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ARTICLE

New records and range extensions of Carabidae of Ontario's boreal forest

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Abstract
The distribution and diversity of fauna of remote regions, including much of the boreal forest, are incompletely known. We took part in extensive biodiversity surveys in the Far North of Ontario (north of 51° N), Canada from 2009 to 2015. In the family Carabidae Latreille (Coleoptera), we report new records and range extensions for 600 specimens representing 99 species. We documented the first record for Canada of one species, the first records for Ontario of 11 species, and range extensions (> 100 km from the known range) for 70 species. The range extensions were largely in a northwards direction, with a median distance of 650 km and a positive skew in the distribution of these distances. These new records fill an important gap in knowledge of the distribution of this family.

Introduction

The Far North region of Ontario, Canada, covers 42% of the province's landmass, an area of 451 000 km^2. This region makes up a large portion of the third-largest wetland in the world (Crins *et al.* 2009). Like many boreal regions, few biodiversity surveys have taken place here (Potapov *et al.* 2017), with much of the region accessible only *via* aircraft (Far North Science Advisory Panel 2010; Ringrose *et al.* 2013). Of the few biodiversity and ecological studies, the majority have focused on charismatic vertebrates such as caribou, moose, and wolves (Poley *et al.* 2013), bats (Layng *et al.* 2019), and birds (Abraham 2014). The arthropod studies that have been conducted in the Far North have focused on collembolans, odonates, dipterans, lepidopterans, hymenopterans, and some beetles (Fjellberg 1985; Danks and Foottit 1989; Sutherland *et al.* 2005; Beresford 2011; Ringrose *et al.* 2013, 2014, 2019; Fleming and Beresford 2016, 2019; Jumean *et al.* 2017; Gibson *et al.* 2018; Langer *et al.* 2018; Vezsenyi *et al.* 2021). Large gaps remain in our knowledge of the diversity and distribution of insects, even though the species' ranges represent the fundamental unit of biogeography (Lomolino *et al.* 2017).

Indeed, such baseline data are essential for understanding how impending climate change, resource extraction, and other economic activity may affect the ecology of the region. The lack of baseline information represents a serious impediment to gauging anthropogenic effects (Mihoub *et al.* 2017). To address this need for a better understanding of a broader range of

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taxa, including ground beetles, we completed extensive sampling of the region from 2009 to 2015 in partnership with the Province of Ontario and local communities.

Ground beetles are taxonomically well known, and these insects are regarded as useful and rapid responders to ecosystem changes (Thiele 1977; Rainio and Niemela 2003; Koivula 2011). They are one of the largest families of insects, with more than 2000 described species in North America (Bousquet 2010). Ground beetles have been collected in nearly every type of terrestrial habitat, including Arctic meadows, ice fields, forests, bogs, marshes, and agricultural fields (Lindroth 1961, 1963, 1966, 1968, 1969a, 1969b). Although the distribution of ground beetles is well documented in southern Ontario (Lindroth 1961, 1963, 1966, 1968, 1969a, 1969b; Bousquet 2010, 2012; Bousquet *et al.* 2013), there is a paucity of information on ground beetles in remote regions such as Ontario's Far North.

Here, we present a summary of our bioinventory of 99 species, including one first Canadian and 11 provincial records of the family Carabidae from Ontario's Far North region. In addition, we analyse range records of 105 species – the 99 reported in this paper and six from previous publications (Fleming and Beresford 2017, 2019).

Materials and methods

Study area

Ontario's Far North is a vast region that includes two ecozones – the Ontario (Boreal) Shield and the Hudson Bay Lowlands. At a macroscale, the boreal forest in the northern portion of the province appears as a large continuous and essentially homogeneous landscape comprising mixed-wood and coniferous forests and low-lying areas of bogs and fens (Fraser and Keddy 2005; Crins *et al.* 2009). However, at the finer scale pertinent to ground beetles, the boreal forest is a patchwork of heterogeneous habitats (Rainio and Niemela 2003).

Collecting methods

Specimens were collected through four different projects. The largest in scope was the Far North Biodiversity Project, followed by the Natural Heritage project, and two localised surveys – one of the Moosonee region and another that focussed on coastal regions of Attawapiskat, Burnt Point, and Peawanuck (Fleming 2021, Fig. 1). Across the four projects, 534 sites were surveyed (Fig. 1). Individual trapping details are provided in Table 1.

The Far North Biodiversity Project was conducted at 65 sites accessed by helicopter over a two-week period at each site between 2009 and 2014. Carabidae were collected using six pitfall traps at each site, set out along bisecting transects and deployed for eight days (site sampling details provided by Goertz 2011), as well as by hand, in pan traps, and, for two specimens, in bottle traps.

Pitfall traps consisted of two 500-mL cups that were placed with the lip flush with the ground, one-third filled with nontoxic propylene glycol. A flat natural object, such as a piece of bark, was suspended 1.5 cm above the trap (Fleming and Beresford 2019).

Pan traps consisted of shallow bowls placed in holes deep enough to allow the rim of the pan to be level with the ground (Gibson *et al.* 2018; Fleming and Beresford 2019). A total of nine pans were set at each survey site, consisting of three blue, three yellow, and three white pans. The pan traps were placed in a cross formation and covered a 10-m^2 sampling area (Gibson *et al.* 2018; Fleming and Beresford 2019). Four pans were placed along the edge of the plot, another four pans were placed 2.25 m from the edge of the plot, and a final pan was placed in the centre, 2.25 m from the surrounding pan traps (Gibson *et al.* 2018; Fleming and Beresford 2019). Pans were filled with nontoxic propylene glycol.

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Table 1. Summary of trapping effort for each project. Years represent the years in which each project took place; months sampled are the months in which sampling took place (for specific dates each location was sampled, see Table 2); and trap type and trap days are the type of trap used in the different projects and the number of days the trap was set. N/A indicates that trap type was not used for that project.

		Far North Biodiversity Project	Natural Heritage	Moosonee Research Project	Attawapiskat, Burnt Point, and Peawanuck research projects
Years		2009–2014	2009–2014	2011, 2015	2010, 2011, 2012
Months sampled		June, July	June, July, August	July	June, July
Number of sites surveyed		65	400	41	28
Trap type and days deployed	Pitfall trap	8 days	1 day	3 days (2011)	1–10 days
				10 days (2015)	
	Pan trap	10 days	1 day	10 days (2015)	N/A
	Netting	10 days	1 day	N/A	1 day
	Bottle traps	10 days	1 day	N/A	N/A

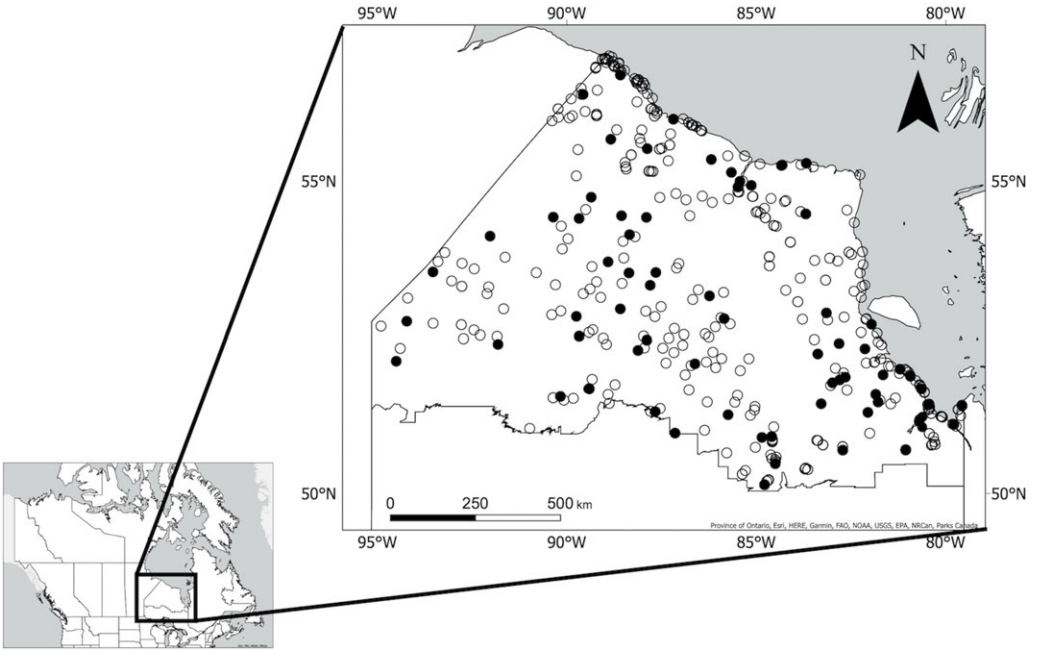

Fig. 1. Far North of Ontario, Canada. Open circles (534) represent all survey locations, 2009–2015, and filled circles (112) represent locations where ground beetles were collected. The line at approximately 50° latitude North represents the northern limit of timber harvesting in Ontario.

Specimen identification and storage

All specimens collected were stored in 70% ethanol. In January 2016, all specimens were pinned, labelled, and identified. We identified specimens using dichotomous keys (Lindroth 1961, 1963, 1966, 1968, 1969a, 1969b; Goulet 1983; Liebherr and Will 1996;

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Bousquet 2010), from which we also based our taxon concept and classifications. In cases where species identifications have changed since Lindroth (1961, 1963, 1966, 1968, 1969a, 1969b), we used the updated nomenclature from Bousquet (2010, 2012) and Bousquet *et al.* (2013). All specimens are housed in the entomological collection at Trent University (Peterborough, Ontario, Canada), except for a reference collection maintained by the Peawanuck First Nation community, Ontario, Canada.

Analysis

New records and range extensions were determined using publications and databases (Lindroth 1961, 1963, 1966, 1968, 1969a, 1969b; Goulet 1983; Liebherr and Will 1996; Bousquet 2010; Bousquet *et al.* 2013; Canadian National Collection of Insects, Arachnids and Nematodes 2022; Global Biodiversity Information Facility 2022a). We denoted a range extension as any specimen more than 100 km from the closest edge of the species' known range. We created a histogram of these distances from the range edge and the number of species that fell within each distance bin. Range maps were produced with ArcGIS 10.8.1 (Environmental Systems Research Institute 2011).

To estimate the number of species of Carabidae expected from the Far North region, we used Chao1 (Gotelli and Colwell 2010) to produce a species rarefaction curve (Hammer *et al.* 2001).

Results

In total, 644 specimens were collected from 112 sites across Northern Ontario (Table 2; Fig. 1; see Fleming and Beresford 2017 for *Carabus granulatus* and Fleming and Beresford 2019 for Elaphrinae). There were 335 specimens collected as part of the Far North Biodiversity Project, of which six were damaged and could not be identified. Natural Heritage surveys resulted in the collection of 68 specimens. The remaining independent projects collected 241 specimens. Six of the 644 specimens could not be identified to species: one specimen, *Agonum* Bonelli (Coleoptera: Carabidae), was identified to genus, and the remaining five were damaged and could not be identified further than Carabidae.

Including specimens first reported elsewhere, *Carabus granulatus* (Fleming and Beresford 2017), and five species of Elaphrinae (Fleming and Beresford 2019), we identified 638 specimens representing 105 species from 31 genera that were collected from Ontario's Far North. Of these 105 species, one species was new to Canada, 11 species were new to Ontario (including the species new to Canada), and 70 range extensions at least 100 km from known range limits were identified. These range extensions include the species new to Canada and Ontario and the species reported in Fleming and Beresford (2017, 2019; Table 2; Fig. 2). The species new to Canada was *Notiophilus nemoralis* Fall (Fig. 2). The 10 species new to Ontario (excluding *N. nemoralis*) were *Agonum simile* Kirby, *Amara pseudobrunnea* Lindroth, *Bembidion bruxellense* Wesmael, *Bembidion postremum* Say, *Bembidion rufotinctum* Chaudoir, *Bembidion simplex* Hayward, *Dicheirotrichus mannerheimii* Sahlberg, *Dyschirius larochellei* Bousquet, *Paranchus albipes* (Fabricius), and *Pterostichus articola* (Chaudoir) (Fig. 2). Eight nonnative species were collected as part of this work. The eight species not native to North America were *Agonum muelleri* (Herbst), *Bembidion bruxellense*, *Blemus discus discus* (Fabricius), *Carabus granulatus* Linnaeus, *Clivina fossor* (Linnaeus), *Harpalus affinis* (Schrank), *Paranchus albipes*, and *Pterostichus melanarius* (Illiger) (Table 2; Fig. 3).

We found a median range extension of 650 km, demonstrating a positive skew (Fig. 4). As well, the vast majority (66; 95%) of the 69 range extensions were in a northward direction, and only three range extensions were in a southward direction (Fig. 5).

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Table 2. Species of ground beetles collected in Ontario's Far North, 2009–2015.

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
Agonum affine	1	54.429290	–89.669410	2 June 2011
	1	52.780870	–81.963360	10 June 2012
	1	53.396050	–87.802400	24 June 2013
	1	54.751720	–89.362700	20 June 2014
Agonum anchomenoides •	1	52.305200	–83.386670	15 July 2012
Agonum canadense •	1	54.450350	–90.360550	18 June 2011
	1	52.824430	–94.227280	2 July 2011
	2	52.774060	–81.957980	6 June 2012
				10 June 2012
	1	51.929660	–82.653700	9 June 2012
Agonum consimile	1	52.773980	–81.955270	9 June 2012
Agonum cupreum •	1	51.275556	–80.635556	13 July 2011
Agonum cupripenne	1	51.840380	–82.991430	4 July 2013
	1	50.507033	–84.503040	5 August 2009
	1	51.011040	–87.148430	4 July 2012
Agonum errans	4	51.929140	–82.654400	7 June 2012
				8 June 2012
	1	51.968740	–81.660220	23 June 2012
	3	50.937020	–84.851630	10 July 2013
				12 July 2013
	5	52.902232	–89.751088	25 June 2013
Agonum gratiosum •	1	51.970800	–81.656280	21 June 2012
	1	52.193363	–94.508842	30 June 2011
Agonum lutulentum •	1	51.317180	–85.746240	6 July 2013
Agonum muelleri •§	1	51.367222	–87.679807	10 August 2010
Agonum mutatum •	1	51.741243	–89.438835	7 August 2010
Agonum palustre •	2	51.929660	–82.653700	9 June 2012
	1	52.525825	–87.891402	30 June 2013
	26	52.824430	–94.227280	30 June 2011
				1, 2 July 2011
	13	52.826150	–94.227290	30 June 2011
	1	53.022580	–88.591330	19 June 2013
	1	54.160080	–92.028810	10 June 2011
Agonum piceolum	9	51.275556	–80.635556	13 July 2011
	1	53.592150	–88.363830	20 June 2013
	1	54.160080	–92.028810	10 June 2011
Agonum picicornoides •	1	53.753450	–88.920211	11 June 2011
Agonum quinquepunctatum	1	55.323030	–86.185550	4 July 2014

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
Agonum retractum •	4	51.499980	–83.290060	29 June 2012
	1	51.617989	–90.171531	8 August 2010
	1	52.525825	–87.891402	30 June 2013
	1	52.773980	–81.955270	7 June 2012
	11	52.824430	–94.227280	30 June 2011
				1, 2 July 2011
Agonum simile ••	1	52.774060	–81.957980	5 June 2012
Agonum sordens •	1	51.968740	–81.660220	22 June 2012
	23	52.824430	–94.227280	30 June 2011
				1, 1 July 2011
	2	52.826150	–94.227290	1 July 2011
	1	53.604210	–93.535890	9 July 2011
Agonum thoreyi •	1	53.592150	–88.363830	21 June 2013
Agonum trigeminum •	1	50.730399	–82.719133	28 July 2009
Agonum damaged	1	52.824430	–94.227280	30 June 2011
Amara alpina	2	51.492770	–80.443258	10 July 2009
	1	55.241389	–84.317778	12 June 2011
	1	55.267086	–83.687288	7 July 2010
Amara avida •	2	54.995326	–85.434010	20 July 2011
				27 July 2011
Amara glacialis •	1	54.995326	–85.434010	21 July 2011
Amara latior •	4	55.241389	–84.317778	13 June 2011
	1	56.567790	–88.593000	3 July 2014
Amara pseudobrunnea *	6	55.241389	–84.317778	10, 12, 13 June 2011
Anisodactylus nigrita •	1	51.011040	–87.148430	5 July 2013
Bembidion bruxellense ••§	1	56.291890	–89.572500	8 July 2014
Bembidion carinula	1	50.954922	–84.595029	30 July 2009
	2	54.181521	–88.346906	27 June 2013
Bembidion castor •	1	50.937020	–84.851630	11 July 2013
	1	51.011040	–87.148430	4 July 2013
	1	51.886559	–82.802176	25 July 2012
Bembidion honestum •	1	51.525997	–81.786995	3 July 2012
	1	51.886559	–82.802176	15 July 2012
	2	51.929140	–82.654400	7 June 2012
Bembidion incrematum •	2	52.865858	–85.850899	23 July 2013
Bembidion interventor •	2	51.207222	–80.710833	27 July 2015
	2	52.306290	–83.384280	11 July 2012
	1	56.291890	–89.572500	10 July 2014

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
Bembidion lacunarium •	3	56.291890	–89.572500	9 July 2014
Bembidion levettei	3	56.291890	–89.572500	8, 9 July 2014
Bembidion mutatum •	1	51.213333	–80.706111	26 July 2015
Bembidion nigripes •	2	56.291890	–89.572500	8, 9 July 2014
Bembidion nitidum •	3	52.865858	–85.850899	23 July 2013
	1	56.291890	–89.572500	8 July 2014
Bembidion obtusidens •	1	51.157785	–79.787863	7 July 2009
	1	51.284167	–80.614722	19 July 2015
Bembidion postremum •*	2	51.220278	–80.703333	25, 26 July 2015
	1	51.284167	–80.614722	21 July 2015
	1	51.492770	–80.443258	10 July 2009
Bembidion rufotinctum •*	1	54.912899	–85.482290	2 July 2010
Bembidion salebratum •	1	51.886559	–82.802176	15 July 2012
Bembidion simplex •*	1	51.525997	–81.786995	3 July 2012
Bembidion sordidum	8	51.945772	–80.932609	14 July 2012
Bembidion transparens •	1	51.357970	–82.056720	13 July 2012
Bembidion transversale •	1	51.211389	–80.707500	20 July 2015
	1	52.956334	–83.150901	13 July 2012
	3	56.291890	–89.572500	9 July 2014
Bembidion variegatum •	1	56.291890	–89.572500	9 July 2014
Blemus discus •§	1	51.284167	–80.614722	20 July 2015
Bradycellus badipennis •	1	51.211389	–80.707778	21 July 2015
Calathus ingratus	1	51.014810	–87.146600	5 July 2013
	10	51.929660	–82.653700	7, 8, 9 June 2012
	1	52.525825	–87.891402	30 June 2013
	3	52.824430	–94.227280	30 June 2011
				2 July 2011
	1	52.826150	–94.227290	1 July 2011
	1	53.025600	–88.594810	21 June 2013
	1	54.430530	–89.678520	3 June 2011
	2	54.995326	–85.434010	20, 27 July 2011
	5	56.567790	–88.593000	3, 4, 5 July 2011
Carabus chamissonis	1	56.288290	–89.573010	10 July 2014
Carabus maeander	1	51.471396	–79.575731	8 July 2012
	4	51.929140	–82.654400	5, 6, 10 June 2012
	1	52.061690	–81.207540	14 July 2012

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
	1	52.190095	–94.504928	30 June 2011
	2	52.774580	–81.963210	7 June 2012
	1	52.778180	–81.963290	7 June 2012
	1	54.429290	–89.669410	2 June 2011
	4	55.241389	–84.317778	8, 10, 11 July 2011
	1	55.323030	–86.185550	3 July 2014
	1	55.481990	–87.879810	28 June 2014
	1	55.621770	–88.841750	25 June 2014
	1	55.923725	–87.190845	2 July 2014
Carabus taedatus agassii •	1	56.568530	–88.589840	4 July 2014
	1	54.995326	–85.434010	23 July 2011
	5	55.241389	–84.317778	12 June 2011
Chlaenius alternatus •	1	51.157777	–79.787949	7 July 2009
	1	52.774580	–81.963210	9 June 2012
Chlaenius lithophilus •	1	51.011040	–87.148430	4 July 2013
	1	51.284167	–80.614722	24 July 2015
	1	51.367222	–87.679807	10 August 2010
	3	52.470120	–82.819020	1 July 2012
Chlaenius nemoralis •	2	50.937020	–84.851630	12 July 2013
Chlaenius sericeus •	1	50.507033	–84.503040	5 August 2009
	1	50.937020	–84.851630	11 July 2013
	19	51.929140	–82.654400	7, 8, 9 June 2012
Clivina americana •	1	54.450350	–90.360550	18 June 2011
Clivina fossor §	1	51.220278	–80.703333	20 July 2015
	2	51.275556	–80.635556	14, 15 July 2011
Cymindis cribricollis •	1	52.061690	–81.207540	14 July 2012
Cymindis unicolor	1	55.482590	–87.880580	27 June 2014
Dicheirotrichus mannerheimii •*	1	56.288290	–89.573010	8 July 2014
Diplocheila obtusa •	1	52.956334	–83.150901	13 July 2012
Dyschirius hiemalis	1	54.756690	–89.359470	23 June 2014
Dyschirius dejeanii	1	51.284167	–80.614722	19 July 2015
Dyschirius larochellei •*	2	56.291890	–89.572500	9 July 2014
Dyschirius sphaericollis •	1	56.291890	–89.572500	10 July 2014
Harpalus affinis •§	1	52.956334	–83.150901	11 July 2011
Harpalus erythropus •	1	50.737994	–81.055836	4 July 2009
Harpalus lewisii •	1	52.363204	–88.124398	23 June 2013

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
Harpalus somnulentus morph. *pleuriticus* •	1	54.995326	–85.434010	25 July 2011
Lebia moesta •	1	51.931430	–82.653730	8 June 2012
Loricera pilicornis pilicornis	8	51.284167	–80.614722	19, 20, 21, 26, 28 July 2015
	1	52.773980	–81.955270	9 June 2012
	1	54.912899	–85.482290	2 July 2010
	1	56.291890	–89.572500	10 July 2014
Miscodera arctica	3	54.995326	–85.434010	18, 23, 25 July 2014
	3	56.567790	–88.593000	4, 5 July 2014
Nebria gyllenhali	1	54.995326	–85.434010	23 July 2011
Notiophilus nemoralis •Φ	1	53.592150	–88.363830	21 June 2013
Notiophilus semistriatus •	1	54.995326	–85.434010	25 July 2011
	5	56.567790	–88.593000	3, 4, 5 July 2014
Omophron americanum •	2	51.011040	–87.148430	6, 7 July 2013
	23	51.929140	–82.654400	7, 8, 9 June 2012
Oxypselaphus pusillus •	1	50.507033	–84.503040	5 August 2009
Paranchus albipes •*§	1	50.737994	–81.055836	4 July 2009
	1	53.604210	–93.535890	8 July 2011
Patrobus foveocollis	1	51.014810	–87.146600	5 July 2013
	1	52.824430	–94.227280	1 July 2011
Patrobus longicornis	3	51.284167	–80.614722	21, 24, 26 July 2015
	1	51.492770	–80.443258	10 July 2009
Platynus decentis	1	53.020800	–88.591010	19 June 2013
Platynus indecentis •	1	56.567790	–88.593000	5 July 2014
Platynus mannerheimii	1	53.595060	–87.653290	26 June 2013
Pterostichus adstrictus	1	51.013710	–87.146420	4 July 2013
	1	51.157785	–79.787863	7 July 2009
	1	51.275556	–80.635556	14 July 2011
	1	51.498130	–83.289860	28 June 2012
	1	51.499980	–83.290060	28 June 2012
	2	51.968740	–81.660220	22, 24 June 2012
	2	51.969000	–81.656250	21 June 2012
	1	52.061690	–81.207540	14 July 2012
	1	52.462180	–91.819060	8 July 2011
	3	52.824430	–94.227280	30 June 2011
				2 July 2011
	2	52.956334	–83.150901	11 July 2011

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
	1	53.022580	−88.591330	19 June 2013
	1	53.025600	−88.594810	18 June 2013
	1	53.592150	−88.363830	19 June 2013
	1	54.995326	−85.434010	25 July 2011
	1	55.241389	−84.317778	13 June 2011
Pterostichus arcticola *	2	51.275556	−80.635556	14, 15 June 2011
Pterostichus brevicornis	2	52.824430	−94.227280	30 June 2011
	1	53.019020	−88.590700	20 June 2013
	4	54.995326	−85.434010	18, 20 July 2011
	6	55.241389	−84.317778	7, 12, 13, 18 June 2011
	1	56.567790	−88.593000	4 July 2014
	2	56.570320	−88.589990	3 July 2014
Pterostichus castor •	1	51.275556	−80.635556	13 July 2011
Pterostichus caudicalis	2	51.929140	−82.654400	9 June 2012
	1	52.865858	−85.850899	23 July 2013
Pterostichus commutabilis •	1	50.937020	−84.851630	13 July 2013
Pterostichus corvinus •	1	50.937020	−84.851630	13 July 2013
	1	50.954922	−84.595029	30 July 2009
	1	51.929660	−82.653700	9 June 2012
Pterostichus melanarius §	1	50.149178	−84.771488	6 August 2009
	12	51.113889	−80.624167	19, 20, 21, 25, 26, 28 July 2015
	2	51.157785	−79.787863	7 July 2009
	5	51.205556	−80.712778	21, 24, 27, 27, 28 July 2015
	4	51.209722	−80.708611	24, 25, 27, 28 July 2015
	1	51.211667	−80.707222	25 July 2015
	4	51.207222	−80.710833	19, 24, 25 July 2015
	2	51.213333	−80.706389	21, 24 July 2015
	2	51.213333	−80.706111	19, 21 July 2015
	2	51.220278	−80.703333	23, 26 July 2015
	52	51.275556	−80.635556	13, 14, 15 July 2011
				19, 21, 26, 27 July 2015
	4	51.284167	−80.614722	19, 21, 26, 27 July 2015
	8	51.284167	−80.615000	19, 25, 27 July 2015
	1	51.222500	−80.699722	19 July 2015

(*Continued*)

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
Pterostichus patruelis	2	55.481990	–87.879810	25, 27 June 2014
Pterostichus pensylvanicus	1	51.275556	–80.635556	15 July 2011
	1	52.824430	–94.227280	1 July 2011
Pterostichus punctatissimus	1	51.354380	–82.056640	14 July 2012
	2	51.499980	–83.290060	28, 29 June 2012
	2	51.650240	–81.849060	16 June 2012
	2	52.363204	–88.124398	24 June 2013
	2	52.388850	–82.133790	5, 6 July 2012
	1	52.590920	–89.676720	11 June 2013
	1	52.956334	–83.150901	11 July 2011
	1	53.022580	–88.591330	19 June 2013
	1	53.025600	–88.594810	20 June 2013
	1	53.592150	–88.363830	20 June 2013
	2	53.759650	–88.921860	8 June 2011
	4	54.443860	–87.899830	22 June 2014
	1	54.471200	–88.564900	18 June 2011
	1	54.499255	–83.696538	6 July 2010
	1	54.751250	–89.361850	23 June 2014
	3	55.241389	–84.317778	18 June 2010
				10, 13 June 2011
	5	55.323030	–86.185550	3, 4, 5 July 2014
	1	55.484050	–87.880200	27 June 2014
	1	55.486180	–87.880670	27 June 2014
Pterostichus rostratus •	1	51.739080	–80.643890	15 June 2012
	1	52.147253	–86.621118	18 July 2013
	6	53.025600	–88.594810	19, 21 June 2013
	1	54.450350	–90.360550	19 June 2011
	1	54.995326	–85.434010	23 July 2011
Sphaeroderus nitidicollis •	1	51.744551	–89.411501	7 August 2010
	2	54.995326	–85.434010	20, 27 July 2011
Stereocerus haematopus	1	53.019020	–88.590700	20 June 2013
	1	53.022580	–88.591330	19 June 2013
	1	53.592150	–88.363830	21 June 2013
	2	54.995326	–85.434010	27 July 2011
	13	55.241389	–84.317778	10, 11, 12, 13 June 2011
	1	56.567790	–88.593000	3 July 2014

(*Continued*)

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Table 2. (*Continued*)

Species	Number of specimens	Latitude (° N)	Longitude (° W)	Collection date
Trechus apicalis	1	51.275556	−80.635556	15 July 2011
Damaged and unidentifiable specimens	2	52.824430	−94.227280	30 June 2011
				1 July 2011
	3	53.025600	−88.594810	20, 21 June 2013

Φspecies new to Canada;
*species new to Ontario;
• species with range extension;
§ species not native to North America. Entries represent the number of specimens. For *Carabus granulatus*, see Fleming and Beresford (2017) and for the five species of Elaphrinae, see Fleming and Beresford (2019).

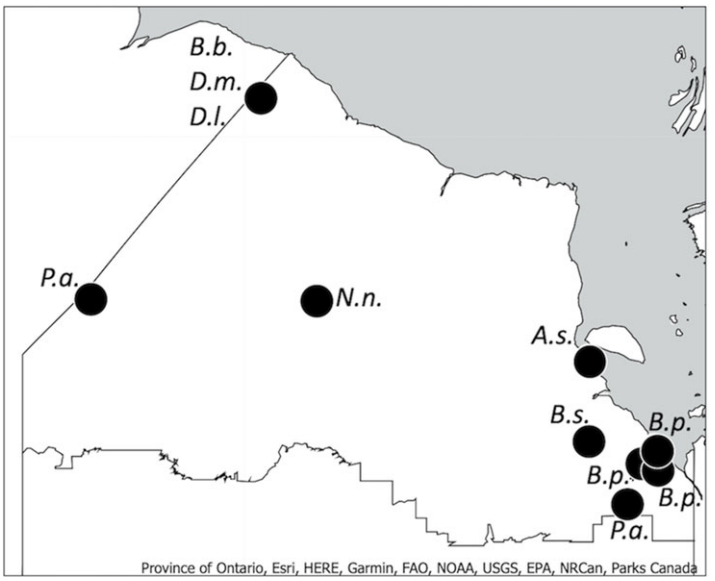

Fig. 2. Species locality maps of new records to Canada for *Notiophilus nemoralis* (*N.n.*) and Ontario for *Agonum simile* (*A.s.*), *Bembidion bruxellense* (*B.b.*), *Bembidion postremum* (*B.p.*), *Bembidion simplex* (*B.s.*), *Dicheirotrichus mannerheimii* (*D.m.*), *Dyschirius larochellei* (*D.l.*), and *Paranchus albipes* (*P.a.*).

From the Chao1 analysis, we surmised a total of 171 Carabidae species across the study region, 66 more species than we collected. Rarefaction analysis also indicated that our survey did not capture specimens from all species (Fig. 6).

Discussion

Species new to Canada

Notiophilus nemoralis was previously recorded from the northeastern United States of America (Table 3; Bousquet 2012). *Notiophilus nemoralis* has a restricted distribution to mountainous habitats, occurring below the timber limit (Lindroth 1961). We collected a single individual from the interior of Ontario's Far North, representing the first Canadian record of this species and a large range extension (Tables 2–3; Figs. 2, 7).

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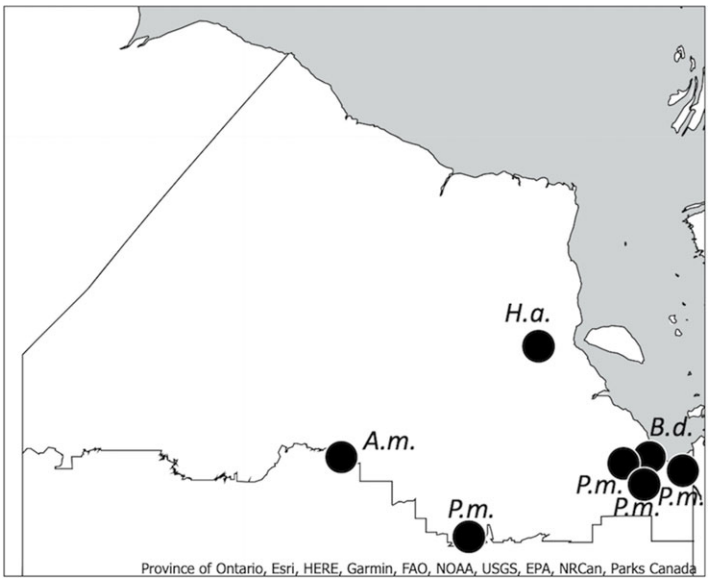

Fig. 3. Collection sites of nonnative species with range extensions or gap infills in Ontario, Canada for *Agonum muelleri* (*A.m.*), *Blemus discus* (*B.d.*), *Harpalus affinis* (*H.a.*), and *Pterostichus melanarius* (*P.m.*).

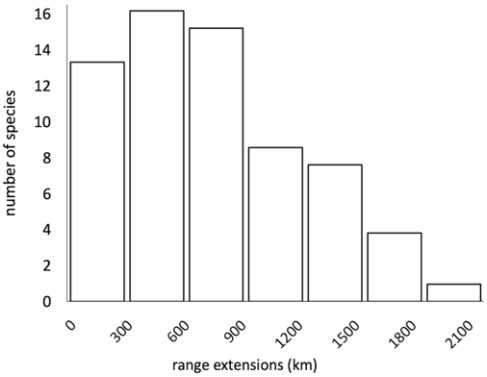

Fig. 4. Frequency distribution of range extensions for species of ground beetles in Ontario's Far North, Canada.

Species new to Ontario

Eleven of the species collected were new to Ontario, including the one (*N. nemoralis*) mentioned above (species new to Canada; Fig. 2). Of the remaining 10 species, we documented one species in the genus *Agonum*: *A. simile*; one species of *Amara* Bonelli: *A. pseudobrunnea*; and four species of *Bembidion* Latreille: *B. bruxellense*, *B. postremum*, *B. rufotinctum*, and *B. simplex*. The remaining species were single representatives of their genera: *Dicheirotrichus* Jacquelin – *D. mannerheimii*; *Dyschirius* Bonelli – *D. larochellei*; *Paranchus* (Fabricius) – *P. albipes*; and *Pterostichus* Bonelli – *P. articola*. As we discuss below, *A. simile*, *B. bruxellense*, *B. postremum*, *B. simplex*, *D. mannerheimii*, *D. larochellei*, and *P. albipes* are of particular interest, given their previously known distributions.

Agonum simile is generally a species from the northwest of North America (Table 3; Bousquet *et al.* 2013). The species was largely restricted to the northern coniferous region from scattered locations (Table 3; Lindroth 1961; Bousquet 2012). We collected one specimen from Attawapiskat (Tables 2–3; Fig. 2).

Bembidion bruxellense is an exotic species in Canada, introduced from Europe. It was first discovered in Newfoundland in 1907 (Lindroth 1963; Bousquet 2012). *Bembidion bruxellense*

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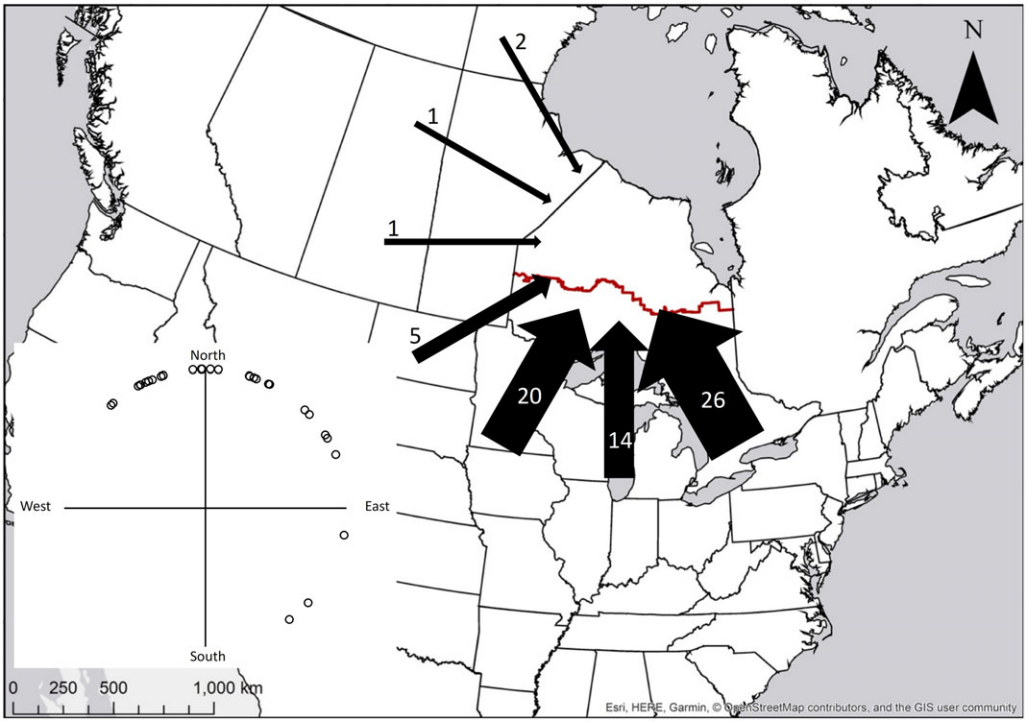

Fig. 5. Directions of range extensions of species of ground beetles collected in Ontario's Far North, Canada. Values represent the number of species. Note: *Bembidion obtusidens* was excluded from this figure as the previous exact collection location was not noted (Bousquet 2012). However, based on the previous collection in northwestern Ontario, we can tentatively estimate the direction to be northeastward.

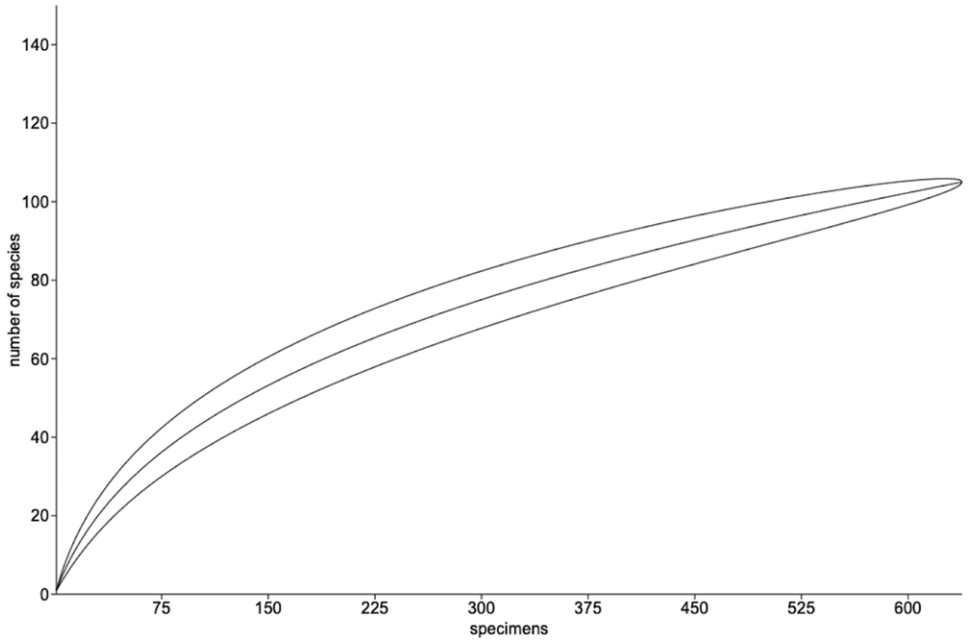

Fig. 6. Rarefaction curve of Carabidae sampling data from 2009 to 2015 in Ontario's Far North, Canada.

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Table 3. Previously known distributions of ground beetles in Canada and the United States of America and the approximate distance for each species with range extensions. Provincial and state records and distance of range extensions were determined using Lindroth (1961, 1963, 1966, 1968, 1969a, 1969b), Goulet (1983), Liebherr and Will (1996), Bousquet (2010), Bousquet *et al.* (2013), Canadian National Collection of Insects, Arachnids and Nematodes (2022), and Global Biodiversity Information Facility (2022a). See the notes at the end of the table for a key to abbreviations.

Species	Province	State	Distance of range extension (km)
Agonum anchomenoides	AB, BC, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	AK, IA, ME, MI, MO, NH, NY, PA, VT	225
Agonum canadense	LB, MB, NB, NF, NS, ON, PE, QC	NH, VT, WI	1300
Agonum cupreum	AB, BC, MB, NB, NT, ON, PE, QC, SK, YK	AK, AZ, CA, CO, MI, MN, ND, NM, SD, UT, WA, WY	590
Agonum cupripenne	AB, BC, MB, NB, NS, NT, ON, PE, QC, SK	AZ, CA, CO, CT, DE, IA, ID, IL, IN, MA, ME, MI, MN, NC, ND, NH, NJ, NM, NV, NY, OH, OR, PA, TN, UT, VT, WI, WY	480
Agonum errans	AB, BC, MB, ON, QC, SK	CO, ID, MI, MT, ND, NE, NH, NM, SD, TX, UT, VT, WY	650
Agonum gratiosum	AB, BC, LB, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	AK, CO, CT, IA, IL, MA, ME, MI, MN, ND, NH, NJ, NV, NY, OH, PA, SD, VT, WI	950
Agonum lutulentum	AB, BC, MB, NB, NS, NT, ON, PE, QC, SK	DE, IA, IL, MA, ME, NH, NJ, NY, OH, PA, SD, VT	160
Agonum muelleri	AB, BC, LB, NB, NF, NS, ON, PE, QC	CA, IA, ID, MA, ME, NH, NY, OR, PA, VT, WA, WY	700
Agonum mutatum	AB, BC, LB, MB, NB, NF, NS, NT, ON, PE, QC, SK	AK, CT, DE, ME, MI, NH, NY, OH, PA, VT	1000
Agonum palustre	NB, ON, QC	IA, KS, MA, ME, MI, NH, NY, OH, PA, VA, VT, WI, WV	1500
Agonum picicornoides	AB, BC, MB, NB, NS, ON, PE, QC, SK	CO, ME, NH, VT	600
Agonum retractum	AB, BC, MB, NB, NF, NS, NT, ON, PE,QC, SK	CO, MA, ME, MI, MN, NH, NY, OH, PA, RI, VA, VT, WI	600
Agonum simile	AB, BC, MB, SK, YK	AK	1000
Agonum sordens	AB, BC, LB, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	CO, ID, IL, ME, NH, NY, VT, WI	400
Agonum thoreyi	AB, BC, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	AK, CO, MA, ME, MI, MN, ND, NH, PA, UT, VT, WI	580
Agonum trigeminum	MB, NB, NS, ON, PE, QC	DC, ME, NH, VT, WI	630
Amara avida	AB, BC, MB, NB, NF, NS, NT, NU, ON, PE, QC, SK, YK	AK, AZ, CO, ME, NH, NM, UT, VT, WA, WY	800
Amara glacialis	BC, LB, MB, NT, NU, ON, QC, SK, YK	AK	240
Amara latior	AB, BC, MB, NB, NF, NS, ON, PE, QC, SK	AZ, CA, CO, ID, ME, MI, MN, ND, NH, NM, NY, OR, PA, UT, VT, WI, WY	1000
Anisodactylus nigrita	AB, BC, MB, NB, NS, ON, PE, QC, SK	CO, IA, MA, ME, MI, MN, MS, ND, NH, NY, PA, SD, UT, VT, WY	240

(*Continued*)

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Table 3. (*Continued*)

Species	Province	State	Distance of range extension (km)
Bembidion bruxellense	NB, NF, NS, PE, QC	ME	1550
Bembidion castor	AB, MB, NB, NF, NS, ON, QC, SK	AZ, CO, ME, MI, NH, NM, NY, TXNE, VT, WY	275
Bembidion honestum	NB, NS, ON, QC	KY, ME, NC, NH, NY, OH, OK, PA, TX, UT, VA, VT, WV	470
Bembidion incrematum	AB, BC, LB, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	CA, ID, ME, MT, NH, NV, OR, UT, VT, WA	400
Bembidion interventor	AB, BC, MB, NT, ON, QC, SK, YK	AK, CO, ND	800
Bembidion lacunarium	NB, ON, QC	AZ, IA, KY, MD, ME, NH, NM, NY, OH, PA, TX, VA, VT	1500
Bembidion mutatum	AB, BC, MB, NB, NF, NS, NT, ON, QC, SK, YK	CA, CO, ND, NH, NM, NV, OR, SD, VT, WI	240
Bembidion nigripes	AB, BC, LB, MB, NB, NF, NS, NT, NU, ON, PE, QC, SK	AK, AZ, CO, ID, MA, ME, MT, ND, NM, NV, OR, UT, WA	950
Bembidion nitidum	AB, BC, MB, NB, NT, ON, PE, QC, SK, YK	AK, AZ, CA, CO, ID, ME, MI, MN, ND, NH, NM, SD, UT, VT, WA	470
Bembidion obtusidens	AB, MB, ON, SK	ND, WY	Distance unknown (Bousquet *et al.* 2013)
Bembidion postremum	NB, QC	IA, ME, MO, NH, PA, VT	1000
Bembidion rufotinctum	NB, QC	MA, NC, NH, VT	1300
Bembidion salebratum	AB, BC, MB, NB, NF, NS, NT, ON, QC, SK	CO, IA, ME, NH, VT	330
Bembidion simplex	QC	ME, MI, NC, NH, OH, TN, VT, WV	1300
Bembidion transparens	AB, BC, LB, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	AK, KY, ME, MI, MN, MO, ND, NH, VT, WI	100
Bembidion transversale	AB, BC, LB, MB, NB, NF, NS, NT, ON, QC, SK, YK	AK, AZ, CA, CO, ID, MO, MT, NM, NV, OR, UT, WAs, WY	800
Bembidion variegatum	NB, ON, QC	CO, IA, IL, IN, MA, ME, MI, MS, NE, NH, NJ, NY, OH, OK, PA, SD, UT, VT	1540
Blemus discus	NB, NS, ON, PE, QC	ME, NH, VT	800
Blethisa julii	AB, BC, MB, NB, NF, NS, NT, ON, QC, SK	ME, NH, VT	500
Bradycellus badipennis	NB, ON, QC	CO, IL, KY, MD, ME, MO, NH, NY, OH, VA, VT	740
Carabus granulatus	AB, BC, LB, MB, NB, NF, NS, NT, NU, ON, PE, QC, SK	CT, ID, MA, ME, MN, NH, WA	200
Carabus taedatus agassii	AB, BC, MB, NF, NT, ON, QC, SK, YK	AZ, CA, CO, NM, NV, OR, UT	570
Chlaenius alternatus	AB, BC, MB, NB, NF, NS, NT, ON, QC, SK	ID, ND	190

(*Continued*)

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Table 3. (*Continued*)

Species	Province	State	Distance of range extension (km)
Chlaenius lithophilus	AB, BC, MB, NB, NF, NS, NT, ON, PE, QC, SK	CO, IA, IL, IN, KS, ME, MO, NC, NH, NY, OK, PA, TN, TX, UT, VT	190
Chlaenius nemoralis	ON	AL, AR, AZ, CO, DC, DE, FL, IA, IL, IN, KS, KY, LA, MD, MI, MO, NY, OH, OK, PA, SC, TX, WI	970
Chlaenius sericeus	AB, BC, MB, NB, NF, NS, ON, PE, QC, SK	AR, AZ, CA, CO, DE, FL, IA, ID, IL, KS, KY, MA, MD, ME, MI, MN, MO, MT, ND, NH, NJ, NM, NV, NY, OH, OK, OR, SD, TX, UT, VA, VT, WA, WI, WV, WY	290
Clivina americana	NB, NS, ON, QC	AL, AR, CT, DE, FL, GA, IL, KS, LA, ME, MI, MS, NC, NE, NH, NJ, OH, OK, PA, SC, TN, TX, VA, VT	1300
Cymindis cribricollis	AB, BC, LB, MB, NB, NF, NS, NT, ON, QC, SK, YK	AK, AZ, CA, CO, MA, ME, MI, MT, ND, NH, NM, TN, UT, VT, WI, WY	300
Dicheirotrichus mannerheimii	AB, BC, LB, MB, NT, QC, SK, YK	AK, CO	400
Diplocheila obtusa	AB, BC, MB, NB, NS, NT, ON, PE, QC, SK	CO, IA, IL, KS, MA, ME, NC, ND, NH, NM, NY, OK, PA, SD, TX, UT, VT, WI, WY	650
Dyschirius larochellei	NB, NF, NS	FL, NH, TX	2040
Dyschirius sphaericollis	AB, BC, MB, NB, NF, NS, ON, PE, QC, SK	AZ, CO, FL, KS, MO, NE, NH, NJ, NM, OH, OK, OR, PA, SD, TX, UT, UT, VT, WA, WY	815
Elaphrus californicus	AB, BC, MB, NB, NS, NT, ON, PE, QC, SK	AK, CA, CO, IA, IN, KS, MD, ME, MI, MN, MT, ND, NE, NH, NM, NV, NY, OH, OK, OR, PA, SD, UT, VT, WI, WY	200
Elaphrus lecontei	AB, BC, MB, NT, ON, QC, SK	AZ, CA, CO, ID, NM, NV, SD, UT, WY	300
Harpalus affinis	AB, BC, LB, NB, NF, NS, ON, PE, QC	CA, IA, IL, KY, MA, ME, MI, NH, NJ, NY, OH, OR, PA, UT, VT, WA, WI	450
Harpalus erythropus	MB, NS, ON, QC	AL, CO, CT, DE, GA, IA, IL, IN, KS, KY, MA, MD, ME, MI, MN, MO, NC, NH, NJ, NY, OH, OK, PA, TN, UT, VA, VT, WI, WV	710
Harpalus lewisii	AB, MB, NB, NS, NT, ON, QC, SK	ME, MI, ND, NH, VT	1190
Harpalus somnulentus morph. *pleuriticus*	AB, BC, LB, MB, NB, NF, NS, NT, ON, PE, QC, SK, YK	AK, AL, AZ, CA, CO, DE, IA, KS, MA, ME, MI, MN, MO, MT, ND, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SD, TX, UT, VA, VT, WA, WI, WY	700
Lebia moesta	AB, BC, LB, MB, NB, NF, NS, ON, PE, QC, SK	ID, ME, ND, NH, RI, VT, WA	470
Notiophilus nemoralis		ME, NH, VT	1600
Notiophilus semistriatus	AB, BC, LB, MB, NB, NF, NS, NT, ON, QC, YK	AK, AL, CO, DC, DE, IN, KS, KY, NH, NM, OH, OK, PA, SD, TN, TX, VA	975
Omophron americanum	AB, BC, MB, NB, NF, NS, NT, ON, PE, QC, SK	AL, AZ, CA, IA, IN, KS, LA, MD, ME, MI, MO, MS, MT, NH, NJ, NM, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, WY	470

(*Continued*)

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Table 3. (*Continued*)

Species	Province	State	Distance of range extension (km)
Oxypselaphus pusillus	AB, BC, MB, NB, NS, ON, PE, QC, SK	IA, MA, ME, MI, ND, NH, NY, OH, PA, VT, WI	675
Paranchus albipes	LB, NB, NF, NS	ME	1300
Platynus indecentis	NB, NS, ON, QC	ME, MI, VT, WI	1600
Pterostichus castor	NB, ON, QC	NH, VT	570
Pterostichus commutabilis	BC, MB, NB, NS, ON, PE, QC, SK	CO, CT, DE, IA, IL, ME, MI, MN, ND, NH, NY, OH, PA, UT, VT	620
Pterostichus corvinus	AB, BC, MB, NB, NS, NT, ON, PE, QC, SK	CO, CT, IA, KS, MA, ME, MI, MN, ND, NH, NJ, NY, OH, PA, SD, UT, VT, WA, WI, WY	740
Pterostichus rostratus	NB, ON, QC	GA, IA, ID, MA, ME, NC, NH, NY, PA, TN, UT, VA, VT, WV, WY	1300
Sphaeroderus nitidicollis	MB, NB, NF, NS, NT, ON, QC, SK	ME, NH, NY, OH, VT	615

Province abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NF, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; ON, Ontario; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan; YK, Yukon Territory.
State abbreviations: AK, Alaska; AL, Alabama; AR, Arkansas; AZ, Arizona; CA, California; CO, Colorado; CT, Connecticut; DC, District of Columbia; DE, Delaware; FL, Florida; GA, Georgia; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Mexico; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WY, Wyoming; WV, West Virginia.

is found in temperate and boreal climate zones (Bousquet 2010). It is a habitat generalist with no documented habitat preferences (Lindroth 1963) and has been documented in a variety of habitats such as open places, vacant fields, sand and gravel pits, and on the borders of marshes and ephemeral pools (Bousquet 2010). Previous records for *B. bruxellense* were confined to eastern Canada and Maine, United States of America (Table 3; Bousquet *et al.* 2013). Our record of *B. bruxellense* was from the most northwestern point of Ontario (Table 3; Fig. 2).

Bembidion postremum is distributed across much of eastern North America and to the midwestern United States of America (Table 3). We collected four specimens clustered around Moosonee, Ontario near the Moose River (Table 2). This finding aligns well with the species' habitat preferences, particularly along riverbanks and on damp ground of sandy or silty soils (Bousquet 2010). Our collection of *B. postremum* is the first Ontario record (Table 3; Fig. 2).

Bembidion simplex is distributed across much of the eastern United States of America to the midwest, and several specimens have been collected in southern Quebec (Table 3; Lindroth 1961; Bousquet 2012). The origins of the two records in the Global Biodiversity Information Facility (2022b, 2022c) are uncertain. The first specimen is noted to have a "Country coordinate mismatch." Canada is noted as the country of collection; however, the geographic coordinates place this specimen in Michigan, United States of America (Global Biodiversity Information Facility 2022b). The second specimen, collected in the Northwest Territories, Canada, was noted on the label as "might be *B. simplex*, if not it is *planuisculum*" (Global Biodiversity Information Facility 2022c). If these two records are incorrect, our collection represents the first Ontario record for *B. simplex* (Table 3; Fig. 2).

Dicheirotrichus mannerheimii is circumpolar in North America and Europe (Table 3; Bousquet 2012). In southern locations (Colorado, United States of America), *D. mannerheimii* is isolated at high-altitude localities (Global Biodiversity Information Facility 2022d).

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Fig. 7. High-resolution macrophotograph of *Notiophilus nemoralis* (dorsal and lateral view), a new Canadian record. Photographs were taken with a Canon 5DS digital SLR camera (Canon Inc., Ota, Tokyo, Japan) with a Canon MPE-65 lens (Canon Inc.). Original photographs were processed (stacked) using Affinity Photo (Serif (Europe) Ltd. (https://affinity.serif.com/en-us/photo/).

Lindroth (1968) and Bousquet (2012) noted a present-day distributional gap in Ontario; however, fossil remnants of *D. mannerheimii* from the early Wisconsinan glacial period have been discovered in southern Ontario (Morgan and Morgan 1981). *Dicheirotrichus mannerheimii* is a cold-hardy species, found primarily on the tundra (Lindroth 1968). The southern

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distributional range of *D. mannerheimii* likely has been contracting since the last glaciation. We collected a single specimen along the northern Hudson Bay coastline, representing a new record for contemporary Ontario (Table 3; Fig. 2).

Dyschirius larochellei has a limited distribution in North America, largely confined to the eastern seaboard (Table 3; Bousquet 2012; Global Biodiversity Information Facility 2022e). We collected two specimens from one locality in the Far North. This extends the known range of *D. larochellei* northwestwards and is the first record for Ontario (Table 3; Fig. 2).

Paranchus albipes is an adventive species that is not native to North America. It was introduced from western Europe before 1835, with the first inventoried specimen collected in Newfoundland (Bousquet 2012). As well, Bousquet (2012) notes that the Canadian Museum of Nature (Ottawa, Ontario, Canada) has in its collection drawings of the insect; these drawings were created before 1834 by Philip Henry Gosse (*Entomologia Terrae Novae* [manuscript] https://www.biodiversitylibrary.org/bibliography/128443). Since its introduction, the species has expanded its range in Canada throughout the Maritime provinces (Table 3; Bousquet *et al.* 2013). We collected the specimens from two locations: along Moose River and along the shores of an unnamed lake in Opasquia Provincial Park (Tables 2–3; Fig. 2). *Paranchus albipes* generally occurs on clay soil with little to no vegetation and along the edges of aquatic ecosystems (Lindroth 1968).

Range extensions and updates of nonnative species

We found eight species not native to North America, including the two nonnative species discussed above (species new to Ontario) and one, *Carabus granulatus*, discussed in Fleming and Beresford (2017). Of the remaining five species, three species exhibited range extensions, one species had gap infills (*i.e.,* in the interstices of its known range), and the remaining species, *Clivina fossor*, was found within its known range.

Agonum muelleri is a Palaearctic species, found across much of northern Europe and Eurasia. It was initially identified in Newfoundland in 1840 and in British Columbia in 1933 (Lindroth 1966; Bousquet 2012). *Agonum muelleri* has been collected in Ontario along the north coast of Lake Superior (Lindroth 1966). Our collection extends the known range northwards by 300 km (Table 3; Fig. 3). *Agonum muelleri* is a habitat generalist, found in a variety of open habitats (Lindroth 1966).

Blemus discus discus was introduced in Canada from Europe in 1933, with the first inventoried specimen collected in Montréal, Quebec (Bousquet 2012). *Blemus discus discus* has been collected from several eastern provinces (Table 3; Bousquet *et al.* 2013). We collected one specimen from Moosonee (Table 3; Fig. 3). *Blemus discus discus* prefers habitats of moist clay and peat ground, close to water (Bousquet 2012).

Harpalus affinis was introduced before 1798 in Pennsylvania, United States of America, with separate western and southern introductions (Bousquet 2012). The species is widely distributed in Canada, having been collected from eight provinces (Table 3; Lindroth 1968; Bousquet 2012). The species was previously collected in Cochrane, Ontario. Our collection of *H. affinis* extends the known range northwards (Table 3; Fig. 3).

Pterostichus melanarius was first introduced in Nova Scotia in 1926, originating from Europe (Bousquet 2012). A second introduction was noted in Seattle, Washington, United States of America (Bousquet 2012). *Pterostichus melanarius* is widely distributed, having been recorded from all 10 provinces (Table 3; Bousquet 2012), and it was previously collected from Moosonee in Ontario (Ernst 2016). The specimens collected as part of this project include multiple locations near Moosonee and three locations in the interior of Ontario's Far North. The specimens from Moosonee do not represent a range extension, but the specimens collected in the interior represent a gap infill for the province (Fig. 3).

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Range extensions

In addition to the range extensions and gap infills of the nonnative species, we found range extensions for another 55 species not already discussed in previous sections (11 species) or in Fleming and Beresford (2017, 2019; four species; Table 3).

In examining these range extensions, we found a median distance of 650 km (Fig. 4). This positive skew is similar to the distribution of dispersal distance among vertebrates, with most dispersers moving short distances and few species dispersing long distances (Sutherland *et al.* 2000). For extensions of the distribution of ground beetles, we too found most range extensions were of short distances and few range extensions were of long distances – up to 2040 km.

We found strong directionality in these documented range extensions: three instances of southwards range extensions *versus* 66 instances of northwards range extensions. The three species with southwards range extensions were *Agonum simile*, *Amara glacialis* (Mannerheim), and *Dicheirotrichus mannerheimii* (Sahlberg) (Table 2). Range extensions for most of the species collected were in northwards directions, with 48 extensions in a northwest direction and 18 extensions in a northeast direction (Table 2; Fig. 5). We found no southwestward range extension (Table 2; Fig. 5). This tendency for northwards range extension could be due to three reasons. First, there have been few scientific studies in Ontario's Far North: most entomological surveys and species records occur near human settlements, which, in Canada, are largely along the southern border (Potapov *et al.* 2017). Second, latitudinal gradients in species richness (Lomolino *et al.* 2017) mean that more speciose southern assemblages serve as the source for northwards range extensions. The relative paucity of species to the north of our study region may be exacerbated by Hudson Bay, which is likely a major barrier to dispersal. Lastly, this directional skew could be the result of climatic changes that have occurred since the end of the Wisconsin glaciation: as the glaciers retreated, newly accessible areas opened up (Ball and Currie 1997; Dyke 2004). The large range extensions could be due to some ground beetle species being stranded in climatic refugia as temperatures rose, which might explain the presence in Ontario's Far North of *Notiophilus nemoralis*, a species previously known only from the spruce-dominated Appalachian Mountains region in the New England region of the United States of America (Lindroth 1961). This is also consistent with the presence of *Dicheirotrichus mannerheimii*, a northern and high-elevation species. Fossilised specimens have been found across much of North America (Morgan and Morgan 1981; Schwert 1992; Motz and Morgan 1997; Bousquet 2012), demonstrating a more widespread earlier range.

Many of the species we collected were expected. Specifically, these were the species that had previous records from surrounding provinces (Table 3). Species that were new to Ontario and Canada are likely not new to these jurisdictions; they just probably had never been recorded. It is also possible some of these species were translocated through phoresy on migratory birds or aboard aircraft or cargo transported to the region. The Chao1 analysis indicated that our survey did not include all species, consistent with our rarefaction analysis (Fig. 6). There are still many other species present in this region, and this survey, although extensive, is incomplete. This is not surprising, given that the Far North of Ontario is a vast territory.

Nevertheless, we collected one species new to Canada, 10 species new to Ontario, and numerous range extensions and gap infills in Ontario's boreal forest. Indeed, the documentation of species ranges is a longstanding pursuit in biology (Lomolino *et al.* 2017). Only with such knowledge are we likely to understand the biotic shifts due to climate change and an expanding industrial footprint.

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