Range Extensions for Northern Redbelly Dace (*Chrosomus eos*), Fathead Minnow (*Pimephales promelas*), and Iowa Darter (*Etheostoma exile*) in Ontario, Canada

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Relatively little is known of the distribution of small fish in the far north of Ontario, Canada, particularly in the Hudson Bay Lowlands. Between 2009 and 2014, we sampled 81 locations across six study areas in Ontario's far north to determine the extent of species occurrences beyond their reported ranges. We used galvanized minnow traps and a standardized effort as well as incidental sampling that included dip and seine netting. We documented 25 fish species across the region, including three species beyond their known geographic ranges: Northern Redbelly Dace (*Chrosomus eos,* Cyprinidae), Fathead Minnow (*Pimephales promelas,* Cyprinidae), and Iowa Darter (*Etheostoma exile,* Percidae).

Key Words: Northern Redbelly Dace; *Chrosomus eos*; Fathead Minnow; *Pimephales promelas*; Iowa Darter; *Etheostoma exile*; Hudson Bay Lowlands; range extension; Ontario

Introduction

Previous ichthyological sampling across Ontario's far north has focused primarily on the region's larger lakes or species of economic importance. Relatively little is known about the region's fish communities (Mandrak and Crossman 1992a; Browne 2007), especially those in its creeks, rivers, and small- to medium-sized lakes (Marshall and Jones 2011). Much of our knowledge comes from the earlier sampling efforts of Dymond and Scott (1941), Ryder *et al.* (1964), and the Ontario Ministry of Natural Resources' Aquatic Habitat Inventory (Zalewski and Weir 1981; Marshall and Jones 2011). In addition, during the summer of 2011 and 2012, the Ontario Ministry of Natural Resources and Forestry sampled the fish communities of 22 selected lakes (ranging in size from 298 ha to 63 000 ha) in fisheries management zones 1, 2, and 3, using both large- and small-mesh gill nets as described in the Manual of Instructions for Broad-scale Fish Community Monitoring (Sandstrom *et al.* 2013). The geographic boundaries of zones 1, 2, and 3 roughly correspond to those of Ontario's far north (Figures 1–3). The state of aquatic ecosystem knowledge in the far north has been summarized by Marshall and Jones (2011) and illustrates the lack of sampling effort in the Hudson Bay Lowlands beyond the larger lakes.

Climate change models and trends suggest that this region may undergo dramatic ecological change over the coming decades resulting from warmer temperatures and an increase in precipitation (FNSAP 2010). With current land use activities shifting from hunting, trapping, fishing, and resource-based tourism toward development, including large-scale mineral exploration, it is becoming increasingly important to improve our knowledge of the baseline biological condition to inform land use planning and resource management decisions more effectively and evaluate the associated effects on the region's biological resources.

From 2009 through 2014, we undertook small-fish sampling across Ontario's far north as a component of a larger study to investigate the biodiversity of this area in support of community-based land use planning. The specific objective of our small-fish sampling was to determine the extent of species occurrence beyond their reported ranges.

Study Area

The sampling took place across the Hudson Bay Lowlands and Ontario Shield ecozones within the boundaries of Ontario's far north as defined by Ontario's Far North Act, 2010, S.O. 2010, c.18 s.2.

The Hudson Bay Lowland is the third largest wetland in the world (Abraham and Keddy 2005) and covers approximately 25% of Ontario's land mass (Crins *et al.* 2009). This ecozone is dominated by saturated peatlands (Riley 2003) comprising open and treed bogs and fens over a very flat topography of underlying limestone. Lakes are generally shallow and rivers are typically low gradient. Together, lakes and rivers account for less than 3% of the region's surface area (Marshall and Jones 2011). Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh) and Tamarack (*Larix laricina* (Du Roi) K. Koch) are the dominant tree species. Upland coniferous forests occur on well-drained sites along

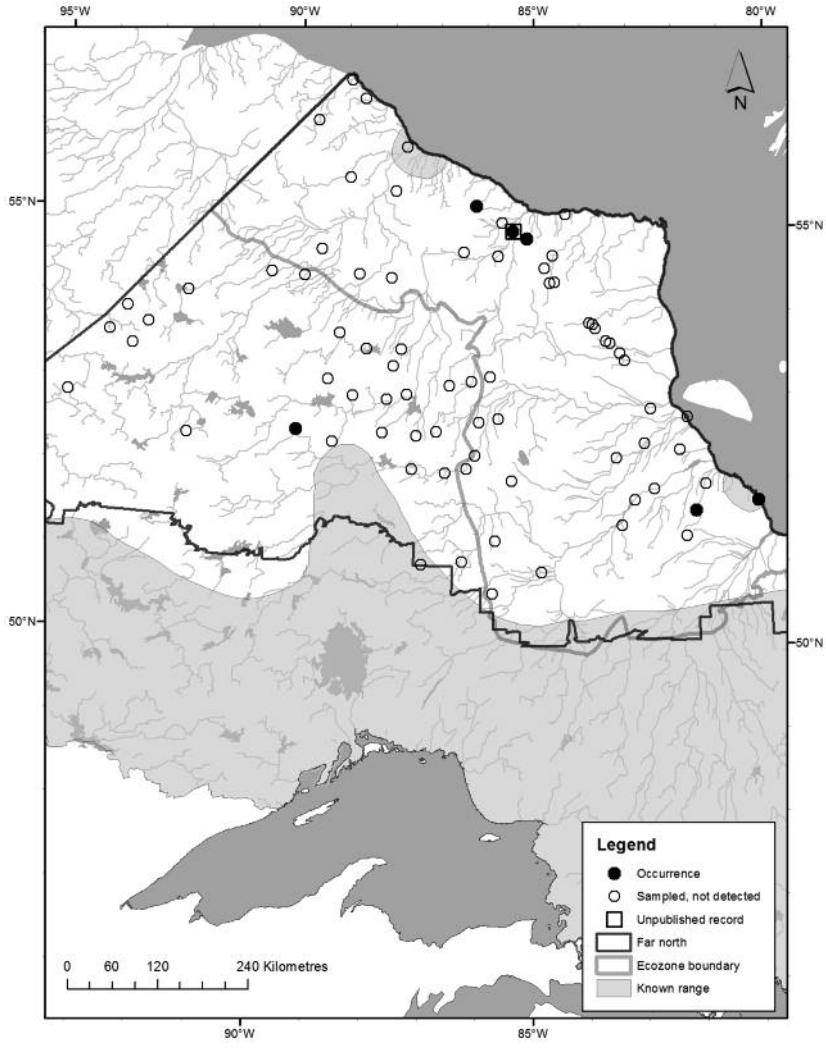

FIGURE 1. Distribution of Northern Redbelly Dace (*Chrosomus eos*) in northern Ontario. Previous known range (light gray) is according to Holm *et al.* (2009) and Eakins (2014). Square indicates unpublished record from the Royal Ontario Museum Ichthyology Collection.

river levees and old beach ridges (Riley 2003); marsh ecosystems predominate in supratidal areas along the coast (Glooschenko 1980); and, tundra heath occupies the northernmost portion of the ecozone adjacent to the Hudson Bay coast (Crins *et al*. 2009). Mean annual temperature ranges from −5.1 to 0.5°C, mean annual precipitation from 490 to 833 mm, and mean summer rainfall from 204 to 286 mm (Mackey *et al.* 1996a,b; Crins *et al*. 2009).

The project area also spans the northern portion of the Ontario Shield ecozone (ecoregions 2W and 3S), represented by underlying Precambrian bedrock, typically gneisses and granites. Land cover includes coniferous and mixed forest with wetlands and open water becoming more abundant in the north and east (ecoregion 2W), where it reaches more than 30% coverage (Crins *et al*. 2009). Black Spruce predominates the landscape, with Jack Pine (*Pinus banksiana* Lambert) becoming more common on upland sites to the south (ecoregion 3S). Lakes are widespread across the ecozone and vary in size, depth, and shoreline complexity, while high-gradient rivers occur occasionally (Marshall and Jones 2011). Lowlands are dominated by bogs and fens. Mean annual temperature ranges from −4.1 to 1.0°C, mean annual precipitation from 550 to 787 mm, and mean summer rainfall from 222 to 299 mm (Mackey *et al.* 1996a,b).

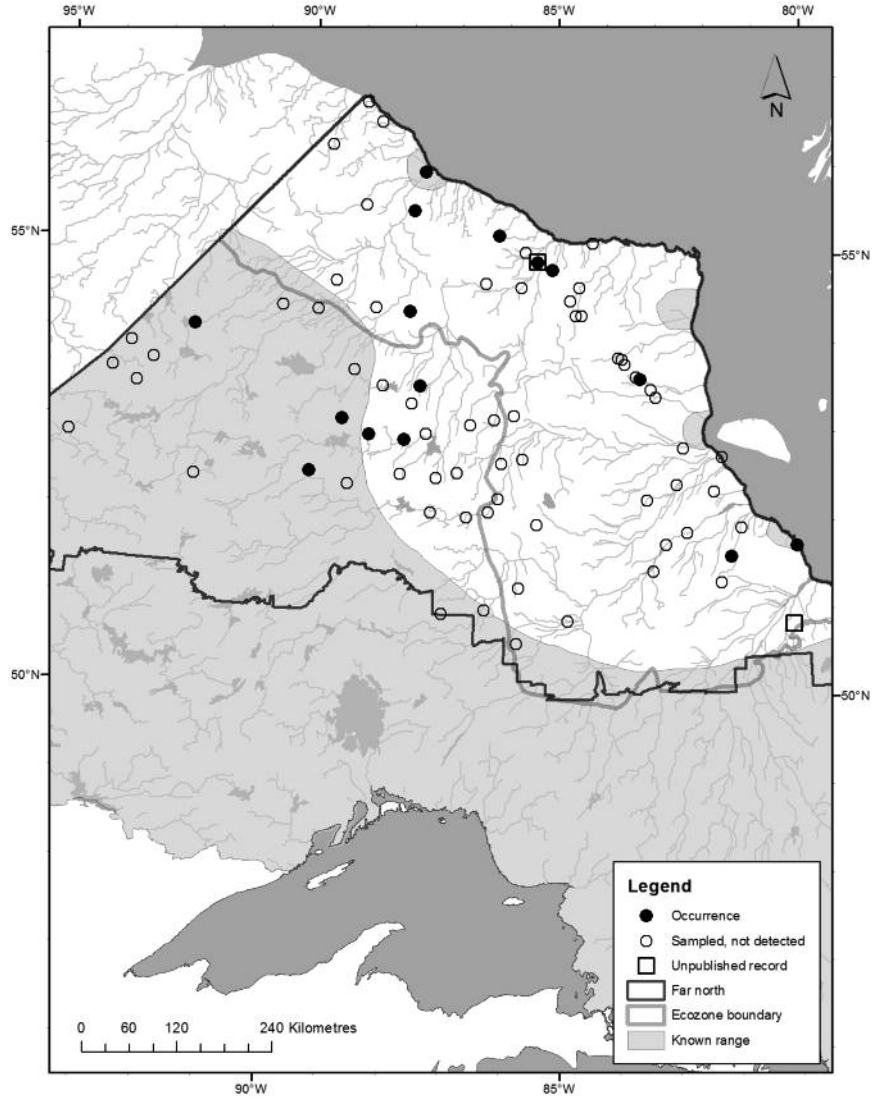

FIGURE 2. Distribution of Fathead Minnow (*Pimephales promelas*) in northern Ontario. Previous known range (light gray) is according to Holm *et al.* (2009) and Eakins (2014). Squares indicate unpublished records from the Royal Ontario Museum Ichthyology Collection.

Each year, study areas were selected based on existing information gaps, community land use planning status, and community interest, with the objective of achieving representative geographic and ecological coverage across the far north. One or two communities were selected each year as staging centres. A 150-km radius around each of these communities was used to delineate the outer limit of the study areas, based on the operational range of a fully loaded EC130 B4 helicopter (Airbus Helicopters Canada, Fort Erie, Ontario) used to shuttle field crews and gear to survey plots. In 2010, the study area was centred on a proposed large-scale chromite mining development known as the Ring of Fire, rather than on a single community. The greater distances to the nearest staging community necessitated a smaller study area than in other years. A 100-km study area radius was used to limit flight distances to 150 km from staging communities.

Over the six-year period (2009–2014), sampling was conducted during June and July with some sampling carried out in August of 2009 and 2014. Table 1 lists study areas, survey dates, and sampling effort.

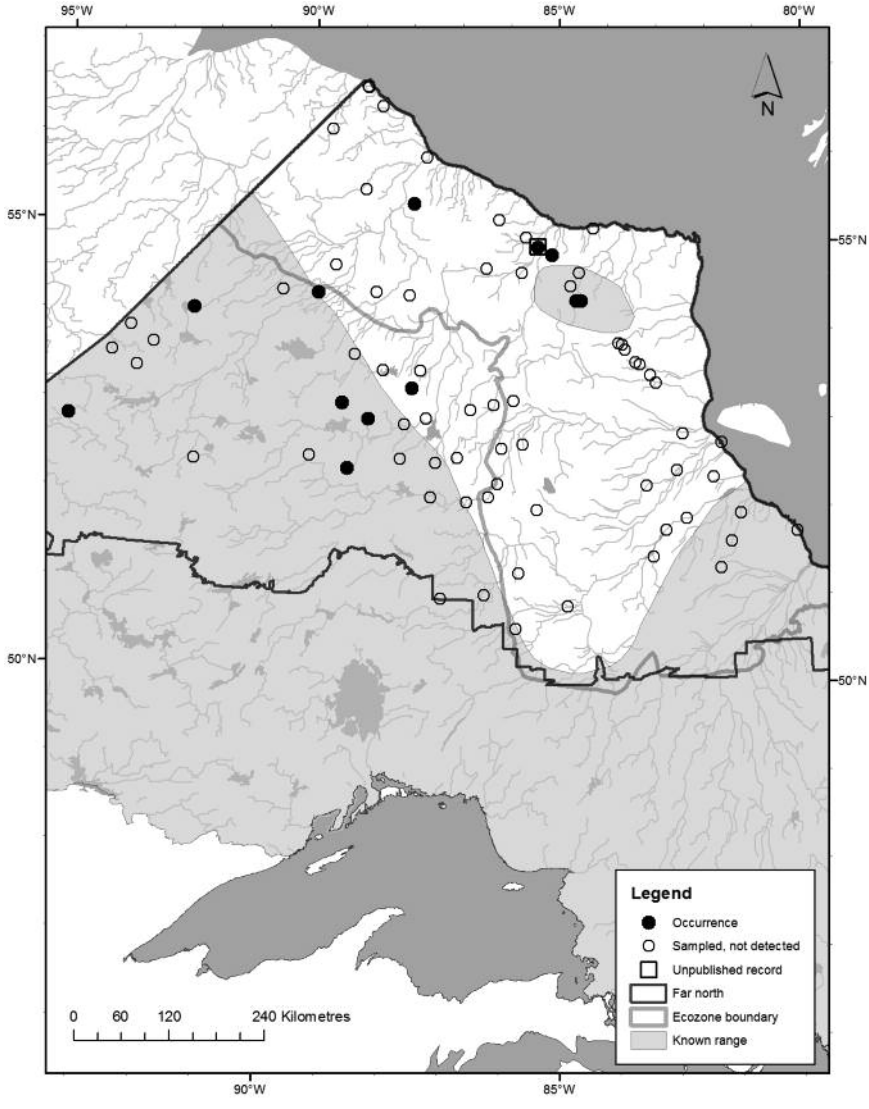

FIGURE 3. Distribution of Iowa Darter (*Etheostoma exile*) in northern Ontario. Previous known range (light gray) is according to Holm *et al.* (2009) and Eakins (2014). Square indicates unpublished record from the Royal Ontario Museum Ichthyology Collection.

TABLE 1. Study areas in northern Ontario, survey dates, and fish trapping effort from 2009 to 2014.

Study area	Coordinates	Survey dates	Effort (trap-nights)
Peawanuck	54.99760°N, 85.42729°W	6 June–15 August 2009	68
Ring of Fire	52.76884°N, 86.75541°W	3 June–22 July 2010	201
Kitchenuhmaykoosib Inninuwug	53.82391°N, 89.88082°W	2–21 June 2011	75
Keewaywin	53.00689°N, 92.79464°W	29 June–17 July 2011	64
Fort Albany	52.19999°N, 81.66670°W	5 June–14 July 2012	180
Nibinamik	52.74583°N, 88.51388°W	7–27 June 2013	88
Marten Falls	51.63566°N, 85.93040°W	2–22 July 2013	94
Fort Severn	55.99846°N, 87.61549°W	3 June–13 August 2014	239

Methods

Sample plots within the year's study areas were randomly selected from the National Forest Inventory 20 km × 20 km sampling grid (Gillis *et al.* 2005). Study areas typically spanned multiple ecodistricts and, as a result, plots were stratified across ecodistricts to ensure representative coverage. When selected plots were inaccessible due to unsuitable helicopter landing conditions (e.g., very wet or heavily forested sites), they were relocated to the nearest available landing area in similar habitat.

Four galvanized steel minnow traps (dimensions = 21 cm × 40 cm) were placed in aquatic environments in each plot to target small fishes. Trap locations were selected by field crews on arrival, based on the available habitat and an attempt to sample different aquatic habitats (preferably two lotic and two lentic). Traps were placed a minimum of 100 m apart and were completely submerged adjacent to cover (if available) to maximize the potential for captures.

Each trap was baited with a handful of dry dog food and a ball of crumpled tinfoil and checked at approximately 24-h intervals with an intended sampling effort of 16 trap-nights per plot; eight nights in 2009. All specimens were identified and counted each time traps were checked, and three voucher specimens per species (or presumed species) were kept and preserved in 70% denatured ethanol (denaturing agent: methanol). Up to six voucher specimens of a presumed species were collected at each trap location. Remaining captures (represented by vouchers) were released. Voucher specimens were identified according to Holm *et al.* (2009), Hubbs and Lagler (2004), and Scott and Crossman (1998). Nomenclature follows that of Page *et al.* (2013).

Although minnow trapping was the primary method used to capture small fishes, specimens were often collected incidentally through the use of dip nets and, in a few cases, non-standardized seine netting.

Data associated with species not presented in this paper can be obtained through the Ministry of Natural Resources and Forestry's Northeast Biodiversity and Monitoring Unit. Voucher specimens are curated at the Royal Ontario Museum.

Results

Of the 25 species encountered during this study (Table 2), three were beyond their known geographic range: Northern Redbelly Dace, Fathead Minnow, and Iowa Darter (Table 3). We hypothesize that these range extensions are an artifact of historical undersampling in the region and not a result of expansion into previously uninhabited areas during recent times. Examination of the postglacial dispersal history of Ontario's freshwater fishes supports our hypothesis; it suggests that these species recolonized this portion of Ontario via the same dispersal routes as other generally distributed species currently known from these areas (Mandrak and Crossman 1992b). All individuals of these species were found in habitats consistent with their preferred habitats as described in Holm *et al.* (2009). Northern Redbelly Dace and Iowa Darter are categorized as cool water species with thermal tolerance similar to that of known small fish communities of this area of Ontario (Eakins 2014). Fathead Minnow, although a warm water species (Eakins 2014), is similarly found in association with cool water species, such as Northern Pearl Dace (*Margariscus nachtriebi*) and Finescale Dace (*Chrosomus neogaeus*), both known from this region (Scott and Crossman 1998; Eakins 2014). Although our detection of the three species may have resulted from recent intentional or unintentional release and subsequent establishment, that is unlikely given the extremely remote and dispersed locations of much of our sampling.

TABLE 2. Fish species encountered in eight study areas in Ontario's far north during a 2009–2014 biodiversity study.

Scientific name	Common name
Chrosomus eos	Northern Redbelly Dace
Chrosomus neogaeus	Finescale Dace
Couesius plumbeus	Lake Chub
Notropis atherinoides	Emerald Shiner
Notropis heterolepis	Blacknose Shiner
Notropis hudsonius	Spottail Shiner
Pimephales promelas	Fathead Minnow
Rhinichthys cataractae	Longnose Dace
Margariscus nachtriebi	Northern Pearl Dace
Catostomus commersonii	White Sucker
Moxostoma macrolepidotum	Shorthead Redhorse
Salvelinus fontinalis	Brook Trout
Esox lucius	Northern Pike
Percopsis omiscomaycus	Trout-perch
Lota lota	Burbot
Culaea inconstans	Brook Stickleback
Gasterosteus aculeatus	Threespine Stickleback
Pungitius pungitius	Ninespine Stickleback
Cottus bairdi	Mottled Sculpin
Cottus cognatus	Slimy Sculpin
Etheostoma exile	Iowa Darter
Etheostoma nigrum	Johnny Darter
Perca flavescens	Yellow Perch
Percina caprodes	Logperch
Sander vitreus	Walleye

Discussion

Northern Redbelly Dace is a small slightly deep-bodied fish (Holm *et al.* 2009), averaging 5.1 cm total length (Scott and Crossman 1998). It is widely distributed in Ontario south of approximately 51°N where it inhabits cool, heavily vegetated, and often "tea-stained" waters of lakes and streams (Holm *et al.* 2009). Current distribution mapping indicates two records that constitute two disjunct ranges in the coastal areas adjacent to Hudson and James Bays (Holm *et al.* 2009; Eakins 2014). We captured 23 individuals across six plots located throughout the region. Five of these locations are beyond the current known geographic range of this

TABLE 3. Range extension records for three species collected in Ontario's far north during a 2009–2014 biodiversity study.

Species	Location of sampling station*	Number of individuals†	Collection date(s)	ROM catalogue number(s)‡
Chrosomus eos				
(Northern Redbelly Dace)	51.65170°N, 81.85013°W	8	14 June 2012	97683, 97779
	52.58490°N, 89.68137°W	1	8 June 2013	97828
	54.93470°N, 85.13696°W	8	29 July 2009	97782, 97787, 97790, 97793, 97799, 97806, 97809
	55.02319°N, 85.42319°W	1	4 June 2014	97767
	55.32119°N, 86.18961°W	2	2 July 2014	97733, 97744
Pimephales promelas				
(Fathead Minnow)	51.65170°N, 81.85013°W	33	14–16 June 2012	97681, 97682, 97778
	52.98093°N, 87.92592°W	2	7 June 2010	95901
	53.02609°N, 88.59720°W	160	17–20 June 2013	97865, 97867, 97870, 97873
	53.59674°N, 87.65428°W	11	25, 27 June 2013	97690, 97701, 97703, 97704,
	53.68443°N, 83.46362°W	1	7 June 2014	97698
	54.44064°N, 87.90157°W	148	20, 22 June 2014	97691, 97700, 97719, 97721, 97729, 97752, 97769, 97772, 97833
	54.93217°N, 85.13396°W	2	11 June 2009	97783, 97823
	55.02308°N, 85.42307°W	175	12 August 2014	97705
	55.32135°N, 86.18558°W	44	2, 4 July 2014	97670, 97724
	55.58220°N, 87.87726°W	712	25, 26 June 2014	97737, 97749, 97754, 97756, 97760, 97763, 97771, 97776
Etheostoma exile				
(Iowa Darter)	53.39635°N, 87.80255°W	2	24 June 2013	97875
	54.43194°N, 89.66885°W	2	4 June 2011	97711
	54.93470°N, 85.13696°W	10	11, 12 June, 29 July 2009	97797, 97805, 97813, 97818, 97824
	55.02319°N, 85.42319°W	4	4 June 2014	97742, 97768
	55.48249°N, 87.88128°W	2	25, 28 June 2014	97764, 97775

*Coordinates are given for a single sampling station within a plot where a record was obtained. In some cases, records were obtained from multiple stations.
†Total number of individuals captured from plot (sum of all station totals).
‡Royal Ontario Museum Ichthyology Collection catalogue numbers for all vouchers collected from a given plot.

species (Figure 1). Eighteen individuals (from one to eight per plot) were captured at these locations, which are 40–150 km (approximately) from the edge of this species' known range.

Fathead Minnow is a small deep-bodied fish, averaging 5.1 cm total length (Scott and Crossman 1998). It is widely distributed in Ontario south of the Hudson Bay Lowlands where it inhabits shallow lakes and streams (Holm *et al.* 2009). Current distribution mapping indicates five records that constitute four disjunct ranges in the coastal areas adjacent to James and Hudson Bays (Holm *et al.* 2009; Eakins 2014). We captured 3311 individuals across 15 plots located throughout the region. Ten of these locations are beyond the current known geographic range of this species (Figure 2). A total of 1288 individuals (one to 712 per plot) were captured at these locations, which are 10–150 km (approximately) from the edge of this species' known range.

Iowa Darter is a small elongate fish, averaging 5.1 cm total length (Scott and Crossman 1998). It is widely distributed in Ontario south of the Hudson Bay Lowlands where it inhabits clear waters of lakes and streams (Holm *et al.* 2009) with organic to sand substrates (Eakins 2014). Current distribution mapping indicates four records that constitute a disjunct range within the Hudson Bay Lowlands in the vicinity of the Sutton Ridges (Holm *et al.* 2009; Eakins 2014). We captured 97 individuals across 12 plots located throughout the region. Five of these locations occur beyond the current known geographic range of this species (Figure 3). In total, 20 individuals (two to ten per plot) were captured at these locations, which are 2–160 km (approximately) from the edge of this species' known range.

Databases associated with the Canadian Museum of Nature (2014), the Royal Ontario Museum (2014), and the Ontario Ministry of Natural Resources and Forestry's Broad-scale Fish Community Monitoring program (J. Amos, personal communication) were searched for unpublished records of each of these species. The Royal Ontario Museum Ichthyology Collection contains unpublished records for Northern Redbelly Dace (ROM 84983), Fathead Minnow (ROM 36391 and 84985), and Iowa Darter (ROM 84984) (Figures 1–3).

Given the remoteness of Ontario's far north and the logistic and financial challenges associated with accessing it, especially the interior, it is not surprising that there is a paucity of information about the region's fish communities, particularly its small-fish communities. As the far north receives more attention through planning and development initiatives, the need to establish baseline natural conditions and implement monitoring programs will be paramount. Increasing our knowledge of the region's biodiversity will undoubtedly lead to a finer resolution of the geographic distribution of many species, including small fish.

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