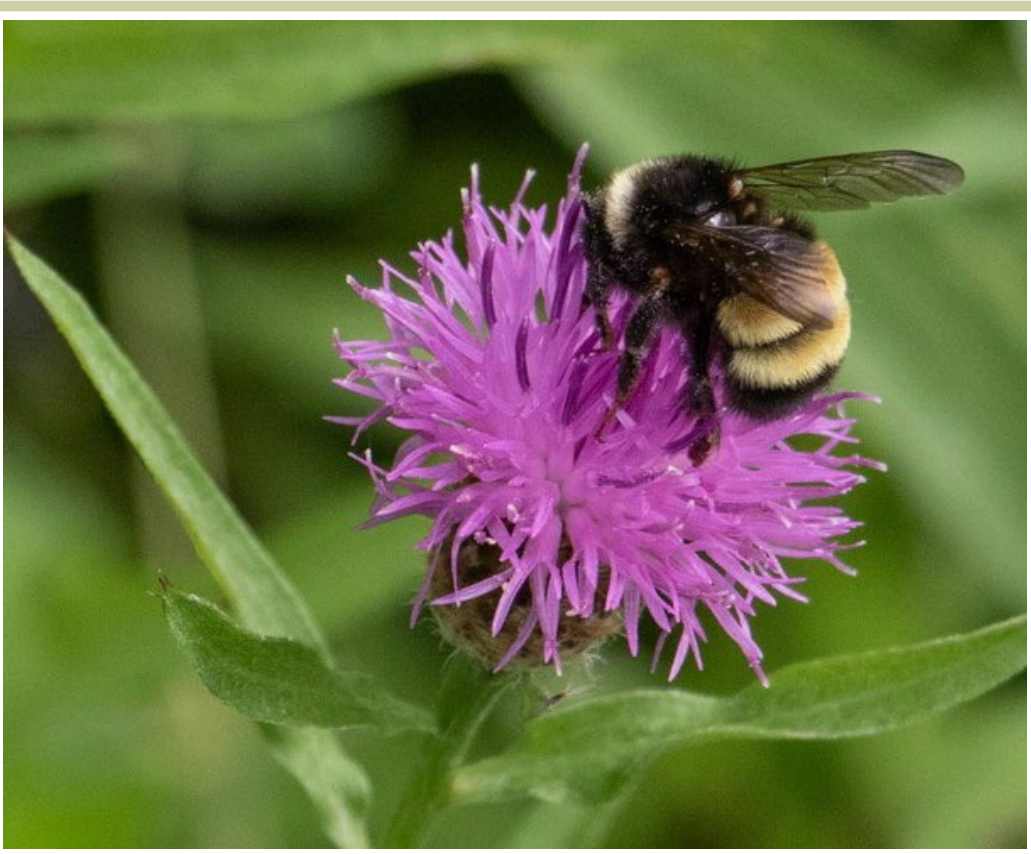
MANAGEMENT PLAN FOR THE YELLOW-BANDED BUMBLE BEE *(BOMBUS TERRICOLA)* IN NOVA SCOTIA



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PREFACE

The Yellow-banded Bumble Bee was assessed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2015 and listed under Schedule 1 of the Species at Risk Act (S.C. 2002, c. 29) in 2018. The species was listed as Vulnerable under Nova Scotia's Endangered Species Act in 2017. The International Union for the Conservation of Nature (IUCN) Red List ranks the Yellow-banded Bumble Bee as Vulnerable.

Under the *Nova Scotia Endangered Species Act (2007)*, a Management Plan must be prepared for Vulnerable species and is defined as "…*a statement of needs and actions to be undertaken to keep a vulnerable species from becoming at increased risk.*"

This Management Plan borrows heavily from existing literature, primarily the Proposed Management Plan for the Yellow-banded Bumble Bee (*Bombus terricola*) in Canada (ECCC 2022) and the COSEWIC Assessment and Status Report on the Yellow-banded Bumble Bee *Bombus terricola* in Canada (COSEWIC 2015).The objectives and actions identified in this Management Plan are based upon the best available information on the species and is subject to modifications and/or revisions as new information becomes available. Management of Vulnerable species at risk is a shared responsibility and the collaborative approach emphasized in this document is reflective of this.

Implementation of the actions and approaches identified in this plan are subject to budget constraints, appropriations, and changing priorities.

ACKNOWLEDGEMENTS

The Department would like to thank Environment and Climate Change Canada for use of the federal Management Plan in the preparation of this document. This Management Plan was reviewed by the following members of the provincial Insect Recovery Team and Department of Natural Resources and Renewable staff:

- Calum Ewing
- Dan Kehler
- John Klymko
- Paul Manning
- David McCorquodale
- Jeff Ogden
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- Donna Hurlburt

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EXECUTIVE SUMMARY

The Yellow-banded Bumble Bee is a medium-sized bumble bee, with queens, reproductive males, and a smaller worker caste. They have a short face and tongue length relative to other bumble bees. The hair on the upper side of most of the abdomen is black, but there is a distinctive, broad band of golden yellow across segments 2 and 3. Segment 5 is black or pale yellow-brown. The males are similar in colour to the females, although they usually have more yellow hairs on the face. They have relatively short antennae (COSEWIC 2015).

In 2017, the Yellow-banded Bumble Bee (*Bombus terricola*) was assessed by the Nova Scotia Species at Risk Working Group as Vulnerable due to a large observed decline in abundance in southern Canada, including within Atlantic Maritime Ecozone, although declines in Nova Scotia may not be as severe. This bee ranges across most of Canada south of treeline, from the southeastern Yukon and eastern British Columbia east to the island of Newfoundland.

The Yellow-banded Bumble Bee requires a consistent floral resources to support colony growth: pollen and nectar need to be available throughout the growing season. Bumble bees have a type of sex determination that makes them extremely susceptible to extinction when effective population sizes are small.

The four main threats impacting the Yellow-banded Bumble Bee are: Invasive non-native/alien species/diseases (competition for floral resources by Common Eastern Bumble Bee (*B. impatiens*)), Problematic native species (pathogen spillover from greenhouse bumble bees and introduced blueberry crop pollinators), Pollution (agricultural and silvicultural pesticides), and Climate change and severe weather (habitat shifting and alteration).

The management objectives for the Yellow-banded Bumble Bee are to maintain abundance and distribution of the species throughout its known Nova Scotia range.

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1. NSSARWG and/or COSEWIC ASSESSMENT SUMMARY*

Assessment Summary: May 2017

Common Name: Yellow-banded Bumble Bee

Scientific Name: *Bombus terricola*

Status: Vulnerable (Nova Scotia); Special Concern (SARA)

Reason for Designation: This once common and wide-ranging bee is found throughout Nova Scotia and most of Canada. However, despite being adaptable and being able to use a wide variety of habitats, it has recently declined by at least 34% in areas of southern Canada for poorly understood reasons. Pesticide use, habitat conversion, and pathogen spill over from managed bumble bee colonies are suspected contributing factors.

Nova Scotia Occurrence: Counties: Cumberland, Colchester, Halifax, Hants, Kings, Lunenburg, Annapolis, Queens, Shelburne, Digby, Yarmouth, Pictou, Guysborough, Antigonish, Inverness, Richmond, Victoria and Cape Breton.

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

Status History: Designated Special Concern in Canada in May 2015 and as Vulnerable in Nova Scotia in 2017.

* The following definitions are applicable in this section and elsewhere: NSSARWG (Nova Scotia Species at Risk Working Group); COSEWIC (Committee on the Status of Endangered Wildlife in Canada); NSESA (Nova Scotia Endangered Species Act); SARA (Species at Risk Act).

2. SPECIES STATUS INFORMATION

The Yellow-banded Bumble Bee is considered globally vulnerable (G3G4). In 2014, the IUCN Red List classified the species as Vulnerable under criteria A2b, based on range wide declines assessed as greater than 30% (Hatfield *et al.* 2015). At the provincial level, the species has a rarity rank of S3 or Vulnerable (Table 1).

In Canada, the species was assessed Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2015 and listed as Special Concern under Schedule 1 of the Species at Risk Act (S.C. 2002, c. 29) in 2018. The Yellow-banded Bumble Bee has been listed as Vulnerable under *Nova Scotia's Endangered Species Act (NSESA)* since 2017.

Table 1. NatureServe conservation status ranks for the Yellow-banded Bumble Bee in Canada (NatureServe 2023). *

Global (G) Rank[a]	National (N) Rank[b]	Subnational (S) Rank[c]
G3G4	N4?	S3 - Yukon S3 - Northwest Territories S3S4 - British Columbia S4 - Alberta S3S5 - Saskatchewan S3S5 - Manitoba S3S5 - Ontario SNR - Quebec SU - Labrador S3S4 - Newfoundland S4 - New Brunswick S3 - Nova Scotia S3 - Prince Edward Island

[a] G-Rank – Global Conservation Status Rank, G1 = Critically Imperiled; G2 = Imperiled; G3 = Vulnerable; G4 = Apparently Secure; G5 = Secure
[b] N-Rank – Provide ranking for each province the species is found in. National Conservation Status Rank, N1 = Critically Imperiled; N2 = Imperiled; N3 = Vulnerable; N4 = Apparently Secure; N5 = Secure
[c] S-Rank – Sub-national (provincial or territorial) ranks, S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; and S5 = Secure. B = breeding; and U = Unrankable.
*A full list of definitions can be found in Definitions of NatureServe Conservation Status Rankings at http://help.natureserve.org/biotics/Content/Record_Management/Element_Files/Element_Tracking/ETRACK_Definitions_of_Heritage_Conservation_Status_Ranks.htm

3. SPECIES INFORMATION

3.1. Species Description

The Yellow-banded Bumble Bee is a medium-sized bumble bee, with queens, reproductive males, and a smaller worker caste. They have a short face and tongue length relative to other bumble bees. The hair on the upper side of most of the abdomen is black, but there is a distinctive, broad band of golden yellow across segments 2 and 3. Segment 5 is black or pale yellow-brown (Figure 1).

The males are similar in colour to the females, although they usually have more yellow hairs on the face. They have relatively short antennae (COSEWIC 2015).

Figure 1. Queen Yellow-banded Bumble Bee,

Population and Distribution

Global Distribution

The Yellow-banded Bumble Bee occurs only in North America. It ranges from Georgia, north to Labrador, and west through the northern United States and Canada to Montana, British Columbia (BC), and the Northwest Territories (NT) (Figure 2). Its northern limit roughly follows latitudinal treeline. Approximately 50-60% of its global range is in Canada (COSEWIC 2015).

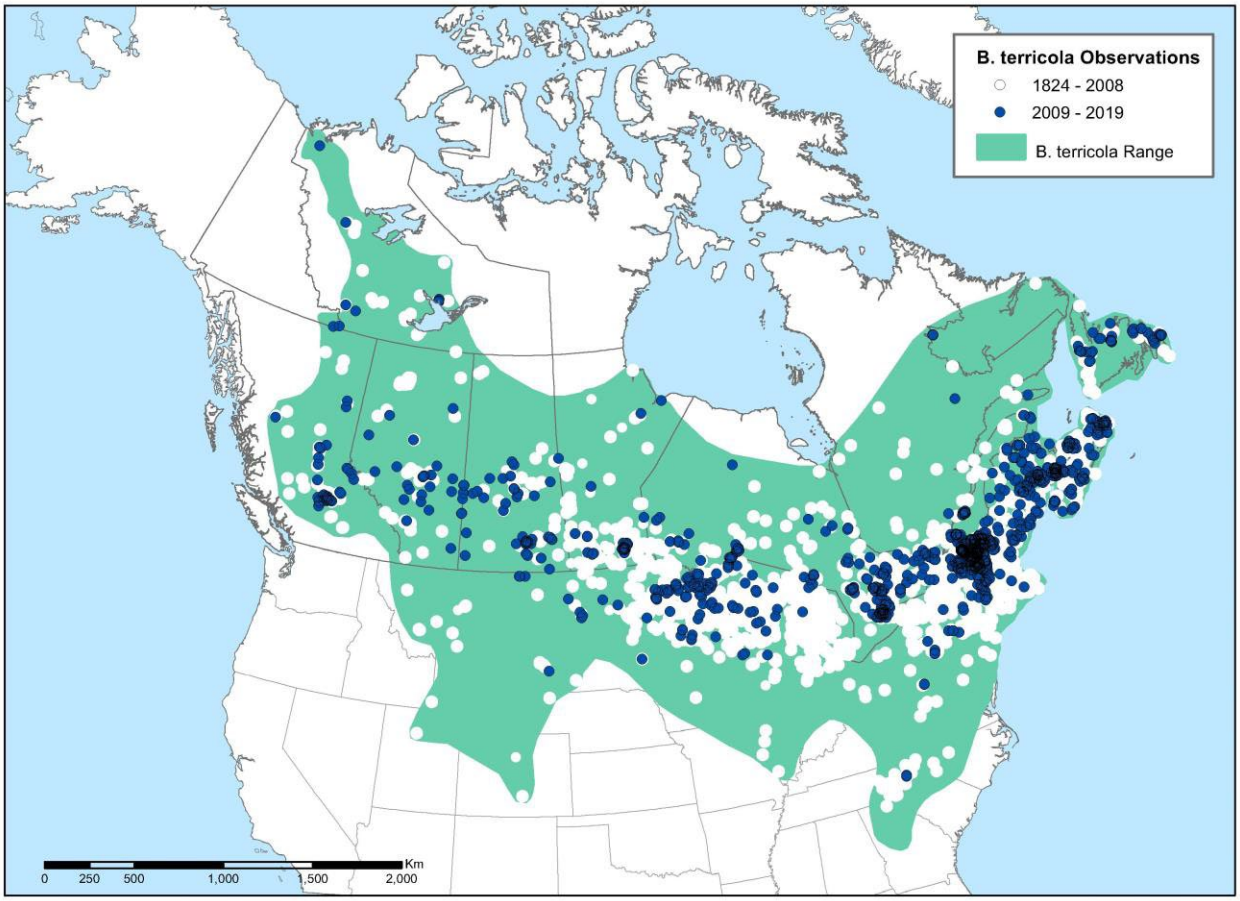

Figure 2. Global range of Yellow-banded Bumble Bee. Observations since 2009 are represented by dark blue dots. Northern limit of range uncertain, especially in central Canada. Data from L. Richardson, map by B. Fournier (Government of Northwest Territories). (ECCC 2022)

Canadian Range

The Yellow-banded Bumble Bee is known to occur in every Canadian province and territory except Nunavut (NU) (COSEWIC 2015), although it likely occurs there as well.

Despite being one of the commonest bumble bees of eastern and boreal Canada the species began to decline in the early 1990s. Despite declines, the distribution of the species has remained similar to historic distributions prior to the 1990s.

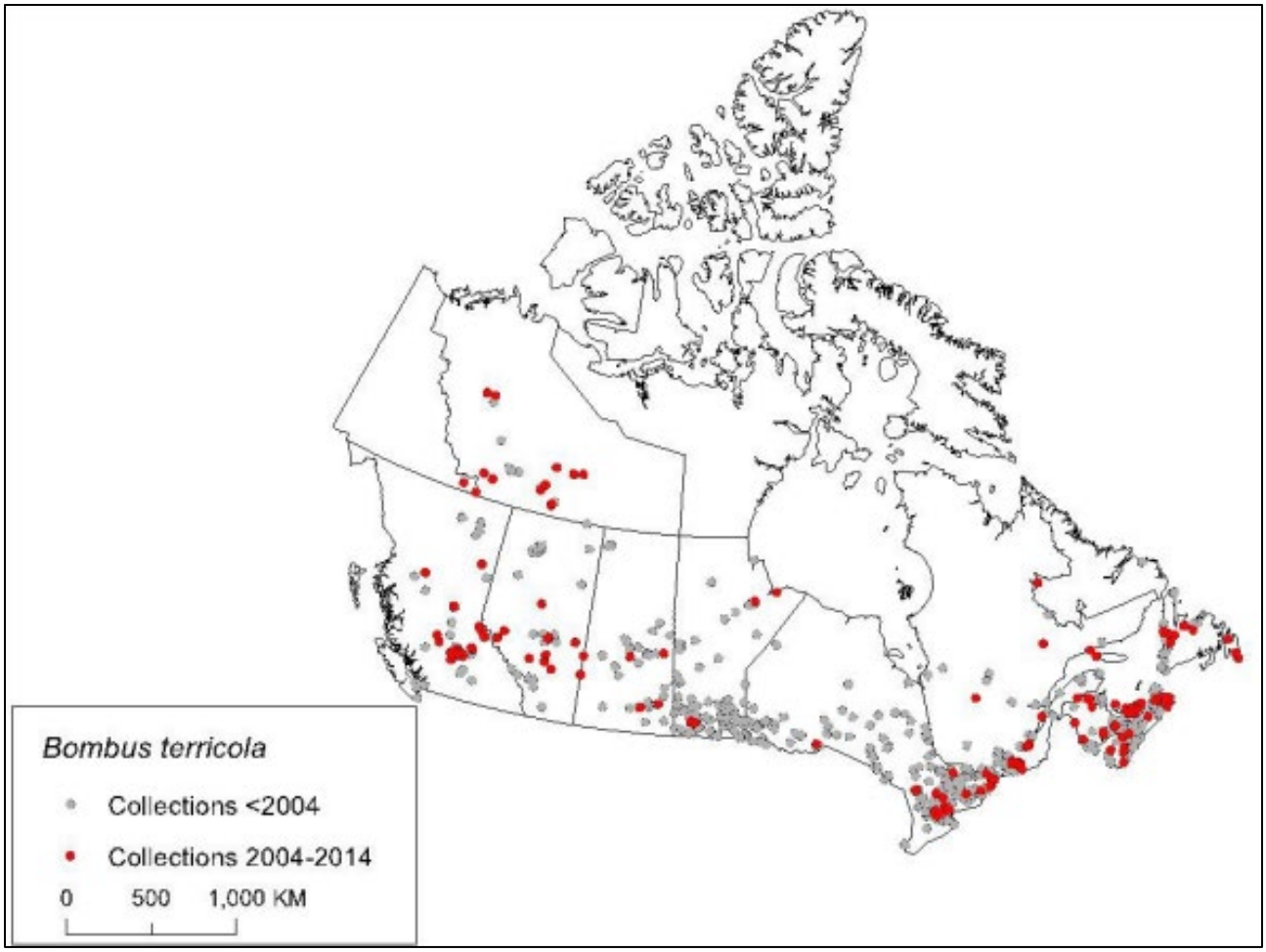

Figure 3. Museum specimen records of Yellow-banded Bumble Bee in Canada from 2004-2014 (red) and those made prior to 2004 (grey). Data are from most major academic and museum collections in Canada and many U.S. collections, but some additional Yellow-banded Bumble bee collections data exist in collections that have not been digitized. (COSEWIC 2015)

Nova Scotia Range

The Yellow-banded Bumble Bee is found throughout Nova Scotia. Between 2014 and 2022 more than 360 observations of Yellow-banded Bumble Bee have been posted to iNaturalist, covering each of the 18 counties. The most recent Atlantic Canada Conservation Data Centre dataset (AC CDC 2020) shows larger concentrations in the Cape Breton Highlands and smaller concentrations along the southwestern areas of the province. The high density of observations in Cape Breton may be due to increased search effort in the area; however, more cross-provincial surveys for the species would be required to validate. iNaturalist data used to supplement the ACCDC datasets has allowed for a better understanding of the distribution of the species in Nova Scotia.

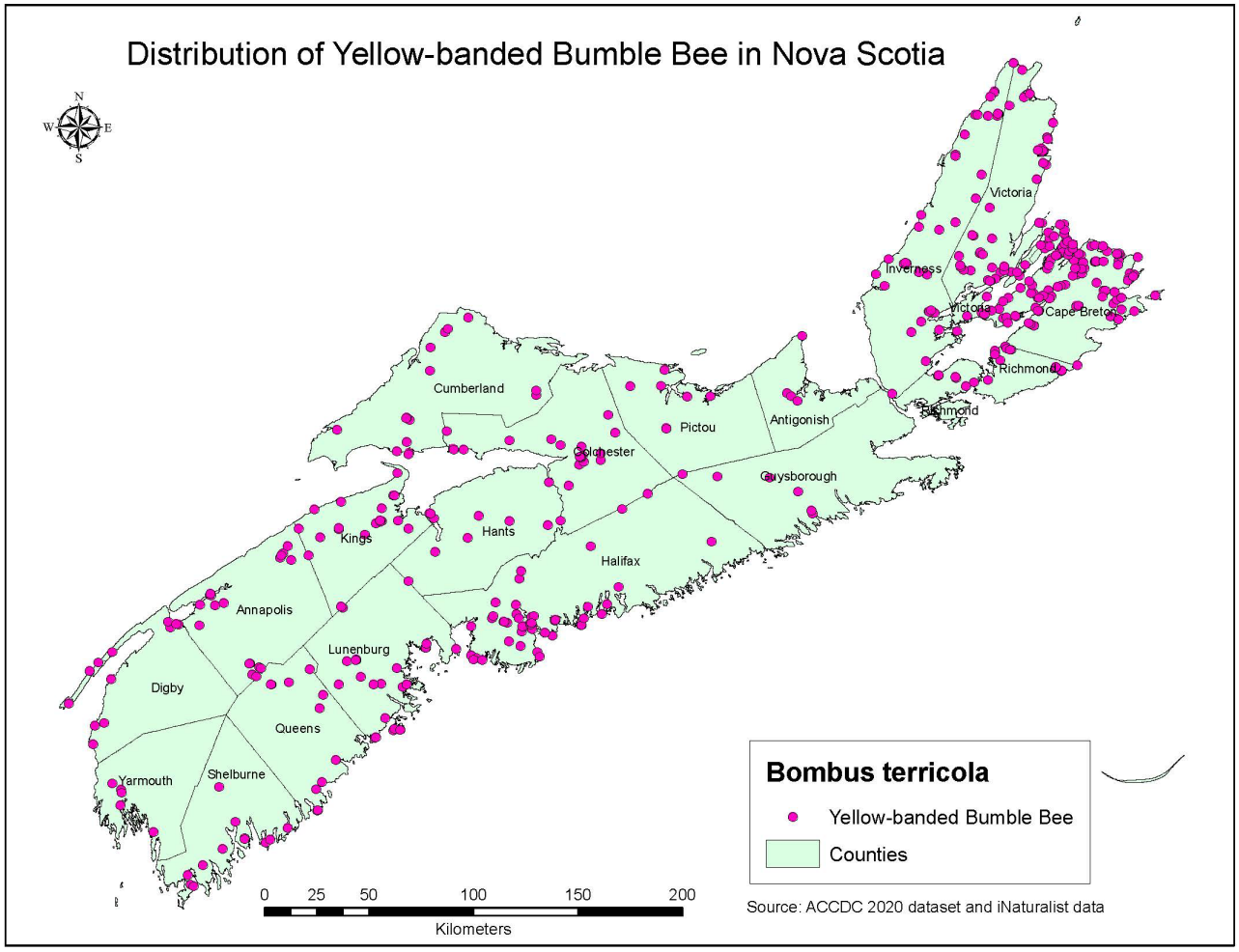

Figure 4. Distribution of Yellow-banded Bumble Bee in Nova Scotia

Population Size and Trends

Yellow-banded Bumble Bee was once one of the most common species in collections of bumble bees made in Canada. However, in the early 1990s populations began to decline in the southeastern part of their range in Ontario. At many sites, Yellow-banded Bumble Bees once accounted for > 20% of all bumble bees collected, yet in recent studies (in the past ten years), they typically make up < 4%. The Yellow-banded Bumble Bee has declined significantly at nine of 10 sites analyzed across southern and central Canada, with an average of 66.5% reduction in proportional abundance between pre- and post-10-year sampling periods. The species is now thought absent from many historical collection sites in these areas. However, there are few historical and modern collection data across the northern part of the species' range in the boreal forest (ECCC 2022).

3.2. Species Needs

Diet

Like other bumble bees, the Yellow-banded Bumble Bee is a generalist pollen forager and visits the flowers of a wide variety of plant species, from willows to raspberries to clovers (see Appendix A). As a colonial species that is active throughout the growing season, its primary requirement is a series of pollen and nectar sources throughout the spring and summer (Goulson 2010), which makes foraging resources the most important variable in Yellow-banded Bumble Bee habitat selection (Liczner and Colla 2020). Many of the flowers used are considered invasive or exotic weeds in disturbed habitats (e.g., White Sweet-clover, *Melilotus alba*; Common Dandelion, *Taraxacum officinale*; White Clover, *Trifolium repens*). A variety of floral resources are required at the landscape level, given that geographic availability within home ranges may vary both within and among years (e.g., blueberries may have abundant blooms one spring, but not the next). The Yellow-banded Bumble Bee is short-tongued, requiring relatively shallow flowers for pollen gathering, but can rob nectar from deeper flowers by chewing through the corolla (Evans *et al.* 2008).

Breeding Habitat

The Yellow-banded Bumble Bee is a habitat generalist. It is found in a wide variety of open areas, including meadows within coniferous, deciduous and mixed-wood forests and woodlands; taiga; prairie grasslands; riparian zones; urban parks, gardens, and agricultural areas; and along roadsides (COSEWIC 2015). In southern Ontario, Yellow-banded Bumble Bee habitat is positively correlated with coniferous forest and is negatively correlated with agricultural pesticide use, honey bee colonies, roads, and high summer temperatures (Liczner and Colla 2020).

Dispersal occurs primarily in spring by overwintering queens searching for suitable nest sites (Goulson 2010). There is evidence that bumble bees disperse relatively long distances, between 2.6 and 10 km from the colony of origin (Kraus *et al*. 2008, Stout and Goulson 2000, Lepais *et al*. 2010).

Yellow-banded Bumble Bees nest underground (Laverty and Harder 1988), often in abandoned rodent or rabbit burrows (Plath 1927; Hobbs 1968; Macfarlane 1974; Colla and Dumesh 2010).

Overwintering Habitats

In August and early September, reproductive adults (new queens and males) emerge from the nest to find mates. Mated females disperse to select an overwintering site, travelling an unknown distance to do so. Like other bumble bees, Yellow-banded Bumble Bee males die at the onset of cold weather, as do the queens of the previous summer (Williams *et al.* 2014, COSEWIC 2015). The specific overwintering habitats of Yellow-banded Bumble Bee queens are unknown (Liczner and Colla 2019), but bumble

bees typically burrow 2-15 cm deep in loose soil or rotting logs (Macfarlane 1974; Benton 2006; Liczner and Colla 2019). Queens do not survive more than one winter so there is no overwintering site fidelity by individuals.

4. THREATS

4.1. Threat Assessment

The Yellow-banded Bumble Bee threat assessment is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threat classification system (IUCN 2012). Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (in this case, the province of Nova Scotia). Limiting factors are not considered during this assessment process. For purposes of the threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in Section 4.2

Table 2. Threat calculator assessment.

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
1	Residential & commercial development	Negligible	Negligible (<1%)	Serious - moderate	High (continuing)	Urban development is limited in scope within range; however, cumulative impacts of housing and industrial development surrounding the urban centers can result in complete loss of local habitat.
1.1	Housing & urban areas	Negligible	Negligible (<1%)	Serious - moderate	High (continuing)	Urbanization has the potential for greatly reducing floral resources, although bee-friendly green spaces may allow bees to still live within cities. Scope is quite small for this particular threat in Nova Scotia but is continuous.
1.2	Commercial & industrial areas	Negligible	Negligible (<1%)	Serious - moderate	High (continuing)	Commercial and industrial development may have a greater impact than housing/urban development but see comments above. Scope is quite small for this particular threat in Nova Scotia but is continuous.
1.3	Tourism & recreation areas	Negligible	Negligible (<1%)	Serious - moderate	High (continuing)	Some types of recreational development could cause habitat to be lost, though other developments can be beneficial. Scope is

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
						quite small in Nova Scotia for this particular threat but is continuous.
2	Agriculture & aquaculture	Negligible	Negligible (<1%)	Moderate - slight	High (continuing)	Habitat loss as a result of agricultural expansion and intensification.
2.1	Annual & perennial non-timber crops	Negligible	Negligible (<1%)	Moderate - slight	High (continuing)	The increased reliance on intensive agriculture (decreased 'edge meadows' around planted fields) has reduced foraging habitat for bumble bees. The footprint of increased intensification on the province is small, where it is happening is severe but it is not a large area.
2.2	Wood & pulp plantations					Not applicable
2.3	Livestock farming & ranching					Threat removed for Nova Scotia as there is little conversion of natural habitats into new pasture/rangeland habitat in this region.
2.4	Marine & freshwater aquaculture					Not applicable
3	Energy production & mining	Negligible	Negligible	Extreme-Serious	High (continuing)	
3.1	Oil & gas drilling					Not applicable
3.2	Mining & quarrying	Negligible	Negligible (<1%)	Extreme-Serious	High (continuing)	Some long-term loss of relatively small portions of habitat, but some could result in longer term increase in flowers at localized sites.
3.3	Renewable energy	Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	Habitat impacts - Direct habitat loss is minimal and primarily due to roads to construct and service wind turbines. Functional habitat loss or displacement is expected to be negligible, although it

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
						depends on the availability of pollinator habitat prior to development versus after. It is plausible that the activity could increase habitat for the Yellow-banded bumble bee at the site level (through the creation of gaps that allow light permeability, or nest site w/ the gravel road). Both wind and Solar farm pose a potential threat to bumble bees.
4	Transportation & service corridors	Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	Loss of habitat in travelled portion of road; increased mortality from collisions with cars; benefit from increased flowers in roadside rights-of-way
4.1	Roads & railroads	Negligible	Restricted - small	Negligible or <1% pop. decline	High (continuing)	Mortality is due to bee collisions with cars and trains, but benefit from increased production of roadside weeds (COSEWIC 2015). Potential threat from pesticide/herbicide application will be addressed in section 9.
4.2	Utility & service lines	Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Potential benefit from maintenance of early successional shrub lands and grasslands. Potential threat from pesticide application will be addressed in section 9.
4.3	Shipping lanes					Not applicable
4.4	Flight paths					Not applicable
5	Biological resource use	Negligible	Negligible (<1%)	Restricted (11-30%)	High (continuing)	

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
5.1	Hunting & collecting terrestrial animals	Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	Not applicable. Scientific collecting may be a threat, but this is likely negligible. The use of iNaturalist and Bumble Bee Watch has potentially decreased the amount of scientific collections occurring.
5.2	Gathering terrestrial plants					Not applicable
5.3	Logging & wood harvesting	Not a threat	Restricted (11-30%)	Neutral or Potential Benefit	High (Continuing)	Potential benefit given the large openings created.
5.4	Fishing & harvesting aquatic resources					Not applicable
6	Human intrusions & disturbance					
6.1	Recreational activities					Not applicable
6.2	War, civil unrest, & military exercises					Not applicable
6.3	Work & other activities					Not applicable
7	Natural system modifications	Negligible	Negligible (<1%)	Unknown	High (continuing)	
7.1	Fire & fire suppression	Negligible	Negligible (<1%)	Unknown	High (continuing)	The impacts of fire can be detrimental in the short term but beneficial in the medium-longer term. Fire suppression can be detrimental in the longer term.
7.2	Dams & water management/use					Not applicable
7.3	Other ecosystem modifications					Not applicable

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
8	Invasive & other problematic species, genes & diseases	Medium-Low	Large (31-70%)	Moderate-Slight	High (continuing)	Primarily the effects of pathogen spillover from greenhouse operations and blueberry crop pollination.
8.1	Invasive non-native/alien species/diseases	Medium-Low	Large (31-70%)	Moderate-Slight	High (continuing)	Problematic pathogens appear to be largely native in origin (see threat 8.2), but over much of the Yellow-banded Bumble Bee's range are transmitted by non-native Common Eastern Bumble Bees. Honey bees can transmit non-native pathogens and can compete with native bees when kept at high densities. The introduction and use of Common Eastern Bumble Bee (*B. impatiens*) for pollination services outside its natural range (e.g., in Maritimes and BC) may result in competition for floral resources and nesting habitat. There is debate about its providence in the province, it is unclear about whether it is a native species.
8.2	Problematic native species	Medium-Low	Large (31-70%)	Moderate-Slight	High (continuing)	Native pathogens are a major threat, including pathogen spillover from greenhouses (managed populations of Common Eastern Bumble Bee) and managed bee boxes in field crops (e.g. blueberries).
8.3	Introduced genetic material					Not applicable
8.4	Problematic species/diseases of unknown origin					Not applicable
8.5	Viral/prion-induced diseases					Not applicable
8.6	Diseases of unknown cause					Not applicable

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
9	Pollution	Low	Small (1-10%)	Moderate - slight	High (continuing)	Insecticides can be directly detrimental. Herbicides reduce floral resources for all bees. Fungicide effects unknown but implicated in increasing susceptibility of bumble bees to pathogens.
9.1	Domestic & urban waste water					Not applicable
9.2	Industrial & military effluents					Not applicable
9.3	Agricultural & forestry effluents	Low	Small (1-10%)	Moderate - slight	High (continuing)	Cumulative effects from chronic exposure to neonicotinoid insecticides lead to colony failure; persistent. Fungicides are implicated in the prevalence of Nosema; the concentration of a widely used fungicide, chlorothalonil, is the best predictor of Nosema abundance. Widespread herbicide use (especially in conjunction with genetically modified crops) kills flowers within and adjacent to crops, and thus reduces floral resources for bees. Herbicides also widely used in reforestation.
9.4	Garbage & solid waste					Not applicable
9.5	Air-borne pollutants					Not applicable
9.6	Excess energy					Not applicable
10	Geological events					
10.1	Volcanoes					Not applicable
10.2	Earthquakes/tsunamis					Not applicable
10.3	Avalanches/landslides					Not applicable

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
11	Climate change & severe weather	Low	Pervasive	Slight	High (continuing)	Primarily a decline in climate envelope along southern edge of its range.
11.1	Habitat shifting & alteration	Low	Pervasive	Slight	High (continuing)	Climate envelopes shifting north. Bumble bees are losing southern portions of their ranges but not moving correspondingly north; attributed to climate warming. Bees also may be affected by mismatch in timing of active period with flowering plants.
11.2	Droughts	Unknown	Unknown	Unknown	High (continuing)	Increased drought predicted in some regions; reduces floral resources. However, given Nova Scotia is surrounded by water which influences its climate, it is unlikely to experience extreme drought.
11.3	Temperature extremes	Unknown	Unknown	Unknown	High (continuing)	Research in Europe attributes loss of southern portion of ranges to increasing summer extreme heat events. Some potential effects of temperature extremes: longer periods of winter warm-ups; shorter winters; false/early springs with sudden severe frost events; periods of unseasonably warm temps earlier in season etc. These may impact host phenology, bee overwinter survival rates, availability of forage (in the case of severe frost events following a usually early warm period) or prolonged fall weather conditions ending suddenly before bees enter dormancy.
11.4	Storms & flooding	Unknown	Unknown	Unknown	High (continuing)	Some evidence of flooding in its range (nest flooding) but may have an effect on spring queens and foraging (unknown).

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
						Flooding of individual colonies has been seen in the past few years in Nova Scotia as the province has seen more frequent rain events.
12	Other options					
12.1	Other threat					Not applicable

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

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

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11-30%; Slight = 1-10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

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

4.2. Description of Threats

The Yellow-banded Bumble Bee is thought to be impacted by four primary threats (Table 2 above): Invasive non-native/alien species/diseases (competition for floral resources by Common Eastern Bumble Bee (*Bombus impatiens*)), problematic native species (pathogen spillover from greenhouse bumble bees), pollution (agricultural and silvicultural pesticides), and climate change and severe weather (habitat shifting and alteration).

Invasive and Other Problematic Species and Genes - Invasive non-native/alien species (Medium-Low)

Competition with Honey Bees

Honey Bees compete directly with bumble bees for pollen and nectar resources. Pollen can be a limiting resource; in the absence of Honey Bees, native bees can remove 97-99% of the available pollen daily (Schlindwein *et al.* 2005, Larsson and Franzen 2007). Henry and Rodet (2018) found that high-density beekeeping (greater than 14 colonies/km2) triggers foraging competition that depresses both the occurrence (−55%) and nectar foraging success (−50%) of local wild bees. However, Mallinger *et al.* (2018) caution that more competition studies that include measures of wild bee reproductive success are needed to quantify ongoing effects.

Competition with exotic bumble bees

The introduction and use of the Common Eastern Bumble Bee (*Bombus impatiens*) for pollination services in Nova Scotia may further impact the Yellow-banded Bumble Bee in parts of its range. The Common Eastern Bumble Bee may out-compete some native bee species for nesting habitat or foraging resources and may serve as a source for pathogens or diseases. The recent establishment of wild populations of Common Eastern Bumble Bee in the Maritime Provinces (Palmier and Sheffield 2019) has likely had a negative impact on native species, as has been documented in other parts of the world (Williams and Osborne 2009).

Invasive and Other Problematic Species and Genes - Problematic native species (Medium-Low)

The introduction and/or spread of pathogens from commercially-raised bumble bees and honey bees, are direct, serious threats to the Yellow-banded Bumble Bee.

Parasites and pathogens of bumble bees

The prevalence of the microsporidian pathogen *Nosema bombi* in North American bumble bees increased dramatically from low detectable frequency in the 1980s to significantly higher frequency in the mid- to late-1990s, corresponding to a period of reported massive infectious outbreak of *N. bombi* in commercial bumble bee rearing

stocks in North America (Cameron *et al.* 2016). Although *N. bombi* is native to North America, it has been postulated that a novel strain was imported from Europe about this time; however, genetic evidence to date does not support this (Cameron *et al.* 2016; Brown 2017). There is debate in Nova Scotia about the providence of *N. bombi* and status as a native species. *Nosema ceranae*, a prevalent pathogen associated with managed European honey bees, has also been detected in *Bombus* spp. worldwide, though the impact of this pathogen on bumble bees remains unclear and requires further investigation (Goblirsch 2018).

Studies have shown the parasites *Crithidia bombi, C. expeoki* and *N. bombi* can have a potentially devastating effect on bumble bee colonies (Brown *et al.* 2000, 2003; Otterstatter *et al.* 2005; Otti and Schmid-Hempel 2007, 2008; van der Steen 2008). These parasites are found in a variety of bumble bee species (Macfarlane 1974; Macfarlane *et al.* 1995; Colla *et al.* 2006). However*, N. bombi* infection rates and infection intensities were significantly higher in the Yellow-banded Bumble Bee and its sibling species, the Western Bumble Bee, than they were in bumble bees with stable populations, such as the Common Eastern Bumble Bee (*B. impatiens*) and the Two form Bumble Bee (*B. bifarius* [now considered to be *B. vancouverensis*]) (Cameron *et al*. 2011). Similar trends were also seen for Yellow-banded Bumble Bees and Rusty-patched Bumble Bees, but small sample sizes precluded statistical analyses (Cameron *et al*. 2011). A recent genetic study of the Yellow-banded Bumble Bee revealed activation of immune system function in southern populations that had experienced declines, indicating possible “novel pathogen pressures” (Kent *et al.* 2018).

The rapid rise in *N. bombi* infection in commercial bumble bees, the coincident decline in the Yellow-banded Bumble Bee, and the fact that these pathogens are more prevalent in Yellow-banded Bumble Bees relative to healthy species have together caused pathogen spillover to be cited as one of the primary causes of the declines of the Yellow-banded Bumble Bee (Thorp and Shepherd 2005; COSEWIC 2010; Cameron et al. 2011; Szabo *et al.* 2012; Graystock *et al.* 2016; all cited in Colla 2017; Arbetman *et al.* 2017). Pathogen spillover occurs when managed populations of bees introduce pathogens to wild populations or amplify pathogens (spillback) that may have been naturally in lower abundances (Power and Mitchell 2004; Graystock *et al.* 2016). The use of infected commercial bumble bees in Canada for greenhouse pollination as well as for blueberry crops in Nova Scotia are known to cause pathogen spillover into populations of wild bumble bees foraging nearby (Colla *et al.* 2006; Otterstatter and Thomson 2008). However, there is much to learn about the effects of pathogen spillover on wild bumble bee populations, and new pathogens are still being discovered (K. Palmier, pers. comm. 2020). See also section on Pollution (Threat 9, below) for apparent interactions between fungicides and pathogen prevalence.

Honey Bees as vectors of pathogens and viruses

Honey Bees appear to be another vector for the transmission of pathogens to wild bumble bees. Graystock *et al.* (2014) showed that, in Great Britain, the prevalence of *C. bombi* was 18% greater in bumble bees near an apiary than in those farther away from

it. There is also increasing evidence that a number of Honey Bee pathogens are transferable to bumble bees (Plischuk *et al*. 2009; Meeus *et al.* 2011; Peng *et al.* 2011; Graystock *et al.* 2013). Under controlled conditions, *N. ceranae*, a common parasite of Honey Bees, produced fewer spores in bumble bees than in Honey Bees but exhibited greater virulence, reducing survival by 48% and having sublethal effects on behaviour (Graystock *et al*. 2013). The potential impact of Honey Bees as vectors is unknown in Nova Scotia.

Honey Bees that are infected with *Deformed wing virus* through the Varroa Mite *(Varroa destructor)* during pupal stages develop into adults showing wing and other morphological deformities. Researchers in Germany and the United Kingdom have found this Honey Bee virus in deformed individuals of *Bombus terrestris* and *B. pascuorum* (Genersch *et al.* 2005; Fürst *et al.* 2014), and recent studies in Vermont have found *Deformed wing virus* and *Black queen cell virus* in bumble bees collected near Honey Bee apiaries (Alger *et al*. 2019). Because the Varroa Mite is widespread in Canada (Ontario Ministry of Agriculture, Food and Rural Affairs 2019), this disease therefore poses a serious potential threat to bumble bee populations there. Deformed wing virus is an issue in Nova Scotia Honey Bee colonies, being widespread but not abundant. However, it has not currently been observed in native bumble bees (personal communication with Jason Sproule).

Risk of commercially available Bumble bees

The importation of commercially available Bumble Bee colonies for pollination of lowbush blueberry and greenhouse crops may pose a substantial risk to Nova Scotia indigenous bees. Issues can/may arise due to the improper disposal of these colonies which become a reservoir for bee pests and disease. More research and development of screening process would need to be done to confirm the presence of Nosema and Crithidia species in the colonies when imported (Personal communication with Jason Sproule).

Other potential vectors for disease transfer between bee species are the Waxmoth, Small Hive Beetle, Chalkbrood and *Nosema* spp. Waxmoth can frequently be found in commercial bumble bee nests and honey bee hives, it is present in Nova Scotia but to what extent is unknown (personal communication with Jeffrey Ogden). *Nosema apis* and *N. cerenae* are present in Honey Bee colonies. Small Hive Beetle is not yet found in Nova Scotia, although it is established in New Brunswick. Chalkbrood is known to be found in commercial Alfalfa leafcutter bees, suggesting it may impact other indigenous bees. Varroa mites are widespread in Nova Scotia but not a direct concern to non-*Apis* bee species (Personal communication with Jason Sproule).

Pollution - Agricultural and forestry effluents (Medium-Low)

It has long been known that pesticides can have negative impacts on bees (e.g., Johansen and Mayer 1990; NRC 2007). Although the recent focus has largely been on neonicotinoid insecticides, other insecticides, herbicides and fungicides have also been tied to Bumble Bee declines. The queens and workers of Yellow-banded Bumble Bees are exposed to pesticides while they forage, and while they burrow into the soil to expand nest sites.

Neonicotinoid insecticides

Around the time when the declines of Bumble Bees in the subgenus *Bombus* were observed in North America, the neonicotinoid insecticide imidacloprid was registered for use in the United States and Canada (1994 and 1995 respectively: Cox 2001). Neonicotinoids can pose a particularly severe threat to bees because they can be harmful even at concentrations in the parts-per-billion (ppb) range (Marletto *et al.* 2003). These pesticides are systemic, travelling throughout plant tissues and integrating with pollen and nectar. They are routinely used on golf courses and agricultural lands (Sur and Stork 2003). They are also used prophylactically; that is, they are being applied even if there is no apparent insect outbreak needing attention (van der Sluijs *et al*. 2014).

Imidacloprid is used in Nova Scotia on hemlock forests for the treatment of the Hemlock Woolly Adelgid, however it is expected to have little impact on pollinators at the stand or landscape level. As hemlock is wind pollinated, it is unlikely to be collected by insect pollinators and any exposure would be limited to flowering plants growing within 50-100cm of the treated trees. Imidacloprid concentrations in soil diminish significantly with distance from initial point of application, therefore only a small fraction of flowering plants pollinators may encounter could potentially have imidacloprid in the nectar or pollen (McCarty 2020). There is current research at Acadia University (Luca Voscort, MSC candidate) to determine the risks of imidacloprid basal bark spray to wild bee pollinators in hemlock forests (personal communication with Jeff Ogden).

Other neonicotinoids such as thiamethoxam and clothianidin also have effects on Bumble Bees, although these effects are not identical. Moffat *et al.* (2016) found that both thimethoxam and imidacloprid reduced “colony strength” (number of live bees), but clothiandin did not. However, although Arce *et al*. (2017) found only subtle effects by clothianidin on worker behaviour, they did find reduced numbers of adult bees at colonies exposed to the insecticide.

Neonicotinoid exposure in concert with other threats can also have significant deleterious results. In a study on *Bombus impatiens*, imidacloprid exposure followed by an immune challenge significantly decreased survival probability relative to control bees (Czerwinski and Sadd 2017). However, given that agricultural intensification is lesser in Nova Scotia compared to the rest of Canada, the impact of this threat is most likely not as high in this province.

Bacillus thuringiensis kurstaki (Btk)

Bacillus thuringiensis kurstaki (Btk) is a naturally occurring bacteria found in soil, foliage, water, and in the air. Btk has been used to control major forest pests such as the Spruce Budworm, Hemlock Looper, and Whitemarked Tussock Moth in Nova Scotia. Btk is also registered for use against agricultural and horticultural pests and is also registered for organic use. Other than impacting Lepidopteran species, Btk has been safely used for over 30-years with little or no impact to other species (Nui *et al,* 2017, personal communication with Dan Lavigne).

Herbicides

Glyphosate is used as a broad-spectrum, systemic herbicide. Generally considered to have low toxicity to terrestrial insects, there are indications that glyphosate may have sub-lethal effects on bees (Vázquez 2018; Balbuena *et al*. 2015; Helmer *et al.* 2014; Herbet *et al.* 2014) and increase susceptibility to infection by pathogens (Motta *et al*. 2018). Glyphosate is registered with the Health Canada's Pest Management Regulatory Agency (PMRA) for use as a forestry herbicide and other purposes, such as in the production of food crops and residential home and garden use. (NSEL 2007).

In Nova Scotia, the use of herbicides such as glyphosate could be approved for use on Crown land if a licensee gets approval from Environment and Climate Change Canada (ECCC), however funding for the treatment is at the expense of the licensee. In 2022, an average of 2306 hectares of leased Crown land was approved for treatment with glyphosate herbicides (ECCC 2022), however the amount of that approved land actually treated with glyphosate is unknown. With the recent adoption of the Triad approach (Lahey 2018) which introduced the concept of Ecological Forestry and High Production Forestry (NSDNRR 2023), the use of Glyphosate could potentially increase at localized sites in Nova Scotia.

More importantly, however, the intensive and extensive use of glyphosate and other herbicides in heavily managed landscapes, like areas of intensive agriculture, forestry and linear infrastructure maintenance has undoubtedly resulted in a great reduction in floral resources in treated landscapes, and has thus likely contributed to reduced bumble bee colonies and reproductive success.

Fungicides

There is increasing evidence suggesting that fungicides may have detrimental effects on bees. *Pettis et al.* (2013) found that 100% of honey bee-collected pollen in agricultural landscapes contained fungicide residue, and Bernauer *et al.* (2015) demonstrated that colonies of the Common Eastern Bumble Bee (*Bombus impatiens*) produced fewer workers, less bee biomass, and had smaller mother queens following exposure to chlorothalonil, a widely used fungicide on crop and ornamental plants. Fungicides also interact with other Bumble Bee threats. A study by McArt *et al.* (2017) found that exposure to chlorothalonil was the strongest predictor of the prevalence of

the pathogen *Nosema bombi* in four declining bumble bee species, including the Yellow-banded Bumble Bee.

In February 2018, PMRA initiated a special review of Chlorothalonil (i.e., Bravo, Echo, etc.) “Proposed Special Review Decision PSRD2022-01 Special review of chlorothalonil and its associated end-use products” which poses a concern for human health and the environment. Health Canada is proposing continued registration of greenhouse ornamentals but all other uses of chlorothalonil are proposed for cancellation (PMRA 2022). This in turn should reduce the potential threat of fungicides on *Bombus* species, limiting their exposure to only greenhouse ornamentals.

Climate Change and Severe Weather - Habitat shifting and alteration (Low)

Climate change is a threat to bumble bees worldwide (Williams and Osborne 2009; Soroye *et al.* 2020). Bumble bee species with narrow climatic tolerances are shown to be more vulnerable to extrinsic threats (Williams *et al.* 2009). There are no direct estimates for the Yellow-banded Bumble Bee, but climate change scenarios modelled by Rasmont *et al.* (2015b) predict that the climatic niche of its close relative *Bombus terrestris* in Europe will decline by 34 to 71% by the end of this century.

In general, bumble bees are cool-adapted species that live in temperate areas. Kerr *et al.* (2015) assembled long-term bumble bee data for Europe and North America and showed that, as climate warms, bumble bees are disappearing from the southern edges of their ranges but not correspondingly shifting northward at the northern edges. These effects were independent of changing land uses or pesticide applications. Across a range of climate change scenarios and assumptions about the capacities of bumble bees to disperse into new areas, range declines are expected to continue and even to accelerate among North American bumble bees (Sirois-Delisle and Kerr 2018; Soroye *et al*. 2020). Rasmont and Iserbyt (2012) attribute some declines in European bumble bees to increasing occurrences of extreme heat waves.

Pollen serves as the only source of protein for developing larvae. Recent research has shown that the rise in carbon dioxide levels in the atmosphere has led to a 33% decline in protein content in Canada Goldenrod (*Solidago canadensis*) pollen since the beginning of the industrial era, and that a similar drop is expected in most flowering plant species (Ziska *et al*. 2016).

Although one might think that longer growing seasons might be beneficial to bumble bees, this is not necessarily the case. Ogilvie *et al.* (2017) studied the effects of growing season length in the United States Rocky Mountains and found that longer seasons had a negative effect on the interannual abundance of three species of bumble bees. This result was attributed to more days of low flower availability within the longer growing season.

The climate in Nova Scotia is strongly influenced by the Atlantic Ocean. Winter temperatures average -5ºC and summers average 14ºC, with coastal areas having

slightly warmer winters and cooler summers than inland. The growing season in Nova Scotia, ranging from 100 to 200 days, has a well-distributed pattern of high rainfall with mean precipitation of 900mm a year inland and over 1500mm a year on the coast (DoA, 2021).

Climate Change and Severe Weather – Temperature extremes (Unknown)

Typically, in Nova Scotia, there is 400-500mm of precipitation distributed evenly during the growing season. However, this high precipitation also means a higher frequency of storms than anywhere else in Canada. Precipitation is slightly greater in late fall and early winter because of the more frequent and intense storm activity (DoA, 2021).

Severe weather such as extreme changes in temperature during the spring and summer months, which is the principal activity period of many bee species, is believed to be a factor in their decline. However, exactly how temperature affects bee survival is unknown. In 2022, a study done on *bombus terrestris* found that even just a few hours of exposure to heatwave-like temperatures, severely impair the cognitive performance of the bumble bee (Gérard *et al*. 2022a). Another study done that same year suggests that elevated temperature during development affects bumble bee foraging behaviour (Gérard *et al*. 2022b).

Climate change can also disrupt the phenology of overwintering mated queen bumble bees during the winter. In areas of moderate winters (such as those in the southern United Kingdom), overwintering mated queen bumble bees can become winter-active, especially if autumn temperatures are above normal (Owen *et al.* 2013). Although *Bombus terrestris* (a close relative of the Yellow-banded Bumble Bee) overwintering mated queen bumble bees can rapidly adapt to cold winter temperatures while active, they will die if they remain outside the colony overnight when the temperatures fall to about -10°C. This is not anticipated to be a major threat to Yellow-banded Bumble Bees in Nova Scotia, since they are not present in areas with really moderate winters.

Climate Change and Severe Weather – Storms and Flooding (Unknown)

There is some evidence of flooding of nests in the Yellow-banded Bumble Bee range, but it is unknown what effect this has had on spring queens and foraging. Flooding of individual colonies has been seen in the past few years in Nova Scotia as the province has seen more frequent rain events.

Negligible Threats

Energy production & mining – Renewable energy

Nova Scotia has seen a recent increase in development of alternative energy such as wind turbines and solar farms. Direct habitat loss from these developments is minimal but is primarily due to roads construction to service these wind turbines and solar farms. Functional habitat loss or displacement is expected to be negligible, although it depends

on the availability of pollinator habitat prior to development versus after. It is plausible that the activity could increase habitat for the Yellow-banded Bumble Bee at the site level, through the creation of gaps that allow light permeability, or nest site with the gravel road. Both wind and Solar farm pose a potential threat to bumble bees as a whole.

Limiting Factors

Bumble bees have a type of sex determination that makes them extremely susceptible to extinction when effective population sizes are small (Zayed and Packer 2005). As numbers decline, more and more females develop as sterile males instead. In practical terms, if a bee population decreases to a few reproducing individuals, it is certain to become locally extirpated even under stable environmental conditions unless its number increases within a few generations.

A genetic study of the Yellow-banded Bumble Bee in southeastern Canada has shown that it is experiencing inbreeding where its populations have declined, and this may contribute to further declines (Kent *et al.* 2018).

5. MANAGEMENT OBJECTIVE(S)

The Yellow-banded Bumble Bee was assessed by COSEWIC (2015) as Special Concern and the technical assessment stated that “while this species remains relatively abundant in the northern part of its range, it has recently declined by at least 34% in areas of southern Canada” and "causes for declines remain unclear, yet pesticide use, habitat conversion, and pathogen spill over from managed bumble bee colonies are suspected contributing factors.” Halting the decline of a species for which the primary cause of decline is unclear is challenging.

The management objectives for the Yellow-banded Bumble Bee in Nova Scotia are to:

- Maintain abundance of the species in its Nova Scotia range.
- Maintain the distribution of the species throughout its known Nova Scotia range.

The Yellow-banded Bumble Bee has experienced declines that are probably primarily the result of invasive non-native/Alien species/diseases, problematic native species, pathogen spillover and spillback from managed bumble bee populations in greenhouse operations and blueberry production and from an increase in pesticide use over the last three decades (COSEWIC 2015). Threats also include climate change and energy production and mining. Maintaining the current population will require the mitigation or elimination of these threats. Given the lack of information on historical and current abundance, achieving management objectives will require developing monitoring methods designed to measure an index of abundance for the species, which is currently lacking. Knowledge gaps around threats will have to be addressed. Increased outreach

and communication with industry, landowners, and the general public will assist in achieving these objectives.

The distribution of the species within the province has not shown a strong change over time, as it still appears to be present throughout much of its known range. Therefore, the management objective aims to continue to maintain the known range of the species in Nova Scotia.

6. GENERAL APPROACHES TO MANAGEMENT

6.1. Actions Completed or Underway

Surveying

- Federal government, provinces and territories
    - General bumble bee surveys being undertaken over much of populated Nova Scotia for example:
        - UINR surveys
        - UCB opportunistic surveys
    - Citizen Science initiatives, such as
        - Bumblebee Watch: https://www.bumblebeewatch.org/ and
        - iNaturalist: https://inaturalist.ca/home;
        - Bioblitzes: bioblitzcanada.ca

Monitoring (repeatable surveys)

- Roadside monitoring: Ongoing surveys modelled after the Breeding Bird Survey (Droege 2009; McFarland et al. 2015): Nova Scotia (2 in 2018)

Habitat restoration

- CARP projects
    - Nova Scotia Habitat and Biodiversity Assessment Tool
    - Implementing priority conservation actions for the Kespukwitk/Southwest Nova Scotia Priority Place agro-ecosystem target
    - Bug Friendly Annapolis

Stewardship

- Habitat stewardship program
- Species at Risk Fund (NSDNRR)
    - Atlantic Coastal Plain Pollinator Surveys (ACCDC 2013)
    - Surveys for two At-Risk bee species (ACCDC 2018)
- Pollinator Action Project, “Protect the Bees in Mi’kma’ki,” (CMM Climate Action Program 2019)

Research

- Bee species of Nova Scotia, Canada with New Records and Notes on Bionomics and Floral relations. 2003 Journal of the Kansas Entomological Society
- Diversity of cavity-nesting bees (Hymenoptera: Apoidea) within apple orchards and wild habitats in the Annapolis Valley, Nova Scotia, Canada. 2008. The Canadian Entomologist.
- Pesticides in Honey Bee Hives in the Maritime Provinces: Residue Levels and Interactions with Varroa mites and Nosema in Colony Stress. 2013. Nova Scotia Beekeepers Association Agri-Futures, Dalhousie University.

Outreach

- Acadia Beekeeping Club

6.2. Recommended Actions for Management

Table 3 provides the recommended conservation measures for achieving management objectives for the species and the timeframe for completing these actions. Conservation measures are organized according to the following categories: Habitat protection, monitoring and stewardship; surveys and monitoring; communication, outreach, and education; law, policy, and enforcement; and research to address knowledge gaps.

Table 3. Conservation measures in support of management objectives and implementation schedule.

Conservation Measure	Threat(s) Addressed*	Priority**	Timeline
Habitat Protection, Monitoring, and Stewardship			
Establish or demarcate protected areas	All threats to habitat	Low	Ongoing
Create and maintain partnerships focused on coordinating conservation implementation, knowledge generation & sharing	All threats	Medium	Ongoing
Promote habitat protection measures (such as conservation easements) to preserve and enhance bumble bee habitat. Consider native pollinators in land use planning.	All threats to habitat	Low	Ongoing
Surveys and Monitoring			
Minimize use of pesticides; develop, promote and follow best practices in the application of pesticides (insecticides, fungicides, herbicides)	9.1, 9.2	High	2020-2022 and ongoing
Develop protocols and implement intensive, repeatable monitoring at select sites throughout range; deposit specimens and data in central repositories	8.1, 8.2, 11.1	High	2020 and ongoing
Collaborative research into the effects of pesticides (insecticides, herbicides, and fungicides) on this species. Further research into detecting and/or confirming the level of impact.	9.3, Knowledge Gaps	High	Ongoing
Collaborative research into competition and footprint covered by managed Honey Bee and Bumble bees.	8.1, 8.2	Medium	Ongoing

Communication, Outreach, and Education			
Provide conservation capacity development through hands-on coaching & technical assistance and developing training materials (e.g., bee identification, monitoring protocols)	All threats	Medium	2020-2022 and ongoing
Raise awareness of Yellow-banded Bumble Bee (e.g., species' needs (i.e., flowers with short or open corollas, blooming through the active season), nesting habitat (underground burrows), overwintering habitat (rotting logs, loose soil, mulch), occurrences, direct threats) with relevant government agencies, land owners and managers, farmers, beekeepers, and public via reported media, social media, advertisements and marketing, displays, person-to-person engagement, and workshops/experiential learning.	All threats	Medium	Ongoing
Law, Policy, and Enforcement			
Create, amend, or influence environment-related provincial/territorial and/or municipal laws and/or regulations, policies, and/or guidelines/best practices for pesticide use, and agricultural land management.	All threats	High	2020-2024 and ongoing
Manage introduced bumble bee and honey bee populations to reduce transmission of pathogens and to reduce competition with Yellow-banded Bumble Bee (biosurveillance use to benefit Yellow-banded Bumble Bee (e.g., regarding transport and housing of bumble bees, disease testing of bumble bees, honey bees, and other managed pollinators.))	8.1	High	2020-2022 and ongoing
Research to Address Knowledge Gaps			
Research into the effects of pathogens (e.g., *Nosema bombi*), and pathogen spillover from managed bees (*Bombus* in greenhouses, Honey Bees, etc.)	8.1, 8.2, Knowledge Gaps	High	Ongoing
Research into the effects of climate change (shifting climate envelopes, temperature extremes, droughts)	11.0, Knowledge Gaps	High	Ongoing

*Threat or Limitation should refer to the IUCN Threat Classification Table Rankings. Either the first level or second level threat ranking can be used depending on how the Broad Strategy affects the threat. Multiple threats can be addressed under a single Recovery Measure.

**Priority should be classified as High(H), Medium(M), or Low(L). “Priority” is a qualitative measure of the relative degree to which an approach will have a positive impact on the recovery objective. High priority conservation approaches are considered those most likely to have an immediate and/or direct influence on reaching the management objective for the species. Medium priority conservation approaches may have a less immediate or less direct influence on reaching the management objective but are still considered important measures to implement. Low priority conservation approaches will likely have an indirect or gradual influence on reaching the management objective and are more tied to increasing knowledge or public perception/education.

6.3. Narrative to Support the Recovery Options Planning Table

Lack of knowledge on the impact of threats and threat interaction makes the development of actions in support of Yellow-banded Bumble Bee recovery challenging. Successful management of the Yellow-banded Bumble Bee in Nova Scotia will require engagement with national partners and researchers to support important monitoring and research initiatives; this is indicated through the adoption of management actions developed in support of the national and provincial management plan for the species.

Habitat Protection, Management and Stewardship

Existing foraging and nesting habitat for bumble bees needs to be maintained and enhanced if they are to return to viable numbers in more developed regions such as urban and suburban areas. Programs that promote voluntary stewardship of pollinators would be valuable in this regard.

In areas of extensive private land such as in Nova Scotia, conservation easements could be a key strategy in the enhancement of habitat. Protected areas that are managed for pollinators could help establish populations in areas that are otherwise poor in appropriate habitat.

Other habitat conservation options that would be useful in the protection of the Yellow-banded Bumble Bee are the consideration of potential bee habitat in land use planning and development and restoration and ongoing maintenance of green spaces in urban areas using bee-friendly native vegetation.

For this wide-ranging species with complex needs, partnerships focused on coordinating conservation implementation, knowledge generation, and information sharing will be necessary for conservation efforts to be successful. Workshops on the habitat needs of bees and how the public can assist will not only help habitat restoration but also raise general awareness of the bees and their needs.

Surveys and Monitoring

The continued development of protocols that are intensive and repeatable in order to monitor select sites throughout their Nova Scotia range is essential for long-term population management and to document ongoing trends.

These surveys would greatly enhance the re-assessment of the species, but they are also the only way of measuring progress in conservation efforts. Examples of survey methods used in Nova Scotia include standardized roadside netting surveys and blue vane trap surveys.

Each method has its advantages and disadvantages; the key feature is repeatability so that results can be compared directly among years. Ensuring that survey methods are streamlined/aligned with Federal surveys will allow for comparability at a national scale.

However, the development of non-lethal survey methods for population assessment should be considered in order to reduce the impact of national surveys on the species.

Data and reference specimens from the surveys should be kept in central repositories (for example, data in Atlantic Canada Conservation Data Centre, and specimens in recognized research collections). Investments also must be made in regional natural history collections in order to safely store specimens. Monitoring of bumble bees could be done within the context of a broader plan to monitor all bees, or even all pollinators.

Monitoring of threats, such as the long-term effects and impact of pesticides (insecticides, herbicides and fungicides), as well as competition with managed honey bee colonies and introduced non-native bumble bee populations, will help to understand how both of these threats are impacting the Nova Scotia population of the Yellow-banded Bumble Bee.

Communication, Outreach and Education

Successful monitoring is dependent on investments in the training of paid and volunteer biologists and naturalists; including training in monitoring protocols, bumble bee identification, specimen preparation, and database entry.

Public education about the threats to bees and the enhancement of habitat for bees will support the broader conservation and recovery of bees in a number of ways. Raising awareness with relevant government agencies, greenhouse operators, beekeepers, land owners and managers is also essential.

The use of tools such as reported media, social media, advertisements, and marketing, displays, person-to-person engagement, and workshops/experiential learning will help to raise awareness about the species needs (i.e., flowers with short or open corollas, blooming through the active season), nesting habitat (underground burrows), overwintering habitat (rotting logs, loose soil, mulch), occurrences, and direct threats. Citizen science programs such as Bumble Bee Watch and iNaturalist may be useful to monitor and map bumble bees while conservation and recovery efforts take place.

Law, Policy and Enforcement

There is now considerable evidence showing that neonicotinoid and other insecticides have serious sub-lethal effects on bumble bees. Reduction and control of insecticide use through regulations and best practices is vital to the conservation and recovery of bumble bee populations in agricultural areas. The widespread use of herbicides in both agriculture and silviculture has undoubtedly greatly reduced the floral resources needed by bumble bees; best practices need to be followed to minimize the destruction of bee forage. Particular attention needs to be paid to drift of herbicides beyond the crop boundaries (even by a few metres) during mechanical or aerial spraying.

Pathogens and pathogen spillover from managed bumble bee colonies are widely believed to be central threats to the Yellow-banded Bumble Bee, so the control of these

pathogens and their carriers may be key to the conservation of this species. More regulation and oversight of the managed Honey Bee and bumble bee industry is needed. It is important to know how many managed bees are being moved, and to where they are being moved.

Research to Address Knowledge Gaps

Regular testing for diseases within production facilities, and protocols to minimize disease spread to the wild (e.g., greenhouse vent covers, freezing of colonies before disposal, etc.) is crucial. The “Bumblebee Sector Guide” to the National Bee Farm-level Biosecurity Standard (CFIA 2013) should be updated and followed. Because it is impossible to prevent all escapes from greenhouses, policies should be put in place to prevent the shipment of managed bumble bees outside their natural ranges.

Continued pathogen and pesticide research is essential to the conservation and recovery of this and other bumble bee species, especially research into the sub-lethal effects of insecticides (including the relatively new insecticides that are being developed to replace neonicotinoids), documentation of the effects of herbicides on pollinator forage resources, and the link between fungicides and bumble bee pathogens. Important pathogen research questions include: What is the geographic origin of these pathogens (i.e., are they exotic or native); how are pathogens transferred between individuals; and why is the prevalence of *Nosema* related to the concentration of fungicides in the environment.

The issue of potential competition with Honey Bee apiaries needs to be studied and, if deemed necessary, appropriate limits placed on Honey Bee densities in Yellow-banded Bumble Bee habitat. Gaining a better understanding of Yellow-banded Bumble Bee habitat requirements in Nova Scotia and defining a density threshold of Honey bees on the landscape is essential to characterize at what density Honey bees are problematic.

The use of *Bombus impatiens* as pollinator is a significant concern in Nova Scotia. With the introduction of the Blueberry Pollination Expansion Program in the Nova Scotia agricultural sector in 2021, now called Apiculture Sustainability Growth and Health Program (DoA 2023), there will be an even greater demand for *Bombus impatiens* which may become a significant issue. Understanding the effects of its presence on the Yellow-banded Bumble Bee will be essential.

The impacts of climate change on Yellow-banded Bumble Bee requires additional study, looking into whether increased drought may reduce floral resources, the impact of extreme heat events on their range, and whether flooding (nest flooding) may affect spring queens and their foraging. Habitat shifting caused by climate change could potentially cause mismatch in timing of active period with flowering plants; more research on this topic and the long-term impacts is required.

7. MEASURING PROGRESS

7.1. Performance Indicators

The performance indicators presented below provide a way to measure progress towards achieving the management objectives and monitoring the implementation of the management plan:

- The abundance of the Yellow-banded Bumble Bee (as reflected by its relative abundance) is stable (with minor fluctuations) or increasing.
- The present range (extent of occurrence) of the Yellow-banded Bumble Bee in Nova Scotia is stable or increasing.

Table 4. Performance measures used to determine whether Yellow-banded Bumble Bee recovery objectives are being met.

Performance Measure	Check-In
Planning:	
Number of Recovery Team meetings to discuss activities and assess performance to date (minimum one per year).	Annually.
Number of initiatives and groups involved in delivering conservation messaging.	Annually.
Number of individuals or teams assigned to, or supported to implement, recovery-related projects such as land protection efforts, habitat mapping, the production of educational material, etc.	Annually.
Conservation:	
Track the area in which the density of honey bees above a certain threshold	Every 5 years given data availability
Total amount of large suitable foraging habitat protected	Every five years
Total amount of private land or number of landowners involved in stewardship	Every five years

7.2. Monitoring

Monitoring will be required to assess the effectiveness of actions towards the success of the management objective.

Monitoring threats will be challenging given the lack of information that is currently available (e.g., climate change) or difficulty in assessment (e.g., abundance). Monitoring will likely occur opportunistically as need arises. At a minimum, information on threats should be collected at the time of any observation.

The focus of monitoring should be on the collection of detailed information required to develop and refine monitoring methodology. Unless it is through the support of dedicated research projects, habitat assessments will likely occur opportunistically in support of other initiatives such as population and distribution monitoring.

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APPENDICES

Appendix A: Plant food sources for the Yellow-banded Bumble Bee in Nova Scotia
Bumble bees are generalist feeders; these are examples of flowers they forage on, given in Williams *et al.* (2014), Colla and Dumesh (2010), and Macfarlane (1974).

Pearly Everlasting (*Anaphalis margaritacea)*
Canadian Columbine *(Aquilegia Canadensis)*
Sarsaparilla *(Aralia sp).*
Bearberry *(Arctostaphylos uva-ursi)*
Swamp Milkweed *(Asclepias incarnata*)
Common Milkweed *(Asclepias syriaca*)
Milk Vetches *(Astragalus sp.)*
Japanese Barberry *(Berberis thunbergii)*
Nodding Thistle (*Carduus nutans)*
Fireweed *(Chamaenerion [=Epilobium] angustifolium)*
Canada Thistle (*Cirsium arvense)*
Crocus *(Crocus sp.)*
Bush Honeysuckle (*Diervilla lonicera)*
Trailing Arbutus; Mayflower (*Epigaea repens)*
Philadelphia fleabane *(Erigeron philadelphicus)*
Spotted Joe Pye Weed *(Eutrochium maculatum var. maculatum)*
Bigleaf Aster (*Eurybia macrophylla)*
Grass-leaved Goldenrod (*Euthamia graminifolia)*
Blueweed; Viper's Bugloss (*Echium vulgare)*
Huckleberry *(Gaylussacia sp.)*
Cow parsnip *(Heracleum lanatum or maximum)*
Common St. John's-worts (*Hypericum perforatum)*
Spotted Touch-me-not; Jewelweed (*Impatiens capensis)*
Laurels *(Kalmia angustifolia)*
Canada Lettuce (*Lactuca canadensis)*
Labrador Tea (*Rhododendron groenlandicum formerly Ledum groenlandicum)*
Toadflax *(Linaria vulgaris)*
Blue Honeysuckle *(Lonicera caerulea)* aka Haskcap
Tatarian Honeysuckle *(Lonicera tatarica)*
Lupines (*Lupinus sp.)*
White Sweet-clover *(Melilotus albus)*
Alfalfa *(Medicago sativa)*
Oyster Plant *(Mertensia sp.)*
Scotch Thistle (*Onopordum acanthium)*
Pickerelweed (*Pontederia cordata)*
Sour Red Cherry (*Prunus cerasus)*
Pin-cherry; Bird-cherry (*Prunus pensylvanica)*
Common Apple *(Malus pumila)*
Virginia Meadow Beauty (*Rhexia virginica)*
Staghorn Sumac (*Rhus typhina)*
European Gooseberry *(Ribes uva-crispa)*

European Black Currant (*Ribes nigrum)*
Bristly Locust *(Robinia hispida L.)*
Rose species *(Rosa sp.*)
Brambles (*Rubus sp.)*
Willow species *(Salix sp.)*
Ragwort *(Senecio)*
Bittersweet Nightshade (*Solanum dulcamara*)
Canada Goldenrod (*Solidago canadensis)*
Wood Goldenrod; Zigzag Goldenrod (*Solidago flexicaulis)*
Hairy Goldenrod (*Solidago hispida)*
Early Goldenrod (*Solidago juncea)*
Common Sow-thistle (*Sonchus oleraceus)*
American Mountain-ash; Dogberry (*Sorbus americana)*
White meadowsweet *(Spiraea alba var. latifolia)*
Calico Aster *(Symphyotrichum lateriflorum*)
New England Aster (*Symphyotrichum novae-angliae)*
Common Comfrey *(Symphytum officinale)*
Common Lilac *(Syringa vulgaris)*
Dandelion (*Taraxacum officinale)*
Tall Meadow-rue (*Thalictrum pubescens)*
Alsike Clover (*Trifolium hybridum)*
Red Clover (*Trifolium pratense)*
White Clover (*Trifolium repens)*
Horned bladderwort **(***Utricularia cornuta)*
Late Lowbush Blueberry (*Vaccinium angustifolium)*
High-bush Blueberry (*Vaccinium corymbosum)*
Tufted Vetch (*Vicia cracca)*
Source for Nova Scotia species validation: www.accdc.com/webranks/NSvasc.htm