Bombus occidentalis in Alaska and the need for future study (Hymenoptera: Apidae)

by Megan McHugh[1] *and Derek Sikes*[1]

Pollinators are important for ecosystem health in Alaska and across the world (Cameron et al., 2011). While all members of this group are important, the role of bumblebees as native pollinators has received considerable recent attention. Bumblebees are especially good at pollination due to their ability to buzz while collecting pollen and nectar from flowers (Cameron et al., 2011). Their tendency to be long distance foragers (Heinrich, 1979) also makes them ecologically important. They pollinate a wide variety of plants, making them a valuable component of ecosystems throughout their range (Hatfield et al., 2015). Bumblebees usually are also among the first insects to pollinate plants that emerge and bloom in early spring (Heinrich, 1979). They are more common than solitary bees in cooler habitats such as closed canopy boreal forest or alpine zones (Armbruster and Guinn, 1989). Bumblebees are important to the success of many agricultural enterprises that are dependent on pollinators, primarily for greenhouse crops (Williams et al., 2012; Pampell et al., 2015). Although agriculture is not a predominant business in Alaska (Koch and Strange, 2012) bumblebees are the primary pollinators of many native berries used by Alaskans.

Half of the species of bumblebees in North America occur in Alaska (Williams et al., 2012). One of these is *Bombus occidentalis* (Greene, 1858), also known as the Western Bumblebee. The range of this species covers the western portion of the continent of North America from Arizona to Alaska, stretching above the Arctic Circle, and as far inland as Nebraska and Saskatchewan (Williams et al., 2012). Although once among the most common *Bombus* species in western North America, since the late 1990s this species has declined and is now considered rare enough to warrant the IUCN's Vulnerable Fed List category (Goulson et al., 2008; Hatfield et al., 2015). Estimates based on the current rate of decline indicate this species will become extinct in 60–70 years (Hatfield et al., 2015). Its distribution and status within Alaska is poorly known but of interest because preliminary findings indicate the species may not be declining in Alaska (Koch and Strange, 2012; Pampell et al., 2015). However, adequate sampling in Alaska of bumblebees, including *B. occidentalis*, has not been performed on a regular enough basis to be confident that the population is stable. Few studies have sampled bumblebee populations in Alaska and these have been in limited areas of the state. These studies have also examined the prevalence of parasites within the colonies of *B. occidentalis* that may be playing a part in the species decline (Koch and Strange, 2012; Pampell et al., 2015). Given the global interest in the status of this species, we thought it would be helpful to summarize what is known about this species in Alaska.

The University of Alaska Museum has 2,619 *B. occidentalis specimens* (see Figures 1 and 2), making it the 4th most prevalent Alaskan bumblebee species in the collection of 23,368 specimens; 1,971 of these *B. occidentalis* specimens were collected during a brief two-year study carried out by R. Pampell working for the USDA ARS in 2009 and 2010. The aim of their study was to document the bumblebee species of Alaska, including the distribution, species composition, seasonal biology, and parasite prevalence of bumblebees in agricultural areas and also to set a baseline for future studies of bumblebees in the state. They focused their collections in Delta, Palmer, and Fairbanks, Alaska. Within this sampling, *B. occidentalis* made up 10.4% of the 16 species collected, indicating that, within Alaska, this species' population might remain healthy (Pampell et al., 2015). This species has been known to carry a high parasite load. It is hypothesized that the parasites may be linked to the population decline and the loss of genetic variation within the species (Pampell et al., 2015). Several authors (Whittington and Winston, 2004; Thorp, 2005; Thorp and Shepherd, 2005; Hatfield et al., 2015) have proposed that the recent catastrophic decline throughout North America of *B. occidentalis* was due to *Nosema*.

A study by Koch and Strange (2012) also found that *B. occidentalis* had a large distribution across Alaska. *Bombus occidentalis* made up 28% of the bumblebees they collected, of a total of 15 species. To understand the parasite influence on *B. occidentalis*, Koch and Strange (2012) also studied the parasites found within the bees they sampled while focusing on the fungus, *Nosema bombi*, a parasite that is dependent on host cells for reproduction and cannot survive outside of the host (Koch and Strange, 2012). *Nosema bombi* is not a native parasite to North America, but made its way from Europe, most likely through the introduction of non-native species from greenhouse contamination (Koch and Strange, 2012). It is unknown if this "spillover," as it is termed, plays a role in the prevalence of *N. bombi* in Alaska because, as previously stated, Alaska does not have much agriculture. Nonetheless, they found that while many species of bumblebees suffer from the parasite, *B. occidentalis* had the highest rate of parasitism, with 44% of the specimens collected containing *N. bombi* within their study.

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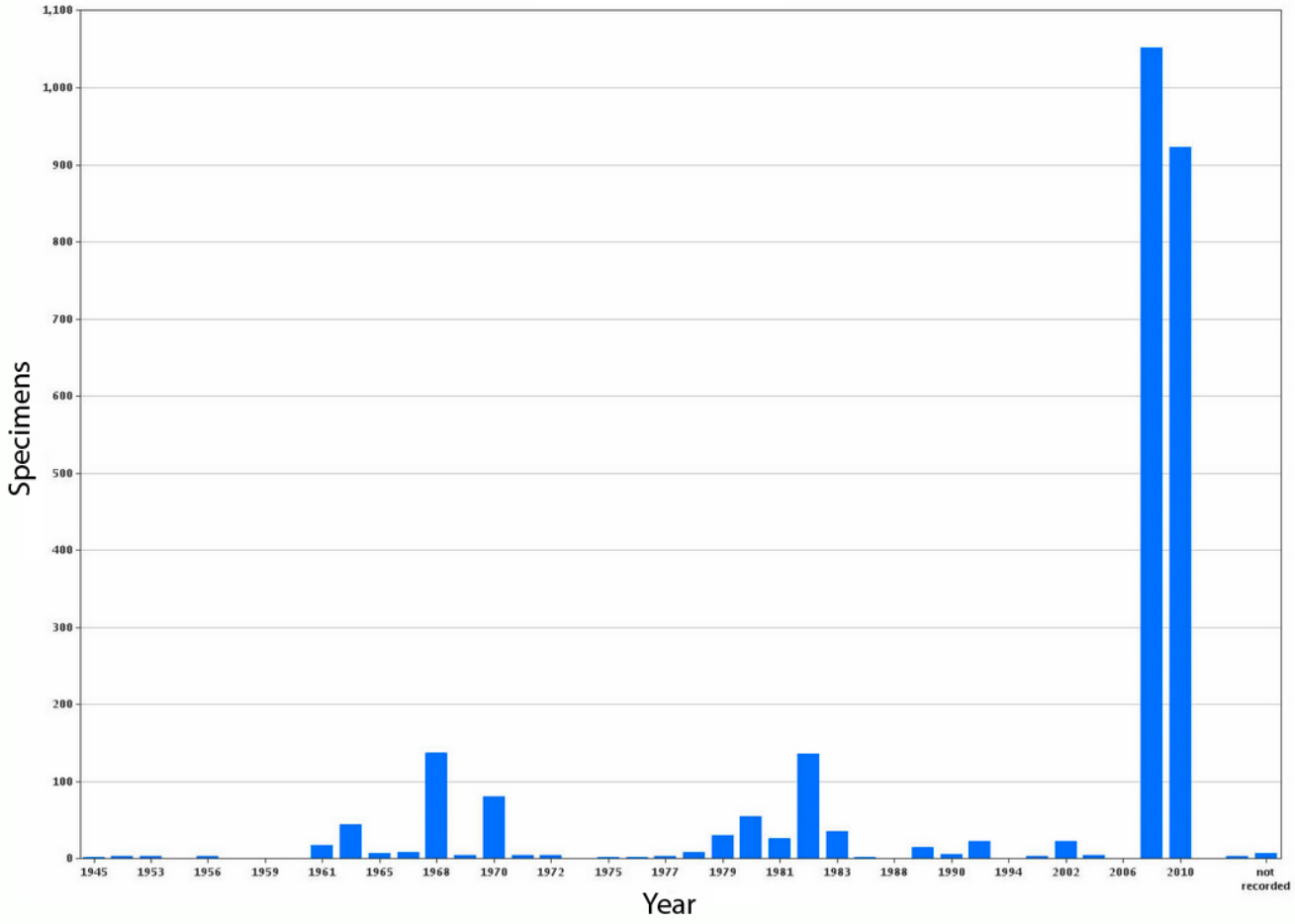

Figure 1: The number of *B. occidentalis* specimens collected over time, archived in the University of Alaska Museum. The large collections made in 2009 and 2010 were from the Pampell et al. (2015) study.

It is important to acknowledge this species' decline as a call for further investigation and monitoring in Alaska, now and in the future. The species is apparently at risk of population collapse due to various factors including parasite spillover, habitat loss, insecticide use, climate change, habitat fragmentation, and introduction of invasive species (Goulson et al., 2008; Williams et al., 2014; Kerr et al., 2015). Accurate representation of the population numbers of *B. occidentalis* in Alaska will allow for an in-depth understanding of this species' prognosis of survival. While yearly sampling on a large scale could negatively affect the species in Alaska, small scale sampling every few years shouldnt, and would help us understand population trends of *B. occidentalis* in Alaska.

Habitat *Bombus occidentalis* prefers meadows, tundra, alpine fields, gardens and other open areas where flowering shrubs grow (Williams et al., 2014). This species pollinates a wide variety of plants but is mostly limited to flowers with short petals due to the short length of its tongue (Williams et al., 2014). Which plant species *B. occidentalis* pollinates most in Alaska is unknown.

Genetics and taxonomy Williams et al. (2012) concluded the species status of *B. occidentalis* is well supported by a number of molecular and morphological diagnostic traits. DNA barcoding supports two subspecies: the northern, long-haired subspecies known as *B. occidentalis mckayi* Ashmead, 1902, which is present in Alaska and the Yukon territory, and a southern short-haired subspecies known as *B. occidentalis occidentalis* Green, 1858, which is present in most states and provinces within the range south of Alaska and the Yukon Territory (Williams et al., 2012, 2014). To date, all known population declines have been restricted to the southern subspecies (Hatfield et al., 2015). However, the southern subspecies has also received much more survey effort than the northern.

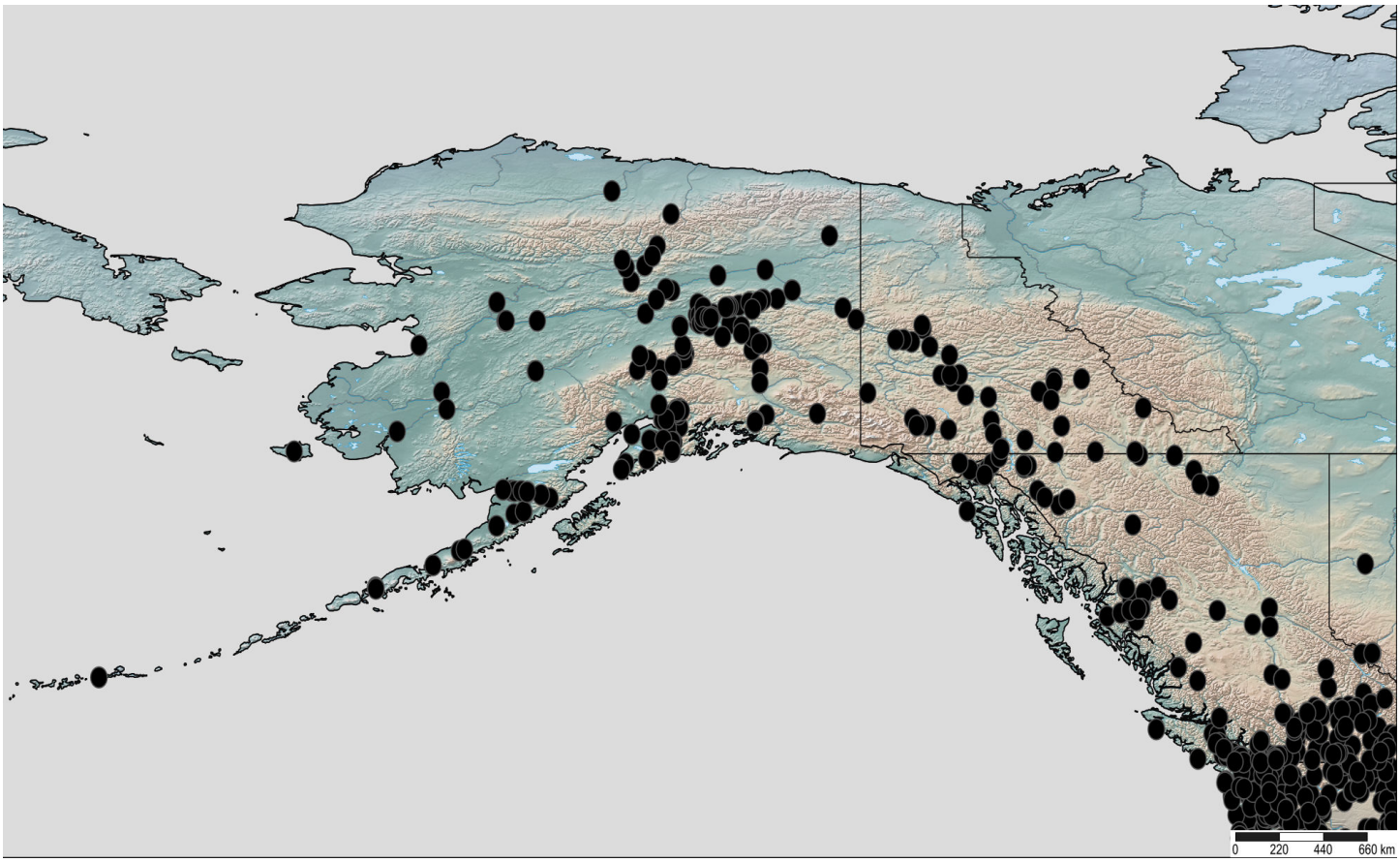

Figure 2: Occurrence data for *B. occidentalis* from GBIF (`http://www.gbif.org`) for Alaska and western Canada, 18.March.2016 (doi:10.15468/dl.tq9ujy). The data mapped originated from the following institutions: Biodiversity Institute of Ontario, USGS PWRC - Native Bee Inventory and Monitoring Lab - US-CA-MX, Canadian National Collection (CNC), Kenai National Wildlife Refuge (KNWR), Snow Entomological Museum Collection (SEMC) at the University of Kansas, the University of Alaska Museum at the Unviersity of Alaska Fairbanks (UAM), the USDA-ARS, and the Yale Peadbody Museum (YPM).

The University of Alaska Museum has DNA barcoded two Alaskan specimens from their collection (UAM:Ento:187982, UAM:Ento:188350) and the Kenai National Wildlife Refuge collection has DNA barcoded one Alaskan specimen (KNWR:Ento:2800). Unsurprisngly, within the Barcode of Life Database (`http://bins.boldsystems.org`) these all fall into a BIN (Ratnasingham and Hebert, 2013) corresponding to the northern subspecies *B. occidentalis mckayi* (BOLD:ACE8361). It is not clear exactly where in British Columbia the break between the two subspecies occurs (although it is known that the northern subspecies occurs in the northern portion of British Columbia and the southern in the southern portion); how much, if any, gene flow occurs in this region; or if the southern subspecies is expanding its range northward, as would be expected due to climate change.

Historical and current range and distribution patterns *Bombus occidentalis* has been collected from Atka in the Aleutian Islands to north of the Brooks Range in Alaska (Figure 2). While most collection has been done along main roadways in Alaska, it is assumed that the species has a broad distribution across the entire state primarily south of the Brooks Range. The niche-modeled range map in Williams et al. (2014) does not correspond well to the known sites of collection in Alaska. We suspect the niche model used was influenced by the large amount of data for the southern subspecies. Future research should establish a niche model focused only on the northern subspecies. This could be used to help predict future range changes under various climate change scenarios.

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Data resources

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