	
BBNA 157321	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/17/1950	
BBNA 157322	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/9/1950	
BBNA 157323	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/7/1950	
BBNA 157324	CNC	*B. bohemicus*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/17/1950	
BBNA 157342	CNC	*B. bohemicus*	W.G.Helps	Fort Smith	60	-111.8833	6/4/1950	
BBNA 157343	CNC	*B. bohemicus*	J.B.Wallis	Fort Smith	60	-111.8833	6/13/1950	
BBNA 157344	CNC	*B. bohemicus*	J.B.Wallis	Fort Smith	60	-111.8833	6/9/1950	
BBNA 157345	CNC	*B. bohemicus*	J.B.Wallis	Fort Smith	60	-111.8833	6/13/1950	
BBNA 157937	CNC	*B. bohemicus*	P.R.Ehrlich	Hay River	60.8166	-115.7833	7/21/1951	
BBNA 157938	CNC	*B. bohemicus*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 1064391	CNC	*B. bohemicus*	E.F.Cashman	Aklavik	68.2166	-135	6/18/1956	
BBNA 1064393	CNC	*B. bohemicus*	E.F.Cashman	Aklavik	68.2166	-135	6/18/1956	
BBNA 153319	CNC	*B. bohemicus*	R.E.Leech	Aklavik	68.2166	-135	7/6/1956	
BBNA 153320	CNC	*B. bohemicus*	R.E.Leech	Aklavik	68.2166	-135	6/28/1956	
BBNA 153322	CNC	*B. bohemicus*	R.E.Leech	Aklavik	68.2166	-135	6/22/1956	
BBNA 163425	CNC	*B. bohemicus*	R.E.Leech	Norman Wells	65.2833	-126.8333	8/20/1956	
BBNA 163426	CNC	*B. bohemicus*	R.E.Leech	Norman Wells	65.2833	-126.8333	8/20/1956	
BBNA 290181	JBWM	*B. bohemicus*	D.H. Pengelly	Aklavik	68.227	-135.003	6/18/1956	Georef by LLR
BBNA 157283	CNC	*B. bohemicus*	S.D.Hicks	Fort McPherson	67.4333	-134.8833	6/26/1957	
BBNA 157284	CNC	*B. bohemicus*	R.Hurley	Fort McPherson	67.4333	-134.8833	6/26/1957	
BBNA 157285	CNC	*B. bohemicus*	S.D.Hicks	Fort McPherson	67.4333	-134.8833	6/26/1957	

BBNA 1064477	CNC	*B. bohemicus*	G.E.Shewell	Norman Wells	65.2833	-126.8333	6/27/1969	
BBNA 290186	CNC	*B. bohemicus*	D. Frechin	Norman Wells	65.282	-126.829	6/27/1969	Georef by LLR
BBNA 163244	CNC	*B. bohemicus*	B.V.Peterson	Fort Simpson	61.8315	-121.1955	6/7/1972	No Name Creek, #2, E side Mackenzie Rver, 3 mi. SE Fort Simpson
JH-331	J. Heron	*B. bohemicus*	N.Larter	Norman Wells	65.281	-126.828	7/31/2017	Date approximate, as per J.H. In town.
BBNA 292737	L. Packer Collection York University (PCYU)	*B. o. mckayi*	Shannon Stotyn	South Nahanni River	62.656	-129.1348	7/9/2011	
BBNA 292738	PCYU	*B. o. mckayi*	Shannon Stotyn	South Nahanni River	61.9634	-127.1992	7/16/2011	
BBNA 292739	PCYU	*B. o. mckayi*	Shannon Stotyn	South Nahanni River	62.0876	-127.5872	7/13/2011	
BBNA 292740	PCYU	*B. o. mckayi*	Shannon Stotyn	South Nahanni River	61.6065	-125.7560	7/18/2011	
BBNA 183673	Illinois Natural History Survey	*B. terricola*	C. H. Czickmay	Fort Norman	64.9	-125.58	8/6/1922	
BBNA 981465	USDA-ARS	*B. terricola*	O. Bryant	Wrigley	63.1860	-123.3615	7/18/1929	Original entry recorded as "Fort Wrigley"
BBNA 981466	USDA-ARS	*B. terricola*	O. Bryant	Wrigley	63.1860	-123.3615	7/18/1929	Original entry recorded as "Fort Wrigley"
BBNA 981416	USDA-ARS	*B. terricola*	O. Bryant	Fort Simpson	61.7787	-121.2327	8/6/1929	Original entry recorded as "Simpson"
BBNA 981412	USDA-ARS	*B. terricola*	O. Bryant	Fort Simpson	61.7787	-121.2327	8/16/1929	
BBNA 981413	USDA-ARS	*B. terricola*	O. Bryant	Fort Simpson	61.7787	-121.2327	8/16/1929	
BBNA 981414	USDA-ARS	*B. terricola*	O. Bryant	Fort Simpson	61.7787	-121.2327	8/16/1929	
BBNA 981415	USDA-ARS	*B. terricola*	O. Bryant	Fort Simpson	61.7787	-121.2327	8/16/1929	
BBNA 981476	USDA-ARS	*B. terricola*	O. Bryant	Fort Simpson	61.7787	-121.2327	8/16/1929	
433602	LACM	*B. terricola*	Unknown	Norman Wells	65.2741	-126.6983	6/30/1949	
BBNA 157313	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	6/12/1950	
BBNA 157340	CNC	*B. terricola*	W.G.Helps	Fort Smith	60	-111.8833	6/29/1950	
BBNA 157341	CNC	*B. terricola*	W.G.Helps	Fort Smith	60	-111.8833	6/29/1950	

BBNA 157308	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/2/1950	
BBNA 157312	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/12/1950	
BBNA 157314	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/12/1950	
BBNA 157305	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/20/1950	
BBNA 157307	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/20/1950	
BBNA 157311	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/20/1950	
BBNA 157317	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	7/30/1950	
BBNA 157310	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/7/1950	
BBNA 157316	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/12/1950	
BBNA 157315	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/17/1950	
BBNA 157306	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/18/1950	
BBNA 157309	CNC	*B. terricola*	D.P.Whillans	Fort Simpson	61.8666	-120.35	8/18/1950	
BBNA 157932	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/11/1951	
BBNA 157927	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157928	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157929	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157930	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157931	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157933	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157934	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157935	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 157936	CNC	*B. terricola*	P.R.Ehrlich	Hay River	60.8166	-115.7833	8/12/1951	
BBNA 539368	SanF	*B. terricola*	Unknown	Fort Providence	61.3538	-117.6548	8/27/1960	
BBNA 981508	USDA-ARS	*B. terricola*	E.L. Kessel	Fort Providence	61.3538	-117.6548	8/27/1960	
BBNA 292354	Cory Sheffield (C. Sheffield)	*B. terricola*	K.C. Herrmann	Fort Simpson	61.925	-121.578	7/3/1972	Martin River
BBNA 292351	C. Sheffield	*B. terricola*	P.J. Skitsko	Fort Simpson	61.925	-121.578	8/1/1972	Martin River

BBNA 292350	C. Sheffield	*B. terricola*	P.J. Skitsko	Fort Simpson	61.925	-121.578	9/6/1972	Martin River
BBNA 292352	C. Sheffield	*B. terricola*	P.J. Skitsko	Fort Simpson	61.925	-121.578	9/6/1972	Martin River
BBNA 292353	C. Sheffield	*B. terricola*	P.J. Skitsko	Fort Simpson	61.925	-121.578	9/6/1972	Martin River
BBNA 292355	C. Sheffield	*B. terricola*	P.J. Skitsko	Fort Simpson	61.925	-121.578	9/6/1972	Martin River
BBNA 2582	PCYU	*B. terricola*	Anne Gunn	Yellowknife	62.466	-114.3499	7/1/2001	Willow flats
BBNA 2583	PCYU	*B. terricola*	Anne Gunn	Yellowknife	62.466	-114.3499	7/1/2001	Willow flats
BBNA 2605	PCYU	*B. terricola*	A. Gunn	Yellowknife	62.45	-114.3300	7/23/2002	
BBNA 2603	PCYU	*B. terricola*	A. Gunn	Yellowknife	62.45	-114.333	8/1/2002	lakeside, Great Slave Lake
BBNA 2604	PCYU	*B. terricola*	A. Gunn	Yellowknife	62.45	-114.333	8/1/2002	lakeside, Great Slave Lake
BBNA 2586	PCYU	*B. terricola*	A. Gunn	Yellowknife	62.466	-114.3499	7/9/2003	Willow flats
BBNA 2508	PCYU	*B. terricola*	A. Gunn	Enterprise	60.6	-116.0670	8/7/2004	Gravel Pit
BBNA 2588	PCYU	*B. terricola*	A. Gunn	Behchokǫ̀	62.583	-116.4670	8/8/2004	Gravel pit (Location originally entered as Rae)
BBNA 2587	PCYU	*B. terricola*	A. Gunn	Yellowknife	62.533	-113.3499	8/14/2004	Tibbett Lake
BBNA 292298	Royal Saskatchewan Museum	*B. terricola*	T.V. Cole	Yellowknife	62.53	-113.35	8/14/2004	Tibbett Lake
BBNA 2564	PCYU	*B. terricola*	C. Sheffield and A. Gunn	Fort Providence	61.583	-117.1490	6/21/2005	Hwy 3, near Fort Providence
BBNA 2513	PCYU	*B. terricola*	C. Sheffield and A. Gunn	Hay River	60.652	-115.9940	6/22/2005	"Paradise Garden", near Hay River
BBNA 292164	Royal Ontario Museum (ROM)	*B. terricola*	Unknown	Yellowknife	65.254	-126.6875	6/22/2005	
BBNA 2544	PCYU	*B. terricola*	C. Sheffield and A. Gunn	Kakisa	61.216	-117.5100	6/23/2005	N of Kakisa, Hwy 3
BBNA 2636	PCYU	*B. terricola*	D.C. Currie, R. Popko	Norman Wells	65.254	-125.6880	6/29/2005	
BBNA 2637	PCYU	*B. terricola*	D.C. Currie, R. Popko	Norman Wells	65.254	-125.6880	6/29/2005	
BBNA 292162	ROM	*B. terricola*	L. Masner	Norman Wells	65.254	-126.6875	6/29/2005	
BBNA 292163	ROM	*B. terricola*	L. Masner	Norman Wells	65.254	-126.6875	6/29/2005	

BBNA 292165	ROM	*B. terricola*	L. Masner	Norman Wells	65.254	-126.6875	6/29/2005	
BBNA 292166	ROM	*B. terricola*	L. Masner	Norman Wells	65.254	-126.6875	6/29/2005	
BBNA 2577	PCYU	*B. terricola*	A. Gunn	Yellowknife	62.433	-114.3499	7/3/2005	Negus Pt.
BBNA 2546	PCYU	*B. terricola*	R.A. Layberry	Nahanni River	61.25	-124.07	7/9/2005	Kraus Hot Spring
BBNA 2581	PCYU	*B. terricola*	L. Packer	Yellowknife	62.458	-114.3560	7/10/2010	
BBNA 168921	PCYU	*B. terricola*	Shannon Stotyn	South Nahanni River	61.2554	-124.0596	7/24/2011	Original entry recorded as "Fort Simpson; Sth. Nahanni R.")
BBNA 168924	PCYU	*B. terricola*	Shannon Stotyn	South Nahanni River	61.2554	-124.0596	7/24/2011	Original entry recorded as "Fort Simpson; Sth. Nahanni R.")
BBNA 168925	PCYU	*B. terricola*	Shannon Stotyn	South Nahanni River	61.2554	-124.0596	7/24/2011	Original entry recorded as "Fort Simpson; Sth. Nahanni R.")
BBNA 168933	PCYU	*B. terricola*	Shannon Stotyn	South Nahanni River	61.1016	-122.8819	7/26/2011	Original entry recorded as "Fort Simpson; Sth. Nahanni R.")
BBNA 168935	PCYU	*B. terricola*	Shannon Stotyn	South Nahanni River	61.1016 2	-122.8819	7/26/2011	Original entry recorded as "Fort Simpson; Sth. Nahanni R.")
BBNA 864704	Bumble Bee Watch (Bee-12830)	*B. terricola*	Zoe Guile	Yellowknife	62.4530	-114.3757	7/27/2016	Downtown
JH-229	Jennifer Heron (J. Heron)	*B. terricola*	N.Larter	Fort Simpson	62.0408	-122.0194	12-26.vii.2017	Blue Vane Trap. Day approximated by CE. Km 581 MacKenzie Highway
JH-325	J. Heron	*B. terricola*	N.Larter	Norman Wells	65.2770	-126.8135	8/1/2017	Note from J.H. "Although not databased, there were at least half a dozen yellow-banded bumble bee at Norman Wells (River Beach)". The preparer added 6 records from this location as a conservative approximation.

JH-326	J. Heron	*B. terricola*	N.Larter	Norman Wells	65.2770	-126.8135	8/1/2017	Note from J.H. "Although not databased, there were at least half a dozen yellow-banded bumble bee at Norman Wells (River Beach)". The preparer added 6 records from this location as a conservative approximation.
JH-327	J. Heron	*B. terricola*	N.Larter	Norman Wells	65.2770	-126.8135	8/1/2017	Note from J.H. "Although not databased, there were at least half a dozen yellow-banded bumble bee at Norman Wells (River Beach)". The preparer added 6 records from this location as a conservative approximation.
JH-328	J. Heron	*B. terricola*	N.Larter	Norman Wells	65.2770	-126.8135	8/1/2017	Note from J.H. "Although not databased, there were at least half a dozen yellow-banded bumble bee at Norman Wells (River Beach)". The preparer added 6 records from this location as a conservative approximation.
JH-329	J. Heron	*B. terricola*	N.Larter	Norman Wells	65.2770	-126.8135	8/1/2017	Note from J.H. "Although not databased, there were at least half a dozen yellow-banded bumble bee at Norman Wells (River Beach)". The preparer added 6 records from this location as a conservative approximation.

JH-330	J. Heron	*B. terricola*	N.Larter	Norman Wells	65.2770	-126.8135	8/1/2017	Note from J.H. "Although not databased, there were at least half a dozen yellow-banded bumble bee at Norman Wells (River Beach)". The preparer added 6 records from this location as a conservative approximation.
JH-196	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-197	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-198	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-199	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-200	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-201	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-202	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-203	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-204	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
JH-205	J. Heron	*B. terricola*	N.Larter	Fort Simpson	61.8639	-121.3541	28.vii-17.viii.2017	Blue Vane Trap. Day approximated by CE
BBNA 291993	PCYU	*B. terricola*	Unknown	Yellowknife	64.44	-114.38		Date unknown. Assumed pre-2007.

THREAT CLASSIFICATION TABLE

Threat classification table[20] for the western bumble bee (*Bombus occidentalis mckayi*), yellow-banded bumble bee (*B. terricola*), and gypsy cuckoo bumble bee (*B. bohemicus*) in the NWT, based on the IUCN-CMP unified threats classification system version 3.2. Impact calculations for Level 1 and 2 threats were performed using the NatureServe Threat Calculator (NatureServe 2014). Scope, severity, timing, and impact of Level 1 threats (in **bold**) are based on estimates of scope, severity, and timing of each Level 2 threat in that category. Level 1 threats with non-negligible impact levels (in **red**) are discussed in the main body of the report. Estimates were performed during the preparation of this report by C. Ernst, based on available data and informed by similar assessments performed for each species at the national level. For a detailed description of this system and the threats, see the *Open Standards for the Practice of Conservation* website (CMP 2018).

Threat		Calculated Impact	Scope	Severity	Timing	Comments
1	**Residential & Commercial Development**	**Negligible**	**N**	**S**	**H**	**There are large areas of natural habitat with no ongoing or likely future development. The human population of the NWT is very small (~44,000 in 2016), and may be in a slow decline (Department of Finance [DOF] 2015). Housing, commercial, tourism developments likely to display slow rates of growth over the next 10 years, but it is ongoing (DOF 2015).**
1.1	Housing & urban areas	Negligible	N	S	H	Urban development can lead to natural bumble bee habitat loss, but private/public gardens and green spaces in developed areas can provide resources for bees, especially when large and containing native plant species (e.g., Banaszak-Cibicka and Żmihorski 2012; Kaluza *et al*. 2016).
1.2	Commercial & industrial areas	Negligible	N	S	H	Commercial development (factories and other commercial centers) can lead to natural bumble bee habitat loss; these are typically located within urban areas, and are considered along with threat 1.1.
1.3	Tourism & recreation areas	Negligible	N	S	H	Recreation developments (ski areas, golf courses, campgrounds, resorts, etc.) can lead to natural bumble bee habitat loss. These types of developments are considered along with threat 1.1 as they are typically located in urban areas (and most are also uncommon in the NWT).

[20] Key to short form coding used in this table: scope (N = negligible, S = small, R = restricted, L = large, P = pervasive, U = unknown); severity (N = negligible, S = slight, M = moderate, Se = serious, E = extreme, U = unknown), and timing (L = low, M = moderate, H = high, I = insignificant/negligible).

2	**Agriculture & Aquaculture**	**Negligible**	**N**	**N**	**H**	**There are large areas of natural habitat with no agricultural land use/practices in the NWT. Land use for agriculture is minimal (Statistics Canada 2016).**
2.1	Annual & perennial non-timber crops	Negligible	N	N	H	Non-timber agriculture is a small sector of NWT commerce and does not involve large commercial monocultures in the NWT (Statistics Canada 2016). Land use for agriculture is minimal in the NWT, and thus has had minimal impact on wildlife and wildlife habitat to date (Statistics Canada 2016). The number of farms/amount of farm land used in the NWT is relatively stable but may gradually increase in the future (Industry, Tourism and Investment [ITI] 2017a). The GNWT recently produced a strategy for growing this sector, but it is long term (>10 years) and focused on smaller-scale local food production, and production in greenhouses, so is unlikely to have a major impact (ITI 2017a).
2.2	Wood & pulp plantations					Not applicable. Zero hectares of forest were replanted/seeded in 2016 (Natural Resources Canada 2017).
2.3	Livestock farming & ranching	Negligible	N	N	H	Livestock can modify habitat by reducing floral resources and cause soil compaction. Livestock farming or ranching is very uncommon in the NWT (Statistics Canada 2016).
2.4	Marine & freshwater aquaculture					Not applicable. Not a known threat to bumble bees in the NWT.
3	**Energy Production & Mining**	**Negligible**	**N**	**S**	**H**	**All energy sectors have the potential to cause considerable damage to natural habitats, but mostly on a local scale (Cuddigy *et al.* 2005). Timing is high for oil/gas and mining/quarrying as they are established and ongoing with a possibility of intensifying, but moderate for renewable energy as this sector is currently being investigated for exploitation opportunities (GNWT 2013; Geological Survey 2018).**
3.1	Oil & gas drilling	Negligible	N	S	H	A number of shale gas and oil wells were drilled in the central Mackenzie Valley between 2012-2015, but no commercial production resulted, and there has been no activity since 2015 (National Energy Board [NEB] 2017b). Natural gas production is limited to Norman Wells and Ikhil and accounts for <1% of national production (NEB 2017b).
3.2	Mining & quarrying	Negligible	N	S	H	Mining and quarrying could cause considerable local damage to bumble bee habitat, by altering topography, removing native plants, and fragmenting landscapes (Sengupta 1993). Diamond and gold mining are historically important industries in the NWT, and other minerals/elements are mined as well. The vast majority of mines and deposits are located in the central/southeast, though other major projects are found along the western border (Geological Survey 2018). Although mining has been fairly stable, it might be expected to grow in the future (Geological Survey 2018).

3.3	Renewable energy	Negligible	N	N	M	The construction of wind and solar energy farms and geothermal plants can damage bumble bee habitat. Wind turbines are known to cause significant insect mortality (Corten and Veldkamp 2001), but the proportion of bees affected relative to other insects is not known. The colour of wind turbines can be an attractant for many pollinators, including bees (Long *et al*. 2011). Renewable energy is not currently a significant sector in the NWT: solar and wind power generation is largely limited to personal use or for powering individual buildings (ENR 2012). Wind energy is currently only 4% of the NWT's energy use but the government is actively seeking opportunities to expand wind, solar, and geothermal energy use in the territory (GNWT 2017b). Solar and wind farms could potentially add or replace usable habitat for bumble bees: floral resources could be affected if terrain is covered with gravel, but land clearing could provide open nesting habitat.
4	**Transportation & Service Corridors**	**Low**	**S**	**S**	**H**	**There are large areas of natural habitat where transportation and service corridors are not present, but corridors under development or in planning are extensive in terms of amount of land affected (Infrastructure Canada 2018).**
4.1	Roads & railroads	Low	S	S	H	Roads can modify and fragment bumble bee habitat, and increase road mortality for bees in flight. Only 1/3 of the territory is within 100 km of an all-weather road (total of 2,200 km of roadway) so the total extent of existing roads is not large (DOT 2014). The Mackenzie Valley Highway expansion project (321 km of all-season roadway from Wrigley to Norman Wells) is underway (DOT 2013). Other projects are planned to increase all-season access to remote communities (DOT 2014).
4.2	Utility & service lines	Low	S	S	H	New utility lines can modify and fragment bumble bee habitat. Most utility corridors are placed along existing roadways/right-of ways.
4.3	Shipping lanes					Not applicable. Not a known threat for bumble bees in the NWT.
4.4	Flight paths					Not applicable. Not a known threat for bumble bees in the NWT.
5	**Biological Resource Use**	**Negligible**	**N**	**M**	**H**	**There are large areas of natural habitat with no biological resource use/exploitation practices. Hunting/gathering for personal use is of minimal concern. Timber harvesting poses a bigger threat to natural habitat.**
5.1	Hunting & collecting terrestrial animals	Negligible	N	S	L	Bumble bees collected for scientific surveys are not collected in numbers sufficient to disturb natural population dynamics or cause local extirpations/extinctions, and collections are important for documenting species presence and distributions (Pohl 2009; Sikes *et al.* 2017). Hunting of other terrestrial animals is done on a small, local scale and mostly for personal or community consumption (ENR 2015d), with minimal impact to natural habitats, other than some trampling or damage of terrain along access routes (on foot, by ATV, etc.).

5.2	Gathering terrestrial plants	Negligible	N	M	L	Berry plants and others are harvested by residents, but not at a scale expected to impact bee populations (ENR 2015d). As generalists, many alternative nectar sources are available in the unlikely event that a food plant species is locally extirpated from over-harvesting. Natural plant resources are traditionally well managed and not over-exploited.
5.3	Logging & wood harvesting	Negligible	N	S	H	Timber harvesting can disturb or fragment habitat. Logging in the NWT is mostly small scale, family-run and local: individual operations harvest 500-10,000 m^3 per year, and total annual yields of lumber have been stable for the past decade (ENR 2015e). The most productive areas are along flood plains of major rivers (Bohning *et al*. 1997). There are some new initiatives to develop the wood pellet industry; some communities may explore this as an option for employment opportunities (BW McCloy & Associates 2009; ENR 2017a). Five-year timber harvesting permits have recently been issued in the Fort Providence and Fort Resolution areas, with expected harvests of 1,000-1,200 hectares/year (ENR 2015a, b, e). Only *B. terricola* has been recorded from Fort Providence, and not since 2005.
5.4	Fishing & harvesting aquatic resources					Not a known threat to bumble bees in the NWT.
6	**Human Intrusions & Disturbance**	**Negligible**	**N**	**S**	**H**	**Most potentially threatening human disturbances are associated with development, and are treated under section 1.**
6.1	Recreational activities	Negligible	N	S	H	Recreational activities can result in habitat disturbance and the spread of invasive species. *B. o. mckayi* is found along the South Nahanni River in a National Park, where human recreation takes place. However, human activity in the park is minimal.
6.2	War, civil unrest & military exercises					Not applicable. Not a threat in the NWT.
6.3	Work & other activities					Relevant aspects of this threat have been covered in Threat 6 and 7.
7	**Natural System Modifications**	**Low**	**S**	**S**	**H**	**Habitat modification by unmanaged wildland fires is a potential threat for all three bumble bee species.**

7.1	Fire & fire suppression	Low	S	S	H	Fires are extremely common in NWT forests (about 274/year between 1988-2008), with 600,000 hectares affected annually (ENR 2015c). 88% are caused by lightening strikes (ENR 2018). Fire suppression/management is uncommon in natural areas (ENR 2018). Fires can reduce available nesting habitat for ground-nesting bumble bees 20 years or more after a burn (Williams *et al.* 2010), so unmanaged wildland fires are a current and potentially escalating threat. Non-forested areas do provide suitable habitat in at least some cases, and the three species demonstrate a fairly high level of plasticity in terms of habitat selection.
7.2	Dams & water management/use	Negligible	N	N	H	There are 3 major hydroelectric facilities in the NWT: Snare Group, Bluefish, and Taltson (GNWT 2017a). Flooding has occurred around dams in the NWT and can destroy wildlife habitat (CBC News 2017), but the bumble bees' habitat is not generally associated with land adjacent to water bodies.
7.3	Other ecosystem modifications					Not applicable. No other management actions are identified as problematic.
8	**Invasive & Problematic Species, Pathogens & Genes**	**Low**	**S**	**Se**	**H**	**There are probably large areas of natural habitat where problematic species/pathogens do not exist in the NWT. However, invasive species have the potential to spread rapidly. Pathogens currently appear not to have a significant effect on native bumble bee populations, but invasive species (especially plants) are common and possibly spreading. Invasive plants are widely associated with habitat and biodiversity loss.**
8.1	Invasive non-native/ alien plants & animals	Low	S	Se	H	Non-native honey bees (*Apis mellifera*) are present in the NWT (WG-GSNWTS 2016). No formal surveys have been performed in the NWT, but colonies are probably present in Norman Wells, Yellowknife, Fort Simpson (Gilbert 2015; CBC News 2016; ITI 2017b), and Fort Smith (www.bugguide.net). Honey bees may have negative effects on native species (Mallinger *et al*. 2017) and are known to compete directly with *B. occidentalis* (Thomson 2004). No introduced specialist predators of bumble bees are known in the NWT. Some alien plant species are probably displacing some native species, but impacts on floral and habitat resources are unknown. There has been little initiative at the government level to develop plans to prevent and control invasives, until the last decade or so (Carrière 2009).
8.2	Problematic native plants and animals	Negligible	S	S	L	No native species are known to be problematic (e.g., as predators, disease vectors, parasites, invasives, etc.) for bees in the NWT. A potentially problematic native species is the common eastern bumble bee (*Bombus impatiens* Cresson 1863, used elsewhere for pollination services (National Research Council 2007)). Escaped colonies compete with native bumble bees for habitat, or spread disease (Mallinger *et al*. 2017). According to the COSEWIC report on *B. terricola*, *B. impatiens* may already be used in NWT for commercial pollination services (COSEWIC 2015), but no records to support this claim were available when this report was prepared.

8.3	Introduced genetic material					Not applicable. No record of this threat in the NWT.
8.4	Pathogens & microbes	Low/ Uncertain	N	N	L	Fungal and other pathogens are widely implicated in the decline of North American bumble bees. It is presumed that "pathogen spillover" is to blame (Power and Mitchell 2004). Pathogen spillover is when pathogens spread from a heavily infected bee population to unaffected populations, and is strongly associated with commercially reared bee colonies (Colla *et al.* 2006; Cameron *et al.* 2011; Szabo *et al.* 2012; Murray *et al.* 2013; Goulson *et al.* 2015; McArt *et al*. 2017). An aggressive and virulent strain of the microsporidian pathogen *Nosema bombi* is found in many declining bumble bee species, including wild and commercially-reared colonies of *B. terricola* and *B. occidentalis* (Whittington and Winston 2003; Cameron *et al*. 2016; Arbetman *et al.* 2017). It has long been assumed that this problematic strain was introduced to North America via reared colonies imported from Europe, and that it subsequently spread to wild populations (Cameron *et al.* 2016). However, recent genetic analyses suggest that the strain of *N. bombi* wreaking havoc in North America was present and established before the commercial colony trade (Cameron *et al.* 2016). Although its origins may not be exotic, the fungus' high rate of transmission and impacts are nevertheless likely significant. Commercially-reared bumble bee nests of several species have been found to harbour other parasites, including *Crithidia bombi* and *Locustacarus buchneri*. There are no studies to confirm if these pathogens are present in the NWT. Declining bumble bee populations tend to have a high prevalence of pathogens (Cameron *et al.* 2011). Interestingly, both subspecies of *B. occidentalis* have similar levels of parasitism (about 40%) (Koch and Strange 2012; Pampell *et al.* 2015; Sheffield *et al.* 2016), but *B. o. mckayi* may be more stable than *B. o. occidentalis*. Since commercial bumble bee colonies are not widely used in the north, these relatively high levels of infection may be natural and not caused by pathogen spillover (McHugh and Sikes 2016). If these infection levels are indeed natural, *N. bombi* and other pathogens may not have the same effect on northern bumble bee populations as they do in the south, perhaps because other threats that increase their susceptibility to infections are not concurrent or as prevalent in the north.

						Fungal pathogen prevalence in bumble bees is associated with large-scale agricultural/commercial fungicide use (McArt *et al.* 2017); this is not a significant factor in the NWT. Additionally, since commercial bee-keeping and bee rearing is small in the NWT, it is unlikely that pathogens or spillovers pose a serious threat in the NWT provided that new or more virulent strains are not introduced. Commercial use of bees is unlikely to increase significantly in the next 10 years. Many other microsporidian pathogens exist worldwide, and the potential of these to cause additional disease epidemics in bumble bees is uncertain (Brown 2017). Small, isolated populations with less genetic diversity could be more affected by new diseases than large populations with high genetic diversity (Brown 2017).
9	**Pollution**	**Negligible**	**N**	**N**	**H**	**Pollution levels are very low compared to other regions (ENR 2008) and are very localized. Large-scale oil spills would be a larger concern if pipelines were operational. Agricultural pollutants, which are widely implicated in bumble bee declines globally, are not a significant threat in the NWT.**
9.1	Household sewage & urban waste water					Not applicable. This is the most common type of waste spilled in the NWT, in frequency of spills and in volume (93%) (ENR 2016b). Effects on bumble bees, if any, are unknown. Probably not a threat.
9.2	Industrial & military effluents	Negligible	N	N	H	Petroleum products degrade slowly and can be hazardous to plants and wildlife. Most communities in the NWT rely on fuel for heating and energy, which they receive via tanker trucks if they are accessible by roadway (ENR 2016b). Oil spills are a concern. The Enbridge Norman Wells Pipeline, which runs alongside the Mackenzie River from Norman Wells to Alberta, was shut down in 2016 because slope instability created concerns about pipe failure and environmental contamination (NEB 2017a). It has not been repaired and the line remains closed. Until very recently, there were concerns about the effects of the Mackenzie Valley Pipeline project on natural habitats. Although the project was approved by federal cabinet in 2011, it was abandoned by Imperial Oil in late December 2017. Regardless, it is not inconceivable that the project could be revived. Most oil spills in the NWT are small (<100 litres). In the mining industry, discharges from tailing ponds, waste rock, exposed rock, and accidental mill tailings spillage are pollutants that can be taken up by plants and animals (ENR 2016b). The effects of these effluents on bumble bees is unknown, but they are a continuous threat.
9.3	Agricultural & forestry effluents					Not applicable. Agricultural effluents with the greatest potential threat to bumble bees are pesticides, particularly neonicotinoids as they are harmful to wild bumble bees even at small concentrations (Goulson 2015; Goulson *et al.* 2015; Arce *et al.* 2017). These pesticides are systemic and spread through the plant to pollen and nectar. Pesticides have been globally implicated in pollinator declines (Szabo *et al.* 2012; Williams *et al.* 2014; Goulson *et al.* 2015; IPBES 2016). However, agriculture in general and plant production in particular is an extremely small sector in the NWT so this is not expected to be a threat.

9.4	Garbage & solid waste					Not applicable. Not a known threat in the NWT.
9.5	Air-borne pollutants					Not applicable. Not a known threat in the NWT.
9.6	Excess energy					Not applicable. Not a known threat in the NWT.
10	**Geological Events**					Geological events are not a threat in the NWT.
10.1	Volcanoes					Not applicable. Not a threat in the NWT.
10.2	Earthquakes/ tsunamis					Not applicable. Not a threat to bumble bees in the NWT.
10.3	Avalanches/ landslides					Not applicable. Not a threat to bumble bees in the NWT.
11	**Climate Change & Severe Weather**	**High/ Unknown-uncertain**	**L**	**Se**	**H**	**Climate change is a significant threat to bumble bees worldwide and probably in the in the NWT. Severity is serious: significant deviations from, and variability in, temperature and precipitation regimes, plus ecosystem encroachment, are all expected to have effects on the activity, foraging success, and habitat availability for the three species of interest. Timing is high as the threat is ongoing, and accelerating.**
11.1	Ecosystem encroachment	High	L	Se	H	Arctic temperatures are rising twice as fast as the global average, with associated shifts in vegetation zones, habitat, and species ranges (ACIA 2004; IPCC 2014; ENR 2016b). The entirety of the NWT is expected to be affected, although some regions (for example, the Mackenzie River valley) may be warming even more quickly than others (ENR 2008). Shrub cover above the treeline in the NWT is expanding and becoming more robust (ENR 2016b). Generally in the arctic, woody vegetation is expected to increase by 52% by the 2050s (Pearson *et al.* 2013). Since the three bumble bee species of interest appear to have affinities for habitat adjacent to forests, changes to forest habitat will likely have an impact on them. These effects may be positive or negative, depending on whether forests expand or contract, create or reduce forest edge habitat, and whether they enhance or displace flowering plant communities. Encroachment is likely occurring fairly rapidly and the effects are expected to continue in the next 10 years.
11.2	Changes in geochemical regimes					Not applicable. Greenhouse gas emissions in the NWT are not known to be significant enough to affect floral hosts (ENR 2008).

11.3	Changes in temperature regimes	High/ Uncertain	L	Se	H	Temperatures are rising in the NWT, and generally have been warmer in the past 15 years compared to all years recorded prior to 1990, both in winter and summer (ENR 2016b). These changes could affect the length of the active season for bees. The outcome could be positive if food resources are available when queens emerge in spring, but if there is a timing mismatch with floral resources the effects could be devastating. Bees are cold-adapted species; such species are likely to show population declines with increased annual temperatures, especially in northern latitudes (Goulson et al. 2015; Kerr *et al.* 2015). Habitat suitability models for *B. terricola* and *B. o. mckayi* show that temperature is a key determinant of the species' distributions in northern Canada (Sheffield *et al*. 2016).
11.4	Changes in precipitation & hydrological regimes	High	L	Se	H	The amount and timing of precipitation events in the NWT are becoming increasingly variable between seasons and communities (ENR 2008, 2016b). Drought conditions have been a problem in parts of the NWT in recent years, leading to dropping river and lake water levels (e.g., Great Slave Lake), and low water tables generally (CBC News 2015). This could have an impact on bumble bees' water availability and floral resources (Rasmont and Iserbyt 2012; Thomson 2016). Drought is also associated with increased forest fires, and forest fires are expected to increase in duration and intensity in the NWT (Flannigan *et al.* 2008; ENR 2016b) (see Threat 7.1). Dry weather can also affect soil moisture and other properties, which could affect quality or availability of nesting and hibernacula sites. NWT residents in the Gwich'in Settlement Area report that the soil used to be softer in some areas in the spring, when they usually noted bumble bees emerging (Benson 2012). There are no baseline data available for flooding in the NWT, but it is now being monitored at least in part as a component of forest health monitoring plans, due to rising concerns about climate-change induced flooding (Olesinski and Brett 2017). Flooding could have a direct negative impact on ground-nesting bees in floodplains or other low-elevation areas. Newly established nests of ground-nesting bumble bees display higher rates of failure in flood conditions, either from immersion or increased susceptibility to mold (Harder 1986). Floral resources could also be affected by flooding. Some large-scale flooding has taken place in the Mackenzie River valley, Aklavik, and Fort Good Hope (ENR 2012), as well as near Fort Providence and in the Slave River Delta in the last 5 years (Olesinski and Brett 2017).

11.5	Severe/ extreme weather events	Low	S	M	H	Bumble bees are intolerant of prolonged high heat exposure: it can render them immobile, or result in death (discussed in more detail in *Other Limitations and Considerations*) (Martinet *et al*. 2015). There have been a number of extended heat waves in the NWT in the past decade, and temperature fluctuations are generally less predictable than in the past (ENR 2008, 2016b). Heat waves usually affect some parts of the NWT more than others, so individual heat wave events are not expected to be a threat to all bumble bees within their entire distribution. Bumble bees whose active seasons end early or mid-summer are more likely to escape the negative effects of heat waves (since heat waves are most likely to occur in July/August). *B. terricola* and *B. bohemicus* are both active at least until the end of August, so they are not protected from heat waves by their phenology. *B. o. mckayi* is likely active during the same period.