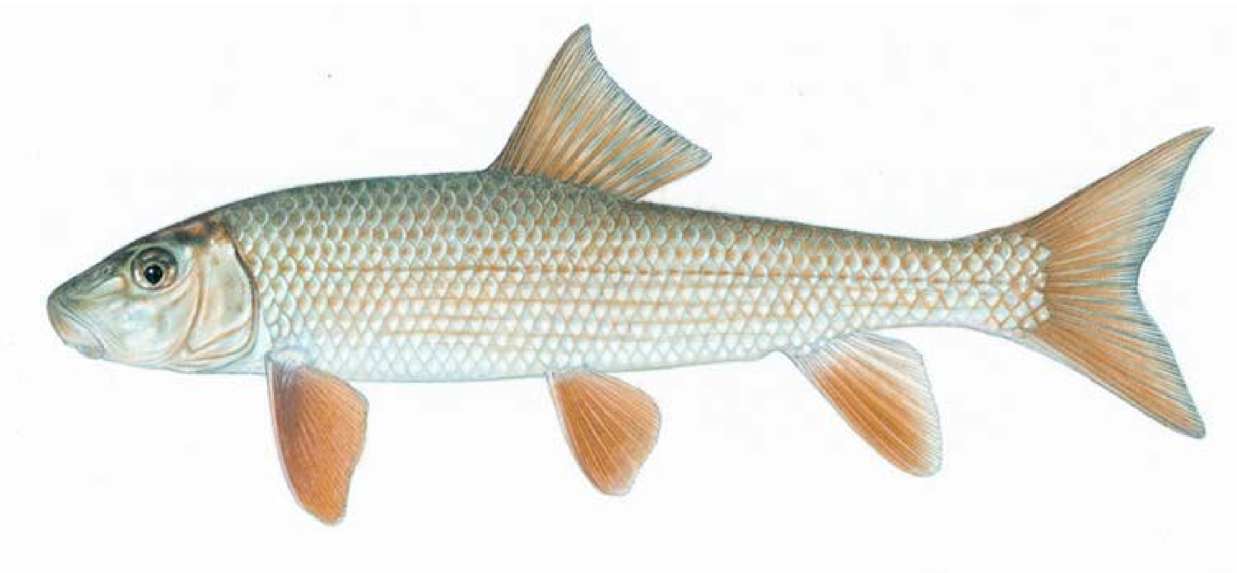
COSEWIC
Assessment and Status Report

on the

Black Redhorse
Moxostoma duquesnei

in Canada



THREATENED
2015

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC 2005. COSEWIC assessment and update status report on the black redhorse *Moxostoma duquesnei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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COSEWIC acknowledges Dr. Christopher Bunt for writing the status report on the Black Redhorse, *Moxostoma duquesnei* in Canada, prepared under contract with Environment Canada. This status report was overseen and edited by Dr. John Post, Co-chair of the COSEWIC Freshwater Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Chevalier noir (*Moxostoma duquesnei*) au Canada.

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Black Redhorse — Illustration by Joe Tomelleri. Used with permission.

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COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Black Redhorse

Scientific name
Moxostoma duquesnei

Status
Threatened

Reason for designation
This species of fish has a limited extent of occurrence and area of occupancy. It is found only in a few rivers in southwestern Ontario, and is under continuing threats to habitat quality due to the cumulative impacts of pollution from urban wastewater and agriculture and alterations to flow regimes.

Occurrence
Ontario

Status history
Designated Threatened in April 1988. Status re-examined and confirmed in May 2005 and May 2015.

COSEWIC
Executive Summary

Black Redhorse
Moxostoma duquesnei

Wildlife Species Description and Significance

The Black Redhorse (*Moxostoma duquesnei*) is one of seven redhorse species in the genus *Moxostoma* of the sucker family Catostomidae found in Canada. It can be distinguished from the other redhorse species based on a combination of physical factors including the tail colour, lip morphology, and lateral line scale count.

Distribution

The Black Redhorse has a wide, but disjunct distribution in the Mississippi and Great Lakes drainages of eastern North America. In Canada, it is known from tributaries of Lake Erie, Lake St. Clair, and Lake Huron in southwestern Ontario. Black Redhorse records have been found in a tributary of Lake Ontario (Spencer Creek) and in Lake Simcoe. However, due to the separation of other established populations, these records are likely introductions. There have been no collection records in Catfish Creek since 1938, and in the Sauble River since 1958, despite sampling, and therefore, it is now considered extirpated in these rivers.

Habitat

Black Redhorse are found primarily in moderate to fast-flowing areas in large warmwater streams with widths ranging from 25 to 130 m. In these areas, they use well-developed riffles and pools adjacent to riffles. They are associated with clean coarse substrate consisting of gravel and cobble, but have also been found in areas with sand, silt and boulders. Adult Black Redhorse are rarely associated with submerged aquatic vegetation. Black Redhorse have been known to migrate and spawn at the edge of riffles, avoiding the highest velocity areas, over substrates ranging in size from fine gravel to large cobble. Juveniles and young-of-the-year are found in low gradient habitat, with reduced flow. They use shallow pools with heterogeneous substrate composed of clean pebble and cobble with a mixture of sand and silt. Both adult and juvenile Black Redhorse have been found in areas influenced by groundwater.

Biology

Maximum known age is 17 years and maximum known length and weight are 658 mm total length and 3200 g, respectively. It is a benthic feeder of crustaceans and insects and the growth rate of juvenile Black Redhorse was determined to be 80 mm per year. Age at maturity ranges from two to six years. The Black Redhorse becomes sexually dimorphic and migrates to spawning habitat in the spring. Spawning occurs in water temperatures from 15 to 21 ºC.

Population Sizes and Trends

Extensive sampling has occurred over the 2004-2013 sampling period with at least 703 individuals captured. Black Redhorse continues to be found in most historical sites as well as some new sites. Black Redhorse populations, although unknown in size, are most abundant in the Grand River and Thames River watersheds. No Black Redhorse have been collected in Catfish Creek since 1939 and the Sauble River since 1958 despite sampling in 2002 and therefore, are now considered extirpated. Smaller populations (based on limited capture records) continue to be detected within the Lake Huron drainage (Ausable River, Maitland River, and Saugeen River). However, during the 2004-2013 period there have been no records of Black Redhorse from the Bayfield River or Gully Creek. This may be a result of small population sizes, insufficient sampling within these areas, or the possibility that previous captures were vagrants from larger Lake Huron tributary populations. The previous record in the Lake Ontario drainage (Spencer Creek – 1998) and a new record from Lake Simcoe (2011) have been interpreted to be from introductions, based on separation between watersheds where established populations exist. Records of Lake Huron drainage Black Redhorse from the lower reaches of the Maitland River, Saugeen River, Bayfield River, Ausable River, Gully Creek and Sauble River, suggest that inter-lake movement between rivers may occur and thus provides insight into potential rescue from populations in the United States, should the Black Redhorse become extirpated in Canada.

Threats and Limiting Factors

The most severe threats to Black Redhorse populations include pollution, and the effects of climate change and extreme weather events. It is likely impacted by changes in water quality and quantity related to agriculture, urbanization, dams and impoundments. Other low-level and, less significant threats include baitfish collection and impacts of invasive species.

Protection, Status, and Ranks

Black Redhorse is indirectly protected by the federal *Fisheries Act*, which provides habitat protection in areas where Black Redhorse share habitat with fishes of Commercial, Recreational, or Aboriginal fishery significance. In Ontario, the Black Redhorse is listed as threatened under the *Endangered Species Act, 2007* and the species and its habitat are protected. In Canada, they are currently assessed as Threatened by COSEWIC. However, it is not listed under Schedule 1 of the *Species at Risk Act* (SARA), due to a lack of scientific data necessary to conduct a socio-economic analysis to make recommendations on the amount of allowable harm that this species can withstand. After socio-economic factors have been evaluated, the Black Redhorse SARA status may be reassessed for listing. In the United States, sub-national ranks are provided for 21 states. The International Union for Conservation of Nature (IUCN) lists the status of this species as least concern on the IUCN Red List of Threatened Species.

TECHNICAL SUMMARY

Moxostoma duquesnei

Black Redhorse Chevalier noir

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time (usually average age of parents in the population	~5 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Current estimated extent of occurrence (EO) * Based on minimum convex polygon around extant records from 2004-2013 Historical estimated extent of occurrence (EO) = 14,592 km^2 *Based on minimum convex polygon around extant records prior to 2004, within Canada’s jurisdiction.	13,617 km^2
Current Index of area of occupancy (IAO) km^2 (2x2 grid value): 247 grids = 988 km^2 Grand River (and vicinity): 132 grids = 528 km^2 Thames River (and vicinity): 97 grids = 388 km^2 Ausable River watershed: 14 grids = 56 km^2 Maitland River: 1 grid = 4 km^2 Saugeen River: 3 grids = 12 km^2 Historical index of area of occupancy (IAO) (2x2 grid value): 360 grids = 1,440 km^2 Maitland River: 38 grids = 152 km^2 Gully Creek: 1 grid = 4 km^2 Bayfield River: 11 grids = 44 km^2	988 km^2

Ausable River: 1 grid = 4 km² Thames River: 142 grids = 568 km² Catfish Creek: 17 grids = 68 km² Grand River: 150 grids = 600 km²	
Is the population severely fragmented?	No
Number of locations (total) Number of current locations based on multiple point source pollutants: 1. North Thames River 2. South Thames River 3. Grand River 4. Conestogo River 5. Nith River 6. Saugeen River 7. Maitland River 8. Bayfield River 9. Ausable River Potential locations: 10. Thames River downstream of the N&S fork (depends on assumptions of the extent of the most likely threat impact) 11. Medway Creek (but likely part of North Thames Location) 12. Middle Thames (but likely part of the South Thames Location) 13. Waubuno Creek ((but likely part of South Thames Location) (Gully Creek, Lake Simcoe, and Spencer Creek have not been included because there is no evidence that Black Redhorse populations are established and specimens that were collected are suspected to be introductions (Lake Simcoe and Spencer Creek)).	9-13 (depending on assumptions of the spatial extend of the threats)
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations?	Unknown
Is there an [observed, inferred or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes, quality
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Data Not Available

Threats (actual or imminent, to populations or habitats)

The IUCN Threat Calculator was used to evaluate eleven different threats to Black Redhorse populations.
Actual: Pollution and habitat degradation from increased urbanization and industrialization in most watersheds resulting in poor water quality, repeated spills and effects from agriculture run-off and wastewater effluent. Dams (with limited access to fishways) and impoundments, climate change and extreme weather
Potential: Invasive species, baitfish collection

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada?	S2 - NY; S3 - MI; S5 – OH, PA
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Low likelihood

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC: Designated Threatened in April 1988. Status re-examined and confirmed in May 2005 and May 2015.

Additional Sources of Information:

Existing Status

Nature Conservancy Ranks (NatureServe 2013)
Global – G5
National
US – N5
Canada – N2
Regional
US – AL – S5, AR – S4, GA – S4, IA – S2, IL – S2S3, IN – S4, KS – S1, KY – S4S5, MI – S3, MN – S4, MO – SNR, MS – S1, NC – S4, NY – S2, OH – S5, OK – S4, PA –

S5,TN – S5, VA – S3, WV – S4, WI – S1 Canada – ON – S2 **COSEWIC** Threatened – (May 2015) **IUCN** Least Concern (LC)

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric code:** B1ab(iii)+2ab(iii)
Reasons for designation: This species of fish has a limited extent of occurrence and area of occupancy. It is found only in a few rivers in southwestern Ontario, and is under continuing threats to habitat quality due to the cumulative impacts of pollution from urban wastewater and agriculture and alterations to flow regimes.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Number of mature individuals is unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(iii)+2ab(iii) due to small extent of occurrence (< 20,000 km²) and small index of area of occupancy (< 2,000 km²), small number of locations (< or = 10), and inferred and projected decline in the quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information on number of mature individuals is available.
Criterion D (Very Small or Restricted Population): Not applicable. No information on number of mature individuals is available.
Criterion E (Quantitative Analysis): Not available.

PREFACE

The Black Redhorse was designated as a Threatened species in April 1988 and re-assessed and confirmed by COSEWIC in May 2005. However, it has not been listed under Schedule 1 of the SARA, due to a lack of scientific data necessary for a socio-economic analysis to determine the amount of harm that could be allowed without jeopardizing recovery or survival for this species. Since the 2005 COSEWIC status report, new information on distribution and habitat use has been collected. Black Redhorse has been sampled at some historical locations as well as several new sites including Big Creek, Fairchild Creek, Wye Creek, the Ausable River, and the Saugeen River. Sampling in Gully Creek, Spencer Creek and Lake Simcoe have each yielded one individual Black Redhorse. However, these records have been removed from the distribution, due to the separation from established populations and lack of detection despite subsequent sampling. Black Redhorse has not been detected in Catfish Creek or the Sauble River since 1938 and 1958, respectively, despite sampling and therefore, it is now considered to be extirpated. This has resulted in a decrease in the extent of occurrence (EO) and the index of area of occupancy (IAO). There has been no assessment of population sizes or abundance of this species; however, a sensitivity analysis was conducted, and recovery targets for population abundance as well as required habitat, have been determined. There has been an increased understanding of threats and limiting factors that may affect Black Redhorse including pollution, and ten other variables.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2015)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Black Redhorse
Moxostoma duquesnei

in Canada

2015

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia

Phylum: Chordata

Class: Actinopterygii

Order: Cypriniformes

Family: Catostomidae

Genus and species: *Moxostoma duquesnei* (Lesueur 1817)

Common English name: Black Redhorse (Page *et al.* 2013)

Common French name: chevalier noir

Morphological Description

Black Redhorse (*Moxostoma duquesnei*) is one of seven redhorse species in the genus *Moxostoma* within the family Catostomidae found in Canada (Scott and Crossman 1998) (Figure 1). This fish is characterized as having a laterally compressed, shallow body (very low arch to back), long rounded snout (39.6-49.8% of head length), inferior mouth overhung by the snout, narrow upper lip, slight concave thick lower lip with deep cleft and long plicae without transverse grooves, club-shaped pharyngeal teeth, circumpeduncle scale count of 12-13, and lateral line count of 44-47 (Holm and Boehm 1998; Scott and Crossman 1998).

The dorsal surface of Black Redhorse is grey or olive-brown with a silver-blue overtone, the sides being lighter and usually silvery-blue, and at the ventral surface is silver to milky white. The scales have dark edges, but not at the base, and all fins are slate grey in colour (Scott and Crossman 1998).

During spawning season, males exhibit bold longitudinal black stripes with colour ranging from orange to pink along their flanks. Males have nuptial tubercles on their anal and caudal fins (Jenkins and Burkhead 1993). Females show little, or no, spawning colour (Kwak and Skelly 1992).

The Black Redhorse differs from the other six Canadian redhorse species in the following ways: Black Redhorse has a slate-grey tail, whereas a red tail is present in the following Redhorse species - River Redhorse (*M. carinatum*), Copper Redhorse (*M. hubbsi*), Shorthead Redhorse (*M.macrolepidotum*) and Greater Redhorse (*M. valenciennesi*) (Holm and Boehm 1999). Black Redhorse can be distinguished from the other two species of grey-tailed Redhorses based on several characters (Holm and Boehm 1998). It can be distinguished from Silver Redhorse (*M. anisurum*) by the presence of transverse grooves in the lips, slightly concave margin of the dorsal fin, lower pelvic fin ray count (nine versus ten), and larger non-overlapping lateral line scale count (44-47 versus 40-42). The Black Redhorse can be distinguished from the very similar Golden Redhorse (*M. erythrurum*) primarily by the larger non-overlapping lateral line scale count (44-47 versus 40-42), lower pelvic fin ray count (nine versus ten), and lack of nuptial tubercles on the head and scales of spawning males. It should also be noted that the colour differentiation may be faint or absent in juveniles making the identification of this species difficult.

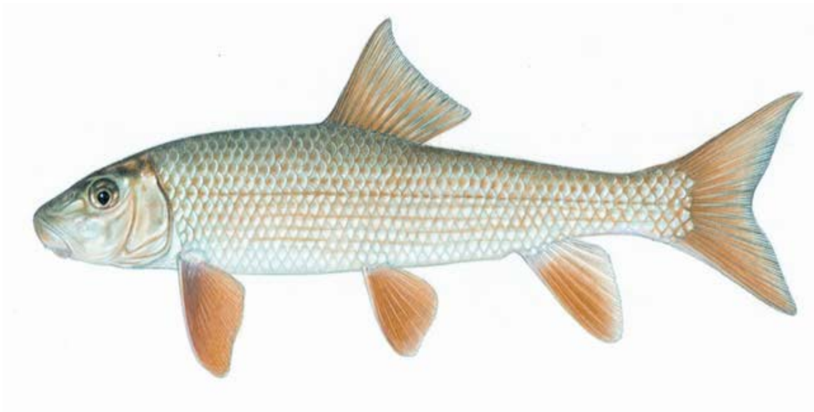

Figure 1. Black Redhorse (*Moxostoma duquesnei*). Illustration by Joe Tomelleri. Used with permission.

Population Spatial Structure and Variability

At a large spatial scale, the population of Black Redhorse is separated by geographic barriers. Within a number of watersheds (Lakes Erie, St. Clair, Huron), individuals (or sub-populations) are fragmented to varying degrees by dams. In previous studies, dams and impoundments have been identified as a threat and limiting factor to Black Redhorse populations (Portt *et al.* 2003; COSEWIC 2005; Reid and Mandrak 2006), by reducing genetic diversity and gene flow (Reid *et al*. 2008a). Reid *et al.* (2008a) reported pairwise F_{ST} estimates that showed statistically significant, but weak differences in population structure in the Grand River (global FST = 0.011). However, recent studies have shown that the Black Redhorse and other Redhorse species are capable of upstream passage in areas with appropriate warmwater fish passage modifications (e.g., Denil fishways at the Mannheim Weir, Bunt *et al.* 2001) and therefore, dams may not pose a major threat in areas where movement is possible, contrary to what was previously documented (DFO 2009).

Designatable Units

The Black Redhorse occurs in at least five watersheds in Canada, among which, populations presumably have little contact with each other. All Canadian populations are found within the Great Lakes-Western St. Lawrence ecozone within the freshwater ecozone classification adopted by COSEWIC (COSEWIC 2011). Because no studies have been conducted on genetic structure in each of these areas that would allow for comparisons to be made, the Canadian populations are considered to be one designatable unit.

Special Significance

Canadian populations of the Black Redhorse are at the northern limit of their global distribution, and are sparse compared to populations in the United States. Black Redhorse are considered to be sensitive to poor water quality and degraded habitat. It plays an important role as a nutrient cycler in aquatic ecosystems. It transfers energy (i.e., nutrients) from the benthic food web where it feeds, to the pelagic food web where it is preyed upon by piscivorous fishes.

Aboriginal people of Ontario recognize this species and it was historically harvested for food during spring spawning runs. It was noted that populations had declined and had been replaced by White Sucker, *Catostomus commersoni*, (H. Lickers, Mohawk Council of Akwesasne, Department of the Environment, pers comm.; COSEWIC 2005).

DISTRIBUTION

Global Range

The Black Redhorse has a wide, but disjunct distribution in the Mississippi and Great Lakes drainages of eastern North America (Figure 2). It is found from Alabama and Mississippi in the south, to Ontario and Michigan in the north, and from New York in the east, to Oklahoma and Minnesota in the west. In the Mississippi drainage, the distribution east of the Mississippi River is continuous, but to the west it is disjunct (Lee *et al.* 1980; Page and Burr 2011). In the Great Lakes basin, disjunct populations are found in Ontario, Michigan and Wisconsin (Lee *et al.* 1980; Page and Burr 2011).

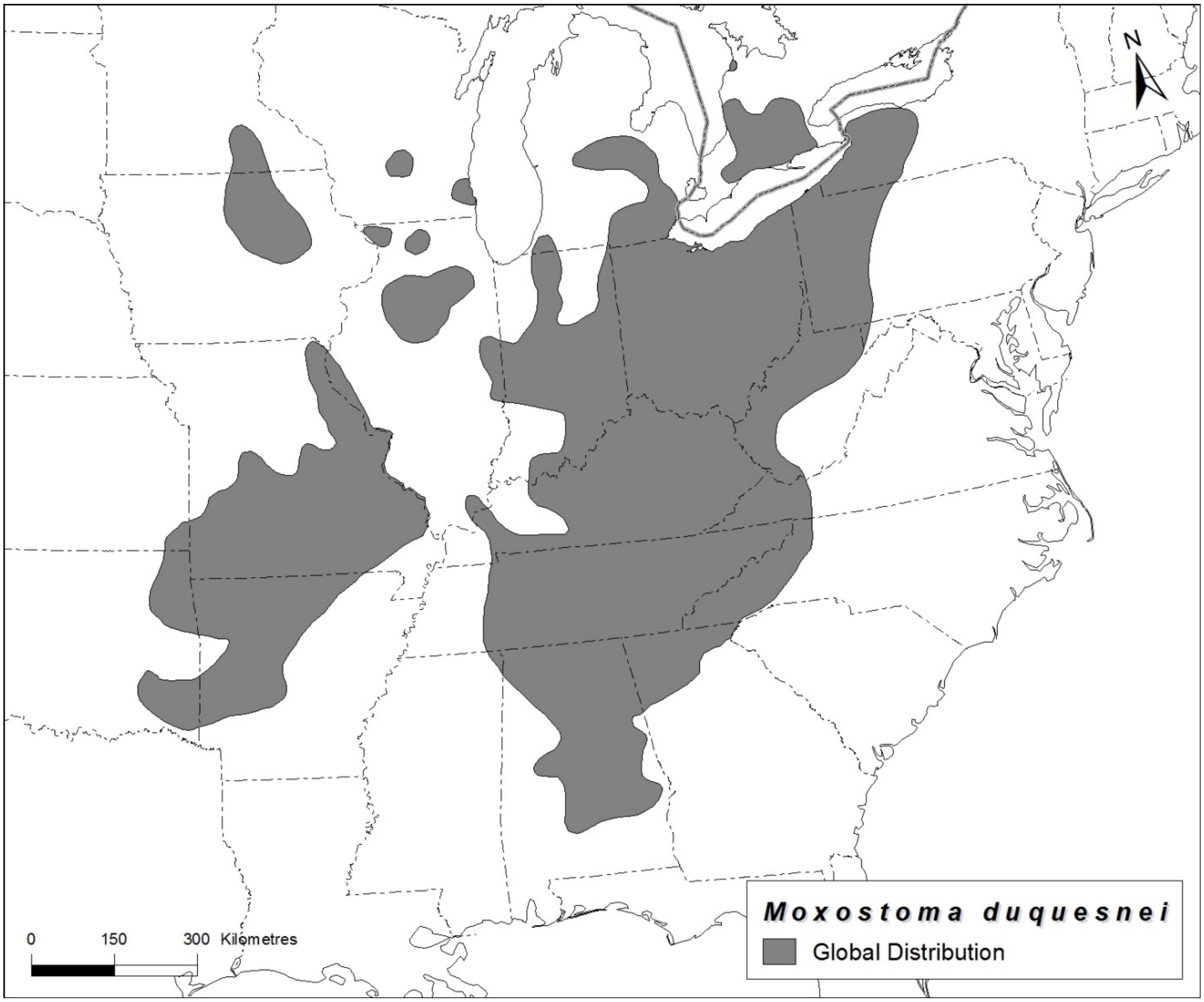

Figure 2. Global Distribution of Black Redhorse, *Moxostoma duquesnei*. Modified from Page and Burr 1991.

Canadian Range

Historically, the Black Redhorse range was limited to southwestern Ontario where it has been found in tributaries of Lake Erie, Lake St. Clair, Lake Huron and Lake Ontario (Figure 3, Table 1). In the Lake Erie drainage, this species was found in Catfish Creek in 1938 (now believed to be extirpated) and continues to occupy areas within the Grand River watershed. Populations are concentrated in the central Grand River. Populations are fragmented by large dams without warmwater fish passage (four in the Grand River), resulting in five disjunctive populations. It also occurs in the lower reaches of two major tributaries (Conestogo River and Nith River). In the Grand River, populations exist in a 160 km stretch from downstream of Inverhaugh to York. In the Conestogo River it has been found in a 25 km stream section from its mouth to Wallenstein. In the Nith River it has been found along a 86 km reach from the Grand River confluence to New Hamburg. Recent collections have verified the presence of Black Redhorse in lower portions of the Grand River watershed (Mount Pleasant Creek) and at two new sites where it was not previously collected (i.e., Big Creek and Fairchild Creek (A. Timmerman, MNRF, unpubl. data)). However, surveys in the Speed River and upstream of Inverhaugh in the Grand River did not detect Black Redhorse (Reid 2004; Reid *et al.* 2008b).

In the Lake St. Clair drainage, Black Redhorse is present In the Thames River watershed. Within this area, it occupies the Upper Thames River (North Thames, Middle Thames, and South Thames) and four tributaries as well as the Lower Thames River. It is distributed along a 192 km stretch from St. Mary's in the North Thames, and Thamesford in the Middle Thames, to Big Bend Conservation Area (Wardsville), in the Lower Thames. However, the last record in the Lower Thames River at this location was in 2003 (DFO unpubl. data). There are also two large dams that lack fish passage, and potentially cause fragmentation, resulting in disjunct populations. The majority of Black Redhorse have been collected in the Upper Thames River and its tributaries including, Stoney Creek, Medway Creek, Waubuno Creek, and Wye Creek. In Stoney Creek and Medway Creek it is found from Medway Road to the main channel of the Thames River, in a 4.5 km and 5 km stretch, respectively. In Medway Creek it is found along a 5 km stretch from Medway Road to its confluence with the Upper Thames River. In Waubuno Creek it is found along a 5.4 km stretch from its confluence to just upstream of Trafalgar Street. In 2005, it was found in one location in Wye Creek at Rebecca Road, 1.7 km upstream from its confluence.

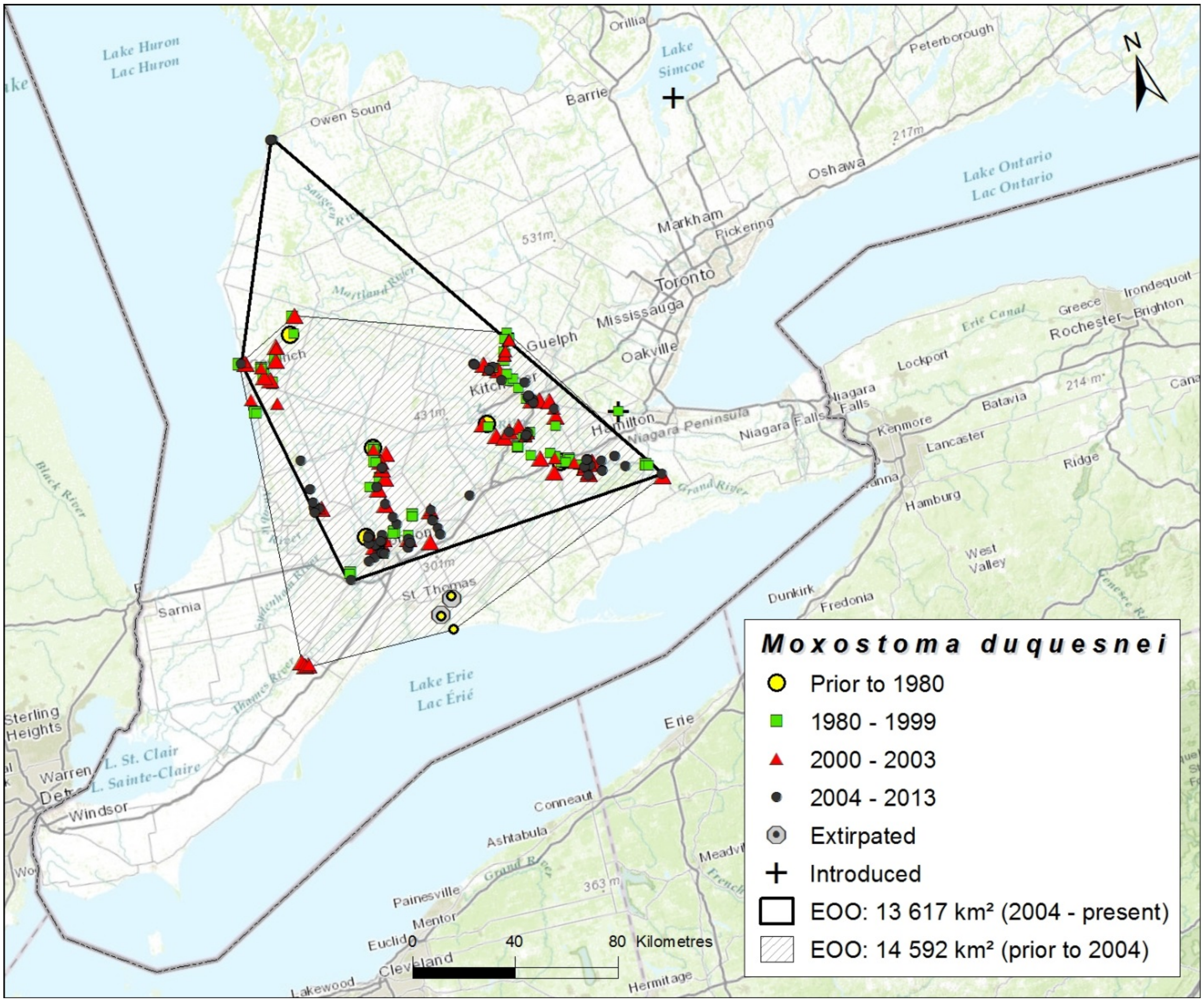

Figure 3. Canadian Distribution of Black Redhorse (Moxostoma duquesnei) across four time periods, showing extent of occurrence (EO), prior to 2004 and from 2004-2013.

Table 1a. Canadian surveys that resulted in the capture of Black Redhorse, 1926-2003.

Waterbody	Year**	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort E-seconds (mean ± S.D.) or hauls	CPUE – EF (per hour)	Collector/Source[3]
Lake Erie Drainage									
Grand River Watershed									
	1975	-	2	3		BEF	-	-	MNRF records
	1997	-	6	11		BEF, BEF	-	-	ROM records

Waterbody	Year**	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort E-seconds (mean ± S.D.) or hauls	CPUE – EF (per hour)	Collector/Source[3]
	1998	-	1	1		SN	-	-	MNRF records
	2000	-	1	-		SN, DN	-	-	MNRF records
	2001	-	3	10		EF	-	-	MNRF records
	2002	7	4	55	BKRH	BEF, BPEF	2076 ± 822	94.8	Mandrak *et al.* 2006
	2002	14	10	12	BKRH	BEF, BPEF, 2 BEF	-	-	S. Reid, MNRF, unpubl. data
	2003	33	16	16	BKRH	BEF, BPEF, 2 BPEF	-	-	S. Reid, MNRF, unpubl. data
	2003	44	3	4	SAR	BPEF, BEF SN	680, 1 haul/site	5.3	Mandrak *et al.* 2010
Conestogo River	2002	2	1	1	BKRH	BPEF	2802 ± 0	1.2	Mandrak *et al.* 2006
	2003	17	5	5	BKRH	2 BPEF	-	-	S. Reid, MNRF, unpubl. data
Nith River	1997	-	2	4		BEF	-	-	MRNF records
	2002	14	3	9	BKRH	BEF	690 ± 0	46.8	Mandrak *et al*. 2006
	2002	5	5	5	BKRH	BPEF, 2 BPEF	-	-	S. Reid, MNRF, unpubl. data
	2003	24	6	6	BKRH	BPEF, 2 BPEF	-	-	S. Reid, MNRF, unpubl. data
Mount Pleasant Creek	2000	-	1	2		-	-	-	MNRF records
Catfish Creek	1926	-	1	1		-	-	-	MNRF records
	1937-1938	-	1	1		-	-	-	MNRF records
Lake St. Clair Drainage									
Thames River Watershed									
Thames River	1998	-	1	1		EF, SN	-	-	MNRF records
	2002	7	2	7	BKRH	BPEF	1356 ± 270	18.6	Mandrak *et al.* 2006
	2003	31	3	5		BEF	660 ± 59	9.0	Edwards and Mandrak 2006
Flat Creek	1997	-	1	1		SN	-	-	MNRF records
Medway Creek	1975	-	1	1		SN	-	-	MNRF records
	2002	-	1	6		BPEF	1547	-	MNRF records
Waubuno Creek	1986	-	1	1		EF	-	-	ROM surveys
Fanshaw Lake	1998	-	2	9		SN, BEF	-	-	MNRF records
Lake Huron Drainage									
Little Ausable River	2002	-	1	4		BPEF	-	-	ABCA surveys
Bayfield River	1982	-	1	2		DN	-	-	MNRF records
	2003	-	1	3		2 BPEF	-	-	ROM records

Waterbody	Year**	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort E-seconds (mean ± S.D.) or hauls	CPUE – EF (per hour)	Collector/Source[3]
Maitland River	1982	-	3	6		SN, EF	-	-	MNRF records
	1999	-	2	5		EF	-	-	MNRF records
	2002	2	2	4	BKRH	BPEF	1188 ± 228	24.0	Mandrak *et al.* 2006
Belgrave Creek	1973	-	1	1		-	-	-	MNRF records
	2002	1	1	4		BPEF	986		Mandrak *et al.* 2006
Bridgewater Creek	1998	-	1	1		SN	-	-	MNRF records
Gully Creek	2003	-	1	1		BPEF	-	-	ROM records
Lake Ontario Drainage									
Spencer Creek	1998	-	1	1		BEF	-	-	

Table 1b. Canadian surveys that resulted in the capture of Black Redhorse, 2004-2013.

Watershed/Stream	Year(s)	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort (E-seconds, hauls)	CPUE – EF (per hour) or CPUE (per haul)	Collector/Source[3]	Comments
Lake Erie drainage										
Grand River Watershed										
Grand River, above Paris	2004	-	1	?		?	?		MNRF records, DFO surveys	
	2004	-	2	2		BPEF	-		MNRF records, DFO surveys	
	2007	-	1	9	BKRH	CN	-		Bunt, C. (Biotactic)	adults
	2007	-	1	3	BKRH	BPEF	615	17.5	Bunt, C. (Biotactic)	adults
	2007	-	1	4	BKRH	BPEF	-		Bunt, C. (Biotactic)	juveniles
	2007	-	2	121	BKRH	BEF	-		Bunt, C. (Biotactic and DFO)	adults
	2007	-	1	14	BKRH	SN	2 hauls	7	Bunt, C. (Biotactic)	adults
	2007-2009	-	2	115	BKRH	SN	-		C. Bunt (Biotactic records)	adults

Watershed/Stream	Year(s)	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort (E-seconds, hauls)	CPUE – EF (per hour) or CPUE (per haul)	Collector/Source[3]	Comments
	2008	-	1	13	BKRH	CN	-		Bunt, C. (Biotactic)	
	2009	-	1	26	BKRH	DN	1	13	Bunt, C. (Biotactic)	Juveniles
	2009	-	1	4		BEF	-		O'Farrell, D.;AGB;NRSI	
	2009	-	7	190		EF from raft	-		LGL Ltd. (MNRF)	
	2010	-	2	8	BKRH	CN	-		Bunt, C. (Biotactic)	
	2012	-	1	26	SAR	SN	-		Bunt, C. (Biotactic)	
	2012	-	1	1			-		Knight, L. (Aquafor Beech Ltd)	
	2012-2013	-	1	3		FWT	-		Bunt, C. (Biotactic)	adult
	2013	-	1	5	SAR	SN	-		Bunt, C. (Biotactic)	
Grand River, below Paris	2004	15	9	9		BEF	-		MNRF records, DFO surveys	
	2004	-	1	1		BEF	-		Richardson, L; Killins, K; Davis, D (GRCA surveys)	
	2009-2013	-		3		TR	-		Barnucz, J., D. Marson (DFO surveys)	
Conestogo River	2005		1	1		BPEF	7	0.4	Beneteau, C., D. Marson (DFO surveys)	
	2007		2	2*		?	-		Timmerman, A. (MNRF surveys)	
Nith River	2005		1	1*		EF	-		Schwindt, J. (UTRCA surveys)	
	2009		2	4		EF	-		LGL limited (consultant)	
Mount Pleasant Creek	2007		1	1		BPEF	-		Timmerman, A. (MNRF surveys)	
Big Creek	2010		1	1		EF	-		Timmerman, A. (MNRF surveys)	

Watershed/Stream	Year(s)	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort (E-seconds, hauls)	CPUE – EF (per hour) or CPUE (per haul)	Collector/Source[3]	Comments
Fairchild Creek	2011		1	1*		BPEF	-		Timmerman, A. (MNRF surveys)	Juvenile *Moxostoma spp* were collected, verified by E. Holm. Although numbers were not quantified
Lake St. Clair Drainage							-			
Thames River Watershed										
South Thames River	2004, 2006-2007	-	4	10*		EF	-		Schwindt, J. (UTRCA surveys)	
	2005	-	4	14		EF	856 ± 41.2	58.9	DFO SAR database 2005	
Middle Thames River	2004-2005; 2007-2008; 2012	-	4	9		EF	-		Schwindt, J. (UTRCA surveys)	
North Thames River	2006-2007; 2012	-	5	10*		EF	-		Schwindt, J. (UTRCA surveys)	
	2011	-	2	2		SN	15 hauls	0.1	(DFO surveys)	
	2013	-	1	1*		EF	-		Schwindt, J. (UTRCA surveys)	
Medway Creek	2004-2012 (excluding 2009-2010)	-	6	46*		EF	-		Schwindt, J. (UTRCA surveys)	
Stoney Creek	2004, 2012	-	2	5*		EF	-		Schwindt, J. (UTRCA surveys)	
Waubuno Creek	2004-2005, 2007-2009, 2012	-	4	15*		EF	-		Schwindt, J. (UTRCA surveys)	
Wye Creek	2012	-	1	1*		EF	-		Schwindt, J. (UTRCA surveys)	
Lake Huron Drainage										
Little Ausable River	2007	4	1	2	BKRH	SN	SN 3 hauls	0.7	Holm, E. (ROM records; ABCA surveys)	

Watershed/Stream	Year(s)	No. of Sites Sampled	No. of sites with Black Redhorse	Total Black Redhorse Captured	Target[1]	Method[2]	Total Effort (E-seconds, hauls)	CPUE – EF (per hour) or CPUE (per haul)	Collector/Source[3]	Comments
Ausable River	2007	6	2	3	BKRH	SN	SN 3 hauls	1.0	Holm, E. (ROM records & DFO records) (ABCA surveys)	
	2007	6	1	9	BKRH	BPEF	860	37.7	Holm, E. (ROM records, ABCA surveys)	
	2008-2009	10	2	5	BKRH	BPEF	903 ± 67	19.9	Holm, E. (ROM records, ABCA surveys)	
Saugeen River	2006	25	2	6	SAR	BEF	638 ± 7.0	33.9	Marson *et al.* 2006 (DFO surveys)	
	2006	-	1	2		?	-		Marson, S; Stackhouse J. (DFO surveys)	
Maitland River	2009	-	1	1		BEF	-		LGL limited (consultant)	
Lake Simcoe Drainage										
Lake Simcoe	2011	**-**	1	1		Found dead in TN	-		Lake Simcoe Fisheries Assessment Unit	

[1]Target - BKRH - Black Redhorse, SAR - fish species at risk, blank - unknown or general survey

[2]BEF - Boat Electrofishing, BPEF - Backpack Electrofishing, CN - Cast Net, DN - Dip Net, EF - Electrofishing, FWT- Fishway Trap, SN - Seine Net, TR- Trawling, TN - Trap Net

[3]Source: MNRF -, DFO - Fisheries and Oceans Canada, GRCA - Grand River Conservation Authority, Ministry of Natural Resources and Forestry, NRSI - Natural Resource Solutions, UTRCA - Upper Thames River Conservation Authority

*In cases where Black Redhorse data were not quantified (e.g 'few'), the values hve been conservatively counted as a record of one individual. Total captured are therefore approximations and likely underestimates

**Data prior to 2004 are incomplete

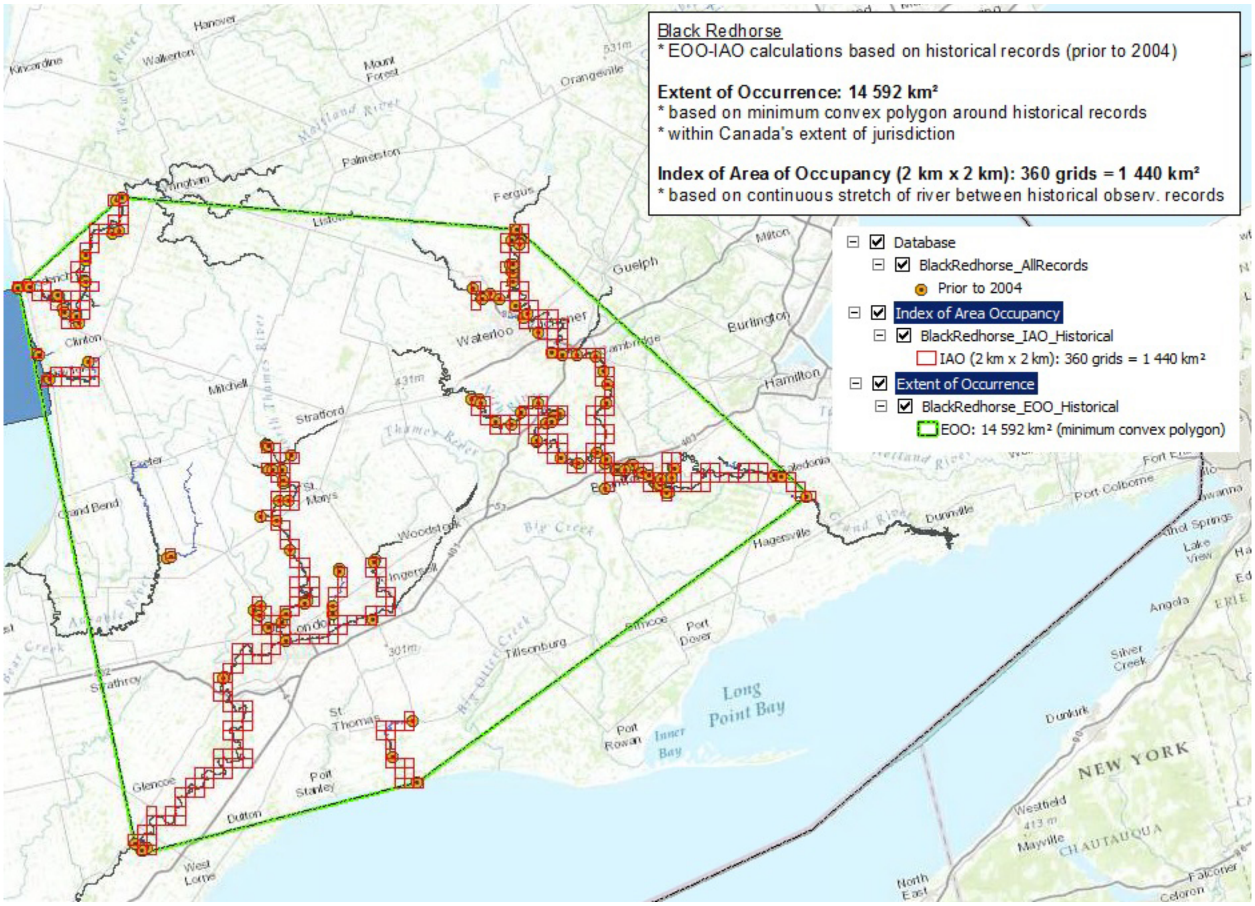

Figure 4. Historical distribution of Black Redhorse (Moxostoma duquesnei) showing extent of occurrence (EOO) and Index of Area of Occupancy (IAO) prior to 2004.

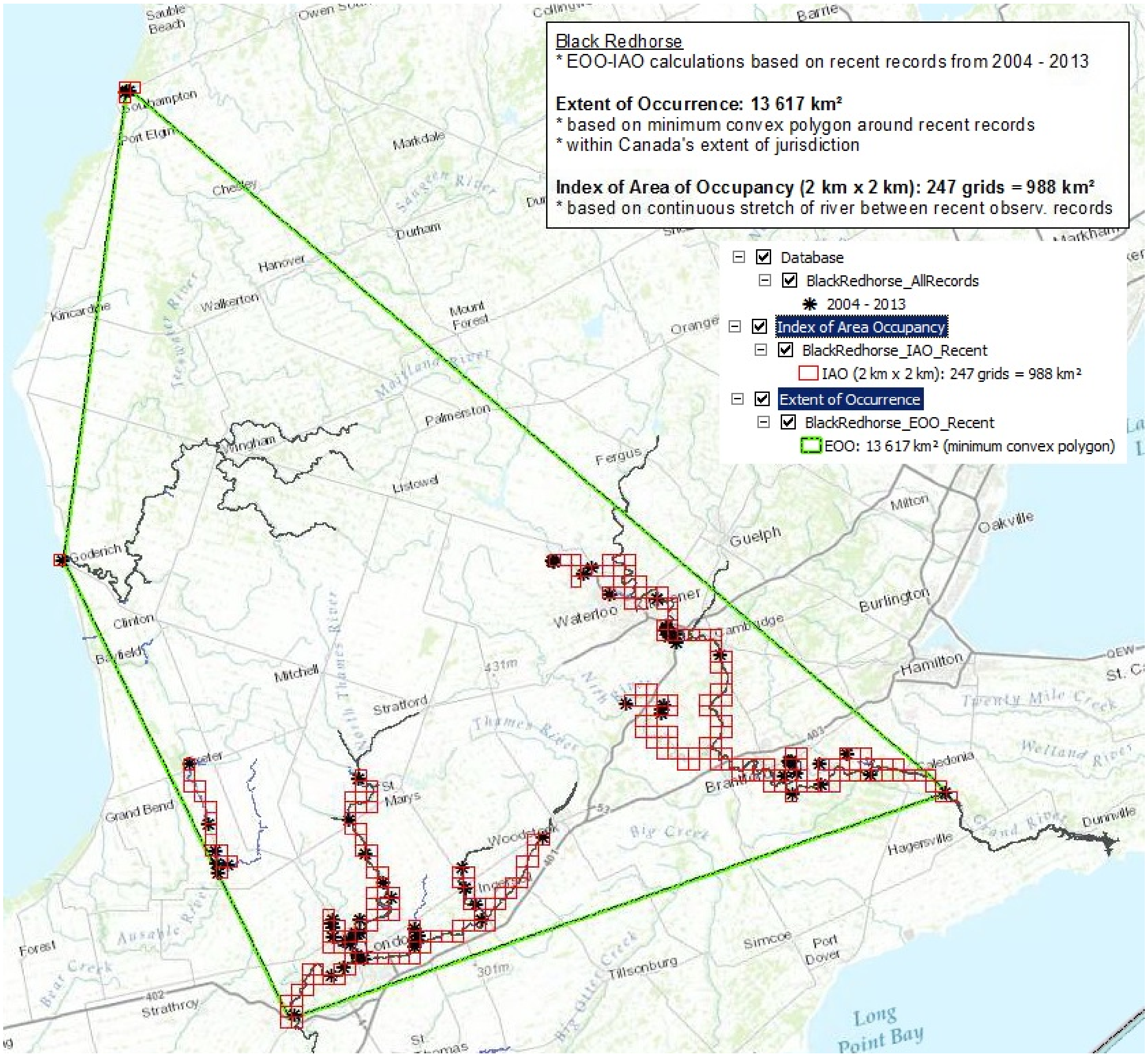

Figure 5. Recent distribution of Black Redhorse *(Moxostoma duquesnei)* showing extent of occurrence (EOO) and Index of Area of Occupancy (IAO) from 2004 until 2013.

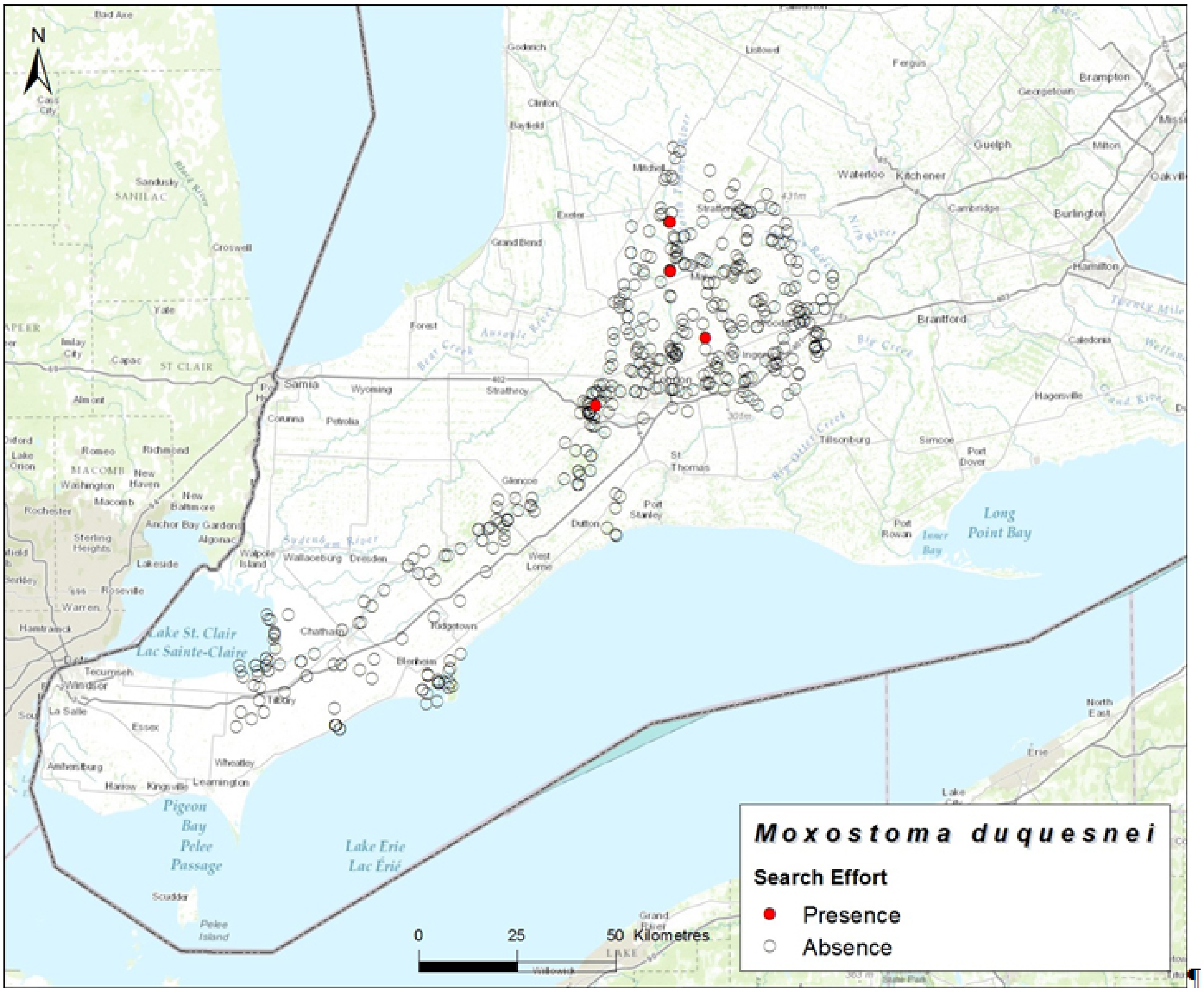

Figure 6. Sample Effort for Black Redhorse (*Moxostoma duquesnei*) in the Thames River prior to 2000.

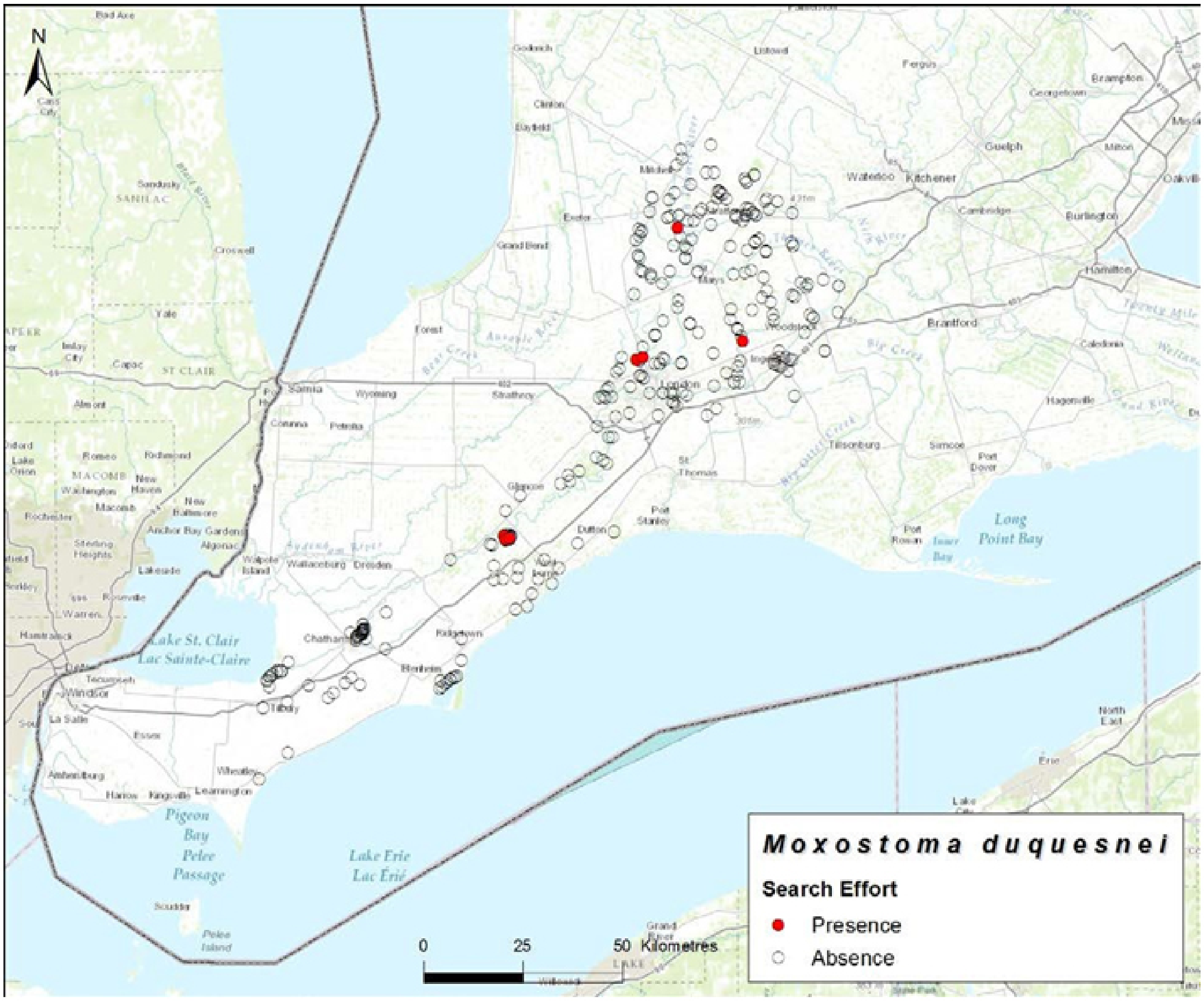

Figure 7. Sample Effort for Black Redhorse (*Moxostoma duquesnei*) in the Thames River prior to 2000.

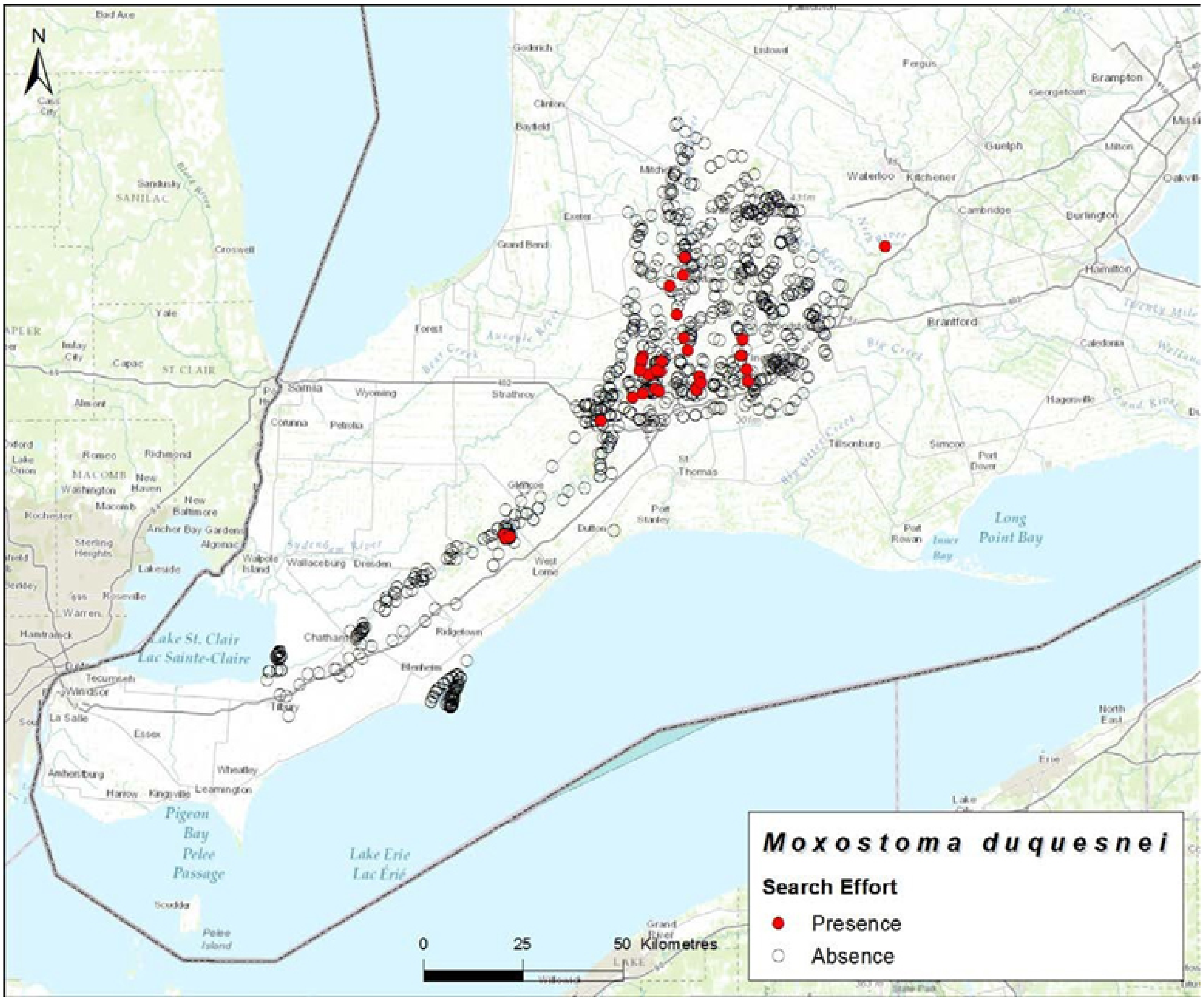

Figure 8. Sample Effort for Black Redhorse (*Moxostoma duquesnei*) in the Thames River from 2004 until present.

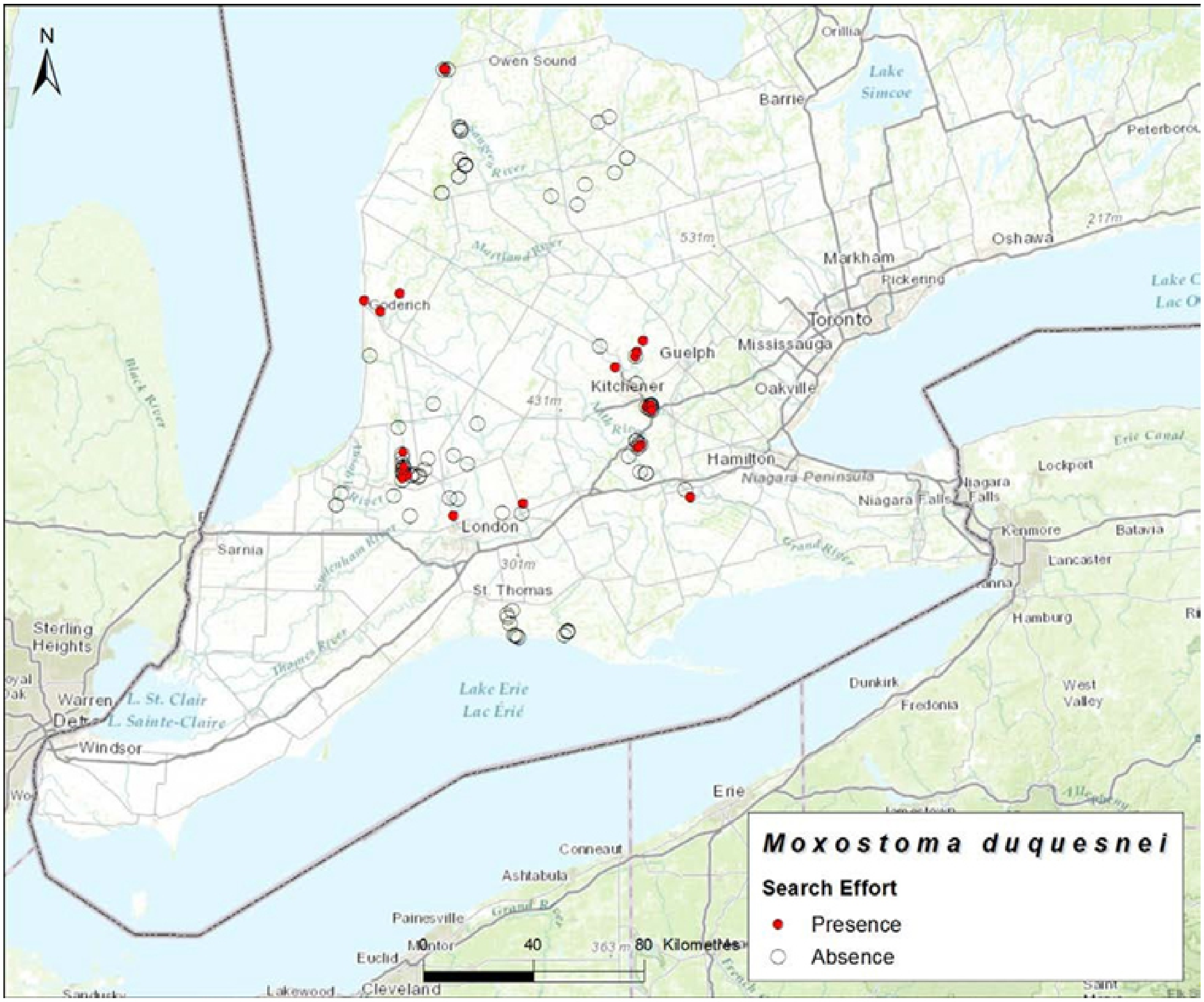

Figure 9. Sample Effort for Black Redhorse (*Moxostoma duquesnei*) in Canada (excluding the Thames River).

In the Lake Huron drainage, Black Redhorse was first detected in the Sauble River in 1958 when two specimens were reportedly collected by the Ontario Department of Planning and Development, and deposited in the Royal Ontario Museum (ROM) (ROM Accession No. RMA0446). The specimens were identified in 1969 by Dr. W. Beamish, University of Guelph, and subsequently discarded by the Royal Ontario Museum (E. Holm, ROM, pers. comm.). However, more recent sampling on the Sauble River failed to reveal any additional specimens and therefore, it is now considered to be extirpated (E. Holm, ROM, pers. comm.). It has also been found in the Bayfield River, Gully Creek, Maitland River and Ausable River watershed. In the Bayfield River it has been found approximately 20 km upstream from Lake Huron at the outlet of Tricks Creek. The last record of Black Redhorse reported in this area was in 2003 (DFO, unpubl. data). Black Redhorse was found in Gully Creek from a single site approximately 1 km upstream from Lake Huron. There are no records from Gully Creek since 2003. In the Maitland River, Black Redhorse has been found within a 63 km reach from its confluence to 9 km west of Wingham, and north of Marnoch. There is one record of a specimen that was collected from the mouth of the Maitland River in 2009 during surveys for the Goderich Harbour Wharf expansion (LGL Ltd., 2014). Black Redhorse was first collected in the Little Ausable River at one site near Maguire Road in 2002. Subsequent sampling resulted in Black Redhorse from the main Ausable River channel in 2007-2009, along a total river reach of 8 km. In 2006, six Black Redhorse were captured in the Saugeen River just 18 km south of the Sauble River (Marson *et al.* 2009).

Black Redhorse was collected at a single site in Spencer Creek (Christie Reservoir) that drains into western Lake Ontario, and it was also found in 2011 in Lake Simcoe. However; no other specimens have been collected in subsequent sampling efforts and due to the separation between established populations these records are considered to be introductions, likely as baitfish.

Extent of Occurrence and Area of Occupancy

The geographic distribution of known populations of Black Redhorse (EO) in Canada has decreased since the assessment of this species in 2005. The species range currently extends West to the Thames River, east to the Grand River, south to Lake Erie and north to the Saugeen River. The previous EO value reported in the COSEWIC 2005 status report was 20 000 km^2. However, a new methodology for calculating EO has changed this value. The EO was calculated to 14 592 km^2, prior to 2004, and 13 617 km^2 from 2004-2013, representing a 4.6% decrease. The index of area of occupancy (reported in a 2 km x 2 km grid in the new methodology) has also resulted in a range decrease of 31.4% from 1 440 km^2 to 988 km^2. The recent calculations for the 2004-2013 sampling period exclude Catfish Creek, Sauble River, Bayfield River, Gully Creek, Spencer Creek and Lake Simcoe, based on extirpation (Catfish Creek, Sauble River), potential introduction (Spencer Creek and Lake Simcoe), as well as unsuccessful attempts to detect the species during subsequent sampling from 2004-2013 (Bayfield River and Gully Creek).

Search Effort

The majority of Black Redhorse records were from non-targeted surveys, which included general sampling of fish communities as well as sampling for species at risk other than Black Redhorse. Non-targeted surveys were conducted using a variety of different gear types by the Department of Fisheries and Oceans Canada (DFO), MNRF, the Royal Ontario Museum, Conservation Authorities and consultants in the Grand River, Catfish Creek, Thames River, Bayfield River, Gully Creek, Spencer Creek, Lake Simcoe and Ausable River watersheds (Table 1).

Throughout most of the Canadian range for Black Redhorse prior to 1990, search effort was sparse and involved boat electrofishing, backpack electrofishing and dip nets. Most targeted studies were conducted by the DFO and the MNRF, and occurred from 1998-2003 using a variety of gear types including backpack electrofishing and boat electrofishing, seine nets/bag seines, and dip nets. In the past ten years, there has been little search effort expended that solely targeted Black Redhorse. The only targeted Black Redhorse surveys in recent years have been conducted by the Ausable Bayfield

Conservation Authority in the Ausable River watershed, from 2004-2009, DFO in the Saugeen River watershed, from 2005-2006, and by Biotactic from 2007 to 2013, in the Grand River. In addition to these specific efforts, Black Redhorse records have been submitted by consultants for other purposes such as the Goderich Harbour Wharf Expansion project (LGL Ltd. 2014). While some targeted surveys provided data that facilitated calculations of presence/absence and the amount of effort expended, many of the other surveys were not designed to provide information necessary to quantify presence/absence or abundance. Due to the paucity of information, it is difficult to determine if the decrease in EO of Black Redhorse is due to lack of search effort, or an actual decrease in distribution or abundance. For a detailed description of sampling effort and methods used to capture Black Redhorse, see **Population Sizes and Trends**.

HABITAT

Habitat Requirements

Adults

The Black Redhorse generally inhabits moderately sized, clear, warmwater rivers (Bowman 1970). It generally prefers pools in the summer and over-winters in deeper pools (Bowman 1970). Although few studies have quantified specific habitat variables associated with the presence of Black Redhorse, it has been reported in streams with gradients ranging from 1.2-1.5 m/km (Parker and Kott 1980) and average annual discharge ranging from 14 to 20 m^3/s (Bowman 1970; Parker and Kott 1980) in well oxygenated and relatively eutrophic water with July water temperature averaging approximately 20 ºC (Parker 1989). In one section of the Grand River between Paris and Brantford, mean water velocity was 0.22 m/s and 1.69 m deep in areas where Black Redhorse were found (Clark 2004). Clark (2004) reported that Black Redhorse were seldom found in slower velocities, and may have been limited to faster moving habitats. However, these data should be treated cautiously, due to the small sample size (n=4). Reid (2006a) determined that Black Redhorse presence was negatively correlated with habitat containing high gradients, as well as small and large upstream drainage areas. In another occurrence study of various Redhorse species, 77 sites in Indiana were surveyed and showed that Black Redhorse occurred at sites characterized by greater depth (mean = 0.61 m vs. 0.31 m) and slower current (mean = 0.06 m/s vs. 0.49 m/s) than sites where Black Redhorse was absent (Brown 1984). Based on collections made in 1997, Holm and Boehm (1998) described the riverine habitat in Canada as 25-130 m wide, 0.1-1.8 m deep with usually moderate to fast, but occasionally slow current, and substrates consisting of rubble, gravel, sand, boulders and silt. Reid (2006a) suggested that suitable habitat for Black Redhorse includes clean coarse bed material (gravel and cobble), stable channels, and well developed riffles. Adult Black Redhorse are rarely associated with submerged aquatic vegetation. The habitat in sites sampled throughout its range in southwestern Ontario in 2002 and 2003 was similar to that described by Holm and Boehm (1998) (COSEWIC 2005: Reid 2006a; N.E Mandrak, DFO, unpubl. data).

Juveniles

Young-of-the-year (YOY or 0+) Black Redhorse were found in shallow pools and slackened current in the Thames and Nith rivers in Ontario (Parker 1989). In the Grand River, YOY were most commonly observed among beds of Swamp Loosestrife (*Decodon verticullatus*) in relatively quiet waters. Recent field work showed that juvenile Black Redhorse occupied vegetated littoral zones, 0.8 - 2.0 m deep, along the edges of pools and runs downstream of riffles in the summer (Bunt *et al.* 2013b; S. Reid, MNRF, unpubl. data). Further data indicate that juveniles also utilize low gradient habitat, with reduced flow, clean pebble, gravel and cobble substrate of a heterogeneous composition, with a mixture of sand and silt (Bunt *et al.* 2013b). This habitat is similar to that of the 0+ Copper Redhorse and the River Redhorse (Bunt *et al.* 2013b). During the summer, large juveniles (approx. 150 mm) have been observed to feed alone along the bottom of sandy pools (Bowman 1970). Immature Black Redhorse have been captured in shallow pools below riffles (Parker and Kott 1980). In the Grand River, approximately 35 % of Black Redhorse collection sites contained both juveniles and adults (S. Reid, MNRF, unpubl. data). Table 2 summarizes the habitat preferences of different life history stages of Black Redhorse in Canada. Current models for allowable harm indicate that it is important to protect 0+ Black Redhorse habitat as it is critical for the conservation / enhancement of Black Redhorse populations (Velez-Espino and Koops 2009). More recent modeling indicates that juvenile survival is critical to the sustainability of viable Black Redhorse populations (Young and Koops 2013).

Table 2. Summary of habitat utilization across different life history stages of Black Redhorse in Ontario

Age Class	Average Distance from Shore (m)	Average Depth (m)	Flow (m/s)	Substrate Type/ Habitat Type	Macrophyte Cover	Source
Egg	0.8	0.2-0.3	Flow Data Unavailable	gravel/cobble/ pebble	none	Bunt, *et al.* 2013a
YOY	1.37	0.22	0.03	gravel/pebble/ silt over sediment (minimal to none)	swamp loosestrife	Bunt, *et al.* 2013b, Parker 1989
Juvenile	3.07	0.83-2.0	0.08	sand/ cobble/ pebble/ silt over sediment	vegetated littoral zones	Bunt, *et al.* 2013b
Adult	n/a	0.61	0.06	-	-	Brown 1984
		2.0-5.0 (Over-wintering habitat)	Flow Data Unavailable	sand/ cobble/ gravel	n/a	Biotactic, unpubl. data; Mandrak and Casselman 2004

Table 3. Boat electroshocking, catches and sizes of Black Redhorse caught in Ontario by various agencies from 2004-2013

Capture Technique	Range of Dates	# Caught	Min TL (mm)	Max TL (mm)	Mean TL (mm)	Source
Boat	2004	1	-	73	-	GRCA (unpubl. data)
Electrofishing	2005-2012	21	128	492	n/a	DFO (unpubl. data)
	2005-2012	32	n/a	n/a	n/a	UTRCA (unpubl. data)
	2009	4	370	504	n/a	LGL limited (unbubl. data)
	2009-2010	n/a	n/a	n/a	n/a	MNRF (unpubl. data)
	2007	121	105	512	421.66	Biotactic (unpubl. data)

Habitat Trends

The quality and quantity of Black Redhorse habitat has clearly deteriorated as watersheds have become more urbanized. Rural areas are under heavy agricultural production, and populations have been fragmented by dams and impoundments. The following paragraphs describe specific information related to changes in habitat including, land use and water quality parameters (e.g. turbidity, nutrients, chloride, metals, pesticides, and toxic spills), as well as results of benthic invertebrate sampling for watersheds where Black Redhorse have been found. Future predictions of population growth, range expansion and resulting consequences will also be described. Variations in the information discussed result from differences in monitoring procedures and reporting format among different agencies as well as year-to-year changes in data collection methodology. Research focus coincides spatially with areas where the majority of known Black Redhorse populations exist.

Land use in the Grand River watershed is approximately 70% agricultural and 5% urban, with the latter distributed mainly in Waterloo, Kitchener, Cambridge, Guelph, and Brantford (Grand River Watershed Water Management Plan, 2014). Soil erosion rates are often very high, resulting in increased turbidity and sedimentation. Mean total suspended solids range from 6.2 to 47.3 mg/L (Grand River and Nith River, respectively (2000-2004), and sometimes exceeds the suspended sediment guideline of 25 mg/L (Cooke 2006). Overall, water quality conditions in the Grand River have greatly improved since the 1930's, as a result of upgrades to sewage treatments facilities (Cooke 2006). Comparisons between years indicate trends that are relatively stable; however, some areas show improvements, while others have deteriorated. Results from the Provincial Water Quality Monitoring Network (PWQMN), for the Grand River watershed, generally show values that exceed water quality objectives or guidelines. Mean total phosphorus levels in the Grand River, Conestogo River, and Nith River ranged from 0.034 – 0.119 mg/L, 0.047 – 0.086 mg/L, and 0.92 – 0.186 mg/L respectively, for the 2000-2004 sampling period (Cooke 2006). The highest value reported was 0.810 mg/L in the Nith River (Cooke 2006). Mean total nitrate values ranged from 1.041 – 4.047 mg/L in the Grand River, 3.076 – 4.605 mg/Lin the Conestogo River, and 4.187 – 4.669 in the Nith River (Cooke 2006). The maximum nitrate concentration was more than four times the provincial guideline at 12.20 mg/L. Furthermore, in recent sampling (2003-2008) phosphorus and nitrate concentrations continued to exceed the provincial water quality guidelines at 50-95% of monitoring sites in the watershed (Loomer and Cooke 2011). Changes in phosphorus and nitrite levels are correlated with variations in climate conditions. Years with increased precipitation results in increases in phosphorus and nitrate/nitrite concentrations as hot and dry patterns result in greater impacts caused by wastewater influxes. The result is prolific algae and macrophyte growth, as seen throughout the watershed (Loomer and Cooke 2011). In addition, there were over 70 spills in the Grand River watershed in 2004, mostly from wastewater treatment bypasses (Cooke 2006).

Sampling of benthic macroinvertebrates (1999-2001) indicated low to moderate levels of pollution in most of the watershed due to high nutrient loading (Cooke 2006). Heavy metal concentrations are only analyzed in areas that are considered to be of concern, which includes most sites within the central Grand River Watershed. A recent study that examined physiological changes in freshwater mussels exposed to municipal wastewater effluent for 4 weeks in the central Grand River showed evidence of cellular damage attributed to the effects of elevated concentrations of various heavy metals (Gillis *et al.* 2014).

In the Upper Thames River and Lower Thames, agriculture accounts for 75% and 88 % of land use, respectively (Upper Thames River Watershed Report Card, 2012; Taylor *et al.* 2004). Urban land use covers 10% of the Upper Thames River Watershed, with London being the main urban center. The percentage of forest is 11.3% in the Upper Thames River, and ranges from 8.1% to 19.8% in sub-watersheds where Black Redhorse are found. Percentage of forest cover in the Lower Thames River is 10% . All of these forest cover values are below the 30% recommended by Environment Canada for healthy watersheds (Upper Thames River Watershed Report Card, 2012). Overall, forest cover has declined slightly in the Upper Thames River. Losses have mainly been attributed to more accurate mapping techniques, however, incremental forest loss still occurs in many areas, and these losses negatively affect water quality through increased run-off and siltation.

Water monitoring studies indicate that turbidity levels are moderate, with suspended sediment concentrations ranging from 0 to 656 mg/l (1999-2000) (Taylor *et al.* 2004). Since the 2007 report card, overall water quality scores involving phosphorus have improved in six sub-watersheds, while three sub-watersheds remained stable, one declined in score, and there were no comparable data available from another watershed. However, total phosphorous levels ranged from 0.039 mg/l to 0.190 mg/l, and remained above the recommended provincial guideline of 0.030 mg/l (Upper Thames River Watershed Report Card 2012). Waubuno Creek had the best water quality score, with phosphorus levels below the provincial standard at 0.027 mg/l, followed by the Middle Thames at 0.045 mg/l. In contrast, the Forks region (London) has the poorest water quality, with more than six times the provincial guideline (Upper Thames River Watershed Report Card 2012). Results from benthic macroinvertebrate monitoring were similar in the 2006 - 2010 sampling period compared to 2001 – 2005. Although, there were some slight improvements (e.g., Middle Thames, Waubano Creek and Wye Creek), values were still above the provincial guidelines for poor water quality tolerance (i.e., the modified Family Biotic Index – FBI) of <5.00. Specifically values ranged from 5.60 at Plover Mills to 6.32 FBI in Stoney Creek (Upper Thames River Watershed Report Card 2012).

Water quality is acutely negatively affected by toxic spills. In the Upper Thames River, most spills involved manure, fuels, industrial chemicals and sewage. Over the period of 2006-2010, there was an average of 27 reported spills per sub-watershed where Black Redhorse are found (299 in total). Within this time period most spills were in the Forks watershed (area where the North Thames River meets the Thames River, London) with 143 reported spills. The number and rate of spills has increased from the 2001-2005 period, when an average of about 16 spills were reported per sub-watershed in areas where Black Redhorse occur (175 in total) (Upper Thames River Watershed Report Card 2012). Heavy metal concentrations are not available for areas where Black Redhorse are found within the Thames River watershed, as the Ministry of the Environment and Climate Change (MOE) has deemed analysis unnecessary due to low levels of contamination (Upper Thames River Watershed Report Card 2012).

The forest cover percentage is 6.4% along the Little Ausable River, 10.6% along the Upper Ausable River, 20.5% at the Lower Ausable and 22.6% along the Main Bayfield River - all below the 30% value recommended by Environment Canada for healthy watersheds (Brock and Veliz 2013). Overall, water quality has declined from the 2007 to 2012 sampling period in the Little Ausable and Ausable River due to increased phosphorus loading (Brock and Veliz 2013). However, improvements have occurred in the Main Bayfield River watershed with phosphorous levels and benthic tolerance measures below the provincial water quality guidelines at 0.021 mg/l and 4.55 FBI, respectively (Brock and Veliz 2013).

The health of the Lower Main Saugeen River Watershed has remained relatively stable from 2008 to 2013. Forest cover percentage increased from 19.0% to 19.5%. During this period, FBI decreased from 5.97 to 5.47 FBI, while total phosphorous levels have improved to 0.026 mg/L, and are now below the Provincial Water Quality Objective of 0.03 mg/L (Saugeen Conservation 2013).

Most habitat degradation is likely due to human population growth and urban development within areas occupied by Black Redhorse. Projections by The Ontario government show an increase in human population growth from 2012-2036 ranging from 15-40% (Ministry of Finance 2013) in areas that overlap with the range of Black Redhorse. For example, in the Grand River watershed, populations are expected to reach 1.51 million by 2051, with most growth occurring in Kitchener, Waterloo, Cambridge and Guelph (Grand River Watershed Water Management Plan 2014). The Grand River Watershed Water Management Plan (2014), considered population growth, agriculture and climate change as factors that affect demand for water resources (drinking water, stormwater management, and wastewater treatment), in addition to increased frequency of extreme events (droughts and floods). These factors affect populations of Black Redhorse to varying degrees throughout most of their Canadian range. Agricultural impacts on stream water quality, as well as on groundwater, includes fertilizers, farm chemicals and animal waste. The Ontario Ministry of Agriculture and Food and Rural Affairs (OMAFRA) reported a decrease in the number of farms and farmers, increasing farm size, increasing retirement and the number of lifestyle farms, and increased mechanization. Although increased farm size and increased mechanization may result in greater localized negative impacts in areas where

Black Redhorse occur, most of the other variables examined by OMAFRA may benefit the species.

BIOLOGY

The maximum known age of Black Redhorse as determined using fin-ray sections was 17 years in the Grand River (Reid 2009). The maximum published length and weight are 658 mm TL (Coker *et al.* 2001) and 3200 g (Howlett 1999), respectively.

Life Cycle and Reproduction

Age at maturity was found to range from two to five years in southwest Missouri (Howlett 1999), and two to six years the Tennessee River drainage (Jenkins and Burkhead 1993). In the Grand River (Ontario), the youngest mature individuals were 3 (female) and 4 (male) years old (Reid 2006b). Black Redhorse fecundity in the Grand River was 4,126-11,551 eggs per female, and egg diameter ranged from 2.6 to 2.9 mm at spawning (Kott and Rathman 1985). The relationship between egg number (m) and female length (L, measured in mm TL) is:

$m = (2.46 \times 10^{-6})\, L^{3.713}$ (Mandrak and Casselman 2004).

Upstream migrations of Black Redhorse begin in April when water temperatures reach 10 °C (Reid and Mandrak 2006). Spawning activity occurs in late May, when water temperatures range between 12.5 – 18.5 °C (Reid and Mandrak 2006). This is similar to data reported by Kwak and Skelly (1992), who observed spring spawning in Illinois at water temperatures ranging from 15 – 21 ºC. Black Redhorse spawn in riffle habitats, avoiding the swiftest areas, over substrates ranging in size from fine gravel to large cobble. However, small cobble is used most frequently. The Black Redhorse spawns on open-substrate and eggs are deposited in a lithophilic manner (Simon 1999).

The Black Redhorse in spawning condition is sexually dimorphic. Males exhibit nuptial body coloration with their sides being greenish-black, with an orange to pink stripe running laterally along the length of the body. Males also have pronounced tubercles on their anal and caudal fins (Jenkins and Burkhead 1993). Females show little, or no, spawning colouration (Kwak and Skelly 1992). Kwak and Skelly (1992) reported that females have no nuptial tubercles, whereas, Scott and Crossman (1998) indicated that females may have minute tubercles. The sex ratio has been examined in only a few populations and none differed significantly from 1:1 (Meyer 1962; Bowman 1970; Parker and Kott 1980). In the Grand River, the sex ratio of populations during spawning was 1.3 males to 1 female (Reid 2009). Males typically outnumber females on the spawning grounds, but this likely indicates that males remain on the spawning grounds longer than females (Meyer 1962; Bowman 1970). The Black Redhorse is a non-guarder species (Simon 1999).

Kwak and Skelly (1992) observed Black Redhorse spawning in an Illinois River. Large numbers (7-80 fish) of both sexes gathered at the edges of riffles, and divided into smaller groups as they moved into riffle habitat. Both sexes established positions, often behind large rocks, with no apparent territoriality. Groups of up to six fish, with individuals positioned within a few centimetres of each other, were common. Both sexes shifted positions frequently, including rolling over the backs of other members of the spawning group—but always maintained a position facing upstream. Females were flanked by up to four males. The mating event took place with a quiver of the caudal regions by all fish involved, and lasted about two seconds. Mating usually ended when one or more of the group members moved rapidly to new positions, but sometimes the group just gradually reduced their vibrating and maintained positions.

Newly spawned eggs are three to five mm in diameter, non-adhesive, yellow, and demersal when fertilized (Bowman 1970; Bunt *et al.* 2013a). Black Redhorse eggs and larvae were artificially reared under hatchery conditions in 2007 and 2008 for an ontogenetic development study. After fertilization, Black Redhorse eggs required 188 degree days to hatch under laboratory conditions (Bunt *et al.* 2013a). Egg hatching success has not been quantified for Black Redhorse; however, under laboratory conditions Robust Redhorse (*Moxostoma robustum*) survival to hatch rate has been determined to be approximately 66% under ideal conditions (Dilts 1995). The sizes of Black Redhorse fry (protolarvae) at emergence range between 7 mm and 9.1 mm (Kay *et al.* 1994; Bunt *et al.* 2013a). Protolarvae become free swimming eight to ten days post-hatch. Fourteen days after hatching, protolarvae have a distinct dorsal finfold and become free swimming in schools (Bunt *et al.* 2013a).

Length-weight equations have been developed through a number of studies and are shown in Table 4. Additionally, von Bertalanffy growth equations have been determined for several populations (Table 5). The growth rate of juvenile Black Redhorse from the Grand River was determined to be 80 mm per year (Reid 2009).

Table 4. Summary of length-weight equations developed for Black Redhorse populations. Form of length-weight equation: log (weight g) = b +mlog(length mm)

b	m	Waterbody/Sex/Life Stage	Source
-4.58	2.94	Niangua River	Bowman 1970
-4.59	2.95	Big Piney River	Bowman 1970
-5.7475	3.363	Immature fish	Smith 1977
-4.748	2.9554	Mature male	Smith 1977
-4.6607	2.9227	Mature female	Smith 1977
-5.39	3.158	Grand River	S. Reid (unpubl. data)

Table 5. Sumary of von Bertalanffy growth equations developed for Black Redhorse. Form of von Bertalanffy equation: $L_t = L_\infty [1-e^{-k(t-t0)}]$.

L_∞	k	T_0	Comment	Source
385.4	0.39	-0.48	James River	Howlett 1999
369.3	0.39	0.30	Bull Creek	Howlett 1999
378.3	0.34	-0.29	Swan Creek	Howlett 1999
426.4	0.45	-0.34	Elk River	Howlett 1999
490.9	0.26	-0.75	Grand River	S. Reid (unpubl. data)

Table 6. Survival rates of Black Redhorse populations from Niangua and Big Piney rivers, Missouri (Bowman 1959).

Age Class	Niangua River	Big Piney River
5	0.49	0.68
6	0.48	0.49
7	0.33	0.03
8	0.03	0.02
9	0.02	0.01
10	0.01	-

Physiology and Adaptability

Poor habitat quality is considered to be a significant threat to the Black Redhorse (Cooke *et al.* 2005). This species is considered to be intolerant of siltation (Scott and Crossman 1998) and is usually found in consistently moderate to fast-flowing areas in medium-sized, warmwater streams. The Black Redhorse is less tolerant of slow currents, turbidity and siltation than the other six Redhorse species in Canada (Scott and Crossman 1998). It has restricted spawning habitat preferences (water depth and substrate), and recruitment is vulnerable to changes in flow and spawning/juvenile habitat. It is likely impacted by changes in water quality and quantity related to agriculture, urbanization, dams and impoundments. In a recent study of areas occupied by juvenile Black Redhorse (Bunt *et al*. 2013b - Doon, Grand River), there was 100 % feminization of two species of darters (*Etheostoma blennioides* and *Etheostoma caeruleum*) as a result of exposure to municipal wastewater effluent from the City of Kitchener (Tettreault, 2011). However, in Pennsylvania, male Black Redhorse did not show signs of endocrine disruption (testicular oocytes and plasma vitellogenin) compared to the White Sucker and Smallmouth Bass, *Micropterus dolomieu*, that did have reproductive indicators of exposure to estrogenic chemicals (Blazer *et al*. 2014).

There are several morphometric differences in body shape of the Black Redhorse that distinguish it from other Redhorse species including more streamlined, fusiform shape, with elongated and narrow caudal peduncle in comparison with the Silver, Greater, and River Redhorse. These physical adaptations suggest greater swimming potential allowing for utilization of areas with higher water velocities, and indicates that this species appears to be more adapted to high flow habitats (Clark 2006). This may partially explain this species' ability to use fishways designed for warmwater fish passage.

The Black Redhorse has been documented to be spatially associated with groundwater, at least from July – October. In a 2009 study by Bunt *et al*.(2013b), juvenile Black Redhorse were detected at numerous sites 10 m to 30 m downstream from groundwater seepages in areas that are known to be affected by poor water quality from municipal wastewater effluent. It was hypothesized that groundwater may create beneficial microhabitats by providing refuge from poor water quality. Potential physiological stress caused by poor water quality and municipal effluent exposure may be partially alleviated by groundwater as it cools surface water, increases oxygen solubility and helps with dilution, particularly during extremely warm and sometimes eutrophic conditions. Occupation of areas influenced by groundwater may be a behavioural adaptation that allows the Black Redhorse to survive in areas with poor water quality. Further information on the importance of groundwater is required and may explain some observed patterns of habitat utilization.

Dispersal and Migration

Access to spawning habitat is essential for Black Redhorse production. During the spring, Redhorse suckers migrate upstream to suitable spawning habitat (Jenkins 1970). Movement of Black Redhorse through fishways during the spawning period has been reported (Reid *et al.* 2008b; Bunt *et al.* 2013b). In addition, two individual Black Redhorse were radio-tracked in the Grand River from June to October 2003. These fish showed limited total movement of 475 m and 2,000 m, respectively, upstream from the original capture location (Clark 2004).

Upstream movement of juvenile Black Redhorse in early November when the water temperature was 5°C has also been observed (Bunt *et al.* 2013b). These movements were presumably to over-wintering habitat and may help explain life-stage specific patterns of movement to seasonally appropriate areas.

Interspecific Interactions

The Black Redhorse is a benthic feeder and uses the grazing and picking foraging method with a strong preference for crustaceans and insects (Coker *et al.* 2001). Young Black Redhorse, less than 65 mm in length, are thought to be primarily planktivorous, while larger fish are primarily benthivorous (Bowman 1970). In Canada, the Black Redhorse is syntopic with up to five other redhorse species. Given their similar morphology, habitat and prey preferences (Coker *et al.* 2001; Clark 2004), competition likely occurs between Redhorse species. However, subtle differences in preferences and morphology may minimize such interactions (Clark 2004). All Ontario *Moxostoma* use the same riffles to spawn as Black Redhorse, as do several darter and cyprinid species; however, utilization of this habitat is temporally partitioned (Kwak and Skelly 1992; Reid 2006b).

POPULATION SIZES AND TRENDS

The current species range extends West to the Ausable River, east to the Grand River, south to Lake Erie and north to the Saugeen River. Since the assessment of this species in 2005, the extent of occurrence (EO) has decreased by 4.6%. EO was calculated to be 14 592 km^2 prior to 2003, and 12 296 km^2 from 2004-2013. The index of area of occupancy (reported in a 2 km x 2 km grid in the new methodology) also decreased by 31.4 %. The IAO was calculated to be 988 km^2 from 2004-2013, compared to 1 440 km^2 prior to 2003. This apparent decrease in range is likely due to a combination of continuous fisheries sampling in sites where Black Redhorse have been previously detected, and gear selectivity. However, there is clearly historical evidence of decreased distribution, as the Black Redhorse has not been collected from Catfish Creek and the Sauble River since 1938 and 1958 respectively, despite repeated sampling efforts.

Sampling Effort and Methods

In the Lake Erie drainage, the Black Redhorse has been widely sampled and collected in the Grand River and its tributaries (Table 1). It has been recently collected within the range of known historical sites, as well as at several new sites. There are records of 146 Black Redhorse collected between 1975 and 2003 from the Grand River watershed, compared to 576 individuals collected from 2004 – 2013. The majority of Black Redhorse records are from the main channel of the Grand River, Conestogo River and Nith River. However, the Black Redhorse has been collected on several occasions between 2000 and 2011 in sub-watersheds within the Grand River system including Mount Pleasant Creek, Big Creek and Fairchild Creek (A. Timmerman, MNRF unpubl. data).

The Black Redhorse has not been collected from Catfish Creek since 1938. Resampling of all historical sites in Catfish Creek on at least 12 occasions between 1941 and 2002 (Mandrak *et al.* 2006) using suitable methods (backpack electrofishing, seining) failed to yield any additional specimens. Furthermore, no sampling has been conducted by the Catfish Creek Conservation Authority (CCCA) in historical sites where the Black Redhorse was previously found (T. Difazio, CCCA pers. comm.). Non-targeted sampling has been limited to headwater tributaries and smaller creeks using backpack electrofishing (T. Difazio, pers. comm.); however, no Black Redhorse have been found. Currently, Catfish Creek is a highly turbid, slow-moving stream in a predominately agricultural watershed (COSEWIC 2005; Mandrak *et al.* 2006). Suitable habitat may no longer exist in Catfish Creek and Black Redhose is now considered to be extirpated.

In the Lake St. Clair drainage, Black Redhorse have been collected on multiple occasions since 2004 and continues to occupy the mainstream of the Thames River and most tributaries (J. Schwindt, Upper Thames River Conservation Authority (UTRCA), unpubl. data). It has been collected at 33 sites from 2004-2013, yielding at least 113 individuals. However, this value has increased since the period prior to 2004, when only 40 Black Redhorse were collected. No Black Redhorse were detected when fish communities were sampled on First Nations Lands on the Thames River (Marson *et al.* 2012).

In the Lake Huron drainage, the Black Redhorse has been historically found in the Bayfield River, Maitland River, Gully Creek and Ausable River watersheds (Figure 3). A total of 58 Black Redhorse were collected prior to 2004, compared to 28 individuals from 2004 – 2013. The majority of these records were from targeted surveys in the Ausable River watershed. No records of Black Redhorse were available from the Bayfield River and Gully Creek within the 2004 – 2013 sampling period; however, no targeted surveys were conducted in these rivers (K. Jean, ABCA. pers. comm.). Although other non-targeted surveys have been conducted in these rivers, none have captured Black Redhorse (MNRF, unpubl. data). In 2006, Black Redhorse was collected for the first time in the Saugeen River. No further community fisheries sampling work has been conducted on the Saugeen River to determine presence/absence or extent of Black Redhorse populations due to limited financial resources (S. Wood, SVCA, pers. comm.). The Maitland Conservation Authority (MVCA) does not perform any fisheries sampling in this area (Matt Shetler, MVCA, pers. comm.). The only record of Black Redhorse from the Maitland River since 2002, was from sampling in 2009 for the Goderich Harbour Warf Expansion (LGL limited, 2014).

The Upper Great Lakes Management Unit conducts sampling every two to three years in Lake Huron following the Near Shore Biodiversity Protocol using multiple fyke nets and gill nets (C. Davis, MNRF. pers. comm.). *Moxostoma spp*. have been collected using these methods. However, voucher specimens sent to the ROM for identification, have not revealed any Black Redhorse. Due to the difficulty with identification from other Redhorse species, it is possible that Black Redhorse have been collected in other surveys and have been misidentified or simply classified as *Moxostoma spp.*

The Lake Simcoe Fisheries Assessment Unit (MNRF) found a single Black Redhorse dead in a trap net in 2011. However, despite extensive yearly sampling efforts following the Nearshore Community Index Netting (NSCIN), there is no evidence of Black Redhorse populations within the Lake (J. La Rose, MNRF, pers. comm.) or surrounding tributaries (G. Little, MNRF, Aurora District; R. Wilson, Lake Simcoe Region Conservation Authority). Since Lake Simcoe is a popular angling destination, it is possible that this record was a result of careless baitfish disposal and therefore has been interpreted as an ‘introduction’.

In 1998, one Black Redhorse specimen was collected in a reservoir on Spencer Creek, a tributary to western Lake Ontario (COSEWIC 2005). Bi- annual sampling conducted by the Hamilton Conservation Authority (HCA) using boat electrofishing, as well as late summer shoreline surveys using seine nets have failed to yield any further records (L. Jennings, HCA, unpubl. data). The disjunct nature of this record, and the apparently unsuitable habitat of the reservoir, suggests that this specimen may have been introduced. However, headwater stream transfer between Spencer Creek and the Grand River cannot be ruled out.

In terms of overall trends related to sampling effort, there have been fewer targeted studies since 2004; however, the studies that have been conducted resulted in increased catches. For example, 209 Black Redhorse were collected prior to 2003 compared to 701 collected from 2004-2013. This pattern appears in the data due to a small number of targeted studies, particularly from the Grand River, in areas where this species was known to occur, and not from presence/absence evaluations or, studies designed to assess changes in range or distribution.

Sampling Effort

Various capture methods have been used to collect Black Redhorse including seining, backpack electrofishing, boat electrofishing, fishway traps, dip nets, cast nets and trawling (Table 1, Table 3). Prior to 2004, Black Redhorse were collected with a variety of different gear types; however, collection records show that the majority of Black Redhorse were captured with electrofishing. This pattern is also apparent from the 2004 – 2013 sampling period. However, in some cases there was no distinction between boat electrofishing and backpack electrofishing. Using two backpack electrofishing units in tandem is, in some cases, more effective than using one backpack electrofishing unit for capturing Black Redhorse (S. Reid, MNRF, unpubl. data; J. Schwindt, UTRCA unpubl. data; K. Jean, ABCA, unpubl. data). Mean (± S.D.) electrofishing CPUE for the period prior to 2004 was 28.5 ± 33.0 fish/hour, whereas the mean CPUE from 2004 - 2013 was 17.3 ± 19.2 fish/hour. Although the sample sizes were small and the variance was high, CPUE data suggest that Black Redhorse catch rates have decreased.

Seining, both with a bag seine and boat seine have also been used successfully to capture adults and juveniles. Marson *et al.* (2012) recommended varied sampling techniques with different gear types including fyke nets, gill nets, and electrofishing, in order to expand fish community surveys, and locate species at risk. In total (excluding the dead specimen collected from the trap net by the LSFAU in 2011), seven different methods have been used to collect Black Redhorse, and electrofishing and seining remain the most effective gear types.

Abundance

There are no population estimates available for any age class, nor are there estimates of the number of mature individuals in any Canadian watershed that contains Black Redhorse.

Fluctuations and Trends

Fluctuations and trends related to Black Redhorse populations are difficult to accurately assess due to lack of regular monitoring, problems with accurate identification, gear selectivity, and non-standardized data collection. Comparisons between the historical (prior to 2004) and current (2004-2013) sampling records suggest that Black Redhorse populations are declining in some areas, while they are increasing in others. In the Grand River and Thames River watershed, it appears that populations remain relatively stable. An apparent range reduction has been observed in the Lower Thames River, but this is likely due to a lack of more recent effective sampling. Apparent range reductions have also occurred in Catfish Creek, Sauble River, Bayfield River, Maitland River, Gully Creek and Spencer Creek. While it has been determined that Black Redhorse populations are extirpated in Catfish Creek, and Sauble River, lack of sampling and/or use of inappropriate sampling techniques may explain the apparent absence in the Bayfield and Maitland River. Spencer Creek and Lake Simcoe records are now considered to be introductions. There is evidence of a range expansion in the Grand River watershed, as it has been collected at two new sites - Big Creek and Fairchild Creek. It has also been collected in Wye Creek (tributary of the Thames River), the Saugeen River and Ausable River (previously collected in the Little Ausable River, in 2002). It is important to note that these new records may have resulted from increased survey efforts rather than a range expansion.

Young and Koops (2013) modelled viability of Black Redhorse populations. Long-term population viability was sensitive to perturbations in the fecundity of young adults and to changes in survival of immature (juvenile) Black Redhorse. The stable stage distribution for Black Redhorse was shown to be 99.89 % YOY (n = 5 million), 0.08 % consisting of juveniles (ages 1 - 3, n = 3900), and 0.03 % adults (age 4 - 16, n = 1700). Using a 15 % probability of catastrophe, which is a 15 % probability per generation that 50 % of the population will be removed in a given year, and an extinction threshold of 50 adults over 100 years, the minimum area for population viability (MAPV) (i.e., the amount of suitable habitat required to support the minimum viable population) was calculated to be 36 ha (range 30.4 - 44.4 ha) of good quality, suitable habitat. The approximate MAPV needed is 21 ha (17.7 - 25.9 ha) for YOY (API, defined as area per individual at 0.04 m^2/individual), 4 ha (3.4 - 4.9 ha) for juveniles (API = 4.1 - 25.6 m^2/individual), and 11 ha (9.3 – 13.6 ha) for adults (API = 38.7 - 107 m^2/individual). Recovery targets have been revised since this initial study was conducted based on new information, which suggests a population abundance estimate of at least 1700 adult Black Redhorse (ages four+), and 3900 juveniles, requiring 14.5 ha of suitable habitat (Young and Koops 2014). Other alternate risk scenarios ranged from approximately 800 adults and 6.5 ha to 5800 adults and 49 ha (Young and Koops 2014). There are no data available for year-to-year changes in population size and density. Calculated areas of occupancy in the Maitland River, Saugeen River, Ausable River watershed, Thames River and Grand River range from 400 ha to 52800 ha, and are 11 to 1466 times greater than the MAPV; however the quality and suitability of habitat within these areas is largely unknown.

Recovery targets and long-term projections for the Black Redhorse were modelled by Velez-Espino and Koops (2008). Results from this study suggest a precautionary recovery target of 8049 adult Black Redhorse per population in order for it to be sustainable (Velez-Espino and Koops 2009). In areas where there are habitat constraints, a recovery target of 8049 young adults may be considered viable; and in areas where there are no habitat constraints, but the population size is below the recovery target, 8049 fish, regardless of age, would be appropriate (Velez-Espino and Koops 2008). The authors suggest that increasing young-of-the-year (YOY) and juvenile survival by 20 % or more through habitat rehabilitation, stocking, or fishing restrictions, may help reach recovery targets (Velez-Espino and Koops 2008).

Rescue Effect

Historically, the idea of a rescue effect was thought to be highly unlikely, based on the disjunct nature of Black Redhorse populations in the American portion of Lake Erie and Lake Huron (Trautman 1981; Bailey *et al.* 2004), and the large expanses of potentially unsuitable habitat between American and Canadian populations (COSEWIC 2005). American populations of Black Redhorse in Great Lakes tributaries have been largely unstudied and no population estimates are available. However, recent records of Black Redhorse captured at new sites outside of the historical extent of occupancy suggest the rescue effect may be possible.

THREATS AND LIMITING FACTORS

Threats

The IUCN Threat Calculator was used to evaluate eleven different potential threats to Black Redhorse populations. (Appendix 1). Several threats were relevant in the majority of the nine estimated locations in which the Black Redhorse is found, and were calculated to be low ("D") to medium ("C") in terms of impact. When considered in terms of cumulative impacts, however, the calculator returned a threat category of "B" (= High). Timing and range percentages for scope and severity were agreed to by the team, and were considered appropriate based largely on known scientific literature.

Most threats that were examined were considered to be low impact (Appendix 1). Threats associated with pollution including municipal wastewater effluent were calculated to have medium impact on Black Redhorse populations. Climate change and severe weather events that may result in habitat alteration and reductions in flow scored medium/low using the IUCN Threat calculator. Other potential threats that were calculated to be low for Black Redhorse included biological resource use, human disturbance, and invasive species. Threats associated with residential and commercial development, agriculture and aquaculture, energy production and mining, transportation and service corridors were considered to be negligible. It should be noted that although scope and timing of a particular threat may be considered large and continuing, if the severity of the threat is unknown, then the Threat Calculator did not provide a score, as was the case with threats associated with natural system modification including dams, water management, and other ecosystem modifications. Information related to dam impacts has been discussed in previous sections, and dams are largely considered a limiting factor rather than a threat. Other potentially significant threats are discussed below in decreasing order of severity.

Pollution

The two largest populations of Black Redhorse in Canada are found in the Grand River and Thames River, where pollution from urban growth, impoundment of riverine habitats and agricultural activities threaten remaining populations.

The majority of Canadian research on Black Redhorse has been conducted In the Grand River. The species is largely distributed along the central and lower portions of the river, where land use is primarily agriculture (79%) and woodland (17%) (Reid *et al.* 2008b). Major urban centres in the central part of the watershed overlap with known locations of Black Redhorse populations. In addition, human population growth in the Grand River basin has been projected to increase by 30 % over the next 20 years which will negatively impact this species. Specifically impacts will include impairment of habitat and water quality resulting from changes in land use that affect run-off, increased water abstraction, and increase wastewater discharge (Portt *et al.* 2003). Habitat quality in the upper Thames River watershed is also adversely affected by urban and rural land use. Anthropogenic pollution that would negatively affect Black Redhorse includes wastewater effluent, acute spills, poor drainage practices, run-off, road salt inputs and siltation from stream bank alteration (Reid and Mandrak 2006). Much of the forest cover in the watershed has been cleared, resulting in increased water temperature, increased siltation events and decreases in water quality.

Endocrine disruptors have not been reported to impact Black Redhorse specifically (Blazer *et al.* 2014). However, for other catostomid species, extensive impacts on the male reproductive system such as the presence of testicular oocytes and elevated levels of plasma vitellogenin have been found to be related to exposure to municipal wastewater treatment effluent (Blazer *et al.* 2014) and other sources of pollution, such as mills (Munkittrick *et al.* 1991; Keme 1998). There is a growing body of literature indicating the negative endocrinological effects of urban pollution on fishes including Redhorse suckers (Maltais *et al.* 2010) and endocrine disruptors are present in the Grand River (Tetreault *et al.* 2011) in areas occupied by a range of age classes of Black Redhorse (Figure 3). Effluent from the Kitchener Wastewater Treatment Plant has been shown to cause reproductive changes in fishes (Tetreault *et al.* 2011) and other species such as mussels (Gillis *et al.* 2014); however the facility is being upgraded with a scheduled completion date of 2022. It is not known if the upgrades will minimize this threat through reductions in concentrations of estrogenic compounds and other pharmaceutical or personal care products (Gillis *et al.* 2014). It is highly likely that similar chronic chemical and hormonal threats are present throughout the species' range; however further research is required for this to be fully substantiated. Additional research on the population-wide effects of de-masculinisation and potential negative impacts on sex ratios and reproduction of Black Redhorse are warranted.

Climate Change and Extreme Weather

Drought may result in partial or complete recruitment failure. Drought leads to reduction in flow, which in turn would lead to reductions in groundwater, which may be an important habitat variable that facilitates the persistence of Black Redhorse populations. Storms and flooding may also impact Black Redhorse by altering flow regimes and siltation patterns. It must be noted that droughts and floods have occurred in the past and there is no evidence to suggest that it has been detrimental to the species. Extreme events resulting from climate change may, however, have severe and unpredictable acute impacts on water quality and habitat availability (Grand River Watershed Water Management Plan 2014)

Limiting factors

The distribution of the Black Redhorse is likely limited by the availability of preferred habitat within its Canadian range (Parker 1989). Access to suitable habitat is affected by dams and impoundments that block movement, as well as expanses of unsuitable habitat that separates populations between watersheds. It prefers moderate-high gradient habitat in medium-sized warmwater streams and rivers (Bowman 1970). Black Redhorse does not seem to prefer low gradients and turbidity as opposed to other redhorse species found within its range, and is considered intolerant of siltation (Trautman 1981; Scott and Crossman 1998). It is often more abundant in cool, swift, rocky streams than the Golden Redhorse, *Moxostoma erythrurum*, (Jenkins and Burkhead 1993). Due to restricted spawning habitat preferences (water depth, water velocity and substrate), Black Redhorse recruitment is vulnerable to changes in the flow regime. High flow levels were observed by Bowman (1970) to result in the abandonment of a historically utilized spawning shoal. In the Grand River, large increases in discharge during the spawning period prevented spawning of ripe individuals of Greater Redhorse, *Moxostoma valenciennesi*, (Cooke and Bunt 1999). The Black Redhorse is sensitive to poor water quality and habitat degradation (Reid 2006a), and as such, improvements to both water quality and habitat in the Illinois River and Ohio River have recently resulted in re-establishment of stable populations of the Black Redhorse (Retzer 2005; Yoder *et al.* 2005).

Number of Locations

'Location' is defined as a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present, which may include part of one or many subpopulations. For Black Redhorse, the total number of locations was established by determining that the most likely threat to populations is pollution including toxic compounds, agricultural activities, sewage, spills and groundwater contamination. Based on distribution and fragmentation of Black Redhorse this threat would affect populations separately in 9-13 locations depending on assumptions of the spatial extend of the water pollution impacts and the observation that Black Redhorse are primarily mainstem inhabitants. We therefore define 9 primary locations including: (1) North Thames River, (2) South Thames River, (3) Grand River, (4) Conestogo River, (5) Nith River, (6) Saugeen River, (7) Maitland River, (8) Bayfield River, and (9) Ausable River. Four additional locations are possible, including: (10) Thames River downstream of the N&S fork, which depends on assumptions of the extent of the most likely threat impact, (11) Medway Creek, but is likely part of North Thames Location, (12) Middle Thames but it is likely part of the South Thames location, and (13) Waubuno Creek but it is likely part of South Thames Location. Areas in which Black Redhorse populations are not considered to be established (i.e., Gully Creek, Lake Simcoe and Spencer Creek), have not been included in the determination of the number of locations. We therefore conclude that there are 9-13 locations of Black Redhorse in Canada.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Black Redhorse and its habitat across its entire Canadian range are protected in Ontario under the ESA. Black Redhorse and its habitat are indirectly protected by amendments made to the federal *Fisheries Act* in November 2013. These amendments only allow for habitat protection for Commercial, Recreational or Aboriginal fisheries, and therefore in areas where Black Redhorse range overlaps with these fisheries, the species is protected. However, it is not listed under the *Species at Risk Act* (SARA), due to perceived deficiencies in the amount of scientific research required to evaluate significant socio-economic factors and allowable harm (Canada Gazette Part I and II, 2007). In addition, there is currently no recovery strategy under the Endangered Species Act.

Non-Legal Status and Ranks

In Canada, Black Redhorse is currently designated as Threatened by COSEWIC. The International Union for Conservation of Nature (IUCN) listed this species status as least concern on the IUCN Red List of Threatened Species. Black Redhorse global (G) rank is G5, national (N) rank is N2, and subnational (S) is S2 (NatureServe 2013). This indicates that globally, Black Redhorse is secure and is at very low risk of extinction due to an extensive range, abundant populations or occurrences, and there is little to no concern about declines or threats (NatureServe 2013). However, nationally in Canada, and sub-nationally in Ontario, the Black Redhorse is imperilled and at high risk of extirpation, due to its restricted range, few populations or occurrences, steep declines, severe threats, or other factors (NatureServe 2013). In the United States, it has been assigned a conservation status by 21 states (Table 7).

Table 7. Global, National, and Subnational (State and Provincial) ranks and status for Black Redhorse (*Moxostoma duquesnei*) (NatureServe2013).

Global	US National	Canadian National	Subnational	
			US States	Ontario
G5	N5	N2 COSEWIC – Threatened (May 2005) No SARA Listing (December 2007)	S1 – KS, MS, WI S2 – IA, NY S2S3 – IL S3 – MI, VA S4 – AR, GA, IN, MN, NC, OK, WV S4S5 - KY S5 = AL, OH, PA, TN SNR – MO	S2

Habitat Protection and Ownership

Destruction or alteration of riparian areas and wetlands are regulated and protected under the *Conservation Authorities Act* and under the Provincial *Planning Act*. Since Black Redhorse has not been listed under SARA, itshabitat is not protected under the Federal Endangered Species Act.

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INFORMATION SOURCES

2012 Upper Thames River Watershed Report Cards, Upper Thames River Conservation Authority, 2012. ISMN 1-894329-11-2.

Bailey, R.M., W.C. Latta, and G.R. Smith. 2004. An atlas of Michigan fishes with keys and illustrations for their identification. University of Michigan Museum of Zoology Miscellaneous Publications No. 192. 215 pp.

Blazer, V.S., D,D, Iwanowicz, H.L. Walsh, A.J. Sperry, L.R. Iwanowicz, D.A. Alvarez, R.A. Brightbill, G. Smith, W.T. Foreman, and R. Manning. 2014. Reproductive health indicators of fishes from Pennsylvania watershed: association with chemicals of emerging concern. Environmental Monitoring and Assessment. 186(10):6471-6491.

Bowman, M.L. 1959. The life history of the Black Redhorse, *Moxostoma duquesnei* (Le Sueuer), in Missouri. Ph.D. Thesis, University of Missouri. 144 pp.

Bowman, M.L. 1970. Life history of the Black Redhorse, *Moxostoma duquesnei* (Le Sueur), in Missouri. Transactions of the American Fisheries Society 98:546-559.

Brock, H., and M. Veliz. 2013. Ausable Bayfield Conservation Authority Watershed Report Card 2013. Ausable Bayfield Conservation Authority. Exeter, Ontario. 102 pp.

Brown, B.A. 1984. Comparative life histories of some species of redhorse, subgenus *Moxostoma*, genus *Moxostoma*. Master's Thesis. Indiana State University, Terre Haute, Indiana. 74 p.

Bunt, C.M., B.T. van Poorten, and L. Wong. 2001. Denil fishway utilization patterns and passage of several warm water species relative to seasonal, thermal and hydraulic dynamics. Ecology of Freshwater Fish 10:212-219.

Bunt, C.M., T. Heiman, and N.E. Mandrak. 2013a. Ontogeny of larval and juvenile Black Redhorse (*Moxostoma duquesnei*). Copeia:121-126.

Bunt, C.M., N.E. Mandrak, D.C. Eddy, S.A. Choo-Wing, T. Heiman, E. Taylor. 2013b. Habitat utilization, movement and use of groundwater seepages by larval and juvenile Black Redhorse, *Moxostoma duquesnei*. Environmental Biology of Fishes 96:1281-1287.

Canada Gazette Part I, Vol 141, No. 32. Statutory Instruments 2007. Pages 2286-2319. August 11, 2007.

Canada Gazette Part II, Vol 141, No. 26. Statutory Instruments 2007. Pages 2520-2919. December 26, 2007.

Canadian Endangered Species Council. 2001. The general status of species in Canada. Ottawa: Minister of Public Works and Government Services.

Clark, J.W. 2004. Redhorse suckers (*Moxostoma*) in the Grand River, Ontario; how do six ecologically similar species coexist? M.Sc. Thesis. Department of Zoology, University of Guelph, Guelph, ON. 79 p.

Coker, G.A., C.B. Portt, and C.K. Minns. 2001. Morphological and ecological characteristics of Canadian freshwater fishes. Canadian Manuscript Report of Fisheries and Aquatic Science. 2554:iv+86p.

Cooke, S.J. 2006. Water quality in the Grand River: A summary of current conditions (2000-2004) and long term trends. Grand River Conservation Authority, http://www.grandriver.ca/Water/2006_WaterQuality_complete.pdf.

Cooke, S.J. and C.M. Bunt. 1999. Spawning and reproductive biology of the Greater Redhorse, *Moxostoma valenciennesi*, in the Grand River, Ontario. Canadian Field-Naturalist 113:497-502.

COSEWIC 2005. COSEWIC assessment and update status report on the black redhorse *Moxostoma duquesnei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2011. Guidelines for recognizing designatable units below the species level. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

DFO. 2009. Proceedings of the Central and Arctic Regional Science Advisory Process on the Recovery Potential Assessment of Black Redhorse; 7 December 2007. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2008/004.

Dilts, E.W. 1995. Effects of fine sediment and gravel quality on survival to emergence of larval robust redhorse *Moxostoma robustum*. Master's Thesis. University of Georgia, Athens, Georgia. 61 p.

Edwards, A. and N.E. Mandrak. 2006. Fish assemblage surveys of the Lower Thames River, Ontario, using multiple gear types: 2003-2004. Can. Manuscr. Rpt. Fish. Aquat. Sci. 2772: vii + 94 pp.

Gillis, P.L., F. Gagne, R. McInnis, T.M Hooey, E.S. Choy, C. Andre, M.E. Hoque and C.D. Metcalfe. 2013. The impact of municipal wastewater effluent on field-deployed freshwater mussels in the Grand River (Ontario, Canada). Environmental Toxicology and Chemistry 33(1): 134-143.

Grand River Watershed Water Management Plan. 2014. Prepared by the Project Team, Water Management Plan. Grand River Conservation Authority, Cambridge, ON. 137p. + appendices.

Holm, E. and D. Boehm. 1998. Sampling for fishes at risk in southwestern Ontario. Unpublished report prepared by the Centre for Biodiversity and Conservation Biology, Royal Ontario Museum, for the Ontario Ministry of Natural Resources, Southcentral Region and Aylmer District. Revised 2001.

Holm, E. and D. Boehm. 1999. Characteristics of adult *Moxostoma* in Ontario. Unpublished report. Royal Ontario Museum, Toronto, Ontario.

Howlett, D.T. 1999. Age, growth and population structure of Black Redhorse (*Moxostoma duquesnei*) and Golden Redhorse (*Moxostoma erythrurum*) in southwest Missouri. M.Sc. Thesis, Southwest Missouri State University. 58 p.

Jenkins, R.E. 1970. Systematic studies of catostomid fish tribe Moxostomidae. Ph.D. Dissertation. Cornell University, Ithaca, New York. 799 p.

Jenkins, R.E., and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland, 1079 p.

Kay, L.K., R. Wallus, and B.L. Yeager. 1994. Reproductive biology and early life history of fishes in the Ohio river drainage. Tennessee Valley Authority, Chattanooga, Tennessee.

Keme, D.E. 1998. Endocrine disruption in fish. Klewer Academic Publishers. Norwell, Massachusetts. pp 133-135.

Kott, E., and N. Rathmann. 1985. Distribution and fecundity of the Black Redhorse sucker (*Moxostoma duquesnei*) in the Upper Grand River basin. Wilfrid Laurier University, Waterloo, Ontario. Research Paper No. 8575. 17 p.

Kwak, T.J. and T.M. Skelly. 1992. Spawning habitat, behaviour, and morphology as isolating mechanisms of the Golden Redhorse, *Moxostoma erythrurum*, and the Black Redhorse, *M. duquesnei*, two syntopic fishes. Environmental Biology of Fishes 34:127-137.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer Jr. Editors. 1980. Atlas of North American Freshwater Fishes. North Carolina Biological Survey Publication Number 1980-12.

LGL limited. 2014. Goderich Harbour Wharf Expansion. Section 3.0 Summary of the Existing Environment.

Loomer, H.A. and S.E. Cooke. 2011. Water Quailty in the Grand River Watershed: Current conditions and trends (2003-2008). Grand River Conservation Authority. http://www.grandriver.ca/water/2011_WaterQualityReport.pdf.

Lower Thames Valley Conservation Authority. 2012. Lower Thames Valley Watershed Report Card 2012. http://www.lowerthames-conservation.on.ca/watershed/LowerThamesValley_print_sm.pdf

Mandrak, N.E. and S. Casselman. 2004. Black Redhorse (*Moxostoma duquesnei*) critical habitat case study. Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada.

Mandrak, N.E., J. Barnucz, G.J. Velema and D. Marson. 2006. Survey of the status of black redhorse (*Moxostoma duquesnei*), and spotted gar (*Lepisosteus oculatus*), in Canada, 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2776: v + 39 pp.

Mandrak, N.E., J. Barnucz, and D. Marson. 2010. Targeted sampling of fish species at risk in the Grand River watershed, 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2922: v + 29 p.

Marson D., N.E. Mandrak, and D.A.R. Drake. 2009. Sampling of the fish communities in the Saugeen River watershed, 2005-2006. Can. Manuscr.. Rep. Fish. Aquat. Sci. 2911: vi + 19 p.

Marson, D, N.E. Mandrak and J. Barnucz. 2012. Sampling the Fish Communities on First Nations Lands on the Thames River, 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2992: vi + 18 p.

Meyer, W.H. 1962. Life history of three species of redhorse (*Moxostoma*) in the Des Moines River, Iowa. Transactions of the American Fisheries Society 91:412-419.

Ministry of Finance. 2013. Ontario Populations Projections Update, 2012-2036. ISBN 978–1–4606–2022–9.

Munkittrick K.R., C. B. Portt, G. J. Van Der Kraak, I. R. Smith, and D. A. Rokosh. 1991. Impact of bleached kraft mill effluent on population characteristics, liver MFO activity, and serum steroid levels of a Lake Superior White Sucker (*Catostomus commersoni*) Population. Canadian Journal of Fisheries and Aquatic Sciences, 48:1371-1380, 10.1139/f91-164.

NatureServe 2013. *Moxostoma duquesnei*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. Website: www.iucnredlist.org. [accessed January 7 2014].

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Website: http://www.natureserve.org/explorer. [accessed: November 6, 2013].

Ohio Department of Natural Resources: Division of Wildlife. Black Redhorse. Publication 5194. Website: www.dnr.state.oh.us/Portals/9/pdf/pub194.pdf [accessed: November 19, 2013].

Page, L.M., and B.M. Burr. 2011. Peterson field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company. Boston, Massachusetts. 185 pp.

Page, L.M., H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, N.E. Mandrak, R.L. Mayden, and J.S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico. 7th Edition. American Fisheries Society, Spec. Publ. 34. Bethesda, MD. 243 pp.

Parker, B.J. 1989. Status of the Black Redhorse, *Moxostoma duquesnei*, in Canada. Canadian Field-Naturalist 103:175-179.

Parker, B. and E. Kott. 1980. The Black Redhorse. pp. 188-206 in: Rare, threatened, and endangered fish species of Southern Ontario. Beak Inc., Mississauga, Ontario; Supply and Services; Fisheries and Oceans; and National Museum of Natural Sciences.

Portt, C., G. Coker and K. Barret. 2003. Recovery strategy for fish species at risk in the Grand River, Ontario. Draft Recovery Strategy submitted to RENEW Secretariat.

Reid, S.M. 2004. Post-impoundment changes to the Speed River fish assemblage. Canadian Water Resources Journal 29:183-194.

Reid, S.M. 2006a. Relationship between habitat quality and occurrence of the threatened Black Redhorse (*Moxostoma duquesnei*) in Lake Erie tributaries. Water Quality Research Journal of Canada. Volume 41, No. 4, 341-350.

Reid, S,M. 2006b. Timing and characteristics of *Moxostoma* spawning runs in three Great Lakes rivers. Journal of Freshwater Ecology 21:249-258.

Reid, S.M. 2009. Age, growth and mortality of Black Redhorse (*Moxostoma duquesnei*) and Shorthead Redhorse (*M. macrolepidotum*) in the Grand River, Ontario. Journal of Applied Ichthyology 25:178-183.

Reid, S.M. and N.E. Mandrak. 2006. Evaluation of Springbank Dam restoration on Black Redhorse (*Moxostoma duquesnei*) and other sucker species in the Thames River, Ontario. Canadian Technical Report of Fisheries and Aquatic Sciences. 2670: vii + 33 pp.

Reid, S.M., C.C. Wilson, N.E. Mandrak, and L.M. Carl. 2008a. Population structure and genetic diversity of Black Redhorse (*Moxostoma duquesnei*) in a highly fragmented watershed. Conservation Genetics 9:531-546.

Reid S.M., N.E. Mandrak, L.M. Carl, and C.C. Wilson. 2008b. Influence of dams and habitat condition on the distribution of redhorse (*Moxostoma*) species in the Grand River watershed, Ontario. Environmental Biology of Fishes 81:111-125

Retzer M.E. 2005. Changes in the diversity of native fishes in seven basins in Illinois, USA. American Midland Naturalist. 153:121-134.

Saugeen Conservation. 2013. 2007-2011 Watershed Report Cards – Lower Main Saugeen Watershed Report Card. http://www.saugeenconservation.com/downloads/Lower_Main.pdf?phpMyAdmin=82c3bRHhDPE3QA%2CLIdaJ3S823H4.

Scott, W.B., and E.J. Crossman. 1998. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pp + xvii. Reprinted by Galt House Publications, Burlington, ON.

Simon, T.P. 1999. Assessment of Balon's reproductive guilds with application to midwestern North American freshwater fishes. Boca Raton, FL. CRC Press, xx + 671 pp.

Smith, C.A. 1977. The biology of three species of *Moxostoma* (Pisces-Catostomidae) in Clear Creek, Hocking, and Fairfield counties Ohio, with an emphasis on the golden redhorse, *M. erythrurum* (Rafinesque). Doctoral dissertation, Ohio State University, Columbus, Ohio. 158 p.

Stewart, J., and M. Veliz. 2005. Ausable River Fisheries Survey Report. Exeter, Ontario

Taylor, I., B. Cudmore, C.A. MacKinnon, S.E. Madzia, and S.L. Hohn. 2004. Synthesis report for the Thames River recovery plan 6th draft. Upper Thames River Conservation Authority, Cambridge, ON. (www.thamesriver.on.ca).

Tetreault, G., C.J. Bennett, K. Shires, B. Knight, M.R. Servos, and M.E. McMaster. 2011. Intersex and reproductive impairment of wild fish exposed to multiple municipal wastewater discharges. Aquatic Toxicology 104: 278-290.

Trautman, M.B. 1981. The fishes of Ohio with illustrated keys. Revised Edition. The Ohio State University Press, Columbus, OH.

Velez-Espino and Koops. 2008. Recovery target and long-term projections for the Black Redhorse (*Moxostoma duquesnei*). DFO Can. Sci. Advis. Sec. Rpt 2008/00

Vélez-Espino L.A., and M.A. Koops. 2009. Quantifying allowable harm in species at risk: application to the Laurentian Black Redhorse (*Moxostoma duquesnei*). Aquatic Conservation 19(6):678-688.

Young, J.A.M. and Koops, M.A. 2013. Pre-COSEWIC population modeling of Black Redhorse (*Moxostoma duquesnei*) in Canada. DFO Canadian Science Advisory Secretariat Research Document 2013/nnn. iv + 15 p.

Young, J.A.M. and Koops, M.A. 2014. Population modeling of Black Redhorse (*Moxostoma duquesnei*) in Canada. DFO Canadian Science Advisory Secretariat Research Document 2014/020. iv + 14 p.

Yoder C.O., E.T. Rankin, M.A. Smith, B.C. Alsdorf, D.J. Altfater, C.E. Boucher, R.J. Miltner, D.E. Mishne, R.E. Sanders, R.F. Thoma. 2005. Changes in fish assemblage status in Ohio's nonwadeable rivers and streams over two decades, p. 399–430. *In* Rinne JN, Hughes RM, Calamusso B (eds), Historical changes in large river fish assemblages of the Americas. American Fisheries Society Symposium 45, Bethesda, Maryland.

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COLLECTIONS EXAMINED

None.

Appendix 1. Threats Assessment Worksheet.

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	**Black Redhorse (Moxostoma duquesnei)**		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	5/30/2014		
Assessor(s):	Scott Reid, Jen Shaw, Nick Mandrak, Mary Sabine, Marie-France Noel, Angele Cyr, John Post, Dave Fraser, Dwayne Lepitzki, Chris Bunt		
References:	draft COSEWIC report		

Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	2	1
	D	Low	3	4
Calculated Overall Threat Impact:			High	High

Assigned Overall Threat Impact:	**B = High**
Impact Adjustment Reasons:	Overall, most significant threat was considered to be pollution/water quality and the most likely number of locations is based on this threat
Overall Threats Comments:	Driven mainly by pollution (even though recently improving slightly) and climate change (though with some uncertainty). Also some major unknowns (dams, water extraction, zebra mussels) which could have significant impacts. Overall, the threats were generally considered to be cumulative.

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						not applicable
1.2	Commercial & industrial areas						not applicable
1.3	Tourism & recreation areas						not applicable
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-Timber crops						not applicable
2.2	Wood & pulp plantations						not applicable
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Trampling is negligible
2.4	Marine & freshwater aquaculture						not applicable
3	Energy production & mining						
3.1	Oil & gas drilling						not applicable
3.2	Mining & quarrying						not applicable
3.3	Renewable energy						not applicable
4	Transportation & service corridors						
4.1	Roads & railroads						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.2	Utility & service lines						no applicable
4.3	Shipping lanes						not applicable. Effects of water quality and siltation from changes in shipping lanes dealt with in 9.1 and 9.2.
4.4	Flight paths						not applicable
5	Biological resource use	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						not applicable
5.4	Fishing & harvesting aquatic resources	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Bycatch mortality, accidental catch, and collection for bait. Targeted angling not present. Some anglers indiscriminate and probably some mortality will result. Closer to 1% rather than 10%
6	Human intrusions & disturbance	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	ATV use occasionally. Impact largely based on areas that are easily accessible. ATV use would occur in riffle areas. People driving down streams, not just fording.
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Electrofishing. Stress from capture for research purposes.
7	Natural system modifications		Unknown	Large (31-70%)	Unknown	High (Continuing)	
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use		Unknown	Large (31-70%)	Unknown	High (Continuing)	Dams, more of a limiting factor than a threat. Unless it has a long term effect on habitat down stream. No new dams planned in fish habitat. Existing dams modify flow stream and this is impacting impounded areas upstream, uniform and slow moving water (this threat is considered under 11.1). Dams do not seem to be blocking migration overall but it is occurring in some areas and causing some population decline. Not 100% blockage but some fishways are not functioning. Increase in ground water pumping. Some of the impacts of dams provide positive effects mitigating their own impacts such as reservoirs that are sheltered habitat.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications		Unknown	Large (31-70%)	Unknown	High (Continuing)	Stream simplification? Non-native invasive species having an ecosystem effect. Zebra Mussels are more likely to establish and persist in the reservoirs and affect the water column (i.e. Grand and Thames River). Humans altering the water course. Increases in water clarity. Predation causes by introduction of new species accounted for in 8.1. Stocking of native fish is 8.2. Over all impact of ecosystem modifications is unknown and may also cause a positive result.
8	Invasive & other problematic species & Genes	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Brown Trout. Other species may have impact (i.e. Asian Carp, Round Goby, Zebra Mussel).
8.2	Problematic native species		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Walleye. Northern Pike.
8.3	Introduced genetic material						not applicable
9	Pollution	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	
9.1	Household sewage & urban waste water	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	Poor water quality and degradation. Sewage exposure. Urban waste water.
9.2	Industrial & military effluents		Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)	Some data to suggest endocrine disruptors and their negative effects on fish (accounted for in 9.1). Impact from mill effluent.
9.3	Agricultural & forestry effluents	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fertilization and siltation. Ausable is the most intensely agriculture area. Water quality levels still above acceptable limits.
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	Moderate - Low	
11.1	Habitat shifting & alteration						Water quantity projections available for next 50yrs but not for the next 10yrs.
11.2	Droughts	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	Moderate - Low	Drought impacting partial recruitment failure.
11.3	Temperature extremes						not applicable
11.4	Storms & flooding	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Some. Changes to flow regimes. In one area, storm felled trees, resulted in additional woody debris, decreased flow, increased siltation, juvenile Black Redhorse not detected at this site since storm event