Electronic Supplementary Material for MacPhail et al. 2019 Journal of Insect Conservation

Incorporating citizen science, museum specimens, and field work into the assessment of extinction risk of the American Bumble bee (*Bombus pensylvanicus* De Geer 1773) in Canada

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Supplementary Methods

Table ESM.1 Bumble bee (*Bombus* spp.) related field survey data collected by authors and colleagues across Ontario and Quebec, from 1907-2016, not already incorporated into the *Bumble Bees of North America* database as of May 2017.

Data Source	Number of records	Notes
Erika Nardone 2013 MSc thesis, as shared with V. MacPhail March 2017 (Nardone 2013)	353	Surveys in Algonquin Park as part of a study on impact of logging on bees, 2010-2011
Sheila Colla 2016 surveys	306	Targeted *B. affinis* and general *Bombus* surveys in 2016
Victoria MacPhail and Mariya Cheryomina 2013 surveys	50	Remainder of the summer habitat and parasites *Bombus* study survey data for 2013 not previously incorporated into the *Bumble Bees of North America* database
Victoria MacPhail 2007 MSc thesis (MacPhail 2007)	23	Observations as part of a study of insect visitors to wild roses, *Rosa* spp., 2004-2007
Victoria MacPhail 2013 American Water Willow surveys	65	Observations as part of a study of insect visitors to American Water Willow (*Justicia americana*) in 2013
Victoria MacPhail 2013 Colicroot surveys	110	Observations as part of a study of insect visitors to Colicroot (*Aletris farinosa*) in 2013
Victoria MacPhail 2013 Dense Blazing Star surveys	110	Observations as part of a study of insect visitors to Dense Blazing Star (*Liatris spicata*) in 2013
Victoria MacPhail 2013 Hoary Mountain Mint surveys	137	Observations as part of a study of insect visitors to Hoary Mountain Mint (*Pycnanthemum incanum*) in 2013
Victoria MacPhail 2013 White Wood Aster surveys	20	Observations as part of a study of insect visitors to White Wood Aster (*Eurybia divaricata*) in 2013
Victoria MacPhail 2014 surveys	3453	Includes targeted *B. terricola* spring queen surveys, targeted *B. affinis* surveys, summer habitat and parasites *Bombus* study surveys, general *Bombus* summer surveys
Victoria MacPhail 2015 surveys	1911	Includes targeted *B. terricola* spring queen surveys, targeted *B. affinis* surveys, and general *Bombus* summer surveys

Data Source	Number of records	Notes
Victoria MacPhail 2016 surveys	5267	Includes targeted *B. terricola* and *B. bohemicus* spring and summer surveys, targeted *B. affinis* surveys, and general *Bombus* summer surveys
Grand Total	**11805**	

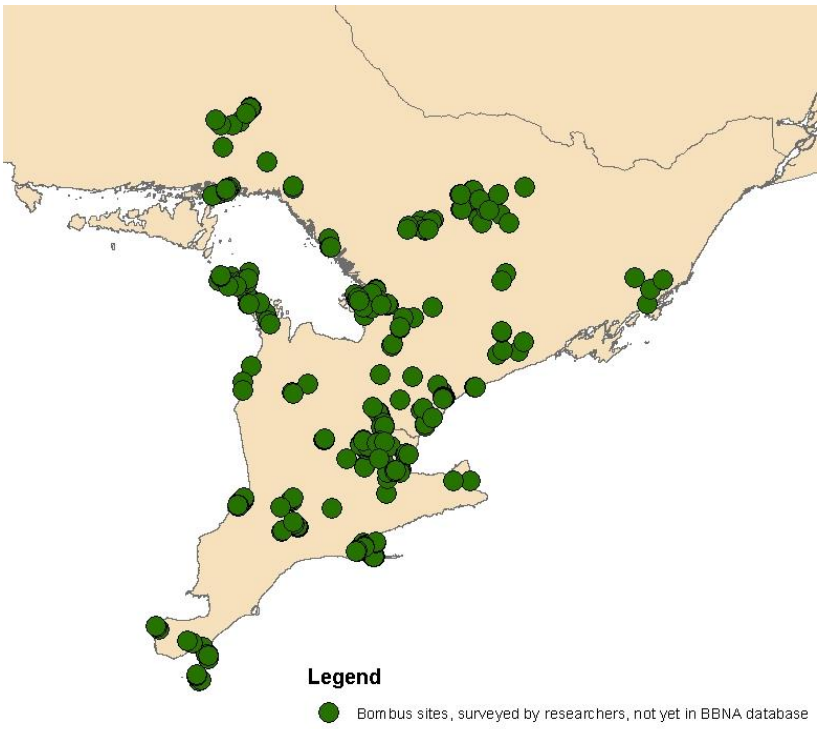

Figure ESM.1 Field survey data collected by authors and colleagues across Ontario and Quebec, from 1907-2016, not already incorporated into the *Bumble Bees of North America* database

Table ESM.2 A comparison of the number of observations of *B. pensylvanicus* in Ontario and Quebec between historic (1907-2006) and recent (2007-2016) periods as found in each of three data sets. BBNA is the *Bumble Bees of North America* database. See the text for more details on the data sources. Note that 20 of the 32 *B. pensylvanicus* observations by MacPhail and Colla were from three visits to a single site in 2016.

Data source	# historic *B. pensylvanicus* 1907-2006	# recent *B. pensylvanicus* 2007-2016
BBNA	279	8
Bumble Bee Watch	0	10
MacPhail and Colla	0	32
Total	**279**	**50**

Supplementary Results

Extent of Occurrence

Table ESM.3 A comparison of the Extent of Occurrence (EOO) for *B. pensylvanicus* from historic (1907-2006) to recent (2007-2016) periods in Ontario and Quebec using three different techniques as described in the text: the GeoCat program (which automatically included the Great Lakes area), ArcGIS including the Great Lakes area, and ArcGIS clipping to the land area of Ontario and Quebec (thus excluding the Great Lakes area).

	EOO Historic period, 1907-2006 (279 records) (km^2)	**EOO Recent period, 2007-2016 (50 records) (km^2)**	**Change in EOO between periods (km^2)**	**EOO Combined, 1907-2016 (339 records) (km^2)**	**Change between Historic and Recent periods (%)**	**Amount of Historic Range still Occupied (%)**
GeoCat - incl Great Lakes	103,084.97	64,821.53	**-38,263.45**	108,552.63	**-37.12**	62.88
ArcGIS - incl Great Lakes	107,732.47	67,579.84	**-40,152.62**	113,353.49	**-40.38**	59.62
ArcGIS - clipped to land	90,458.52	60,282.09	**-30,176.43**	95,378.76	**-36.80**	63.20
difference in GeoCat vs ArcGis incl Great Lakes	-4,647.49	-2,758.32	-1,889.18	-4,800.86	-3.26	3.26
difference in GeoCat vs ArcGis clipped to land	12,626.46	4,539.44	8,087.02	13,173.87	0.32	-0.32
difference in ArcGIS incl Great Lakes vs clipped to land	17,273.95	7,297.75	9,976.20	17,974.74	3.58	-3.58

Relative Abundance

Table ESM.4 A comparison of the results of a series of Z-tests evaluating the difference in proportion of *B. pensylvanicus* to all other *Bombus* spp. on a per decade basis from 1907 to 2016 in Ontario and Quebec. N = sample size; P is significant (*) if <0.05.

Decades	1907 vs 1917	1917 vs 1927	1927 vs 1937	1937 vs 1947	1947 vs 1957	1957 vs 1967	1967 vs 1977	1977 vs 1987	1987 vs 1997	1997 vs 2007
N	738	528	223	493	1013	1279	1353	1425	2753	13883
Z value	1.636	2.570	4.026	1.665	2.462	0.482	0.253	3.378	0.881	1.136
P value	0.102	0.01*	0.00*	0.096	0.014*	0.63	0.801	0.001*	0.379	0.256

Natural History Information

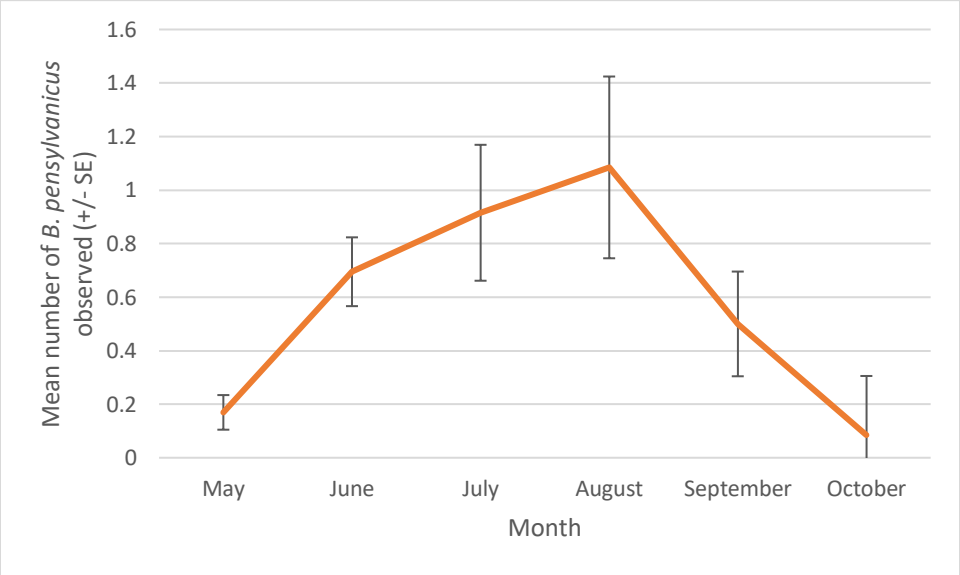

Figure ESM.2 The mean number of *B. pensylvanicus* bees (all castes combined) observed per month per year (+/- SE) from 1907-2016 in Ontario and Quebec. Only records with a known month of observation were included (n=325)

Table ESM.5 A comparison of the number of *B. pensylvanicus* individuals per caste found in Ontario and Quebec from 1907-2016. Only records with a known caste were included (n=314).

Caste	**Number of bees**	**Percent of Total**
Queen or Worker	3	1.0
Male	41	13.1
Queen	93	29.6
Worker	177	56.4

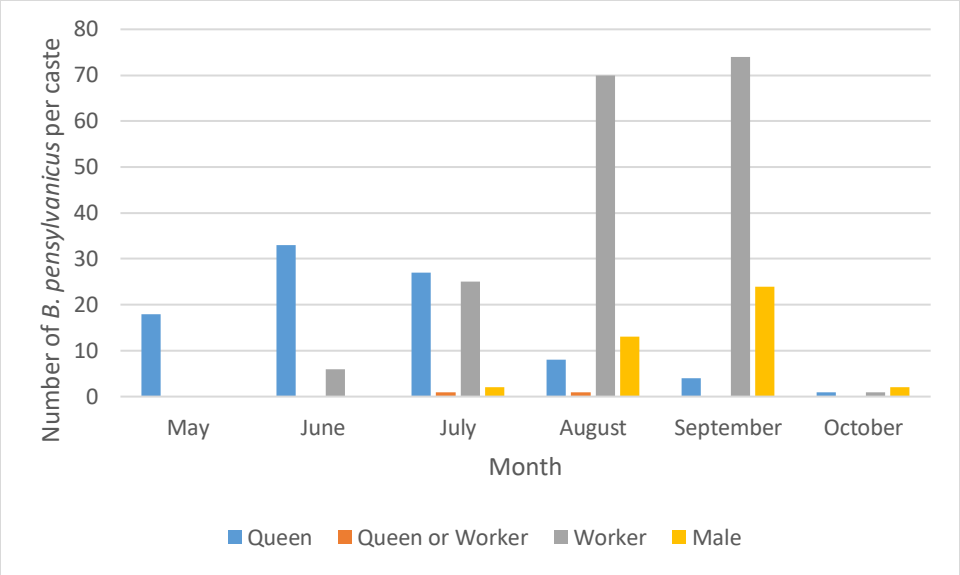

Figure ESM.3 The number of *B. pensylvanicus* bees observed per month and per caste from 1907-2016 in Ontario and Quebec. Only records with both month of observation and caste available were included (n=310)

Supplementary Discussion

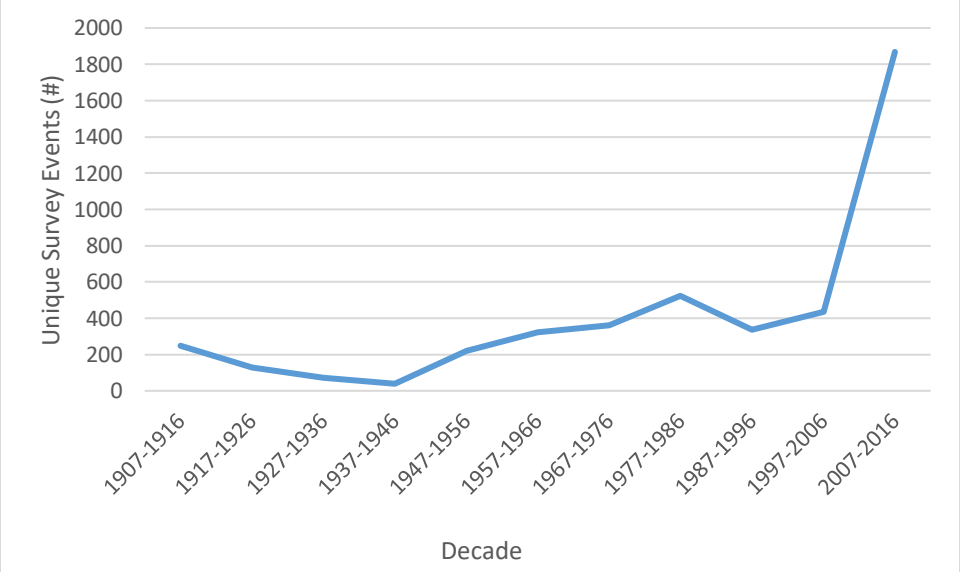

Figure ESM.4 The number of unique *Bombus* survey events that occurred per decade in Ontario and Quebec within the range of *B. pensylvanicus*. One unique event includes all observations from the same observer at the same site and on the same date

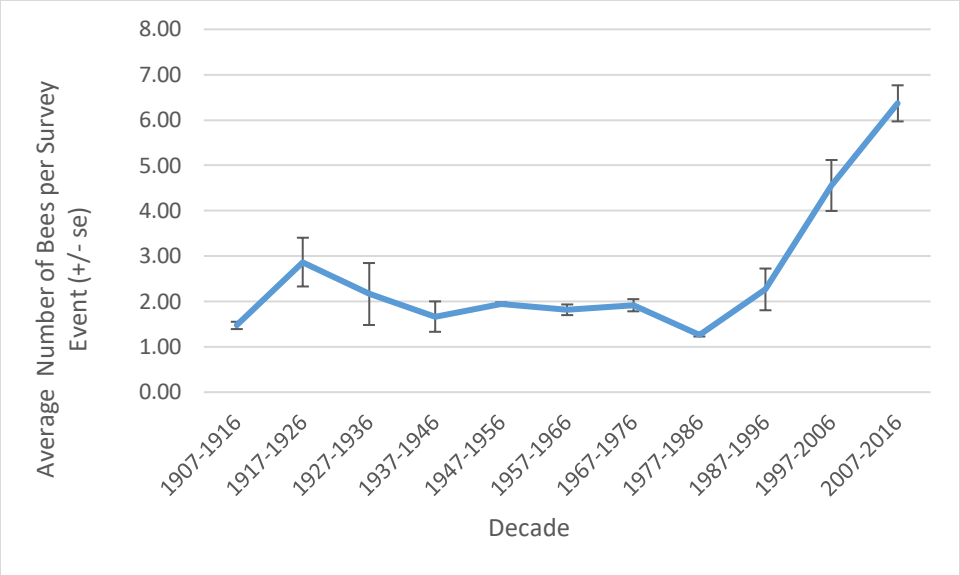

Figure ESM.5 The average number (+/- se) of *Bombus* counted per unique survey event that occurred per decade in Ontario and Quebec within the range of *B. pensylvanicus*

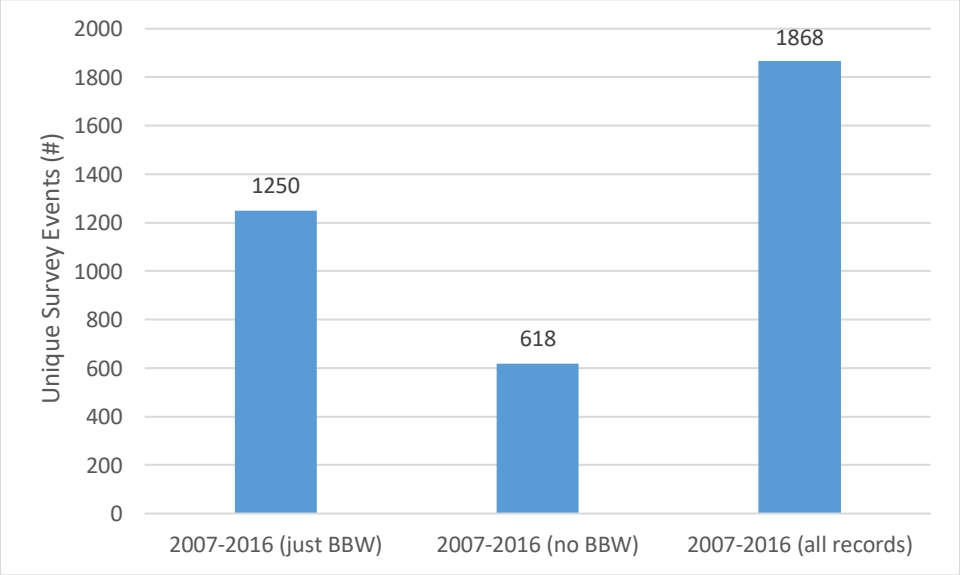

Figure ESM.6 A comparison amongst data sets of the number of unique *Bombus* survey events that occurred in the 2007-2016 decade in Ontario and Quebec within the range of *B. pensylvanicus*. The first column only includes records from the citizen science program Bumble Bee Watch, the second includes all other records (various sources), and the third shows all records combined. One unique event includes all observations from the same observer at the same site and on the same date

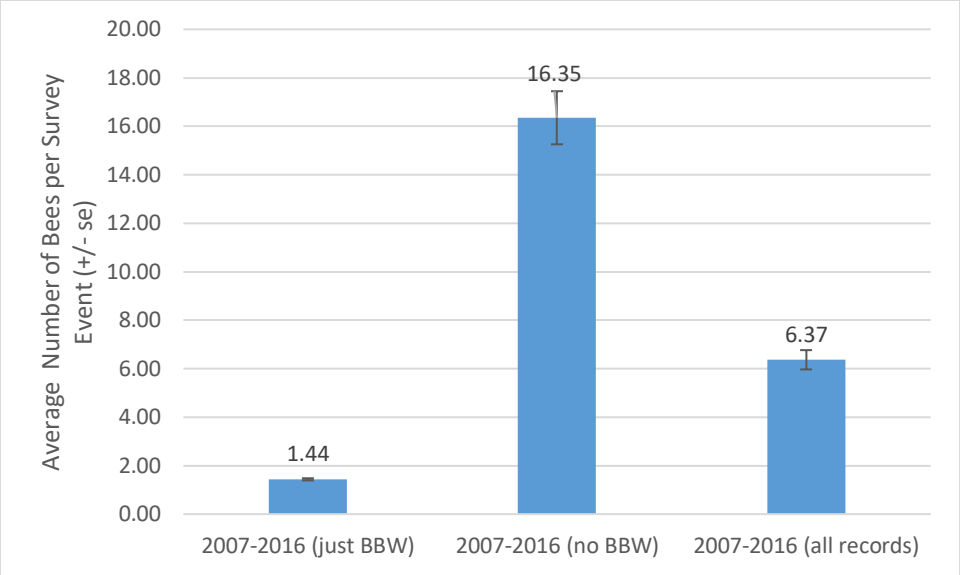

Figure ESM.7 A comparison amongst data sets of the average number (+/- se) of *Bombus* counted per unique survey event that occurred in the 2007-2016 decade in Ontario and Quebec within the range of *B. pensylvanicus*. The first column only includes records from the citizen science program Bumble Bee Watch, the second includes all other records (various sources), and the third shows all records combined

References

MacPhail VJ (2007) Pollination biology of wild roses (Rosa spp.) in Eastern Canada. University of Guelph

Nardone E (2013) The bees of Algonquin Park: a study of their distribution, their community guild structure, and the use of various sampling techniques in logged and unlogged hardwood stands. University of Guelph