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Information in support of a Recovery Potential Assessment of Redside Dace (*Clinostomus elongatus*) in Canada

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

In April 1987, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Redside Dace (*Clinostomus elongatus*) as Special Concern, and this status was re-examined and assessed as Endangered in April 2007. A re-assessment by COSEWIC in November 2017 kept the species designation as Endangered. The reason given for this designation was “this small, colourful minnow is highly susceptible to changes in stream flow and declines in water quality, such as those that occur in urban and agricultural watersheds. The Canadian range of this species largely overlaps with the Greater Toronto Area (GTA), where urban land use is widespread and projected to increase in the future. The continued expansion of the GTA has led to ongoing habitat degradation, causing serious declines in range and number of individuals and populations” (COSEWIC 2017). Redside Dace has been lost from nine of its 25 historical locations, and may now be gone from an additional three; as well, a continued decline is evident in 10 of the 13 remaining historical locations. More than 80% of the Canadian distribution occurs in the ‘Golden Horseshoe Region’ of southwestern Ontario where urban development poses the most immediate threat to the continued existence of this species in Canada. In May 2017, Redside Dace was listed as Endangered under the federal *Species at Risk Act* (SARA). The Recovery Potential Assessment (RPA) provides background information and scientific advice needed to fulfill various requirements of SARA. This research document provides the current state of knowledge of the species including its biology, distribution, population trends, habitat requirements, and threats, which will be used to inform recovery plans. Mitigation measures and alternative activities related to the identified threats, that can be used to protect the species, are also presented. This information may be used to inform the issuing of SARA Section 73 permits.

INTRODUCTION

Redside Dace (*Clinostomus elongatus*) is a small colourful member of the Cyprinidae family that occurs in the Great Lakes basin, the Susquehanna River drainage, and the upper Mississippi River drainage (Scott and Crossman 1973). In Canada, Redside Dace distribution is disjunct and limited to tributaries of Lake Ontario, Lake Erie, Lake Huron, and Lake Simcoe (COSEWIC 2017). The majority of remaining populations are found within the Lake Ontario drainage and have experienced dramatic reductions in range and abundance. The species is now only found in isolated sections of watersheds where it was once more widespread.

In April 1987, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Redside Dace as Special Concern. This status was re-assessed in April 2007 and was uplisted to Endangered. A re-examination by COSEWIC in November 2017 maintained the species assessment as Endangered. The reason given for this designation was that "this small, colourful minnow is highly susceptible to changes in stream flow and declines in water quality, such as those that occur in urban and agricultural watersheds. The Canadian range of this species largely overlaps with the Greater Toronto Area (GTA), where urban land use is widespread and projected to increase in the future. The continued expansion of the GTA has led to ongoing habitat degradation, causing serious declines in range and number of individuals and populations" (COSEWIC 2017). Results from ongoing surveys suggest that it has been lost from nine of its 25 historical locations, and may no longer occupy an additional three historical locations, while continuing decline is evident in 10 additional locations. More than 80% of the Canadian distribution occurs in the 'Golden Horseshoe Region' of southwestern Ontario where urban development poses the most immediate threat to the continued existence of this species in Canada.

Redside Dace was listed as an Endangered species under Schedule 1 of the *Species at Risk Act* (SARA) in May 2017 and was listed as Endangered under the provincial *Endangered Species Act* (2007) in 2009. A Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) to provide background information and scientific advice needed to fulfill various requirements of SARA (DFO 2014). This research document provides the current state of knowledge for the species including its biology, distribution, population trends, habitat requirements, threats and mitigation measures related to the identified threats, which will be used to inform the Recovery Strategy for the species.

BIOLOGY, ABUNDANCE, DISTRIBUTION AND LIFE HISTORY PARAMETERS

SPECIES DESCRIPTION

Redside Dace is a colourful member of the minnow (Cyprinidae) family that reaches a maximum total length of 12 cm. The body shape is very slender, elongated, and laterally compressed. Individuals are known to have relatively short lifespans with adults living to a maximum age of 5 years and maturation occurring between the ages of 2-3 (Schwartz and Norvell 1958, McKee and Parker 1982, COSEWIC 2017). Redside Dace grows quickly, achieving 50% of its total growth within the first year and females growing faster and reaching a larger size than males (Koster 1939, McKee and Parker 1982). The species is easily identifiable due to its extremely large upturned mouth coupled with a distinctly protruding lower jaw (COSEWIC 2017). It also displays a recognizable colouration during the breeding season. Males in particular, will display a distinctive bright red or orange band that extends along the front half of the fish's body. A vivid yellow or gold stripe spanning the fish's entire body runs above the red band, and the back of the fish is generally dark green (Figure 1, Scott and Crossman 1973). Throughout the year, adults generally maintain their vibrant hue, showing iridescent colouration ranging from blue to green (Scott and Crossman 1973).

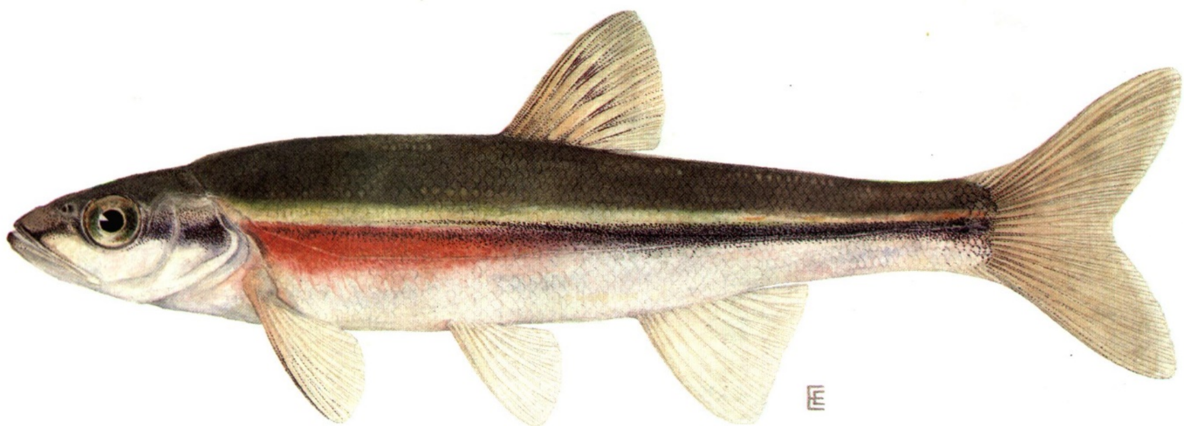

Figure 1. Redside Dace. Illustration © Ellen Edmondson, NYSDEC reproduced with permission.

TAXONOMY

Redside Dace is one of the two species in the *Clinostomus* genus that is endemic to North America. Redside Dace is a glacial relict that originated after the last glaciation event (Novinger and Coon 2000). The closely related Rosyside Dace (*Clinostomus funduloides*) can be found in southeastern and eastern parts of the United States, but does not occur in Canada. *Clinostomus* is considered to be a sister group with the genus *Richardsonius*, consisting of two species, Redside Shiner (*Richardsonius balteatus*) and Lahontan Redside (*Richardsonius egregious*), both of which are limited to the west coast of North America (Schoenhuth et al. 2012).

PHYSIOLOGY

A study performed by Novinger and Coon (2000) observed the differences in physiology between populations of Redside Dace in Michigan and New York. The New York population showed a higher metabolic rate as temperatures increased while the Michigan population had higher resting metabolic rates in general. This difference was attributed to a physiological adaption to variation in environmental conditions. Critical thermal maximum was also identified as 32.6 °C for the New York population when acclimated to 20 °C (Novinger and Coon 2000). The study also predicted the preferred and optimal growth temperature for New York Redside Dace being 24.5 °C and 24.7 °C, respectively. These values are slightly lower than other related minnow species indicating that the New York population displayed a preference for cooler streams.

FEEDING AND DIET

Redside Dace is a visual feeder and as a result is most often found in waters that are clear and colourless (McKee and Parker 1982, COSEWIC 2017). Using its large upturned mouth, it preys on insects that can be found near the water's surface. Up to 95% of the Redside Dace's diet consists of insects and the majority of these are of terrestrial origin (Schwartz and Norvell 1958, Daniels and Wisniewski 1994). Most insects consumed appear to be adult flies (Diptera) (Schwartz and Norvell 1958, McKee and Parker 1982, Daniels and Wisniewski 1994) though a variety of beetles (Coleoptera) and wasps (Hymenoptera) are also important prey items

(Schwartz and Norvell 1958). Aerial insects are caught using a leaping technique that Redside Dace is well adapted for (Schwartz and Norvell 1958, Daniels and Wisniewski 1994). Using its large pectoral fins and streamlined bodies, individuals can jump several inches above the waterline to capture terrestrial insects (Schwartz and Norvell 1958, Daniels and Wisniewski 1994). Benthic invertebrates and mid-water insects also form a small portion of the Redside Dace diet, suggesting they are consumed when aerial insects are unavailable (McKee and Parker 1982). A recent study by Reid et al. (2019) compared prey availability of Redside Dace across 24 sites in the Greater Toronto Area. Results indicated that there were no significant differences with respect to invertebrate prey assemblages between sites with differing population status categories (i.e., extirpated, declining, or stable). However, Acrididae (grasshopper) was the only taxon that was strongly associated with stable Redside Dace populations (Reid et al. 2019).

SPECIAL SIGNIFICANCE

Redside Dace is a unique species of minnow that utilizes terrestrial insects as its main food source (Schwartz and Norvell 1958). This behaviour provides a pathway for allochthonous energy to enter the aquatic environment and increase the amount of energy that is cycled into the stream from the riparian area (Daniels and Wisniewski 1994). Redside Dace is also known to be highly sensitive to environmental changes due to its visual feeding behaviour and reliance on clear water and deep pools, which may serve as a useful environmental indicator.

DISTRIBUTION

In North America, Redside Dace occurs in the watersheds of all five Great Lakes, the upper Mississippi River basin in the west, from Minnesota to New York in the east, and Kentucky to the south (Scott and Crossman 1973). It is found in New York and Pennsylvania in the Susquehanna and Ohio River drainages and occurs in disjunct patches in West Virginia, Kentucky, Iowa, and Michigan (COSEWIC 2017, NatureServe 2018). The current Canadian distribution of Redside Dace is approximately 5% of the global range (inferred from COSEWIC 2007 and COSEWIC 2017).

In Canada, Redside Dace distribution is disjunct and limited to Ontario in tributaries of lakes Ontario, Simcoe, Erie and Huron (Figures 2 - 5). Around 80% of the range lies within the Greater Toronto Area (GTA), and the habitat that supports these populations has a very high potential for degradation due to urban growth and expansion (COSEWIC 2007). The majority of remaining populations within the Lake Ontario drainage have experienced dramatic reductions in abundance and range, and the species is now only found in isolated sections of watersheds where it was once more widespread (Table 1) (RDRT 2010, COSEWIC 2017).

Historically, Redside Dace occurred in 25 watersheds in Ontario, but has since been extirpated from the following nine watersheds: Petticoat Creek, Pringle Creek, Highland Creek, Mimico Creek, Etobicoke Creek, Clarkson Creek, Morrison Creek, Wedgewood Creek, and a Niagara area stream. In addition, sampling indicates large declines or extirpations in parts of Duffins Creek (main channel, Urfe Creek and Reesor Creek), the Credit River system (Levi's Creek, Roger's Creek, Caledon Creek), Morrison Creek, Bronte Creek (main channel and Mountsberg Creek), Don River (west branch), Irvine Creek, and Spencer Creek. Recent surveys (2001-2015) also suggest declines in range and abundance in Lynde Creek, Morningside Creek, Don River (east branch), Irvine Creek, Holland River tributaries, Kettleby Creek and Sharon Creek, as well as the Saugeen River and its tributary Meux Creek. Populations appear stable at Two Tree River and Carruthers Creek while a new Redside Dace population was discovered in South Gully Creek in 2008 (COSEWIC 2017).

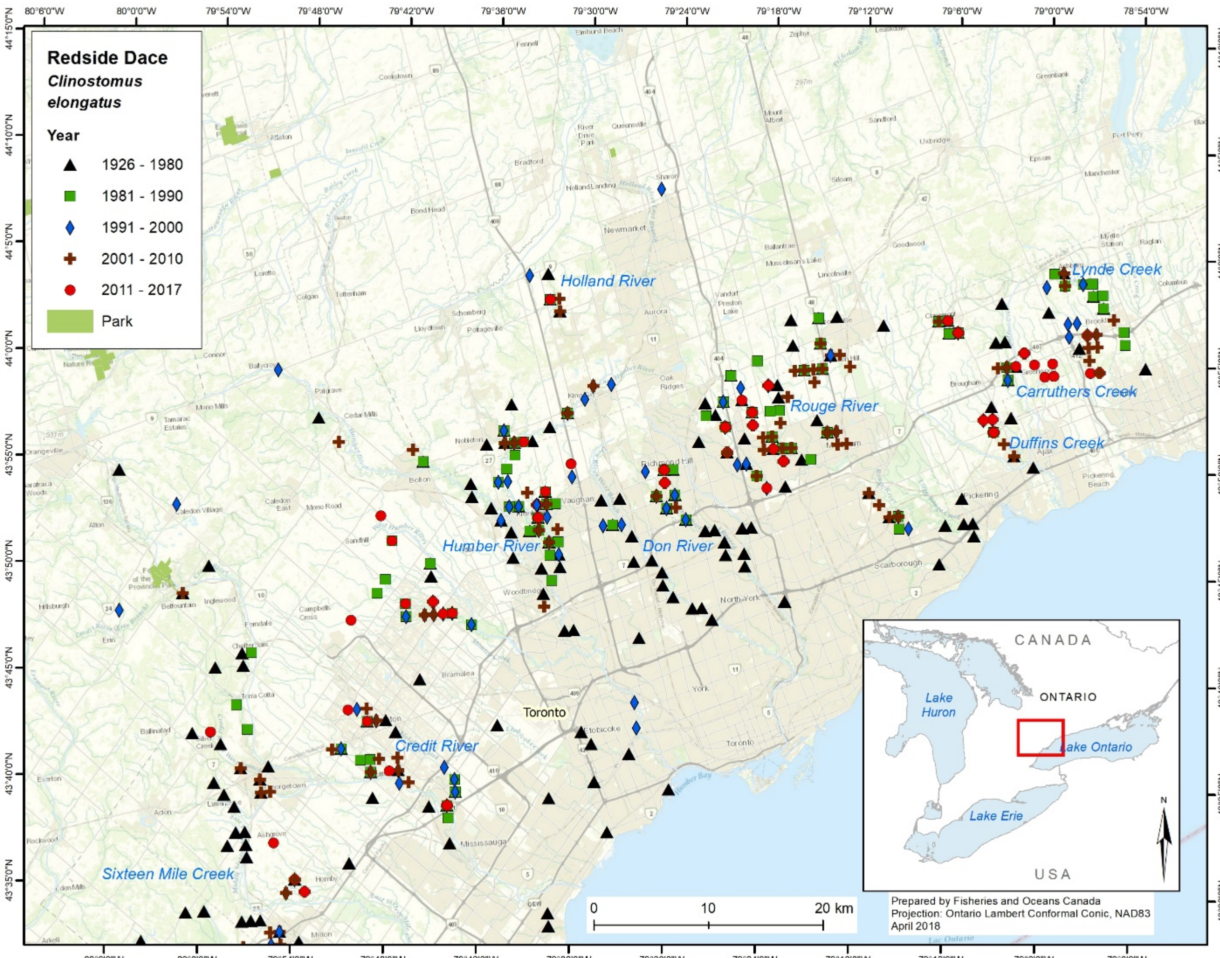

Figure 2. Redside Dace distribution in the eastern portion of the Greater Toronto Area.

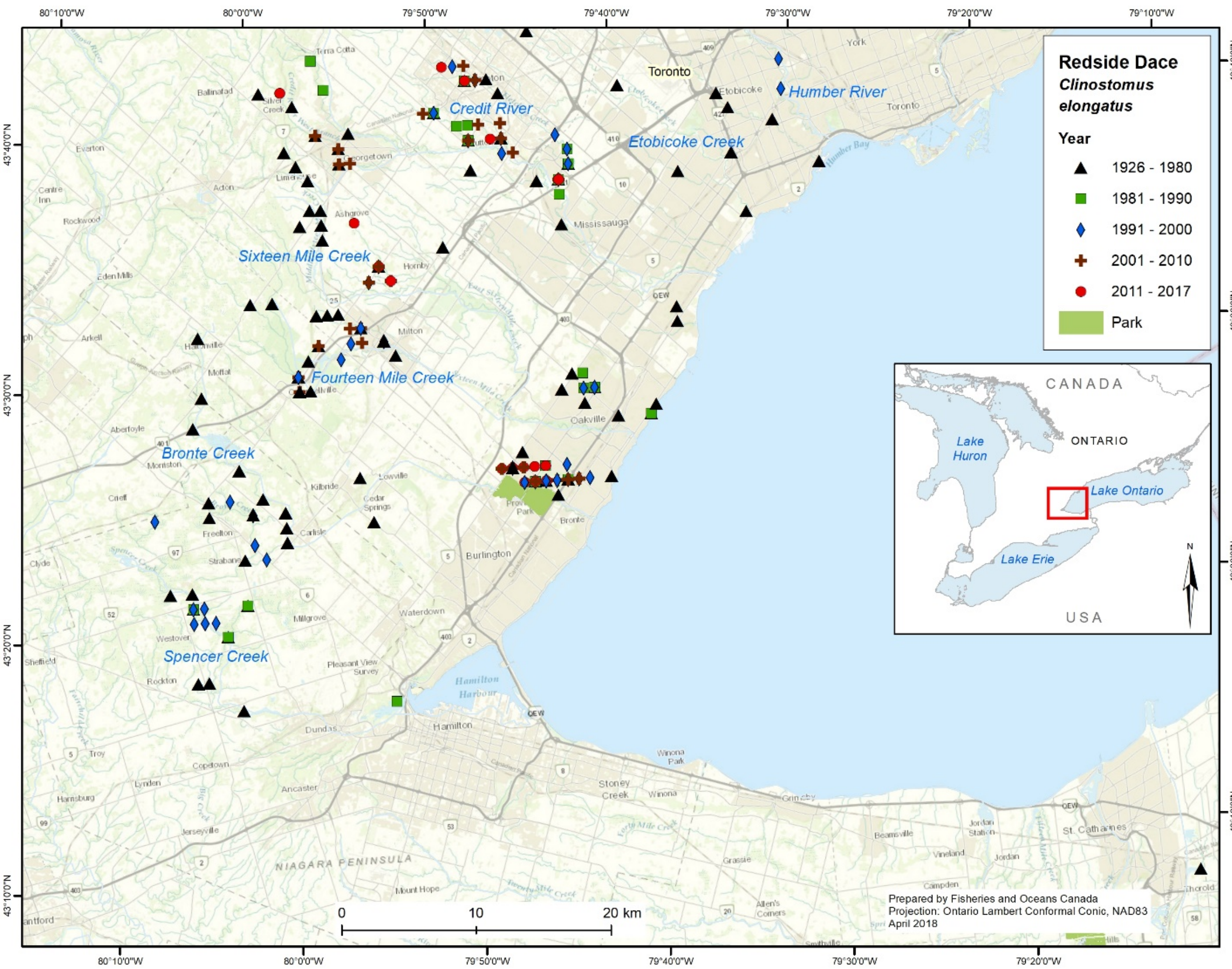

Figure 3. Redside Dace distribution in the western portion of the Greater Toronto Area.

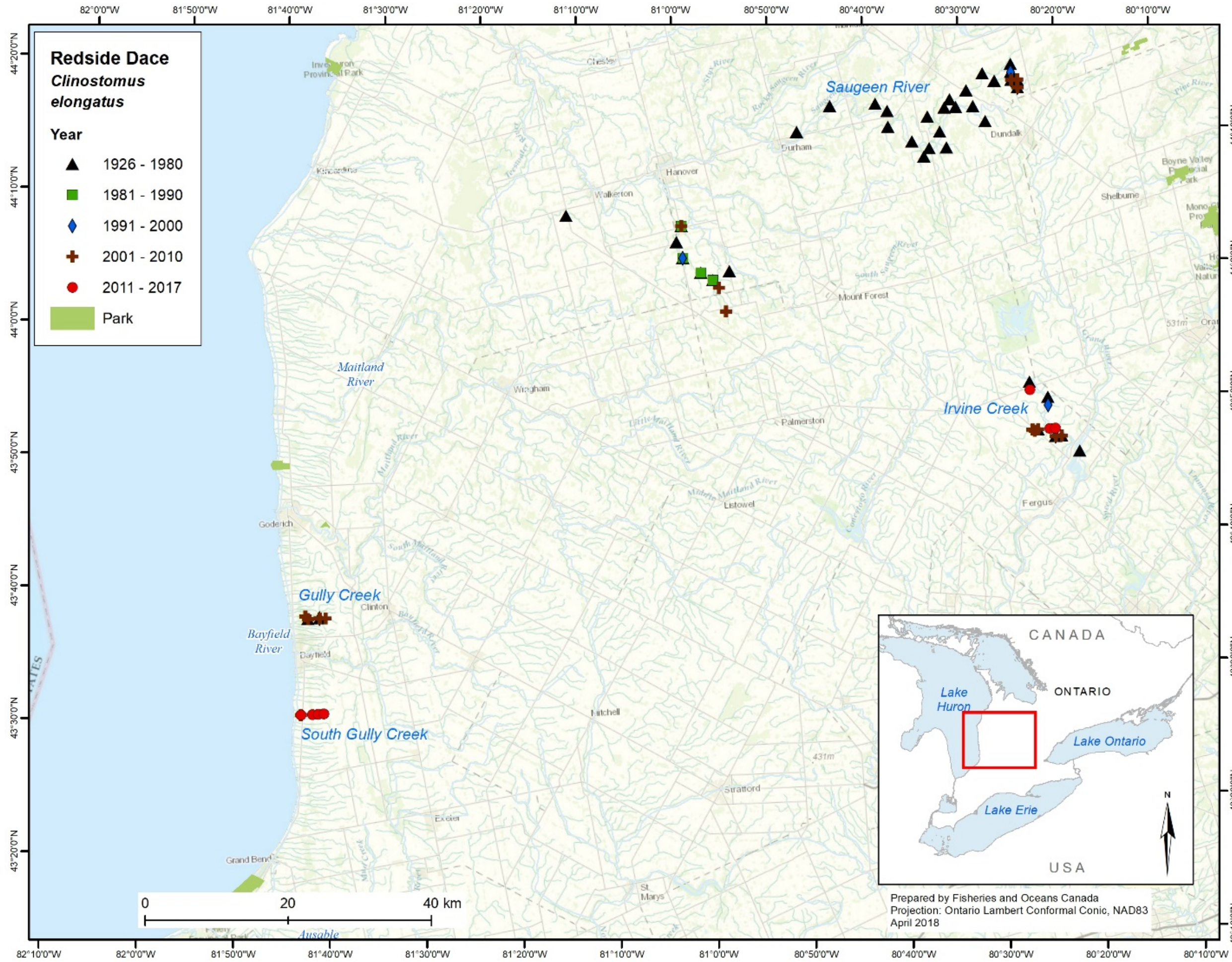

Figure 4. Redside Dace distribution in the Saugeen River, Irvine, Gully and South Gully creeks.

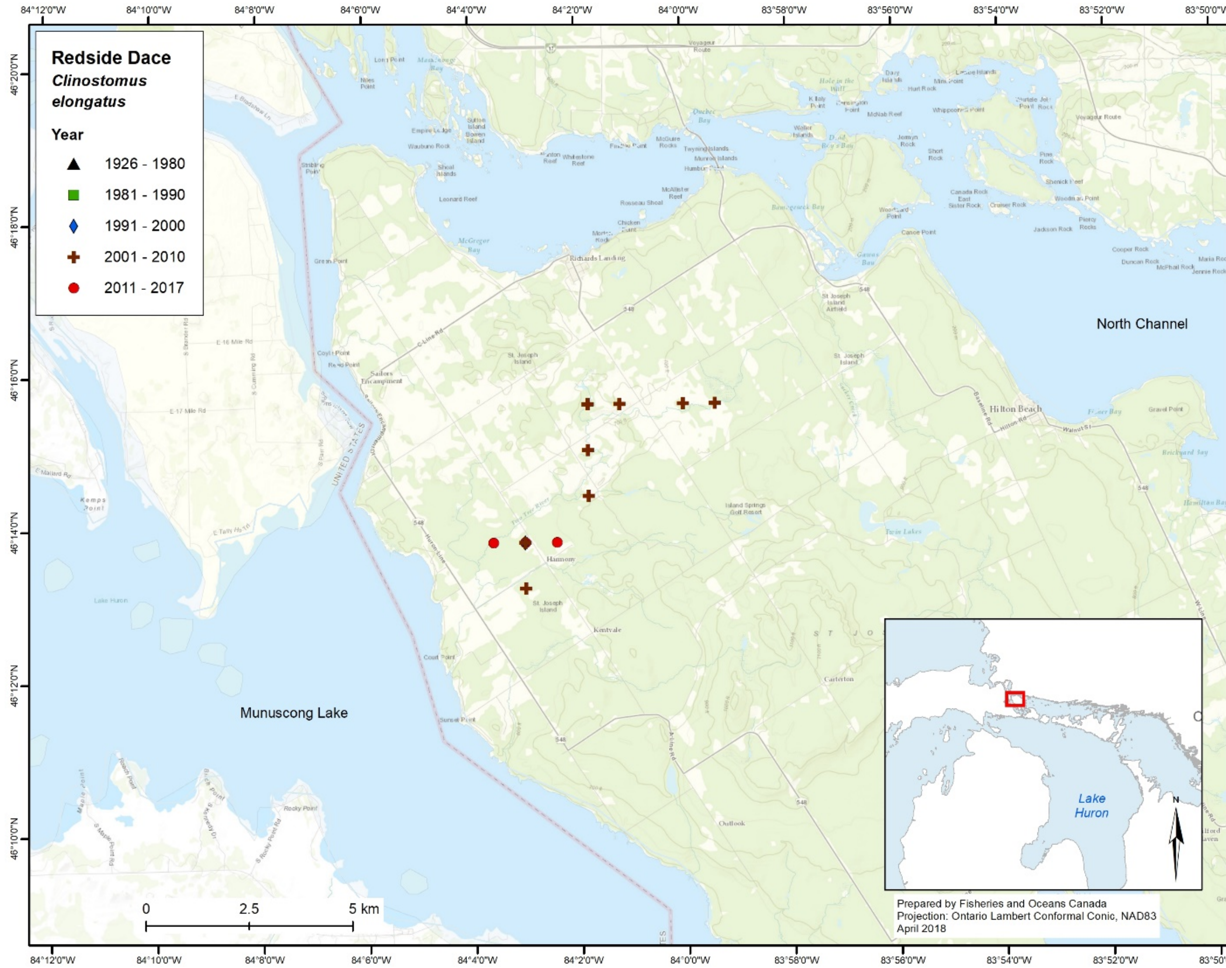

Figure 5. Redside Dace distribution within St. Joseph Island (Two Tree River).

Table 1. Trends in Canadian populations of Redside Dace. Information updated from COSEWIC (2017) as well as from discussion among participants at the Redside Dace RPA meeting. Streams are listed from east to west for each drainage.

Drainage and Stream	Trend in range				Comments
	Increase	Stable	Decline	Extirpated	
Lake Ontario					
Pringle Creek				X	Last seen in 1959.
Lynde Creek			X		Recent surveys of 20 sites between 2015-2017 failed to detect Redside Dace.
Carruthers Creek		X			Presumed stable.
Duffins Creek			X	X?	May be extirpated from Urfe Creek (last seen in 1954), and both Reesor Creek (last seen in 1979) and main stem (last seen in 1979).
Petticoat Creek				X	Last seen in 1954.
Highland Creek				X	Last seen in 1952.
Rouge River		X	X		Range reduction in upper-Rouge River and Morningside Creek. Stable in Berczy and Bruce creeks.
Don River				X?	May be extirpated as repeated sampling by OMNRF in 2017 failed to detect any individuals.
Humber River		X	X		Stable in west branch. Declining in east branch.
Mimico Creek				X	Last seen in 1949.
Etobicoke Creek				X	Last seen in 1935.
“Clarkson Creek”				X	Last seen in 1927.
Credit River		X	X	X	Extirpated from Levi's Creek, Roger's Creek, Caledon Creek. Stable in Silver and Springbrook creeks. Declining in Fletcher's and Huttonville creeks.
Morrison Creek				X	Presumed to be extirpated (last seen in 2000).
Sixteen Mile Creek			X		Range reduction in West and Upper West Branch.
Fourteen Mile Creek			X		Range reduction, last observed downstream of the QEW in 2001 despite recent surveys.
Bronte Creek			X	X?	May be extirpated from main stem (last seen in 1998) and Mountsberg Creek (last seen in 1979).
Wedgewood Creek				X	Last seen in 1957.
Spencer Creek				X?	May be extirpated from Spencer Creek (last seen in 1998) and Flamborough Creek (last seen in 1984).
Niagara Peninsula				X	Last seen in 1960.
Lake Simcoe					
Holland River			X	X?	Range reduction in Kettleby Creek and may be extirpated from Sharon Creek (last seen in 1994).
Lake Erie					
Irvine Creek				X?	May be extirpated as no individuals were found at seven sites in 2016.

Drainage and Stream	Trend in range				Comments
	Increase	Stable	Decline	Extirpated	
Lake Huron					
Gully Creek		X			Presumed stable.
Saugeen River			X		Range reduction in Meux Creek.
South Gully Creek		X?			Presumed stable. Discovered in 2008.
Two Tree River		X			Presumed stable.

ABUNDANCE

Mark-recapture sampling was used to derive abundance estimates of Redside Dace in southern Ontario streams (Lake Huron drainage: Gully Creek; Lake Ontario drainage: Humber River, Don River, Rouge River, and Duffins Creek; Poos et al. 2012). At local scales, mean population estimates in pools varied substantially, where Gully Creek was the lowest (13.5 individuals per pool ± 5.09) and the Don River was the highest (99.2 individuals per pool ± 18.1) (Table 2; Poos et al. 2012). The distribution of Redside Dace also varied with high localization in Don River (found in two of 27 pools) but widespread among sampled reaches in Gully Creek (found in nine of 10 pools).

Table 2. Summary of sampling data for Redside Dace (RSD) at various catchments across its Canadian range. Reproduced from Poos et al. (2012).

Catchment	Distance sampled (m)	Pools with RSD (pools sampled)	Probability of capture (p_{reach})	Density (individuals m^{-1})	Mean population estimate per pool (± 95% CI)	Relative abundance (range)
Gully Creek	491	9 (10)	0.584	0.247	13.5 ± 5.09	19.6% (2-44%)
Humber River	426	4 (10)	0.612	0.289	30.3 ± 6.3	13.8% (4-25%)
Don River	678	2 (27)	0.785	0.277	99.2 ± 18.1	16.5% (15-18%)
Rouge River Leslie Trib.	2625	15 (30)	0.751	0.118	20.3 ± 5.8	12.9% (5-21%)
Rouge River Berczy Creek	600	4 (13)	0.718	0.135	22.7 ± 5.6	10.6% (1-19%)
Duffins Creek	2105	5 (10)	0.608	0.081	36.7 ± 12.3	29.8% (5-38%)

CURRENT STATUS

Sampling has been adequate in most watersheds to qualitatively identify trends in Redside Dace abundance. Many historical records from 1946 to 1959 were a result of extensive surveys by the Ontario Department of Planning and Development (ODPD) using seine nets and traps. Since 1979, targeted surveys have been conducted at new and historical sites by various agencies including the Ontario Ministry of Natural Resources and Forestry (OMNRF), Royal Ontario Museum (ROM), various conservation authorities, DFO, and Ontario Streams to evaluate the distribution and abundance of Redside Dace in Ontario. There are a total of 1,128 historic and current records of Redside Dace in Canada.

LAKE ONTARIO DRAINAGE

Pringle Creek: Redside Dace has not been collected from Pringle Creek since 1959, despite sampling attempts in 1985 and 1999. It is presumed to be extirpated from this tributary (COSEWIC 2017).

Lynde Creek: Redside Dace was first reported in Lynde Creek in 1959 when it was captured at five sites in the upper half of the east and west branches. However, intensive sampling in 1999 and 2001 detected Redside Dace at only one of the five historical sites (COSEWIC 2007). More recent surveys in 2009 and 2014 captured seven Redside Dace at a new site in the lower west branch (J. McNeice, York Region, pers. comm.) and four Redside Dace at a historical site where 13 individuals were caught in 2001 (Andersen 2002, COSEWIC 2017). Despite being found at new sites in the west branch at that time, the Redside Dace population underwent a range contraction in the east branch (COSEWIC 2007). In July of 2014 a major fish kill was observed in the west branch of the creek as a result of an agricultural spill (COSEWIC 2017). The spill, which was a combination of manure and a dairy cleaning agent, occurred just upstream of Watson's Glen Golf Course leading to a reduction of pH and dissolved oxygen for a 21 km-long portion of the stream [S. Reid, OMNRF, pers. comm.; D. Moore, Central Lake Ontario Conservation Authority (CLOCA), pers. comm. *in* COSEWIC 2017]. No dead Redside Dace were recovered but it was assumed that the majority of fish in the affected area were killed (COSEWIC 2017). Recent electrofishing surveys from 2014 to 2017 failed to detect any Redside Dace at 20 sites in Lynde Creek (COSEWIC 2017).

Carruthers Creek: Redside Dace was first reported in Carruthers Creek in 1978 and was subsequently caught at two sites 10 km upstream in 2001 (COSEWIC 2007). Redside Dace continues to be found at new sites in relatively high numbers throughout Carruthers Creek. For example, extensive sampling from 2009-2015 resulted in the capture of 159 Redside Dace at five new sites and one historical site. At one of these sites a total of 56 specimens were caught in 2014. More recently, seven specimens were collected in 2016 at site upstream of Highway 7 (COSEWIC 2017).

Duffins Creek: Redside Dace has been recently collected in three tributaries of Duffins Creek: Mitchell Creek (2012), Brougham Creek (2009), and Ganatsekiagon Creek (2015). A total of 58 individuals were caught at two sites in Mitchell Creek during four sampling events from 2012-2015. In addition, sampling in 2015 yielded a total of 46 specimens at six sites throughout Ganatsekiagon Creek (COSEWIC 2017). Despite being found at new sites, Redside Dace has not been reported from the main channel of Duffins Creek and two other tributaries (Reesor Creek and Urfe Creek) since 1979 and 1954 respectively. As a result, it is presumed extirpated from these parts of Duffins Creek (COSEWIC 2007). The Redside Dace population in Duffins Creek is believed to range from 1,207 to 2,398 individuals (Poos et al. 2012), which is below the minimum viable population (MVP; 18,226–74,687 individuals depending on meta-population structure and a 15% chance of catastrophic decline) estimated by van der Lee et al. (2020). Based on current estimates, it is predicted that the development of a major airport in Pickering in the future may be detrimental to this population.

Petticoat Creek: Redside Dace has not been reported from Petticoat Creek since 1954, despite sampling attempts in 1975, 2003, 2005, 2010, 2013, and 2016 (COSEWIC 2017). The lack of reports of Redside Dace over a 60-year period suggests that it is extirpated from Petticoat Creek (COSEWIC 2017).

Highland Creek: Redside Dace has not been collected from Highland Creek since 1952, despite five sampling attempts in recent years (2008, 2010, 2011, 2014, and 2015) and is presumed to be extirpated from this system (COSEWIC 2017).

Rouge River: Recent sampling (2006-2014) has continued to detect Redside Dace throughout the Rouge River in relatively high numbers. For example, in 2007 a total of 26 individuals were recorded from six different sites (OMNRF unpublished data). Redside Dace has also recently been collected from a tributary of the Rouge River at new sites in Bruce Creek (2012) and its tributary Berczy Creek (2014). Sampling from 2007 to 2015 captured 98 Redside Dace during 15 different sampling events throughout Berczy Creek and one Redside Dace was captured at a new site in upper Bruce Creek. Although Redside Dace was still present in Morningside Creek in 2009, extensive sampling in 2011 at four new sites failed to detect any Redside Dace (D. Lawrie, TRCA, pers. comm.). Based on probability of capture, Poos et al. (2012) estimated the basin-wide population in the Rouge River to be between 4,499 to 9,180 individuals, which is below the minimum viable population (18,226–74,687 individuals depending on meta-population structure and a 15% chance of catastrophic decline) estimated by van der Lee et al. (2020).

Don River: Redside Dace has undergone a dramatic range contraction in both the east and west branches of the Don River (COSEWIC 2007). In 1949, it was widespread throughout the upper half of both branches where it was found at 23 sites. However, recent extensive sampling has yielded both a decrease in the number of individuals captured and the number of sites they have been recorded from. Despite considerable sampling attempts, Redside Dace has not been captured from the Don River west branch since 1998 and is believed to no longer occupy this reach (COSEWIC 2017). Poos et al. (2012) estimated the population size in the Don River to be between 402 to 1,607 individuals, which is below the minimum viable population (18,226 – 74,687 individuals depending on meta-population structure and a 15% chance of catastrophic decline) estimated by van der Lee et al. (2020). Recent sampling by the OMNRF in October 2017 yielded no Redside Dace from the two pools where Poos et al. (2012) captured large numbers in 2008 (S. Reid, OMNRF, pers. comm.), which suggests that Redside Dace may be extirpated from the Don River.

Humber River: Redside Dace was first reported in the East Humber River in 1937. Since then, the species has also been detected in the main and West Humber branches (COSEWIC 2007). In the 1980s it was more widespread in the West Humber but the species can still be found in both east and west branches. Recent sampling efforts (2010-2015) have yielded 64 Redside Dace during eight of 10 sampling attempts at nine sites in the West Humber River and five Redside Dace from two of five attempts at five sites in East Humber River from 2010 to 2014 (D. Lawrie, TRCA, pers. comm.). The basin-wide population estimates for Reside Dace in the Humber River is much higher than the MVP estimated by van der Lee et al. (2020) (18,226–74,687 individuals depending on meta-population structure and a 15% chance of catastrophic decline), ranging from 21,530 to 38,582 individuals (Poos et al. 2012).

Mimico Creek: Redside Dace has not been collected from Mimico Creek since 1949 despite several sampling attempts and is presumed extirpated (COSEWIC 2017).

Etobicoke Creek: Despite considerable effort, surveys in the lower half of Etobicoke Creek have failed to detect Redside Dace since 1935. It is likely extirpated from this creek (COSEWIC 2017).

Clarkson Creek: Redside Dace has not been collected in the creeks near the town of Clarkson, Ontario since 1927. Multiple sampling attempts in Sheridan and Turtle creeks from 1985 to 2004 have failed to capture any Redside Dace (COSEWIC 2007). It is presumed that Redside Dace has been extirpated from this system (COSEWIC 2017).

Credit River: Redside Dace has been documented from the main branch of the Credit River and several of its tributaries: Roger's Creek, Silver Creek and three of its tributaries (Black, Nichols and Snows creeks), Caledon Creek, Huttonville Creek, Fletcher's Creek, Levi's Creek and more recently Springbrook Creek. Repeated sampling has yielded no Redside Dace in Levi's Creek since 1954 and Redside Dace is presumed extirpated from this tributary. It has also not been collected in Roger's or Caledon creeks since 1988 and 1995, respectively. Although it has undergone a reduction in range in the Credit River system, Redside Dace has recently been observed at sites in Silver Creek (2014 and 2016), Fletcher's Creek (2014), Springbrook Creek (2011) and Huttonville Creek (2008). More specifically, over 50 individuals have been spotted annually at a new site in Silver Creek since 2014 [M. Heaton, OMNRF and J. Clayton, Credit Valley Conservation Authority (CVCA), pers. comm. 2017], 17 Redside Dace were captured in Springbrook Creek in 2011 (J. Clayton, CVCA, pers. comm.), one individual was observed in Huttonville Creek at a new site in 2008 (M. Heaton, OMNRF, pers. comm.), and Redside Dace were visually observed at two sites in Fletcher's Creek in 2014 (J. Clayton, CVCA, pers. comm.).

Morrison Creek: Redside Dace was widespread in both branches of Morrison Creek in 1954; however, extensive sampling from 2000-2003 failed to detect the species at five historical sites. Two specimens were found at a new site in 2000, which was the last collection for this creek. Surveys conducted by OMNRF in 2015 and 2016 failed to detect live specimens despite a single positive eDNA detection from the east branch of Morrison Creek in 2015 (Reid et al. 2017, COSEWIC 2017). Redside Dace has likely been extirpated from this tributary.

Sixteen Mile Creek: Redside Dace was widespread in the upper half of all three branches of Middle Sixteen Mile Creek; however, sampling from 1995-2003 failed to detect Redside Dace at the most upstream sites of all three branches (COSEWIC 2007). Despite this apparent range contraction, Redside Dace continues to be found at historical sites in relatively high numbers. For example, a total of 354 Redside Dace were recorded from 2008 to 2015 during 11 sampling events across seven stations in the West, Upper West, and Middle East branches [A. Dunn, Halton Region Conservation Authority (HRCA), pers. comm.]. One of these sites yielded 48 individuals in 2015 compared to two individuals in 1973 (A. Dunn, HRCA, pers. comm.). Despite ongoing occurence in some locations, range reductions in the Upper West and West Branch are evident.

Fourteen Mile Creek: Sampling attempts in 1985 detected Redside Dace at only one of three historical sites (COSEWIC 2007). However, more recent sampling from 2010 to 2016 yielded significant numbers of Redside Dace. For example, 582 individuals were caught at 14 sites in 2012 which indicates a healthy population persists in Fourteen Mile Creek (COSEWIC 2017).

Bronte Creek: Redside Dace was detected at six sites in the main branch of Bronte Creek and at five sites in Mountsberg Creek, a tributary of Bronte Creek, in the 1970s. Extensive sampling from 1995-2000 at seven of these 11 sites yielded only one Redside Dace in the main branch. Redside Dace has not been collected from Bronte Creek since 1998 despite extensive survey efforts since 2008 (COSEWIC 2017).

Wedgewood Creek: At least one Redside Dace was captured near Lakeshore Road in 1957 (A. Dunn, HRCA, pers. comm.). This is the only record from this creek and the species is presumed extirpated.

Spencer Creek: In the 1970s, Redside Dace was widespread in the upper half of Spencer Creek and one of its tributaries, Flamborough Creek. However, extensive sampling at historical sites between 1997 and 2001 detected only a single individual suggesting a population decline (COSEWIC 2007). Despite several sampling attempts, it has not been collected from Spencer Creek since 1998 and Flamborough Creek since 1984.

Niagara Peninsula: Redside Dace was last observed from a stream in the Niagara Peninsula in the 1960s and is presumed to be extirpated (COSEWIC 2017). This stream was located on an island in the Welland Canal near Lock 7 that no longer exists [Nick Mandrak, University of Toronto at Scarborough Campus (UTSC), pers. comm.].

LAKE SIMCOE DRAINAGE

Holland River: Redside Dace was captured from three sites on Kettleby Creek (Holland River tributary) from 1976 to 1980. It was also recorded from one site in another Holland River tributary, Sharon Creek, in 1994, as well as from Four Hundred Creek, a tributary of the South Holland Canal, in 1991. Extensive sampling from 1988 to 2003 in both Kettleby Creek and Sharon Creek yielded only a single specimen from one site on Kettleby Creek (COSEWIC 2007). Sampling in 2006 yielded 10 Redside Dace from one site; however, Redside Dace was absent from five other sites sampled in 2011 and 2013. From 2012-2013, 35 individuals were collected for a genetic variation study by Serrao (2016). Although Redside Dace eDNA was detected in Kettleby Creek in 2014 (OMNRF unpublished data), it is unknown whether this tributary still supports a population.

LAKE ERIE DRAINAGE

Irvine Creek: In the Grand River watershed, Redside Dace was widely distributed in Irvine Creek in the 1970s (COSEWIC 2007). Extensive sampling from 1997-2005 in Irvine Creek failed to yield Redside Dace from three of the five historical sites (COSEWIC 2007). Although relatively high numbers were caught at three new sites from 2001 to 2003, sampling in 2003 yielded just two specimens at a site where 25 Redside Dace were captured in 2001. Recent surveys at seven historical sites in 2016 failed to detect Redside Dace (R. Castaneda, UTSC, pers. comm.), which suggests Redside Dace may be extirpated from Irvine Creek.

LAKE HURON DRAINAGE

Gully Creek: A total of 312 individuals were captured at two historical sites and a new site during 10 sampling events in Gully Creek from 2001 to 2010. At one of these sites, five repeated bag seine hauls conducted by DFO in 2007 yielded a total of 282 specimens. This high-localized abundance may have been due to low water levels in 2007 (COSEWIC 2017), which concentrated the species at the capture site. Poos et al. (2012) estimated the Gully Creek population to be between 462-741 individuals, which is well below the MVP estimated by van der Lee et al. (2020) (18,226–74,687 individuals depending on meta-population structure and a 15% chance of catastrophic decline).

Saugeen River: The abundance of Redside Dace in Meux Creek was relatively high in 1985 with over 100 individuals caught at four sites. However, extensive sampling in 2004 resulted in the capture of a single individual. Failed attempts to capture Redside Dace in the South Saugeen River, most of the upper Saugeen River, and in Meux Creek suggest that its range has declined dramatically in the Saugeen River system since the 1960s (COSEWIC 2007). Since 2000, only 20 individuals have been captured from the 26 historical sites. Ten new sites have been identified since 2000 (three in Meux Creek and seven in the Upper Saugeen River) where at least 34 individuals have been captured.

South Gully Creek: Redside Dace was first reported from South Gully Creek in 2008 when a single individual was caught from a minnow trap. In 2011, six specimens were found at the initial capture site and an additional 36 were found at three additional sites (K. Jean, Ausable Bayfield Conservation Authority, pers. comm.). Additional sampling at one site in 2016 captured 60 Redside Dace (COSEWIC 2017).

Two Tree River: A total of four individuals were captured during two of four sampling events at Two Tree River in 1997 and 2002 (COSEWIC 2007). More recent sampling attempts from 2009 to 2015 yielded 232 Redside Dace from 22 new sites throughout Two Tree River suggesting a healthy population of Redside Dace exists throughout the system (COSEWIC 2017).

POPULATION ASSESSMENT

To assess the population status of Redside Dace in Ontario, each population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory) (Table 3). The Relative Abundance Index was assigned as Extirpated, Low, Medium, High, or Unknown. The Population Trajectory was assessed as Decreasing, Stable, Increasing, or Unknown for each population based on the best available information about the current trajectory of the population. Trends over time were classified as Increasing (an increase in abundance over time), Decreasing (a decrease in abundance over time), and Stable (no change in abundance over time). If insufficient information was available to identify the trajectory, the Population Trajectory was listed as Unknown. Certainty has been associated with the Relative Abundance Index and Population Trajectory rankings and is listed as: 1 = quantitative analysis; 2 = catch per unit effort (CPUE) or standardized sampling; 3 = expert opinion.

Table 3. Relative Abundance Index and Population Trajectory of Redside Dace populations in Ontario. Certainty has been defined as: 1 = quantitative analysis; 2 = CPUE or standardized sampling; 3 = expert opinion.

Population	Relative Abundance Index	Certainty	Population Trajectory	Certainty
Lake Ontario				
• Pringle Creek	Extirpated	3	-	-
• Lynde Creek	Low	2	Decreasing	2
• Carruthers Creek	Medium	2	Stable	2
• Duffins Creek	Medium	2	Decreasing	2
• Petticoat Creek	Extirpated	3	-	-
• Highland Creek	Extirpated	3	-	-
• Rouge River	Medium	2	Decreasing	2
• Don River	Low	2	Decreasing	2
• Humber River	High	2	Decreasing	2
• Mimico Creek	Extirpated	3	-	-
• Etobicoke Creek	Extirpated	3	-	-
• “Clarkson Creek”	Extirpated	3	-	-
• Credit River	Low	2	Decreasing	2
• Morrison Creek	Extirpated	2	-	2
• Sixteen Mile Creek	Medium	2	Decreasing	2
• Fourteen Mile Creek	High	2	Decreasing	2
• Bronte Creek	Low	2	Decreasing	3
• Wedgewood Creek	Extirpated	3	-	-
• Spencer Creek	Low	2	Decreasing	2
• Niagara Peninsula	Extirpated	3	-	-
Lake Simcoe				
• Holland River	Low	2	Decreasing	2
Lake Erie				
• Irvine Creek	Low	2	Decreasing	2
Lake Huron				
• Gully Creek	Low	2	Stable	2
• Saugeen River	Low	2	Decreasing	2
• South Gully Creek	Unknown	3	Unknown	3
• Two Tree River	Medium	2	Stable	2

The Relative Abundance Index and Population Trajectory values were then combined in the Population Status matrix (Table 4) to determine the Population Status for each population. Each Population Status is subsequently ranked as Poor, Fair, Good, Unknown, or Not applicable (Table 5). Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index or Population Trajectory).

Table 4. The Population Status Matrix combines the Relative Abundance Index and Population Trajectory rankings to establish the Population Status for Redside Dace populations in Ontario. The resulting Population Status has been categorized as Extirpated, Poor, Fair, Good, or Unknown.

		Population Trajectory			
		Increasing	Stable	Decreasing	Unknown
Relative Abundance	Low	Poor	Poor	Poor	Poor
	Medium	Fair	Fair	Poor	Poor
	High	Good	Good	Fair	Fair
	Unknown	Unknown	Unknown	Unknown	Unknown
	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated

Table 5. Population Status for Redside Dace populations in Ontario resulting from an analysis of both the Relative Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index or Population Trajectory).

Population	Population Status	Certainty
Pringle Creek	Extirpated	3
Lynde Creek	Poor	2
Carruthers Creek	Fair	2
Duffins Creek	Poor	2
Petticoat Creek	Extirpated	3
Highland Creek	Extirpated	3
Rouge River	Poor	2
Don River	Poor	2
Humber River	Fair	2
Mimico Creek	Extirpated	3
Etobicoke Creek	Extirpated	3
Clarkson Creek	Extirpated	3
Credit River	Poor	2
Morrison Creek	Extirpated	2
Sixteen Mile Creek	Poor	2
Fourteen Mile Creek	Fair	2
Bronte Creek	Poor	3
Wedgewood Creek	Extirpated	3
Spencer Creek	Poor	2
Niagara area stream	Extirpated	3
Holland River	Poor	2
Irvine Creek	Poor	3
Gully Creek	Poor	2
Saugeen River	Poor	2
South Gully Creek	Unknown	3
Two Tree River	Fair	2

LIFE HISTORY PARAMETERS

Fecundity estimates from several studies indicate that females can lay between 409 to 1,971 eggs per spawning period depending on the individual's body size (Koster 1939, McKee and

Parker 1982, Becker 1983). In addition, examination of gonads from individuals collected in Ontario in mid-May and the late summer indicated that all 1 year old fish were immature while most 2 year old fish and all 3 year olds were mature (McKee and Parker 1982). These observations suggest that some Redside Dace may spawn at age 2, but the majority spawn at 3 years of age (McKee and Parker 1982). Individuals grow quickly and achieve approximately 50% of their total growth in the first year (McKee and Parker 1982). It is also a relatively short-lived species reaching a maximum age of 5 years (COSEWIC 2017). The generation time of Redside Dace is estimated at 2-3 years (COSEWIC 2017).

HABITAT AND RESIDENCE REQUIREMENTS

Redside Dace inhabits slow-moving sections of relatively small headwater streams containing both pool and riffle habitats and with moderate to high gradient (McKee and Parker 1982, Meade et al. 1986, Goforth 2000, Andersen 2002). It has been captured over substrates of boulders, gravel, sand, clay, silt, mud, and detritus (McKee and Parker 1982), but is most often associated with gravel (Becker 1983, Holm and Crossman 1986, COSEWIC 2007). Redside Dace seek overhanging riparian vegetation such as grasses, forbs, and small shrubs, as well as undercut banks and in-stream structures such as boulders and large woody debris, as a source of cover and food (Daniels and Wisniewski 1994, Novinger and Coon 2000, COSEWIC 2017). An important feature of Redside Dace habitat is the meander belt, which is defined as the land area on either side of a watercourse representing the furthest potential limit of channel migration (RDRT 2010). The headwaters of streams and presence of a meander belt (including the riparian zone) help maintain riffle-pool morphology and suitable baseflow, and provide coarse sediment for spawning, cover, and terrestrial insects for feeding (RDRT 2010). For these reasons, the OMNRF recommend a minimum of 30 m of vegetated area adjacent to the stream's meander belt to ensure that riparian habitat can provide these ecosystem functions to support Redside Dace populations (RDRT 2010).

Redside Dace spawns around May when water temperatures reach 18 °C in riffle areas with gravel substrate (Koster 1939, McKee and Parker 1982, Goforth 2000). Parish (2004) found that the majority substrate particle size at Redside Dace riffle sites was less than 6 cm. The species has commonly been observed spawning in or near the nests of Creek Chub (*Semotilus atromaculatus*) and Common Shiner (*Luxilus cornutus*) (Scott and Crossman 1973). The guarding behaviour of the Creek Chub and Common Shiner are presumed to keep the nest free of silt and protect the eggs from predation (Koster 1939, RDRT 2010). Drake and Poesch (2020) reported that catch per unit effort of Creek Chub, Common Shiner and White Sucker (*Catostomus commersoni*) were important factors influencing movements of Redside Dace between stream reaches as were habitat variables such as stream depth, volume, width, and distance to a reach.

FUNCTIONS, FEATURES AND ATTRIBUTES

Essential functions, features, and attributes associated with Redside Dace habitat have been described to guide the future identification of critical habitat for this species (Table 6). The habitat required for each life stage has been assigned a function that corresponds to a biological requirement of Redside Dace (e.g., spawning, nursery). In addition to the habitat function, a feature has been assigned to each life stage, considered as the structural component of the habitat necessary to complete the function and for the survival or recovery of the species. Habitat attributes have also been provided, which describe how the features support the function for each life stage. Optimal habitat attributes from the literature for each life stage have been combined with habitat attributes from current records (recorded from 1996 to present) to show the range of habitat attributes within which Redside Dace may be found (see Table 6 and references therein). It should be noted that habitat attributes associated with current records may differ from those presented in the scientific literature as Redside Dace may be currently occupying areas where optimal habitat is no longer available.

Table 6. Summary of the essential functions, features, and attributes for each life stage of Redside Dace. Habitat attributes from published literature and those measured during recent Redside Dace surveys (recorded since 1996) have been combined to derive the habitat attributes required for the delineation of critical habitat (see text for a detailed description of categories).

			Habitat Attributes		
Life Stage	**Function**	**Features**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
Spawn to Hatch (usually May)	Spawning Cover Nursery	Reaches of streams containing both pool and riffle habitats	• Spawning observed in late May in New York when water temperatures reach 18 °C (Koster 1939) • Captured in pre-spawning condition in early May in East Humber at temperatures of 16 – 19 °C (McKee and Parker 1982) • Observed spawning in gravel nests of Creek Chub and Common Shiner in New York (Koster 1939) • The majority of occupied riffle sites had substrate particles less than 6 cm (Parish 2004)	• Redside Dace observed in riffle habitat in Fletcher's Creek in May 2014. Likely spawning with Creek Chub, Blacknose Dace (*Rhinicthys atratulus*), and Common Shiner (OMNRF unpublished data) • Nesting activities of Redside Dace were filmed in 2001 at Fourteen Mile Creek with Common Shiner (DFO unpublished data) • Multiple individuals photographed and filmed in early May from 2014 – 2018 in Silver Creek along with spawning Creek Chub, Common Shiner, and Blacknose Dace (J. Clayton, CVCA, pers. comm.)	• Riffle areas with gravel substrates (<60 mm) • Presence of Creek Chub or Common Shiner (Redside Dace typically spawn over nests constructed by these species) • Late spring water temperatures 16-18 °C (spawning activities initiate when these temperatures are reached; COSEWIC 2017)
YOY	Feeding Cover Nursery	Same as above	• Unknown	• YOY have been caught in similar habitats as adults (DFO unpublished data)	• Same as adult
Juvenile (age 1 until sexual maturity)	Feeding Cover	Same as above	• Unknown	• Juveniles have been caught in similar habitats as adults (OMNRF unpublished data)	• Same as adult

Adult	Feeding Cover Winter refugia	Same as above	• Prefers clear water but has been found in streams with moderate turbidity (Holm and Crossman 1986) • Prefers temperatures of less than 24 °C and dissolved oxygen levels of at least 7 mg/L (McKee and Parker 1982) • Substrates vary from silt to boulder but often associated with gravel (McKee and Parker 1982, Becker 1983, Holm and Crossman 1986) • Typically found in streams with open meadows, pasture, or shrub overstory (Andersen 2002, Parish 2004) • Found in smaller stream segments ranging from 1 – 10 m in width and at depths ranging from 0.1 – 2.0 m (McKee and Parker 1982, Becker 1983) • Captured at stream discharges from 0.01 – 1.6 m^3/s in New York (Unpublished data from Coon in COSEWIC 2007) • An overwintering site in the West Humber River had instream vegetation providing refuge. Turbidity at this site ranged from 1.23 – 3.65 NTU when the species was present. Dissolved oxygen at this site ranged from 12.22 – 12.48 mg/L (Davis 2016) • Streams with healthy populations of Redside Dace had greater contributions of groundwater and more stabilized flow conditions (Reid and Parna 2017)	• Average stream depth was 1.2 m (n = 11; range: 0.3 – 2 m; OMNRF unpublished data) • Average pool width = 6.3 m (n = 8; range:1 – 13 m; OMNRF unpublished data) • Average dissolved oxygen = 8.79 mg/L (n=14; range: 7 – 10.71 mg/L; OMNRF unpublished data) • Median values for substrate percent composition from 20 sites: Detritus (5), Clay (10), Silt (11), Sand (25), Gravel (22), Rock (20), Boulder (10), Rubble (10) (DFO unpublished data)	• Undercut banks and in-stream structure such as boulders and large woody debris (cover for Redside Dace) • Summer wetted stream range from 1 – 10 m in width and 0.1 – 2 m in depth • Substrates include boulders, cobble/rock, sand, clay, silt, mud, gravel and detritus. However, Redside Dace are most often associated with gravel • Relatively clear waters (preference for clear waters but sometimes occur in moderate turbidity) • Summer water temperatures < 24 °C and dissolved oxygen levels > 7 mg/L • Deep pools (> 1.0 m depth) with little current (important as refugia for overwintering) • Adequate supply of overwinter prey species (aquatic insect larvae) • Streams with high contributions of groundwater and more stabilized flow conditions

			Habitat Attributes		
Life Stage	**Function**	**Features**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
All life stages	Feeding Cover Maintenance of water quality	Riparian zone	• Overhanging riparian vegetation (grasses and shrubs) important component of habitat • Feeds primarily on terrestrial insects, especially adult flies (Schwartz and Norvell 1958, McKee and Parker 1982) • Prefers clear water but has been found in streams with moderate turbidity (Holm and Crossman 1986) • Mean channel width was 3.0 m for 20 Lake Ontario tributary sites (Reid et al. 2008) • Percentage of substrate size classes for Lake Ontario tributary sites are as follows: Fine sediment (39.5), Gravel (15.5), Cobble (7.4) (Reid et al. 2008) • Sites with Redside Dace had higher amounts of instream cover than historical sites that no longer have Redside Dace (Reid et al. 2008)	• Several Redside Dace observed and photographed feeding in deep pools that had overhanging streamside vegetation (Rouge River August 2014; OMNRF unpublished data) • Dense riparian vegetation in form of grasses, shrubs, and some trees at site in Purpleville Creek in September, 2014 (OMNRF unpublished data)	• Riparian vegetation including, but not limited to, low, overhanging vegetation (grasses, forbes, and shrubs) • Adequate supply of terrestrial insect species (terrestrial insects,especially adult flies, are an important food resource of Redside Dace) • Relatively clear waters (preference for clear waters but sometimes occur in moderate turbidity)
All life stages	Spawning Cover Nursery Feeding Maintenance of water quality	Meander Belt	• Unknown		• Riparian habitat that is a minimum of 30 m from the meander belt (measured horizontally) is considered an important habitat element (RDRT 2010)

The spatial extent of the areas that are likely to have the habitat properties outlined in Table 6 have not yet been defined. However, the provincial Redside Dace Recovery Strategy (RDRT 2010) provides recommendations on habitat to be considered in developing habitat protection regulations under the provincial *Endangered Species Act* (2007). It is recommended that all reaches that currently support Redside Dace, and any formerly occupied watersheds where there is likelihood for successful habitat rehabilitation, should be considered for inclusion in the regulation (RDRT 2010). In addition, headwater streams, groundwater discharge areas, and wetlands that support the reaches occupied by Redside Dace should also be regulated (RDRT 2010). The inclusion of bankfull stream width, as well as the meander belt and associated riparian habitat of 30 m width, are essential to the maintenance of instream habitat attributes required to support the survival and recovery of Redside Dace. Further research is required to identify and define these areas within Redside Dace habitat for protection.

The extent of spatial configuration constraints in areas occupied by Redside Dace has not yet been quantified. However, due to the fragmented nature of Redside Dace populations in areas of high urban development, it is likely that potential pathways of genetic exchange have been lost through the reduction of connectivity, the construction of barriers, and widespread habitat degradation in the lower reaches of many occupied watersheds. Although Redside Dace can leap out of the water to catch terrestrial insects, it is not known to jump over small dams or other instream barriers, thereby limiting the dispersal of the species (OMNRF 2016). Further research is required to determine the current location of instream barriers within Redside Dace habitat, and whether removal of barriers will facilitate movement between areas of suitable habitat and extend currently occupied reaches.

Residence is defined in SARA (2002) as a "dwelling-place such as a den, nest, or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". Residence is interpreted by DFO as being constructed by the organism. In the context of the above narrative description of habitat requirements during spawn-to-hatch, YOY, juvenile, and adult life stages, Redside Dace do not occupy residences.

THREATS AND LIMITING FACTORS TO THE SURVIVAL AND RECOVERY

THREAT CATEGORIES

A wide variety of threats negatively impact Redside Dace across its range. The greatest threats to the survival and persistence of Redside Dace in Canada are related to habitat alteration and degradation due to urban development and agricultural activities, as well as natural system modifications such as the installation of dams that act as barriers and effectively fragment habitat. Threats have been categorized based on the IUCN (2014) classification system, and ranked following the methods and terminology outlined by DFO (2014). A consensus approach with meeting participants was incorporated to ensure that the best available knowledge was used in the assessment of relevant threats.

Residential and commercial development

Urban development presents one of the most immediate threats to Redside Dace populations, as more than 80% of the Canadian distribution occurs in the 'Golden Horseshoe Region' of southwestern Ontario (COSEWIC 2007, RDRT 2010). Many remaining populations of Redside Dace are on the fringe of urban areas scheduled for development in the immediate or near future. For example, the Don River, which supports declining populations of Redside Dace, is one of Canada's most degraded river systems with over 80% of its 360 km^2 catchment classified as urban land-use (Rumman et al. 2005, TRCA 2009). Human population growth is expected to increase by about 13.5 million people in the Golden Horseshoe Region by the year 2041 (MMAH 2016), further threatening Redside Dace populations and their habitats.

Impacts from urban development include changes to channel structure (e.g., dimensions of riffles, pools, bankfull width), changes in imperviousness of the watershed, reduction in riparian vegetation, reduction in ground water inputs, and changes in the watershed hydrology including increased siltation and discharge (RDRT 2010, COSEWIC 2017). Such changes may be associated with reductions in water clarity and sources of vegetative cover required for feeding, as well as increases in water temperatures and reductions in base flows of streams (COSEWIC 2007, RDRT 2010). A study by Wang et al. (2001) found that levels of connected imperviousness of approximately 12% were associated with sharp declines in species richness, bank erosion, and base flow. The findings were also supported by Poos et al. (2012) who found significant negative associations between population sizes of Redside Dace in areas adjacent to impervious land-use (e.g., roads, residential, industrial) at both the pool and sub-catchment level (Figure 6). Based on a long-term dataset of stream flow conditions in the GTA, streams with healthy populations of Redside Dace had greater contributions of groundwater and more stabilized flow conditions relative to streams with extirpated populations of Redside Dace (Reid and Parna 2017). Additional research is required to identify thresholds for impervious cover in watersheds to maintain Redside Dace populations.

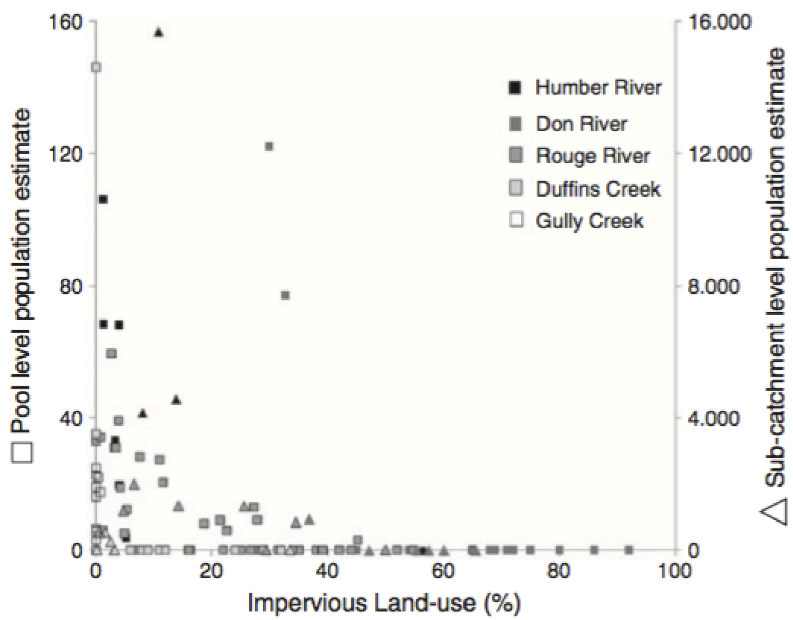

Figure 6. Population estimates for Redside Dace at the pool (□) and sub-catchment (Δ) scale in relation to adjacent impervious land-cover. Reproduced from Poos et al. (2012) with permission.

Agriculture and aquaculture (2.1 Annual & perennial non-timber crops, 2.3 Livestock farming & ranching)

Declines in Redside Dace abundance have been observed in agricultural areas (e.g., Saugeen River, Irvine Creek, and Gully Creek) where intensive agricultural practices such as row cropping, construction of agricultural drains and cattle grazing, present several threats to the species (RDRT 2010, COSEWIC 2017). Livestock access to streams, or the removal of terrestrial vegetation to increase crop production, may increase siltation and change channel morphology, as well as deplete or change the composition of Redside Dace terrestrial food supply (COSEWIC 2017). The excessive use of tile drains may also increase sedimentation in rural streams (Culley et al. 1983). For example, Gully Creek is a Redside Dace catchment dominated by agriculture, with high risks of sedimentation and suspended solids (RDRT 2010). As such, these effects may be contributing to the low population sizes currently observed in the watershed (Poos et al. 2012).

Pollution (9.1 Domestic and urban wastewater; 9.3 Agricultural and forestry effluents)

Redside Dace tolerance to pollution is unknown. However, populations may be impacted by household chemical and storm water run-off associated with urban development. An elevated level of nutrients, metals, chlorides and bacteria was found in two tributaries of the Credit River (Fletcher Creek and Silver Creek) where Redside Dace has declined, presumably due to increased urban runoff (CVC 2002). In addition, the use of pesticides, herbicides, and fertilizers in agricultural landscapes may also lead to irregular or persistent pollution events (COSEWIC 2007). For example, a recent manure spill in Lynde Creek in 2014 killed numerous Redside Dace (D. Moore, CLOCA, pers. comm. *in* COSEWIC 2017).

Natural system modifications (7.2 Dams and water management/use. 7.3 Other ecosystem modifications)

Threats associated with natural system modifications include activities related to the construction of barriers, extraction of aggregates, and anthropogenic-induced succession. The construction of in-stream barriers and weirs may result in habitat fragmentation or affect Redside Dace access to spawning areas, which could reduce genetic diversity by limiting gene flow between populations (RDRT 2010). Further research into the genetic diversity of Redside Dace is required to determine how important these losses are to the conservation of the species. In addition, activities associated with the extraction of aggregates, or the withdrawal of surface or ground water, also pose a threat to Redside Dace populations, as they may cause a reduction of base flow and increase of stream temperature. In Kentucky, Redside Dace disappeared from a stream that was impacted by gravel extraction, septic seepage, and agricultural activities (Meade et al. 1986). Furthermore, the construction of reservoirs near the headwaters of Mountsberg Creek and Spencer Creek altered the thermal regime, which may have been a factor implicated in the decline of Redside Dace in those streams (D. Featherstone, Nottawasaga Valley Conservation Authority (NVCA), pers. comm. *in* COSEWIC 2007).

Anthropogenic-induced succession, defined as the natural or purposeful conversion from open areas to forests, also appears to be a threat to Redside Dace populations. In Ontario, Redside Dace abundance is highest in open areas with riparian zones consisting of grasses and low shrubs. Succession to tree species and canopy closure in riparian areas may reduce the quality of Redside Dace habitat (COSEWIC 2007, RDRT 2010). For example, Andersen (2002) found that agricultural areas that once supported Redside Dace in the 1950s no longer supported the species when they had reverted to forest, though it is difficult to determine whether population loss was driven by forest cover change or delayed agricultural effects.

Invasive and other problematic species, genes, and diseases (8.1 Invasive non-native/alien species/diseases)

The impact of introduced species on Redside Dace is unknown, but declines in populations have been observed in Bronte Creek and Spencer Creek after the introduction of centrarchids, Northern Pike (*Esox lucius*), and other cyprinid species to the watersheds (ROM unpublished data, RDRT 2010). Lyons et al. (2000) also found that Redside Dace disappeared after the introduction of Brown Trout (*Salmo trutta*) to two streams in Wisconsin, however, a causal relationship was not established. Further studies are required to examine interactions between Redside Dace and introduced salmonids particularly Rainbow Trout (*Oncorhynchus mykiss*) and Brown Trout. These two species co-occur with Redside Dace in several Toronto-area streams and are deemed to be of particular importance from a predation perspective. It has been suggested that Redside Dace may be more susceptible to the impacts of introduced species in systems that are affected by multiple stresses (COSEWIC 2007, RDRT 2010).

Human intrusion and disturbance (6.3 Works and other activities)

Incidental harm on Redside Dace during scientific monitoring could be a potential threat, especially for populations that are low in abundance or restricted to small sections of streams or small pools. While unlikely, scientific collection could result in unintended mortality or the removal of a large number of specimens (COSEWIC 2007, RDRT 2010). Further research is required to examine the impacts of non-lethal sampling, including electrofishing and seining, in areas that are known to support Redside Dace populations.

Biological resource use (5.4 Fishing and harvesting aquatic resources)

The use of Redside Dace as baitfish is illegal in Ontario (OMNRF 2015). However, as with most fisheries, the potential for bycatch exists during the harvest of baitfish by anglers and commercial harvesters. The likelihood of bycatch is dependent on the distribution and intensity of baitfish harvest in relation to the distribution and abundance of Redside Dace.

Bycatch of Redside Dace during the angler harvest of bait is currently unknown but bycatch from the commercial harvest has been estimated (Drake and Mandrak 2014a). Commercial harvest occurs in tributary streams of the Great Lakes including those where Redside Dace may be found. Drake and Mandrak (2014a) estimated bycatch-effort relationships based on species-specific catchability and the co-occurrence of target and non-target fishes at stream segments accessible by road. Based on a generic harvest strategy where each road crossing had an equal probability of harvest, the model indicated that 358 harvest events, on average, would be necessary for a single event to have a median 95% chance of capturing Redside Dace. Uncertainty within the models indicated that bycatch could be higher (only 156 events), or lower, with the failure of reaching the 95% bycatch threshold, regardless of effort. For comparison, Silver Shiner (*Notropis photogenis*), an imperilled stream-dwelling cyprinid in southern Ontario, required 373 harvest events to reach a 95% chance of bycatch; whereas, Warmouth (*Lepomis gulosus*), an imperilled centrarchid, would require 34,246 events to reach the 95% threshold. Species predicted to be encountered frequently as bycatch, such as Rock Bass (*Ambloplites rupestris*) and Pumpkinseed (*Lepomis gibbosus*), required only 17 events to reach the 95% threshold.

Generally, the rarity of Redside Dace implies that the potential for incidental harvest is low. Should bycatch occur, the ability of harvesters to sort and remove Redside Dace is unknown. However, a study of the Ontario baitfish pathway (Drake and Mandrak 2014b) did not document any Redside Dace from baitfish purchases in southern Ontario during August-October, 2007 and February, 2008 (16,886 fishes from 68 purchases were analyzed; Drake and Mandrak 2014b). The lack of Redside Dace in purchases indicated that either bycatch did not occur (i.e., sites containing Redside Dace were avoided during harvest), or that Redside Dace was captured as bycatch, but extensive sorting at harvest, wholesale, or retail sites removed the species from catches prior to sale.

Overall, these results indicate that the probability for incidental harvest and transfer throughout the pathway is low.

Climate change and severe weather (11.1 Habitat shifting and alteration)

The effects of global climate change may result in an increase in water and air temperatures, change in water levels, shortening of the duration of ice cover, increase in the frequency of extreme weather events, emergence of disease, and shifts in predator-prey dynamics (Lemmen and Warren 2004). Of these potential negative impacts, a reduction in stream flow, increase in water temperature and increase in frequency of flooding events are expected to have the most detrimental effects on populations of Redside Dace (RDRT 2010, COSEWIC 2017). Although higher rates of precipitation could increase available habitat in northern portions of the province, the potential for colonizing these new areas is low (COSEWIC 2007). In general, the effects of climate change on Redside Dace are largely speculative.

THREAT ASSESSMENT

To assess the Threat Level of Redside Dace populations in Ontario, each threat was ranked in terms of the threat Likelihood of Occurrence (LO), threat Level of Impact (LI), and Causal Certainty (CC) on a population-by-population basis. The Likelihood of Occurrence was assigned as Known, Likely, Unlikely, Remote or Unknown, and the Level of Impact was assigned as Extreme, High, Medium, Low, or Unknown (Table 7). The level of certainty associated with each threat was assessed and classified as: 1 = very high, 2 = high, 3 = medium, 4 = low, 5 = very low. The Population-Level Threat Occurrence (PTO), Threat Frequency (PTF), and Threat Extent (PTE) were also evaluated and assigned a status based on the definitions outlined in Table 8 (Table 9, DFO 2014). The Likelihood of Occurrence and Level of Impact for each population were subsequently combined in the Threat Risk Matrix (Table 9) resulting in the Population-Level Threat Risk (PTR, Table 10). The Species-level Threat Assessment in Table 11 is a roll-up of population-level threats identified in Table 10.

Table 7. Definition and terms used to describe likelihood of occurrence (LO), level of impact (LI), causal certainty (CC), population level threat occurrence (PTO), threat frequency (PTF) and threat extent (PTE). Information taken from DFO (2014).

Term	Definition
Likelihood of Occurrence (LO)	
Known or very likely to occur (K)	This threat has been recorded to occur 91-100%
Likely to occur (L)	There is a 51-90% chance that this threat is or will be occurring
Unlikely (UL)	There is 11-50% chance that this threat is or will be occurring
Remote (R)	There is 1-10% or less chance that this threat is or will be occurring
Unknown (U)	There are no data or prior knowledge of this threat occurring or known to occur in the future
Level of Impact (LI)	
Extreme (E)	Severe population decline (e.g. 71-100%) with the potential for extirpation
High (H)	Substantial loss of population (31-70%) or threat would jeopardize the survival or recovery of the population
Medium (M)	Moderate loss of population (11-30%) or threat is likely to jeopardize the survival or recovery of the population
Low (L)	Little change in population (1-10%) or threat is unlikely to jeopardize the survival or recovery of the population
Unknown (U)	No prior knowledge, literature or data to guide the assessment of threat severity on population
Causal Certainty (CC)	
Very high (1)	Very strong evidence that threat is occurring and the magnitude of the impact to the population can be quantified
High (2)	Substantial evidence of a causal link between threat and population decline or jeopardy to survival or recovery
Medium (3)	There is some evidence linking the threat to population decline or jeopardy to survival or recovery
Low (4)	There is a theoretical link with limited evidence that threat is leading to a population decline or jeopardy to survival or recovery
Very low (5)	There is a plausible link with no evidence that the threat is leading to a population decline or jeopardy to survival or recovery
Population-Level Threat Occurrence (PTO)	
Historical (H)	A threat that is known to have occurred in the past and negatively impacted the population
Current (C)	A threat that is ongoing and is currently negatively impacting the population
Anticipatory (A)	A threat that is anticipated to occur in the future and will negatively impact the population
Population-Level Threat Frequency (PTF)	
Single (S)	The threat occurs once
Recurrent (R)	The threat occurs periodically, or repeatedly
Continuous (C)	The threat occurs without interruption
Population- Level Threat Extent (PTE)	
Extensive (E)	71-100% of the population is affected by the threat
Broad (B)	31-70% of the population is affected by the threat
Narrow (NA)	11-30% of the population is affected by the threat
Restricted (R)	1-10% of the population is affected by the threat

Table 8. Threat Likelihood of Occurrence (LO), Level of Impact (LI), Causal Certainty (CC), Population-Level Threat Occurrence (PTO), Population- Level Threat Frequency (PTF), and Population-Level Threat Extent (PTE) for Redside Dace populations in Ontario. Definitions and terms used to describe likelihood of occurrence (LO), level of impact (LI), causal certainty (CC), population level threat occurrence (PTO), threat frequency (PTF) and threat extent (PTE) can be found in Table 7. The threat ratings were based on COSEWIC (2017) with additional input and consensus from participants at the RPA meeting.

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
Pringle Creek	LO	K	R	K	L	K	UL	UL	K
	LI	E	L	M	L	M	L	L	U
	CC	2	3	1	4	4	4	4	3
	PTO	H,C	H,C	H,C	H	C	C	C	C,A
	PTF	R	R,C	C	R	C	R	R	C
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2,3	-	-	-	-	-	-	-
Lynde Creek	LO	K	K	K	K	K	UL	UL	K
	LI	H	H	M	M	M	L	L	U
	CC	2	2	2	2	3	4	4	3
	PTO	C,A	C	H,C	H,C	H,C	C	H, A	C,A
	PTF	C	R,C	C	C	C	R	R	C
	PTE	B	B	B	B	B	R	R	E
	Ref	3	4	-	4	-	-	-	-
Carruthers Creek	LO	L	R	L	K	R	R	UL	K
	LI	H	L	L	H	L	L	L	U
	CC	4	4	4	3	5	5	4	3
	PTO	C,A	H,C	H,C, A	H,C	H,C,A	C	C	C,A
	PTF	R	R,C	R	C	C	R	R	C
	PTE	E	B	B	B	R	R	R	E
	Ref	1,2, 5	-	-	-	-	-	-	-

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
Duffins Creek	LO	K	R	L	L	K	UL	UL	K
	LI	H	L	L	L	M	L	L	U
	CC	3	4	4	4	4	4	4	3
	PTO	C,A	H,C	H,C, A	H	C	C	C	C,A
	PTF	R	R,C	R	R	C	R	R	C
	PTE	E	B	B	-	-	-	-	-
	Ref	5,6	-	-	-	-	-	-	-
Petticoat Creek	LO	K	R	L	K	K	UL	UL	K
	LI	E	L	U	M	M	L	L	U
	CC	4	4	3	2	3	4	4	3
	PTO	H,C,A	H,C,A	H,C,A	H,C	H,C	C	H, A	C,A
	PTF	R	R,C	R	C	C	R	R	C
	PTE	-	-	-	B	B	R	R	E
	Ref	1,2	-	-	4	-	-	-	-
Highland Creek	LO	K	U	K	K	R	R	UL	K
	LI	E	U	E	H	L	L	L	U
	CC	2	4	3	3	5	5	4	3
	PTO	H,C,A	H,C,A	H,C,A	H,C	H,C,A	C	C	C,A
	PTF	R	R,C	R	C	C	R	R	C
	PTE	-	-	-	B	R	R	R	E
	Ref	1,2	-	-	-	-	-	-	-
Rouge River	LO	K	UL	L	K	R	R	UL	K
	LI	E	L	L	H	L	L	L	U
	CC	2	3	4	3	5	5	4	3
	PTO	C,A	H,C	H,C, A	H,C,A	H,C,A	C	H, A	C,A

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
	PTF	R	R,C	R	R,C	C	R	R	C
	PTE	E	B	B	B	R	R	R	E
	Ref	1,2,5,6	-	-	11	-	-	-	-
Don River	LO	K	R	K	K	R	UL	UL	K
	LI	E	L	H	H	L	L	L	U
	CC	2	5	3	3	5	4	4	3
	PTO	C,A	H	H,C	H,C	H,C,A	C	C	C,A
	PTF	R	R,C	R	R,C	C	R	R	C
	PTE	E	R	E	E	B	R	R	E
	Ref	1,2,5,6,7	-	-	11	-	-	-	-
Humber River	LO	K	R	L	K	R	R	UL	K
	LI	H	L	L	H	L	L	L	U
	CC	3	4	4	3	5	5	4	3
	PTO	C,A	H,C	H,C, A	H,C, A	H,C,A	C	H, A	C,A
	PTF	R	R,C	R	R,C	C	R	R	C
	PTE	E	B	B	B	R	R	R	E
	Ref	1,2,5,6	-	-	11	11	-	-	-
Mimico Creek	LO	K	U	K	K	K	UL	UL	K
	LI	E	U	E	E	L	L	L	U
	CC	2	4	3	3	4	4	4	3
	PTO	H	H	H	H	H	H	H	C,A
	PTF	R	R,C	R	R,C	R	R	R	C
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2	-	-	-	-	-	-	-
Etobicoke Creek	LO	K	K	K	K	K	UL	UL	K

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
	LI	E	U	H	E	L	L	L	U
	CC	2	4	3	3	4	4	4	3
	PTO	H	H	H	H	H	H	H	C,A
	PTF	R	R,C	R	R,C	R	R	R	C
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2	-	-	-	-	-	-	-
"Clarkson Creek"	LO	K	R	K	K	R	R	R	K
	LI	E	L	E	H	L	L	L	U
	CC	2	3	3	4	4	4	4	3
	PTO	H	H	H	H,C	H,C	C	C	C,A
	PTF	R	R,C	R	C	C	R	R	C
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2	-	-	-	-	-	-	-
Credit River	LO	K	R	K	R	K	R	UL	K
	LI	E	L	H	M	M	L	L	U
	CC	1	3	2	4	3	4	4	3
	PTO	H,C,A	H,C	H, C	H,C	H,C	H,C	H,C	C,A
	PTF	C	R,C	R	R	C	R	R	C
	PTE	E	R	E	R,C	B	E	R	E
	Ref	1,2	-	8	-	-	-	-	-
Morrison Creek	LO	K	R	K	K	R	UL	UL	K
	LI	E	L	E	H	L	L	L	U
	CC	2	4	2	3	4	4	4	3
	PTO	H	H	H	H,C	H,C	C	C	C,A
	PTF	C	R,C	C	S,C	C	R	R	C

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2	-	-	11	-	-	-	-
Sixteen Mile Creek	LO	K	K	L	K	R	UL	UL	K
	LI	H	M	H	H	L	L	L	U
	CC	2	3	2	3	4	4	4	3
	PTO	H,C,A	H	H,C,A	H,C	H,C,A	C	C	C,A
	PTF	R,C	C,R	R	S,C	C	R	R	C
	PTE	E	B	E	B	N	R	R	E
	Ref	1,2	-	-	-	-	-	-	-
Fourteen Mile Creek	LO	K	K	L	K	R	UL	UL	K
	LI	H	L	H	M	L	L	L	U
	CC	2	4	2	3	4	4	4	3
	PTO	C,A	H	H,C,A	H,C,A	H,C,A	C	C	C,A
	PTF	R	R,C	R	S,R,C	C	R	R	C
	PTE	E	E	E	N	E	R	R	E
	Ref	1,2	-	-	-	-	-	-	-
Bronte Creek	LO	K	L	L	K	R	UL	UL	K
	LI	M	L	M	H	L	L	L	U
	CC	4	4	4	3	4	4	4	3
	PTO	C,A,H	C,A,H	H,C	H	H, C	C	C	C,A
	PTF	R,C	R	R	C	C	R	R	C
	PTE	NA	NA	E	B	B	R	R	E
	Ref	1,2	-	-	1	2	-	-	-
Wedgewood Creek	LO	K	R	K	K	R	UL	UL	K
	LI	E	L	E	H	L	L	L	U

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
	CC	2	4	2	3	4	4	4	3
	PTO	H	H	H	H,C	H,C	C	C	C,A
	PTF	C	R,C	C	S,C	C	R	R	C
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2	-	-	1	-	-	-	-
Spencer Creek	LO	K	U	U	K	K	UL	UL	K
	LI	M	U	U	M	L	L	L	U
	CC	4	-	-	3	3	4	3	3
	PTO	C,A	-	-	H	H,C	C	H,C,A	C,A
	PTF	R	-	-	C	C	R	R	C
	PTE	B	-	-	B	B	R	R	E
	Ref	1,2	-	-	1	2,9	-	-	-
Niagara Peninsula	LO	K	R	U	U	U	UL	UL	K
	LI	E	U	U	U	U	L	L	U
	CC	4	-	-	-	-	4	4	3
	PTO	H	-	-	-	-	C	C	C,A
	PTF	R	-	-	-	-	R	R	C
	PTE	-	-	-	-	-	-	-	-
	Ref	1,2	-	-	-	-	-	-	-
Holland River	LO	L	K	U	K	K	UL	UL	K
	LI	H	M	U	M	L	L	L	U
	CC	4	-	-	-	-	4	4	3
	PTO	C,A	-	-	-	-	C	C	C,A
	PTF	R	-	-	-	-	R	R	C
	PTE	B	-	-	-	-	R	R	E

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
	Ref	1,2	-	-	-	-	-	-	-
Irvine Creek	LO	UL	K	K	K	U	UL	UL	K
	LI	H	H	U	E	U	L	L	U
	CC	4	4	-	-	-	4	4	3
	PTO	A	C	-	-	-	C	C	C,A
	PTF	R	R	-	-	-	R	R	C
	PTE	B	E	-	-	-	R	R	E
	Ref	1,2	1,2	-	-	-	-	-	-
Gully Creek	LO	R	K	K	R	L	UL	UL	K
	LI	L	H	H	L	M	L	L	U
	CC	3	3	3	5	4	4	4	3
	PTO	C	H,C,A	H,C,A	C	H,C,A	H,C,A	H,C,A	C,A
	PTF	S,R	R	R	C	C	R	R	C
	PTE	NA	E	E	R	B	R	NA	E
	Ref	1,2	6	10	-	-	-	-	-
Saugeen River	LO	R	K	UL	K	R	UL	UL	K
	LI	H	H	M	H	U	L	L	U
	CC	4	2	3	2	4	4	4	3
	PTO	A	H,C,A	A,C	C,H,	A	A,H	C	C,A
	PTF	C	R,C	R,C	C	R	R	R	C
	PTE	NA	E	E	E	B	R	R	E
	Ref	1,2	1,2	-	-	-	-	-	-
South Gully Creek	LO	R	K	K	R	L	UL	UL	K
	LI	L	H	H	L	M	L	L	U
	CC	3	3	3	5	5	4	4	3

Location	Threat Rating	Residential/ commercial development	Agriculture	Pollution	Natural system modification	Invasive species	Human intrusion	Biological resource use	Climate change
	PTO	C	H,C,A	H,C,A	C	H,C,A	H,C,A	H,C,A	C,A
	PTF	S,R	R	R	C	C	R	R	C
	PTE	NA	E	E	R	NA	R	NA	E
	Ref	1,2	-	-	-	-	-	-	-
	LO	UL	K	U	U	U	UL	UL	K
	LI	H	M	U	U	U	L	L	U
	CC	4	-	-	-	-	4	4	3
Two Tree River	PTO	A	-	-	-	-	C	C	C,A
	PTF	R	-	-	-	-	R	R	C
	PTE	NA	-	-	-	-	R	R	E
	Ref	1,2	-	-	-	-	-	-	-

References:

1. COSEWIC (2007)
2. RDRT (2010)
3. Andersen (2002)
4. Code (2010)
5. Ministry of Municipal Affairs and Housing (2016)
6. Poos et al. (2012)
7. Rumman et al. (2005)
8. CVC (2002)
9. ROM unpublished data
10. Ontario Biodiversity Council (2015)
11. COSEWIC (2017)

Table 9. The Threat Level Matrix combines the Likelihood of Occurrence and Level of Impact rankings to establish the Threat Level for Redside Dace populations in Ontario. The resulting Threat Level has been categorized as low, medium, high or unknown.

		Level of Impact				
		Low	Medium	High	Extreme	Unknown
Likelihood of Occurrence	Known or very likely	Low	Medium	High	High	Unknown
	Likely	Low	Medium	High	High	Unknown
	Unlikely	Low	Medium	Medium	Medium	Unknown
	Remote	Low	Low	Low	Low	Unknown
	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Table 10. Threat Level Assessment for Redside Dace populations in Ontario, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty associated with the threat impact (1 = Very High; 2 = High; 3 = Medium; 4 = Low; 5 = Very Low).

	Residential/ commercial development	**Agriculture**	**Pollution**	**Natural system modifications**	**Invasive species**	**Human intrusion**	**Biological resource use**	**Climate change**
Pringle Creek	High (2)	Low (3)	Medium (1)	Low (4)	Medium (4)	Low (4)	Low (4)	Unknown
Lynde Creek	High (2)	High (2)	Medium (2)	Medium (2)	Medium (3)	Low (4)	Low (4)	Unknown
Carruthers Creek	High (4)	Low (4)	Low (4)	High (3)	Low (5)	Low (5)	Low (4)	Unknown
Duffins Creek	High (3)	Low (4)	Low (4)	High (3)	Low (5)	Low (5)	Low (4)	Unknown
Petticoat Creek	High (4)	Low (4)	Unknown	Unknown	Unknown	Low (4)	Low (4)	Unknown
Highland Creek	High (2)	Unknown	High (3)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
Rouge River	High (2)	Low (3)	Low (4)	High (3)	Low (5)	Low (5)	Low (4)	Unknown
Don River	High (2)	Low (5)	High (3)	High (3)	Low (5)	Low (4)	Low (4)	Unknown

	Residential/ commercial development	Agriculture	Pollution	Natural system modifications	Invasive species	Human intrusion	Biological resource use	Climate change
Humber River	High (3)	Low (4)	Low (4)	High (3)	Low (5)	Low (5)	Low (4)	Unknown
Mimico Creek	High (2)	Unknown	High (3)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
Etobicoke Creek	High (2)	Unknown	High (3)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
"Clarkson Creek"	High (2)	Low (3)	High (3)	High (4)	Low (4)	Low (4)	Low (4)	Unknown
Credit River	High (2)	Low (3)	High (3)	Medium (4)	Medium (3)	Low (4)	Low (4)	Unknown
Morrison Creek	High (2)	Low (4)	High (2)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
Sixteen Mile Creek	High (2)	Medium (3)	High (2)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
Fourteen Mile Creek	High (2)	Low (4)	High (2)	Medium (3)	Low (4)	Low (4)	Low (4)	Unknown
Bronte Creek	Medium (4)	Low (4)	Medium (4)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
Wedgewood Creek	High (2)	Low (4)	High (2)	High (3)	Low (4)	Low (4)	Low (4)	Unknown
Spencer Creek	Medium (4)	Unknown	Unknown	Medium (3)	Low (3)	Low (4)	Low (4)	Unknown
Niagara Peninsula	High (4)	Unknown	Unknown	Unknown	Unknown	Low (4)	Low (4)	Unknown
Holland River	High (4)	Unknown	Unknown	Unknown	Unknown	Low (4)	Low (4)	Unknown
Irvine Creek	Medium (4)	High (4)	Unknown	Unknown	Unknown	Low (4)	Low (4)	Unknown

	Residential/ commercial development	Agriculture	Pollution	Natural system modifications	Invasive species	Human intrusion	Biological resource use	Climate change
Gully Creek	Low (3)	High (3)	High (3)	Low (5)	Medium (4)	Low (4)	Low (4)	Unknown
Saugeen River	Low (4)	High (2)	Medium (3)	High (2)	Unknown	Low (4)	Low (4)	Unknown
South Gully Creek	Low (3)	High (3)	High (3)	Low (5)	Medium (5)	Low (4)	Low (4)	Unknown
Two Tree River	Medium (4)	Unknown	Unknown	Unknown	Unknown	Low (4)	Low (4)	Unknown

Table 11. Species-level Threat Assessment for Redside Dace in Canada, resulting from a roll-up of population-level Threat Assessment. Species-level Threat Risk, Threat Occurrence (H = Historical; C = Current; A = Anticipatory), Threat Frequency (S = Single; R = Recurrent; C = Continuous), and Threat Extent (E = Extensive; B = Broad; R = Restricted) .The species-level Threat Extent is calculated as the mode of population-level Threat Extent.

Threat	Species-level Threat Risk	Species-level Threat Occurrence	Species-level Threat Frequency	Species-level Threat Extent
Residential/ commercial development	**High (2)**	H, C, A	S, R, C	E
Agriculture	**High (3)**	H, C, A	R, C	B
Pollution	**High (3)**	H, C, A	R, C	E
Natural system modifications	**High (3)**	H, C, A	S, R, C	B
Invasive species	**Medium (3)**	H, C, A	R, C	B
Human intrusion	**Low (4)**	H, C, A	R	R
Biological resource use	**Low (4)**	H, C, A	R	R
Climate change	**Unknown**	A	C	E

The greatest threats to Redside Dace habitat based on the threat assessment include habitat alteration and degradation due to urban development and agricultural activities, as well as natural systems modifications such as the installation of dams or weirs. Urban development has the potential to impact Redside Dace habitat through: 1) increasing imperviousness of the watershed, which affects runoff patterns, increases erosion, alters hydrology (e.g., water depth, flow patterns) and may increase water temperatures; 2) site dredging and excavation, which may lead to increased sedimentation and erosion of stream banks; and, 3) direct loss of habitat including loss of riparian vegetation, wetlands, headwater streams and groundwater sources (OMNRF 2016). Activities that are carried out without proper sediment and erosion control (e.g., installation of bridges and pipelines, removal of riparian vegetation, unrestricted livestock access to waterbodies) can cause increased turbidity and sediment deposition in pool and riffle habitats. A reduction in water clarity and increased siltation could impair the feeding and spawning success of Redside Dace (Koster 1939).

Degradation of Redside Dace habitat from urban development or agricultural practices may also result in increases in nutrient loading as a result of over-application of fertilizers and improper nutrient management from septic and municipal sewage and animal manure piles. Elevated nutrient levels (phosphorus and nitrogen) can lead to the development of algal blooms and, consequently, to changes in water temperatures and decreased levels of dissolved oxygen required to support Redside Dace populations. In addition, the release of untreated urban stormwater and industrial pollution into habitat may introduce toxic chemical and pollutants into the watercourse, which may lead to an increase in water temperature or change in hydrological regime (OMNRF 2016).

Several natural factors related to Redside Dace spawning may limit the survival and recovery of the species. Redside Dace typically spawns over nests constructed by Creek Chub and Common Shiner (Koster 1939). However, differences in preferred spawning temperatures (12-17 °C vs. 18 °C; Becker 1983) and the shorter spawning period of Redside Dace may limit opportunities for communal spawning in some years (RDRT 2010). In addition, increased in-water velocities may increase the risk of eggs being washed away from nests since they are non-adhesive (Scott and Crossman 1973). Lastly, the bright yellow and red colouration of Redside Dace may make the species more susceptible to predation (RDRT 2010).

The destruction and degradation of habitat, including headwater features and functions, are considered to be the greatest factors contributing to the reduction of Redside Dace distribution. Activities including removal of riparian vegetation, loss of supporting wetlands, extraction of surface flows, groundwater flow alterations, channelization, and pollution from urban and agricultural sources reduce suitable habitat and food sources for Redside Dace populations. For example, removal of riparian vegetation would directly affect the production of terrestrial insects that Redside Dace feed on during a large portion of the year (COSEWIC 2017). Therefore, encouraging riparian rehabilitation by re-establishing grasses and shrubs would improve Reside Dace habitat by reducing agricultural runoff and bank erosion, thereby limiting the input of sediments and nutrients from agricultural lands. Restoration of preferred habitat would also benefit co-occurring species that are normally associated with Redside Dace, including Creek Chub, Common Shiner, and Blacknose Dace, as they prefer shallow, cool streams with riparian cover (Holm et al. 2009).

In addition, fragmentation through the construction of barriers (e.g., dams and weirs) can alter habitat condition, restrict movement of individual fish and limit gene flow between populations. Removing barriers, where appropriate, would benefit the species (and, co-occurring species such as Creek Chub, Common Shiner, and Blacknose Dace) by re-establishing populations that have been separated and increasing access to spawning areas. The potential benefits of barrier removal would have to be weighed against any consequential upstream migration of introduced salmonids.

The OMNRF and conservation authorities have undertaken population-monitoring surveys to assess the status Redside Dace populations and their habitats in Ontario. Municipal stormwater assessments, and rehabilitation work in Fourteen Mile Creek, has also been ongoing through the work of Conservation Halton, Ontario Streams, and OMNRF. Despite recent efforts, further research is required to identify the principal factors associated with each threat including the key factors associated with urban development and agricultural activities, the effects of aggregate operations and water withdrawals, interactions with introduced species, the impacts of succession (i.e., canopy closure), impacts of scientific sampling techniques, and the future impacts of climate change.

SCENARIOS FOR MITIGATION OF THREATS AND ALTERNATIVES TO ACTIVITIES

Threats to species survival and recovery can be reduced by implementing mitigation measures to reduce or eliminate potential harmful effects that could result from works or undertakings associated with projects or activities in Redside Dace habitat.

Within Redside Dace habitat, a variety of works, undertakings, and activities have occurred in the last five years with project types including water crossings (e.g., bridge maintenance and construction), shoreline and streambank works (e.g., stabilization), instream works (e.g., channel maintenance), and the placement or removal of structures in water. A review has been completed summarizing the types of work, activity, or projects that have been undertaken in habitat known to be occupied by Redside Dace (Table 12). The DFO Program Activity Tracking for Habitat (PATH) database has been reviewed to estimate the number of projects that have occurred during a five year period from 2013 through 2017. Thirty five (35) projects were identified in Redside Dace habitat, but these likely do not represent a complete list of projects or activities that have occurred in these areas (Table 12). Four projects were not identified in the table as some smaller creeks had one project each. Some projects occurring in proximity but not in the area of habitat may also have impacts, but were not included. Some projects may not have been reported to DFO as they may have met self-assessment requirements and were not required to be reported. Some projects were likely not submitted due to the timing of species listing under the Act.

No projects were authorized under the *Fisheries Act.* A number of projects had been initiated previously and permits under the *Species at Risk Act* were subsequently required to undertake fish relocations. Most projects were deemed low risk to fishes and fish habitat and were addressed through letters of advice with standard mitigation. Without appropriate mitigation, projects or activities occurring adjacent or close to these areas could have impacted Redside Dace (e.g., increased turbidity or sedimentation from upstream channel works).

The most frequent project type was for water crossings including bridge and culvert replacements and streambank stabilization. Based on the assumption that historical and anticipated development pressures are likely to be similar, it is expected that similar types of projects will likely occur in or near Redside Dace habitat in the future. The primary project proponents were provincial and municipal road departments.

Numerous threats affecting Redside Dace populations are related to habitat loss or degradation. Habitat-related threats to Redside Dace have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 12). DFO FHM has developed guidance on mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Central and Arctic Region (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. Additional mitigation and alternative measures, specific to Redside Dace, related to invasive species and incidental harvest are listed below. The Ministry of Natural Resource has also developed best management practices (BMP) related to developing lands in and adjacent to protected Redside Dace habitat in Ontario (OMNRF 2016). A brief summary of the BMPs is provided below but for a more detailed description see OMNRF (2016).

Table 12. Summary of works, projects, and activities that have occurred during the period of 2013 through 2017 in areas known to be occupied by Redside Dace. Threats known to be associated with these types of works, projects, and activities have been indicated by a checkmark. The number of works, projects, and activities associated with each Redside Dace population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects have been indicated for each threat associated with a work, project or activity (1 - Vegetation clearing; 2 – Grading; 3 – Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration, and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site).

Work/Project/Activity	**Threats** (associated with work/project/activity)						**Watercourse / Waterbody** (number of works/projects/activities between 2013 and 2017)				
	Habitat removal and alteration	**Nutrient loading**	**Turbidity and sediment loading**	**Contaminants and toxic substances**	**Invasive species and disease**	**Incidental harvest**	**Fourteen and Sixteen Mile Creeks**	**Credit River**	**East and West Humber River**	**Rouge River**	**Lynde Creek**
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 15, 18	1, 4, 7, 8, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	1, 4, 5, 6, 7, 11, 12,13, 14, 15, 16, 18							
Water crossings (bridges, culverts, open cut crossings)	✓		✓	✓			5	2	4	5	2
Shoreline, streambank work (stabilization, infilling, retaining walls, riparian vegetation management)	✓		✓	✓			3	1	4	1	1
Instream works **(**channel maintenance, restoration, modifications, realignments, dredging, aquatic vegetation removal)	✓	✓	✓	✓			1		2		

Work/Project/Activity	Threats (associated with work/project/activity)						Watercourse / Waterbody (number of works/projects/activities between 2013 and 2017)				
	Habitat removal and alteration	Nutrient loading	Turbidity and sediment loading	Contaminants and toxic substances	Invasive species and disease	Incidental harvest	Fourteen and Sixteen Mile Creeks	Credit River	East and West Humber River	Rouge River	Lynde Creek
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 15, 18	1, 4, 7, 8, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	1, 4, 5, 6, 7, 11, 12,13, 14, 15, 16, 18							
Water management (stormwater management, water withdrawal)		✓	✓	✓							
Structures in water **(**boat launches, docks, effluent outfalls, water intakes, dams)	✓	✓	✓	✓							
Baitfishing						✓					
Invasive species introductions (accidental and intentional)					✓						

INVASIVE AND OTHER PROBLEMATIC SPECIES, GENES, AND DISEASES

Mitigation

- Removal/control of introduced species from areas inhabited by Redside Dace.
- Monitor for introduced species that may negatively affect Redside Dace populations or preferred habitat.
- Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of introduced species.
- Initiate a public awareness campaign and encourage the use of existing invasive species reporting systems.
- Under circumstances where barriers to fish movement (i.e., dams) are to be removed or fish passage is to be increased (i.e., creation of a fishway) the potential negative effects of introduced species moving into Redside Dace habitat should be considered.

Alternatives

- Do not stock non-native species in areas inhabited by Redside Dace.
- Do not enhance habitat for non-native species in areas inhabited by Redside Dace.

HUMAN INTRUSION AND DISTURBANCE

Mitigation

- Use of non-lethal sampling methods. Consider sampling during less stressful periods or morning hours to avoid periods of spawning or thermal stress. Ensure that personnel are able to identify Redside Dace in the field in order to minimize stress.
- Improve co-ordination of sampling to reduce duplication.

Alternatives

- Consider allowable-harm recommendations when collection for scientific purposes is necessary.

BIOLOGICAL RESOURCE USE

Mitigation

- Provide information and education to anglers and bait harvesters on Redside Dace to raise awareness. Education may include the use of baitfish alternatives when fishing, as well as voluntary avoidance of areas occupied by Redside Dace.
- Immediate release of Redside Dace if incidentally caught, as defined under the Ontario Recreational Fishery Regulations.

Alternatives

- Prohibit the harvest of baitfish in areas where Redside Dace is known to occur.
- Seasonal or zonal restrictions applied to harvesting/fishing during Redside Dace spawning season.

- Restrict gear type used to catch baitfish to minimize the probability of Redside Dace capture.

BEST MANAGEMENT PRACTICES RELATED TO DEVELOPING LANDS IN AND ADJACENT TO PROTECTED REDSIDE DACE HABITAT IN ONTARIO

1) Comprehensive Planning for Subwatersheds: Complete subwatershed plans prior to the Secondary Planning stage to ensure Redside Dace requirements are fully incorporated into the planning and development process (OMNRF 2016).

2) Stream Crossings: Minimize the number of stream crossings (e.g., one per kilometre of stream) while avoiding reaches known to be occupied by Redside Dace, as well as adhering to timing windows and incorporating erosion and sediment control measures (OMNRF 2016).

3) Construction Activities: Prevent total suspended sediment (TSS) concentrations from exceeding 25 mg/L above background conditions, and follow an approved Erosion and Sediment Control Plan (OMNRF 2016).

4) Stormwater Management: Ensure target outflows are consistent with Redside Dace habitat requirements, including water temperatures below 24 °C, dissolved oxygen levels above 7 mg/L and TSS levels less than 25 mg/L (OMNRF 2016).

5) Installation of New Infrastructure: Where possible, utilities should be located either over or under streams to avoid impact to Redside Dace habitat and should be built in conjunction with new or replacement road crossings (OMNRF 2016).

6) Stream Realignments and Relocations: Maintain natural flow and function of streams that Redside Dace requires, including stream corridors (meander belt plus 30 m of riparian habitat) and hydrology (OMNRF 2016).

The mitigation measures outlined above are consistent with the goal of increasing survivorship by reducing threats to the species directly (e.g., pollution, bait harvest) or indirectly by improving habitat quality (e.g., reducing threats of urban and agricultural development).

The feasibility of rehabilitating or restoring degraded habitat features such as the riparian zone, meanderbelt and headwaters, has not been assessed. It is likely that restoration is not feasible in some watersheds due to the extent and nature of changes in the watershed. Therefore, further research is needed to identify and prioritize the streams in highest need of restoration in areas where Redside Dace abundance/range has been reduced. In areas with degraded habitat, including rural streams, the use of best management practices is encouraged to restore a healthy riparian zone, reduce livestock access, establish manure collection systems, encourage conservation tillage, and reduce the impact of tile drains. As such, riparian rehabilitation should focus on the re-establishment of grasses and shrubs. These practices would improve Redside Dace habitat by reducing agricultural runoff and bank erosion, thereby limiting the input of sediments and nutrients from agricultural lands.

SOURCES OF UNCERTAINTY

There are several knowledge gaps related to the distribution, abundance, biology, and threats of Redside Dace in Canada. A long-term monitoring program would be beneficial to assess and confirm the distribution and abundance of extant populations and the status of their habitat and threats. Long term monitoring would allow for further investigations into habitat use by each life stage of Redside Dace. Furthermore, areas that contain essential habitat features (e.g., meander belt, riparian zone) required to support Redside Dace populations need to be identified and prioritized for protection. The feasibility of rehabilitating degraded habitats and re-patriating populations into watersheds that once supported Redside Dace populations should also be investigated.

Additional research is required to identify the causative factors associated with urban development and agricultural activities that cause declines in Redside Dace populations, as well as the impacts of introduced species, anthropogenic-induced succession, scientific monitoring, and climate change on the species. Research on the interactions between Redside Dace and introduced species (i.e., salmonids; particularly Brown Trout, centrarchids, and other cyprinids), the effects of gear type on mortality during scientific sampling, and the implications of canopy closure due to succession will address current knowledge gaps.

Further research on the species' ecology and life history in Ontario is warranted as the majority of studies are from American populations (RDRT 2010). In particular, research about physiological tolerances to key physical and chemical water quality parameters such as critical thermal maximum (CT_{max}), and pollutants would help to understand the effect of key in-stream habitat stressors. Further research about the reproduction such as spawning cues and spawning site locations is also required. Information on movements between areas of suitable habitat, overwintering habitat use, and the effect of flow rate on movement should be addressed to better understand movement patterns of the species. Factors that could be limiting abundance such as prey availability, predation, fish community interactions, genetic diversity among populations, and disease are important sources of uncertainty that also require research in the future.

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