Hardiness at the Edge of the World

Species Distribution Report for the Polar Bumblebee (*Bombus polaris*)

Analysis of the distribution of the Polar Bumblebee over time considering current threats and forecasted climate change impacts.

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Image: Alexandre Beauchemin, Qikiqtaruk Territorial Park, YT

Introduction

Bumblebees (*Inuktitut*: Igutsaq; Genus *Bombus*) are a keystone pollinator in Arctic and alpine tundra due to their ecological role as a generalist pollinator and the niche they fill within a reduced pollinator assemblage in tundra ecosystems (Burns et al., 2022; Heinrich, 1993; Parrey et al., 2021). The polar bumblebee (*Bombus polaris*) is one of the most well-documented bumblebees in the Arctic and alpine subgenus *Alpinobombus*, which is uniquely adapted to some of the most northernly vegetated habitats on Earth yet remains critically understudied.

The polar bumblebee forms colonies in which distinct castes of bees are produced, each carrying out specific functions amongst which is foraging (Plowright & Laverty, 1984; Williams, 2014). Bumblebees are central place foragers and return to their nest with foraged nectar and pollen (Plowright & Laverty, 1984), relying on a continuous supply of flowers across the growing season as colonies only store nectar and pollen for a few days (Brian, 1954). This means that the home range of a singular bumblebee is limited to areas that can be reached from a central nest location. Several tundra plants including ecologically- and culturally-significant berry species can only be pollinated through bee-specific buzz-pollination, a specialized technique in which vibrations emitted by flight muscles allow for pollen to be released from the flower (Buchmann, 1985).

Cold temperatures and short growing seasons limit the range of many insect pollinators as latitude increases, meaning that Arctic ecosystems often show a reduced pollinator assemblage (Burns et al., 2022; Koch et al., 2020). Bumblebees have evolved adaptations to cold which allow them to thrive in cold ecosystems, including the evolution of a thick fur coat and ability to thermoregulate through the activation of thoracic flight muscles (Heinrich, 1974, 1993), making them one of the largest-bodied insect pollinators in tundra and allowing them to fill a unique ecological niche. Their ability to thermoregulate additionally allows them to emerge earlier in the spring than most other pollinators, meaning that they play an integral role in the pollination of early-season flowers. (Kudo & Ida, 2013; Urbanowicz et al., 2018). Yet, as global climate changes and tundra habitats experience warming, bumblebees are facing increasing threats and facing large declines across their range (Soroye et al., 2020). This is particularly true for Arctic bumblebees such as *B. polaris*, which already occur at the extreme northern latitudes and for which range shifts further north may not be possible.

As climate change drives rapid warming in Arctic and alpine ecosystems, the distribution of the polar bumblebee may shift – but with no habitat available further north or further up in elevation, its options for range expansion are limited. This raises the following key questions: Will the species experience a contraction in range that threatens population viability? And could climate change be disrupting the timing of *B. polaris* activity relative to tundra flowering, given evidence that warming alters the phenology of both plants and their pollinators? Lack of information on the historical and current ranges of the polar bumblebee has limited the application of conservation measures, and there is a critical need to track how its range may be shifting over time and where potential suitable habitat may occur. By conducting a literature review, modelling suitable habitat, and identifying historical changes to *B. polaris* range, this report offers insight into changes to *B. polaris* distributions and possible avenues for conservation.

Methods

Literature review

This report first included a comprehensive literature review regarding the distribution and ecology of *Alpinobombus* species, with a focus on *B. polaris*. This review aimed to analyze peer-reviewed distribution range maps and later compare these with georeferenced observation records from the Global Biodiversity Information Facility (GBIF). Literature was accessed through the University of British Columbia Web of Science Core Collection, and the review searched for the common and scientific names for the species with keywords such as “distribution,” “range,” and “threats.” Observation records from GBIF were collected under the species identification *Bombus polaris* *sensu* Curtis, 1835 and filtered to only compile records with GPS data (latitude and longitude). This decreased the number of available records from 2631 to 493. Records were then exported as a .csv. Records were then filtered to only display those obtained since 1980, for comparison as recent records. Observation records were also obtained from E-Fauna BC (Klinkenberg, 2021) to search for records in four primary BC arthropod collections, though later not used due to a scarcity of record (6 total records). Species distribution range maps were obtained from Map of Life (Center for Biodiversity and Global Change, Yale University, 2025) based on literature by Williams et al (2014) covering North America and Rasmont & Iserbyt (2014) covering Europe.

Species distribution modelling

Current suitable habitat for *B. polaris* based on climatic conditions was modelled from geolocated GBIF records using R statistical language (version 4.3.3, R core team, 2024) and packages terra, geodata, and predicts, following a tutorial from Jeffrey Oliver (2024). Code used for this report is publicly available on the following GitHub repository: https://github.com/abeauche/GEOS307-Bombus-polaris-SDM.

Results

Observation records for Bombus polaris obtained from the Global Biodiversity Information Facility (GBIF) show temporal changes in the species' recorded range. Comparing the full dataset from 1832 to 2024 (**Figure 1**) with more recent records from 1980 to 2024 (**Figure 2**) reveals a contraction of observations in both geographic extent and regional density.

From 1832 to 2024, B. polaris was recorded across a circumpolar range. In North America, historical records range from regions along the Western Cordillera, extending south into Washington State and Colorado. The species was also observed in far western Alaska, across northern Canada, Greenland and into parts of eastern Asia. In Europe, records extend across northern Scandinavia.

Observations from 1980 to 2024 show a more restricted range. Recent records are limited primarily to the northwesternmost regions of North America (Alaska, Yukon, northern British Columbia), northern Canada (Northwest Territories, Nunavut), and Greenland. The last documented records in Europe and Washington State were in 1974 and 1971. A few outlier observations in Ontario, Ireland, Guatemala, and Missouri are likely misidentifications or data entry errors, as these areas fall far outside the species' known ecological niche and habitat requirements.

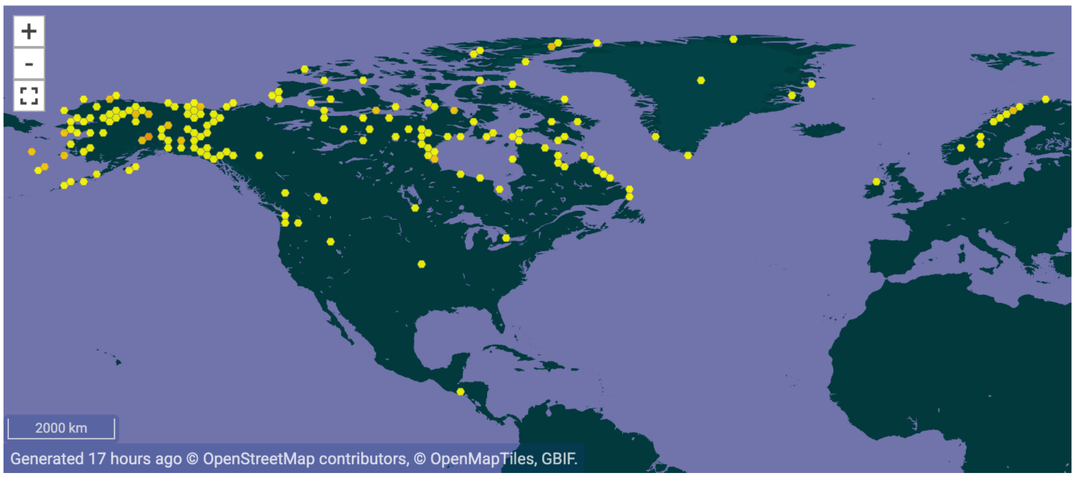

Figure 1. Distribution data from Global Biodiversity Information Facility, collected from 1832 - 2024 (GBIF, 2025).

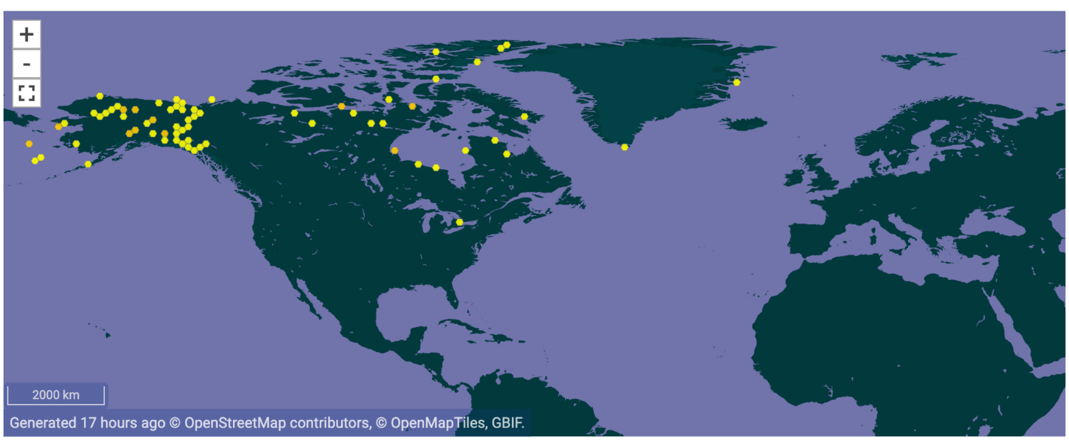

Figure 2. Distribution data from Global Biodiversity Information Facility, collected from 1980 - 2024 (GBIF, 2025). The last record of *B. polaris* in Europe was in 1974, while the last record in Washington state was in 1971.

The species distribution model based on GBIF occurrence records (**Figure 3**) aligned closely with species observations and published range maps from the literature (**Figure 4**). However, there were some differences between the distribution maps, and with observation data. The GBIF-based model predicted suitable habitat in areas where no confirmed observations exist, including the Mackenzie Mountains in the southern Northwest Territories, the Northern Rocky Mountains in British Columbia and Alberta, central Greenland, and Svalbard, Norway. These regions were not identified as suitable habitat in the distribution map by Williams et al. (2014) and Rasmont & Iserbyt (2014).

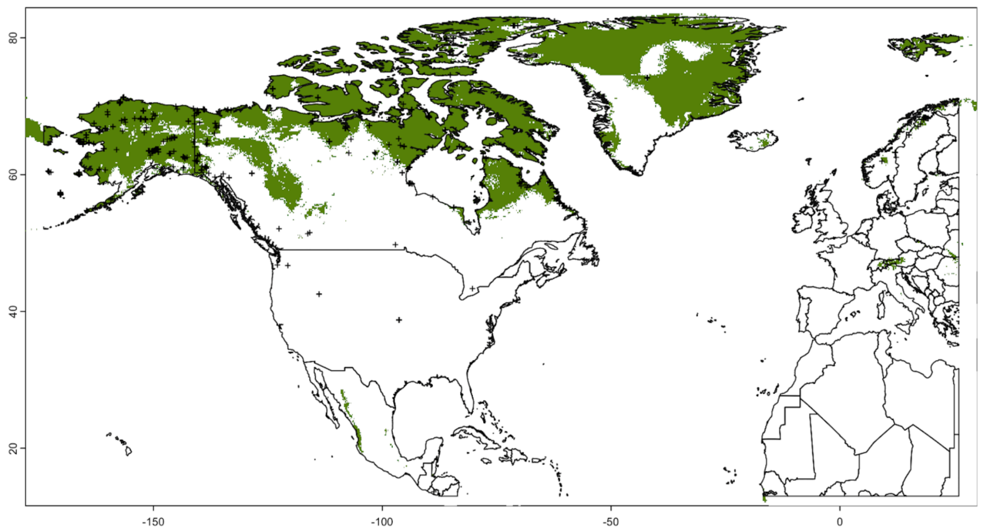

Figure 3. Species distribution model trained with all observations from the 1832 – 2024 GBIF dataset (GBIF, 2025; R packages terra, geodata, predicts). Depicted in green is likely suitable habitat based on climate grids and abiotic conditions, while in black are observations from the GBIF dataset.

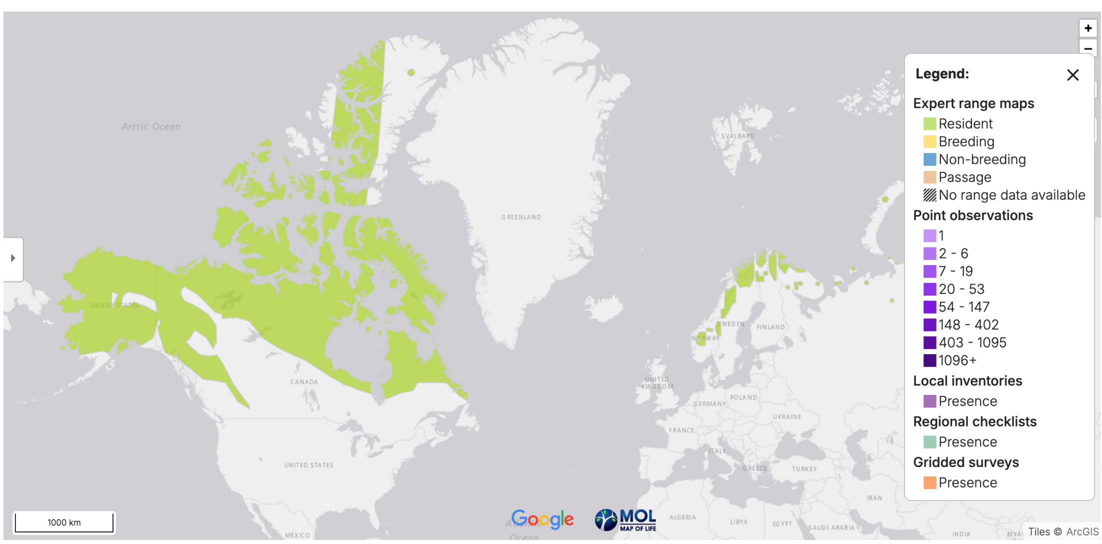

Figure 4. Species distribution range maps as reported by Williams et al. (2014) and Rasmont & Iserbyt (2014). Range maps were obtained from Map of Life (Center for Biodiversity and Global Change, Yale University, 2025).

Discussion

The distribution of *Bombus polaris* based on GBIF records shows a signal of change over time and range contraction, particularly over the last several decades, which aligns with findings from literature (Soroye et al., 2020). While historical records (1832 - 2024) range across a large circumpolar range including western North America, Greenland, far eastern Asia, and northern Europe, recent records (1980–2024) are limited primarily to Arctic and near-Arctic regions of North America and Greenland. This difference could reflect a genuine northward range contraction in response to climate change but could also be influenced by spatial and temporal biases in the data available from GBIF.

Data from GBIF provides a valuable baseline for understanding species distributions but comes with limitations: quality of observations is inconsistent as records are often unevenly distributed and disproportionately obtained from more accessible regions, and include probable misidentifications (e.g., records from Guatemala and Missouri). By contrast, literature-based range maps offer more reliable but likely less up-to-date information, and do not always feature an exhaustive overview of the species' true range. The absence of recent GBIF records from Europe, despite historical presence up until the 1970s, represents either a true regional disappearance or underreporting due to a lack of sampling capacity.

Species distribution models derived from GBIF records closely align with observed data and published range maps, supporting their reliability. However, some differences emerge. For instance, models predict suitable habitat in regions with few or no confirmed records such as the Mackenzie Mountains and Northern Rockies, as well as in areas like central Greenland and Svalbard. These could represent under surveyed regions with suitable habitat, but are more likely areas where local conditions (e.g., absence of vegetation, glaciated landscapes, or biotic interactions) are not favourable to *B. polaris* despite suitable climatic variables. This raises concerns about the reliability of these models which are entirely based on climate suitability and fail to consider biotic factors.

The distribution of *B. polaris* is shaped by both abiotic and biotic conditions. The species is highly cold-adapted and occurs in tundra and alpine ecosystems, and high temperature often acts as a limiting factor for the species distribution. Under climate change, this may be a mechanism driving future range contractions (Soroye et al., 2020). Floral resource availability is another major limitation to the species' distribution: *B. polaris* is dependent on short, highly seasonal blooms, and changes in flowering phenology could impact foraging success (Høye et al., 2013). Moreover, areas with suitable climate may not be suitable for polar bumblebee establishment if there is limited local vegetation or forage availability. Other ecological factors – such as nesting site availability, competition with other pollinators, and limited dispersal – may also play a role in limiting its range.

Temporal changes in the observed range, including the loss of southern and European populations (e.g., in Washington and Scandinavia), are consistent with predictions under climate change. Unlike many species, *B. polaris* cannot shift its range further north, as it already occupies the northernmost landmasses. This geographic constraint, combined with the species' limited adaptability to change, increases its vulnerability to warming temperatures and associated changes in tundra ecosystems. Additionally, climate-driven mismatches between bumblebee activity and plant flowering may further reduce reproductive success and population survival (Hegland et al., 2009).

Conclusion

Together, these findings highlight the need for continued monitoring of *Bombus polaris* populations and habitat conditions. Improving the resolution and accuracy of occurrence data – particularly in regions identified as potentially suitable habitat – could be essential for understanding how the species is responding to environmental change. Given its ecological role as a pollinator and its sensitivity to warming, the polar bumblebee may also serve as a useful indicator of Arctic and alpine ecosystem health, and changes to its populations and range may indicate broader ecological change.

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