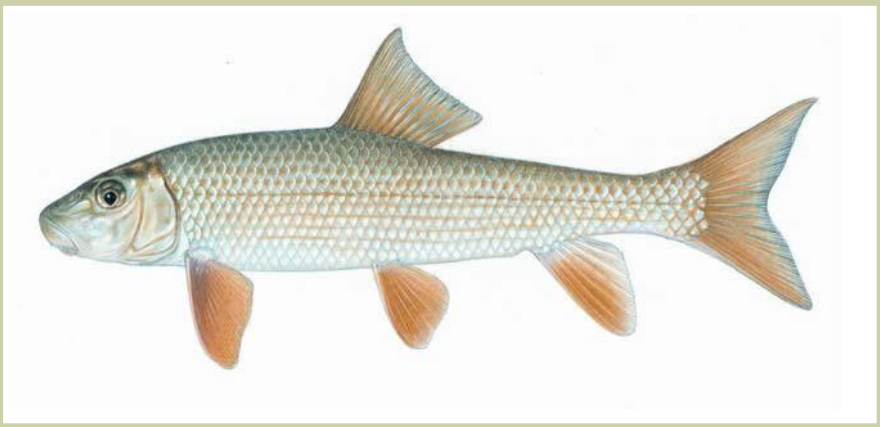
Species at Risk Act
Recovery Strategy Series

Recovery Strategy and Action Plan for the Black Redhorse (*Moxostoma duquesnei*) in Canada

Black Redhorse



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For copies of the recovery strategy and action plan, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy and action plan for listed extirpated, endangered, or threatened species and are required to report on progress five years after the publication of the final documents on the Species at Risk Public Registry.

This document has been prepared to meet the requirements under SARA of both a recovery strategy and an action plan. As such, it provides both the strategic direction for the recovery of the species, including the population and distribution objectives for the species, as well as the more detailed recovery measures to support this strategic direction, outlining what is required to achieve the objectives. SARA requires that an action plan also include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation. It is important to note that the setting of population and distribution objectives and the identification of critical habitat are science-based exercises and socio-economic factors were not considered in their development. The socio-economic evaluation only applies to the more detailed recovery measures (that is, the action plan portion).

The Minister of Fisheries and Oceans is the competent minister under SARA for the Black Redhorse and has prepared this recovery strategy and action plan, pursuant to sections 37 and 47 of SARA. In preparing this recovery strategy and action plan, the competent minister has considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this recovery strategy and action plan has been prepared in cooperation with the province of Ontario as per section 39(1) of SARA.

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and action plan and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this recovery strategy and action plan for the benefit of the Black Redhorse and Canadian society as a whole.

Implementation of this recovery strategy and action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

Fisheries and Oceans Canada (DFO) would like to thank the authors, Jessica Epp-Martindale (DFO), Joshua Stacey (DFO), John Jimmo (DFO contractor), and Peter Jarvis (DFO contractor), as well as the following organizations for their support in the development of the Black Redhorse recovery strategy and action plan: Black Redhorse Recovery Team, Ontario Ministry of Natural Resources and Forestry, and the Ontario Ministry of the Environment, Conservation and Parks. Mapping was produced by Andrew Geraghty (DFO).

Executive summary

Black Redhorse was listed as threatened under the *Species at Risk Act* (SARA) in 2019. This recovery strategy and action plan is considered one in a series of documents for this species that should be taken into consideration together; including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2015), a recovery potential assessment (RPA; Bouvier et al. 2021), and possibly further action plans. Recovery has been determined to be biologically and technically feasible.

The Black Redhorse is a member of the sucker family (Catostomidae) and is one of seven redhorse species found in Canada. Black Redhorse typically grows to an average length of 40 cm, making it one of the smaller redhorse species found in Canada. The species has an olive, gold or brassy dorsal surface with paler sides and a silver or white ventral surface. Its range is limited to eastern North America, where it is found in the Mississippi and Great Lakes basins. In Canada, the species is restricted to southwestern Ontario, specifically, tributaries of Lake Huron (Sauble, Saugeen, Maitland, Bayfield, and Ausable rivers), Lake St. Clair (Thames River), and Lake Erie (Grand River). The Black Redhorse plays a role in benthic-pelagic coupling as it transfers energy from the benthic food web where it feeds, to the pelagic food web where it is preyed upon by piscivorous fishes.

The main threats facing the species are described in section 5 and include: pollution, climate change and severe weather, invasive species, biological resource use, human intrusion, and natural systems modifications. The Black Redhorse is considered sensitive to poor water quality and degraded habitat, which occur due to the cumulative impacts of pollution from urban wastewater and agriculture, and alterations to flow regimes.

The population and distribution objectives (section 6) for Black Redhorse are listed below.

Population objective: Ensure populations in the Grand and Thames river systems, Catfish Creek, and the Lake Huron tributaries (Sauble, Saugeen, Maitland, Bayfield, and Ausable rivers) are viable and are stable or increasing, with low risk of known threats. Note that the inclusion of historical population in Catfish Creek will only be considered within this objective if feasible and warranted.

Distribution objective: Maintain the species' current distribution and restore distribution in historically occupied reaches, where feasible and warranted, at the following locations:

- Sauble River
- Saugeen River
- Maitland River (including Blyth Brook and Hopkins Creek)
- Bayfield River
- Ausable River (including Little Ausable River)
- Thames River (including Middle Thames River, Waubuno Creek, North Thames River, Fish Creek, Wye Creek, Stoney Creek, and Medway Creek)
- Catfish Creek
- Grand River (including Conestogo River, Four Wells Lake, Nith River, Mount Pleasant Creek, and Big Creek)

A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and distribution objectives, are included in section 7.

For Black Redhorse, critical habitat (section 8) is identified to the extent possible, using the best available information, and provides the features and attributes necessary to support the species' life-cycle processes and to achieve the species' population and distribution objectives. This recovery strategy and action plan identifies critical habitat for Black Redhorse in the Sauble River, Saugeen River, Maitland River (including Blyth Brook and Hopkins Creek), Bayfield River, Ausable River (including Little Ausable), Thames River (including Middle Thames River, Waubuno Creek, North Thames River, Fish Creek, Fanshawe Lake, Wye Creek, Stoney Creek, Medway Creek, and Lower Thames River), and Grand River (including Conestogo River, Cedar Creek, Forwell Creek, Four Wells Lake, Laurel Creek, Nith River, Mount Pleasant Creek, and Big Creek).

The action plan portion of this document (tables 4 to 6 and section 9) provides the detailed recovery planning in support of the strategic direction set out in the recovery strategy section of the document. The action plan outlines what needs to be done to achieve the population and distribution objectives, including measures to be taken to address threats and monitor recovery of the species, as well as required measures to protect critical habitat. An evaluation of the socio-economic costs of implementing the action plan and the benefits to be derived from its implementation is provided in section 9.

Recovery feasibility summary

Recovery of Black Redhorse is believed to be both biologically and technically feasible. Recovery feasibility is determined according to four criteria outlined by the Government of Canada (2009):

1. Are individuals of the wildlife species that are capable of reproduction available now or in the foreseeable future to sustain the population or improve its abundance?

Yes. Reproducing populations are best known from the Grand River and tributaries, followed by the Thames River and tributaries. These populations could provide a basis for natural expansions and potential translocations or artificial propagation, if necessary. The reproductive status of the Black Redhorse in the Lake Huron tributaries is poorly understood.

2. Is sufficient suitable habitat available to support the species or could it be made available through habitat management or restoration?

Yes. Suitable habitat is available where reproducing populations of Black Redhorse are found. In watersheds where the species is considered extirpated and/or the population is declining, additional suitable habitat may be made available through restoration actions.

3. Can significant threats to the species or its habitat be avoided or mitigated?

Yes. Primary threats such as habitat degradation due to pollution (for example, contaminants, and increased levels of turbidity) from municipal and agricultural sources can be mitigated through the implementation of best management practices (for example, establishing riparian buffers to reduce sediment and nutrient loading), and other established restoration methods.

4. Do recovery techniques exist to achieve the population and distribution objectives or can they be developed within a reasonable timeframe?

Yes. Techniques to reduce identified threats are well known and proven to be effective. For example, Black Redhorse populations in the Illinois and Ohio rivers have responded positively to improvements in water quality and habitat (Retzer 2005, Yoder et al. 2005). Furthermore, repatriations may be feasible through captive rearing (Bunt et al. 2013a) or adult transfers.

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Background

1 Introduction

Black Redhorse (*Moxostoma duquesnei*) was listed as threatened under the *Species at Risk Act* (SARA) in 2019. This recovery strategy and action plan is part of a series of documents regarding Black Redhorse that should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2015) and the science advisory report from the recovery potential assessment (RPA; Bouvier et al. 2021), as well as the action plan for the Ausable River (DFO 2018a) and possibly further action plans.

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets objectives and identifies the main areas of activities to be undertaken, while the action plan portion provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy portion. Action planning for the recovery of species at risk is an iterative process. The implementation schedule (tables 4 to 6) in this recovery strategy and action plan may be modified in the future depending on the progression towards recovery.

The RPA is a process undertaken by Fisheries and Oceans Canada's (DFO) Science sector to provide the information and scientific advice required to implement SARA, relying on the best available scientific information, data analyses and modelling, and expert opinions. The outcome of this process informs many sections of the recovery strategy and action plan. For more detailed information beyond what is presented in this recovery strategy and action plan, refer to the COSEWIC status report (COSEWIC 2015) and the RPA (Bouvier et al. 2021).

2 COSEWIC species assessment information

Date of assessment: May 2015

Species' 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.

Canadian occurrence: Ontario

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

3 Species status information

Table 1. Summary of existing protection and other status designations assigned to the Black Redhorse.

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Canada	*Species at Risk Act* (SARA)	2019	Threatened	Population
Canada	Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	2015	Threatened	Population
Ontario	*Endangered Species Act* 2007	2008	Threatened	Population
Ontario	Committee on the Status of Species at Risk in Ontario (COSSARO)	2016	Threatened	Population
International	NatureServe	2015	Global: G5-Secure	Species
Canada	NatureServe	2015	Regional (ON): S2-Imperilled	Population

Upon listing as a threatened species, Black Redhorse became protected wherever it is found in Canada by section 32 of SARA:

> "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." [subsection 32(1)]
>
> "No person shall possess, collect, buy, sell or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual." [subsection 32(2)]

Under section 73 of SARA, the competent minister may enter into an agreement or issue a permit authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or its residences.

4 Species information

4.1 Description

The Black Redhorse is a member of the sucker family (Catostomidae) and is one of seven redhorse species in the genus *Moxostoma* found in Canada. The Black Redhorse (Figure 1) has an olive, gold, or brassy dorsal surface, with paler sides and a silver or white ventral surface

(Holm et al. 2009). Females display little or no spawning colour, while males exhibit an orange to pink colour along their sides and black longitudinal stripes (Kwak and Skelly 1992). The caudal and dorsal fins are grey, and the lower fins are often pale red or orange (Holm et al. 2009). Juveniles can be difficult to identify, as colour differentiation may be faint or absent (COSEWIC 2015). Black Redhorse typically grows to an average length of 40 cm (Holm et al. 2009), making it one of the smaller redhorse species found in Canada (Scott and Crossman 1998). Females have been observed to grow larger than males and tend to be larger at any given age (Reid 2006b). The largest recorded length and weight for Black Redhorse in Ontario is 53.4 cm and 1.5 kg, respectively (Holm et al. 2009).

This species shares physical characteristics with several other species in the family Catostomidae found in Canada, including: Northern Hog Sucker (*Hypentelium nigricans*); Spotted Sucker (*Minytrema melanops*); Lake Chubsucker (*Erimyzon sucetta*); Greater Redhorse (*M. valenciennesi*); River Redhorse (*M. carinatum*); Shorthead Redhorse (*M. macrolepidotum*); Silver Redhorse (*M. anisurum*); and Golden Redhorse (*M. erythrurum*) (Holm et al. 2009). In addition to the features listed above, distinguishing characteristics of the Black Redhorse include a long slender body, large and forked caudal fin with pointed lobes (Page and Burr 2011), a concave dorsal fin edge, 44 to 47 (sometimes 43 to 51) large lateral scales,12 to 13 caudal peduncle scales, and a lack of transverse grooves on the lips (Holm et al. 2009). Refer to the COSEWIC status report (COSEWIC 2015) and/or the RPA (Bouvier et al. 2021) for more detailed information.

Figure 1. Black Redhorse (*Moxostoma duquesnei*). Photo by Jason Barnucz, Fisheries and Oceans Canada.

4.2 Population abundance and distribution

4.2.1 Global distribution and population abundance

Like most redhorse species, the Black Redhorse range is limited to eastern North America (figure 2) (Scott and Crossman 1998). It is found in the Mississippi and Great Lakes basins where its distribution is wide, but particularly disjunct in the western portion of its range (Lee et al. 1980, Page and Burr 2011). The Black Redhorse range extends from southwestern Ontario and New York to southeastern Minnesota in the north, to northern Alabama and eastern Oklahoma in the south. In the Great Lakes basin, disjunct populations are found in Ontario,

Michigan, and Wisconsin. Total adult population size is unknown but believed to be relatively large (NatureServe 2017).

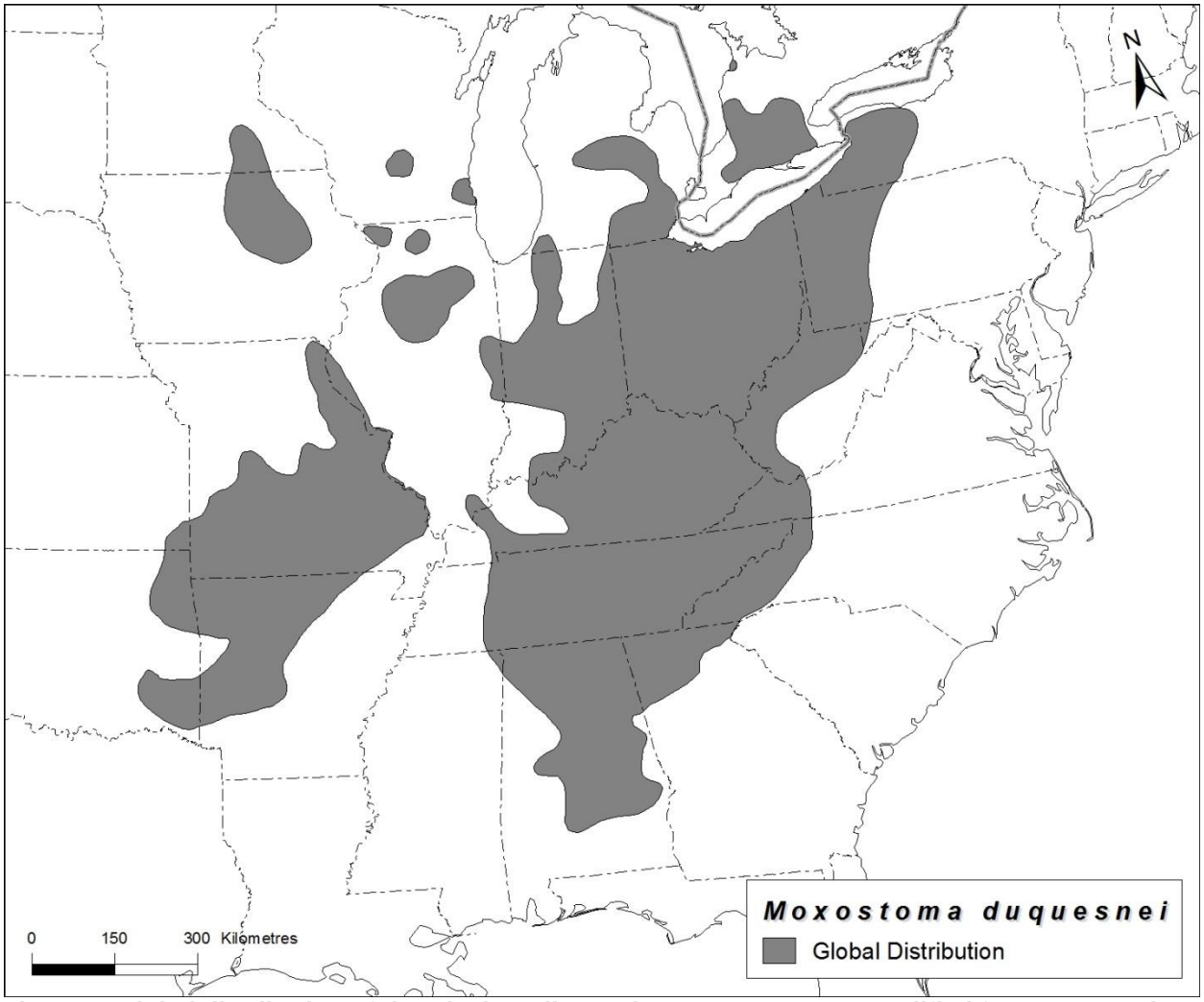

Figure 2. Global distribution of the Black Redhorse (COSEWIC 2015 as modified from Page and Burr 1991).

4.2.2 Canadian distribution and population abundance

Canadian populations encompass the northern-most limit of the Black Redhorse global distribution (figure 2). In Canada, Black Redhorse is restricted to southwestern Ontario (COSEWIC 2015), where it is considered the rarest of the redhorse species found in the province (Holm et al. 2009). Currently, the species is found in tributaries of Lake Huron (Sauble River, Saugeen River, Maitland River, Gully Creek, Bayfield River, and Ausable River), Lake St. Clair (Thames River), and Lake Erie (Grand River). Historically, it was documented in Catfish Creek (Lake Erie tributary), Spencer Creek (Lake Ontario tributary), and more recently, in Lake Simcoe. Black Redhorse was last detected in Catfish Creek in 1938 and is now believed to be extirpated from this watershed (COSEWIC 2015); subsequent sampling efforts have also failed to detect the species in Lake Simcoe and Spencer Creek. The individuals captured in these two systems are believed to be the result of accidental introductions (COSEWIC 2015). Only a

single individual has been collected from Gully Creek (1 km upstream from Lake Huron); therefore, an established population has not been confirmed at this location (COSEWIC 2015). The current distribution of Black Redhorse in Canada is displayed in figure 3 and summarized below. Refer to the RPA (Bouvier et al. 2021) and/or COSEWIC status report (COSEWIC 2015) for greater detail on the Canadian distribution of Black Redhorse.

Lake Huron drainage

Black Redhorse has been detected in six rivers that drain into Lake Huron: the Sauble, Saugeen, Maitland, Bayfield, and Ausable rivers, and Gully Creek.

Sauble River: Black Redhorse was first collected in the Sauble River in 1958 and, despite additional sampling efforts, was not detected again until 2014, 2016, and 2017 (Marson et al. 2016, Colm et al. 2018, 2019a).

Saugeen River: In 2006, Black Redhorse was detected for the first time in the Saugeen River (Marson et al. 2009); subsequent sampling for Black Redhorse has not occurred.

Maitland River: Black Redhorse was initially captured in the Maitland River watershed in 1973 in Belgrave Creek (Bouvier et al. 2021). The species has since been captured by DFO during Asian Carp surveillance in 2016, 2017, and 2018 (Colm et al. 2018, 2019a, b).

Gully Creek: One juvenile Black Redhorse was captured approximately 1 km upstream from Lake Huron in 2003 (COSEWIC 2015). Considering only one specimen has been detected, despite subsequent sampling, it is possible that this record was of a vagrant from larger Lake Huron tributary populations (COSEWIC 2015).

Bayfield River: The first record of Black Redhorse in the Bayfield River occurred in 1982. The species was more recently captured in 2014, 2016, and 2018 by DFO's Asian Carp Program (Marson et al. 2016, Colm et al. 2018, 2019b).

Ausable River: The species was first detected in the Ausable River watershed in 2002 (Little Ausable River) and has subsequently been captured in the Ausable River (2007 to 2009) and in the Little Ausable River (2007) (COSEWIC 2015). Black Redhorse was most recently found during sampling by DFO's Asian Carp Program in 2017 and 2018 (Colm et al. 2019a, b).

One dead individual was found in a trap net in Lake Simcoe in 2011 by the Lake Simcoe Fisheries Assessment Unit. Subsequent sampling was unsuccessful in producing further specimens. Due to the separation between established populations, this record is considered to be an introduction, likely as baitfish (COSEWIC 2015).

Lake St. Clair drainage

Thames River watershed: Black Redhorse occupies the Upper Thames River (Middle Thames, North Thames, and Lower Thames) and numerous tributaries (Waubuno, Flat, Fish, Wye, Stoney, and Medway creeks), as well as Fanshawe Lake. Historically, it was known from the Lower Thames River but no captures have been recorded by DFO since 2003 (DFO, unpublished data). This may be evidence of a range reduction in the Thames River; however, a lack of recent targeted sampling may also be the cause. There are two large dams in the Thames River that lack fish passage (Fanshawe and Pittock), which are potentially causing fragmentation and disjunct populations.

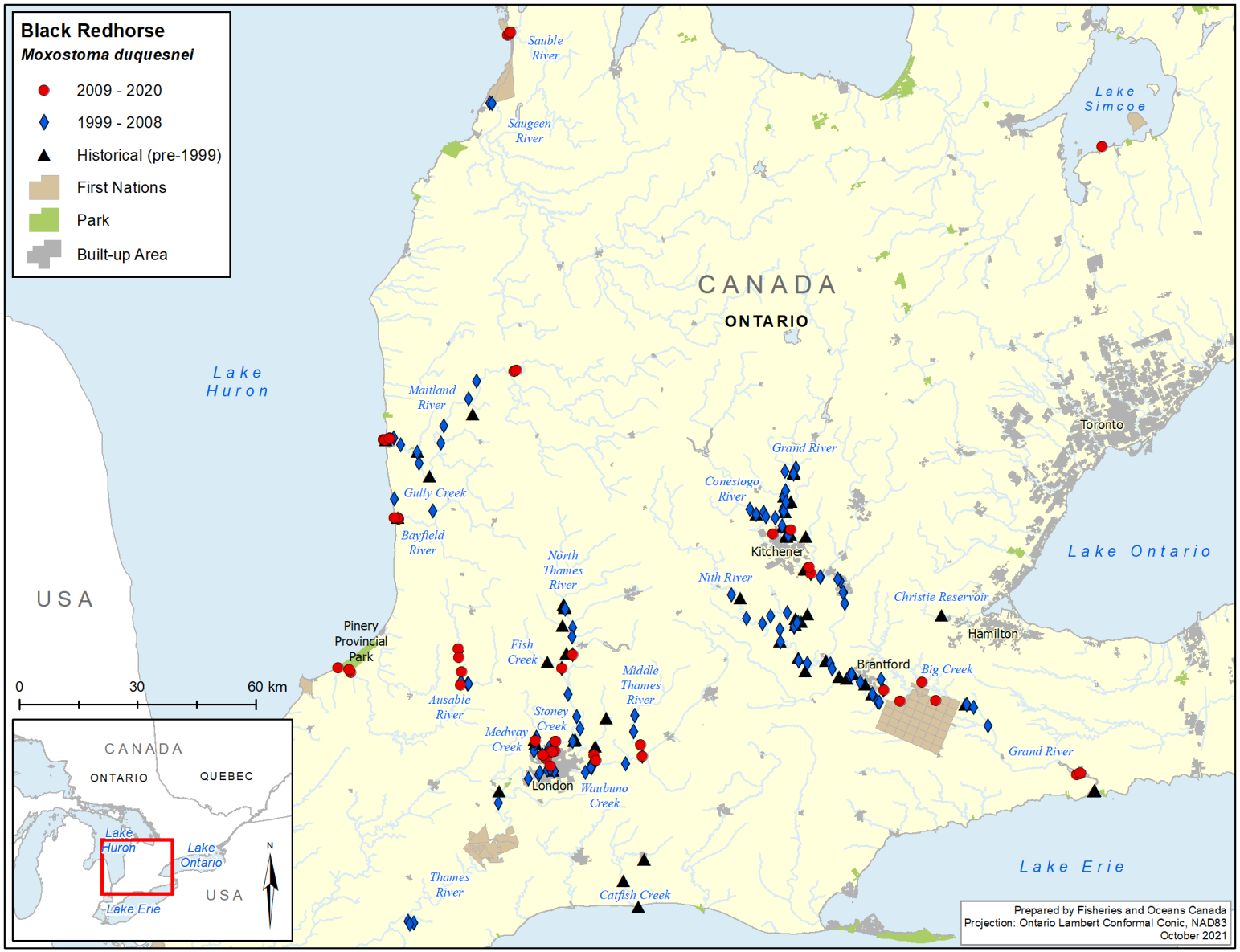

Figure 3. Current (1999 to 2020) and historical (pre-1999) distribution of Black Redhorse in Canada.

Lake Erie drainage

Grand River watershed: Populations appear concentrated in the central Grand River (including the lower reaches of two major tributaries, Conestogo and Nith rivers) but are fragmented by four dams lacking passage for warmwater benthic species, likely resulting in five separate populations. Recent collections have verified the presence of Black Redhorse in upper and lower portions of the Grand River watershed at Mount Pleasant Creek, and at two sites where it had not previously been collected (that is, Big Creek and Four Wells Lake) (A. Timmerman, OMNDMNRF, unpublished data), raising the possibility of a range expansion (Bouvier et al. 2021).

Despite the implementation of several targeted and non-targeted sampling efforts, Black Redhorse has not been detected in Catfish Creek since 1938.

Lake Ontario drainage

One individual was found in Spencer Creek (Christie Reservoir) in 1998. Subsequent sampling has failed to yield further specimens. Similar to the Lake Simcoe record, this individual is considered to be an introduction (COSEWIC 2015).

4.2.3 Population assessment

Population size estimates for Black Redhorse in Canada are unavailable. Repeated sampling efforts have occurred in watersheds occupied by Black Redhorse but a lack of consistent monitoring (with consistent sampling protocols) makes population dynamics difficult to assess. Many of the fish surveys that have captured Black Redhorse were not specifically targeting this species. Furthermore, difficulties with the identification of this species (often leading to lumping of redhorse species, particularly at the juvenile stage) and a lack of suitable sampling gear, may contribute to under-reporting. Comparisons between the historical (prior to 2004) and current (2004 to 2018) sampling records suggest that Black Redhorse populations are declining in some areas (that is, Thames River and vicinity), while increasing in others (Bouvier et al. 2021); however, population trends are confounded by the lack of standardized monitoring effort.

Table 2. Population status of all Black Redhorse populations in Canada. Certainty has been associated with the Relative Abundance Index and Population Trajectory rankings and is listed as: 1=quantitative analysis; 2= catch per unit effort (CPUE) or standardized sampling; and 3=expert opinion (adapted from Bouvier et al. 2021).

Population	Population status	Certainty
Sauble River	Poor	3
Saugeen River	Unknown	3
Maitland River	Poor	3
Gully Creek	Unknown	3
Bayfield River	Poor	3
Ausable River	Poor	3
Thames River (and tributaries)	Poor	3
Catfish Creek	Extirpated	3

Population	Population status	Certainty
Grand River (and tributaries)	Fair	3

The Grand River population appears to be well established as indicated by the highest abundances of Black Redhorse and consistent findings (Bouvier et al. 2021). In the Thames River, and several Lake Huron tributaries, lower but consistent detections suggest that established populations occur in these watersheds. Additional sampling efforts are required to estimate population abundance and trajectory in these watersheds, and ultimately provide a more confident assessment of the population status of Black Redhorse at all locations (Bouvier et al. 2021).

4.3 Needs of the Black Redhorse

Adults: Black Redhorse generally inhabits moderately sized, clear, warm water rivers, typically preferring pools in the summer, and over-wintering in deeper pools (Bowman 1970, Scott and Crossman 1998). It is generally found in sections of rivers with moderate to fast flows; however, it has occasionally been detected in areas with slower currents (Holm and Boehm 2001). It has been detected over a variety of substrate types (for example, rubble, gravel, sand, boulders, clay, and silt) (Holm and Boehm 2001, Reid 2006a; DFO unpubl. data). The species is more often found in wider stretches of rivers (Bowman 1970, Jenkins 1970, Reid 2006a, Reid et al. 2008a). Reid (2006a) suggested that suitable habitat for Black Redhorse includes clean, coarse bed material (gravel and cobble), stable channels, and well-developed riffles, which is consistent with other descriptions of juvenile and adult Black Redhorse collection sites (Bowman 1970, Kott et al. 1979, Clark 2004) and spawning habitats (Bowman 1970, Parker 1989, Kwak and Skelly 1992). Reid et al. (2008a) found Black Redhorse site occupancy positively associated with lower gradients and larger drainages within the Grand River system. The Black Redhorse appears less tolerant of turbidity and siltation than other redhorse species found in Canada (Scott and Crossman 1998). The species is “intolerant of very turbid waters, and increased turbidity and siltation are usually followed by decreases in [its] population” (McAllister et al. 1985).

Spawning: In spring, adults migrate upstream to spawn (Jenkins 1970), most often in shallow riffles, avoiding the swiftest currents, over substrates ranging in size from fine gravel to large cobble (Kwak and Skelly 1992). Kwak and Skelly (1992) suggest that the selection of spawning habitat may be partially determined by competition with other redhorse species. In the Grand River, spawning of Black Redhorse has been observed in the second half of May once water temperature rose above 13°C, and was complete before water temperatures increased above 20°C (Reid 2006b), while laboratory investigations have demonstrated incomplete egg development at temperatures less than 11°C (Bunt et al. 2013a). High flow rates have been observed to result in the abandonment of previously utilized spawning shoals (Bowman 1970), and a large increase in discharge during the spawning period prevented ripe Greater Redhorse, a similar species, from spawning on the Grand River (Cooke and Bunt 1999). Furthermore, high spring flows, during extreme weather or flooding events, can delay upstream migrations and spawning in redhorse species (see Reid 2006b).

Juvenile stages: Young-of-the-year (YOY) remain at the spawning site until their yolk-sacs are absorbed, at which point they disperse and begin feeding (Simon and Wallus 1989), remaining in shallow (<1 m) littoral zones containing vegetation and substrates of mud, silt, and sand (Goodyear et al. 1982). In the Thames and Nith rivers, nursery areas have been observed in shallow pools and areas of slackened currents (Parker 1989). In the Grand River, juvenile

stages were observed to occupy vegetated littoral zones, with shallow slopes and slow currents with clean, pebble, gravel, and cobble substrate of heterogeneous composition, with some mixture of sand or silt (Bunt et al. 2013b). Although both larval and juvenile Black Redhorse were found to occupy riffles, runs, pools, and backwater areas, a strong preference for pools and backwater areas was observed (Bunt et al. 2013b). Juveniles are thought to be primarily planktivorous, while larger fish (>65 mm total length) are primarily benthivorous (Bowman 1970), with a preference for crustaceans and insects (Coker et al. 2001).

Juveniles have been observed to aggregate in areas of groundwater upwelling and/or seepage along the river bank of the Grand River (Bunt et al. 2013b). Areas of groundwater influx into the Grand River may be important features aiding in the persistence of Black Redhorse, as they may act as a refuge from poor water quality and temperature conditions. Upstream movement of juvenile Black Redhorse in the fall has been observed, and thought to be migrations to over-wintering habitat (Bunt et al. 2013b). Hence, the species likely has both seasonal and life stage-specific habitat requirements.

Limiting factors: The Black Redhorse may be limited by its restrictive spawning habitat preferences with respect to water depth and velocity, and substrate. Naturally occurring high spring flows may limit upstream migration or result in the abandonment of previously used spawning sites (Bowman 1970). On the other side of the spectrum, Black Redhorse is also susceptible to drought and decreases in water levels that lead to a reduction in flow and groundwater inputs on which the species relies (Bouvier et al. 2021). The Black Redhorse may also be limited by its decreased tolerance of siltation and turbidity compared to other redhorse species within its range.

5 Threats

5.1 Threat assessment

An assessment and prioritization of threats to survival and recovery of the species is undertaken during the RPA process (Bouvier et al. 2021). Table 3 provides a summary of threats to Black Redhorse populations in Canada. Known and suspected threats were ranked with respect to threat likelihood and threat impact for each population. The threat likelihood and threat impact were then combined to produce an overall threat risk. A certainty level was also assigned to the overall threat status, which reflected the lowest level of certainty associated with either threat likelihood or threat impact. For more details on the threat assessment process, refer to the RPA (Bouvier et al. 2021). For more information on threats to Black Redhorse, refer to the COSEWIC report. Narrative descriptions of the threats listed in the table can be found in section 5.2.

Table 3. Summary of threats to Black Redhorse populations in Canada. The number in brackets refers to the level of certainty associated with the threat impact from 1: very high to 5: very low (table modified from Bouvier et al. 2021).

Threats	Species-level threat risk	Sauble River population threat risk	Saugeen River population threat risk	Maitland River population threat risk	Gully Creek population threat risk	Bayfield River population threat risk	Ausable River population threat risk	Thames River (and tributaries) population threat risk	Grand River (and tributaries) population threat risk
Pollution	Medium (2)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (2)
Climate change and severe weather	Medium (2)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (2)
Invasive species	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)
Biological resource use	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)
Human intrusion	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)	Low (5)
Natural system modifications	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

5.2 Description of threats

Pollution: The majority of Canadian populations of the species reside in areas that are heavily impacted by municipal and agricultural activities. Generic threats to aquatic communities include inputs of potentially toxic chemicals (for example, nutrients, metals, salts, pesticides, pharmaceuticals, flame retardants) via overland run-off, spills, and effluent discharge, along with increased sediment loads and human/animal waste inputs. Suspended sediment and nutrient (phosphorus and nitrogen) levels often exceed provincial water quality guidelines (see Loomer and Cooke 2011) and endocrine disruptors[1] are present (Tetreault et al. 2011) in areas occupied by Black Redhorse within the Grand River. In addition to elevated nutrient levels found in many southwestern Ontario waterways, chloride levels can be elevated beyond federal water quality guidelines throughout this road-dense and heavily salted region (see Todd and Kaltenecker 2012).

The specific sensitivity of the Black Redhorse to these threats is largely unknown. There is some indication that the species may be sensitive to elevated turbidity levels (Trautman 1981, McAllister et al. 1985, Scott and Crossman 1998). Improvements in water quality have occurred in some watersheds (for example, Grand River; see Loomer and Cooke 2011), yet challenges remain. Increasing human densities within watersheds containing Black Redhorse will ensure a challenging environment for species recovery.

Climate change and severe weather: The Black Redhorse is likely to be impacted by drought and severe weather events, such as storms and flooding. Drought could reduce flow and groundwater availability, while storms and flooding may impact flow regimes and siltation patterns. Changing temperature, precipitation, and storm patterns also impact the way potential pollutants enter waterways containing Black Redhorse, and their concentration and persistence within these systems.

Invasive species: Non-native Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*) have been identified as potential consumers of smaller Black Redhorse, and Round Goby (*Neogobius melanostomus*) has been identified as a potential competitor. Dreissenid mussels (Zebra Mussel [*Dreissena polymorpha*] and Quagga Mussel [*D. bugensis*]) and Asian carp species may negatively impact habitat (Bouvier et al. 2021). The invasion of Grass Carp (*Ctenopharyngodon idella*) in the Great Lakes has been predicted to have a moderate effect on YOY Black Redhorse where they occur in coastal habitats (Gertzen et al. 2016).

Biological resource use: Incidental capture and bycatch mortality through baitfish harvesting is a potential threat to the species, and misidentification leading to collection may occur. Drake and Mandrak (2014b) found that a relatively high probability of bycatch exists when sufficient effort is applied; however, the level of mortality incurred as a result of such capture events is currently unknown. Another study (Drake and Mandrak 2014a) investigated the presence of imperilled fishes within samples taken from baitfish dealers across southern Ontario in 2007 and 2008 (a cumulative total of 16,886 fishes). Black Redhorse was not detected within this study (only one related imperilled species, River Redhorse [*Moxostoma carinatum*], was detected), which may suggest that the species is not frequently captured within baitfish harvests. However, should Black Redhorse be caught as bycatch, the ability of baitfish harvesters to sort and remove the species from target baitfishes is unknown. Observations of Black Redhorse in Spencer Creek (tributary of Lake Ontario) and Lake Simcoe are believed to be the result of

[1] Chemicals found in the environment that can interfere with hormone systems, resulting in changes in sex ratios and low rates of reproduction.

introductions, likely as baitfish, suggesting biological resource use may be a realistic concern (COSEWIC 2015).

Human intrusion: In localized areas, a variety of activities (for example, all-terrain vehicle [ATV] operation, wading in streams while angling, canoeing, and kayaking) may result in physical alteration of the streambed and increased turbidity.

Natural system modifications: The level of impact of natural system modifications to Black Redhorse in Canada is currently unknown. Dams are found in watersheds occupied by Black Redhorse and can alter flow regimes and prevent fish passage. A review of literature by Reid and Mandrak (2006) concluded that out of 11 targeted species, Black Redhorse and River Redhorse were the most sensitive to impoundments, and the release of cold hypolimnetic[2] water could have a potentially negative impact on the species. Alteration of flow conditions by water control structures may limit the species by reducing suitable habitat (Parker 1989); population declines have been related to the construction of impoundments in the United States (Bowman 1970, Travnichek and Maceina 1994). Reid et al. (2008a) found a lack of a strong and consistent effect of dams on the distribution of individual redhorse species within the Grand River. Fishway design at the Mannheim and Dunnville weirs may be sub-optimal for passing Black Redhorse (Reid 2006b). There are seven dams in the river systems occupied by Black Redhorse in Canada that do not allow passage of warmwater benthic fishes: four in the Grand River; two in the Thames River; and one in the Maitland River at Wingham. Withdrawal of groundwater for municipal and industrial use may pose a threat to Black Redhorse, as the species in some locations may rely on groundwater inputs as a cold-water refuge during the summer (Bunt et al. 2013b).

Recovery

6 Population and distribution objectives

Population and distribution objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution, that are necessary for the recovery of the species. The population and distribution objectives for the Black Redhorse are:

> **Population objective:** Ensure populations in the Grand and Thames river systems, Catfish Creek, and the Lake Huron tributaries (Sauble, Saugeen, Maitland, Bayfield, and Ausable rivers) are viable and are stable or increasing, with low risk of known threats. Note that the inclusion of historical population, Catfish Creek, within this objective will only be considered if feasible and warranted[3].
>
> **Distribution objective:**
> Maintain the species' current distribution[4] and restore distribution in historically occupied[5] reaches, where feasible and warranted, at the following locations[6]:

[2] Cold stratified water released through a dam, resulting in decreased temperatures downstream.
[3] Further surveys may determine that the species is still extant (that is, present) at sites that are believed to be extirpated (that is, historical).
[4] Currently occupied reaches = sites with live animals from 1999 onward.
[5] Historically occupied reaches = sites with records prior to 1999 (black triangles on distribution map).
[6] In this context, location does not refer to the locality of the discrete population, but rather a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of this species present (COSEWIC 2015).

- Sauble River
- Saugeen River
- Maitland River (including Blyth Brook and Hopkins Creek)
- Bayfield River
- Ausable River (including Little Ausable River)
- Thames River (including Middle Thames River, Waubuno Creek, North Thames River, Fish Creek, Wye Creek, Stoney Creek, and Medway Creek)
- Catfish Creek
- Grand River (including Conestogo River, Four Wells Lake, Nith River, Mount Pleasant Creek, and Big Creek)

The populations at these locations could be considered recovered when they demonstrate signs of reproduction and recruitment throughout their distribution, and major threats have been mitigated where feasible. More quantifiable objectives will be developed once necessary surveys and studies have been completed (refer to section 7.5 “Schedule of studies to identify critical habitat”). Most historically occupied reaches in the watersheds listed above are connected to currently occupied reaches; the intent is to restore the species’ distribution naturally (that is, through reducing threats and restoring areas with degraded habitat). Should natural recolonization not occur, population augmentation and/or repatriation using wild stock and/or captive reared individuals may be investigated. In Catfish Creek, an extirpated population, repatriation may be implemented if deemed feasible.

Recent population modelling conducted by Young and Koops (2014) estimated that the minimum viable population size (MVP) for Black Redhorse is 1,700 adults (ages 4+) and 3,900 juveniles (ages 1 to 3). However, the implementation of such a target is difficult without also having information on population demographics and spatial distribution, habitat quality, frequency of catastrophic declines, and a more complete understanding of the life-history of the species. For example, basics such as fecundity, spawning periodicity, and survival in early life are unknown for Canadian populations. Hence, more confident objectives relating to MVP can be developed and further validation of model results can be obtained as our understanding of this species is improved. Research actions designed to improve baseline information are outlined in tables 5 and 6.

Rationale: Key knowledge gaps currently exist with respect to Black Redhorse in Canada, inhibiting the formulation of quantifiable population and distribution objectives. Refined objectives (extent, abundance, trajectories and targets) will be developed once necessary surveys and studies have been completed.

7 Broad strategies and general approaches to meet objectives

7.1 Actions already completed or currently underway

Research

Actions that are underway include surveys (for estimating abundance and range) and recovery potential modelling (Vélez-Espino and Koops 2007, 2008, 2009, Young and Koops 2014). Targeted studies on Black Redhorse in Canada have already been undertaken including: Reid

(2006a) on the relationship between habitat quality and occurrence; Reid and Mandrak (2006) on the potential impact of restoring the Springbank Dam; Reid et al. (2008b) on population structure and genetic diversity; Reid (2009) on growth characteristics; Bunt et al. (2013a) on ontogeny[7] of larval and juvenile forms; Bunt et al. (2013b) on timing of movement and habitat utilization by larvae and juveniles; and Reid and Glass (2014) on non-lethal age determination. Aside from the Springbank Dam study on the Thames River, all other recent studies focused on Black Redhorse in the Grand River. Mitochondrial DNA-based species diagnostic tests have been developed to validate field identifications of the six Ontario redhorse species (Reid and Wilson 2006).

Stewardship

Conservation authorities (for example, Grey Sauble, Saugeen, Maitland Valley, Ausable Bayfield, Upper Thames River, Lower Thames Valley, and Grand River) continue to play a vital role in stewardship (for example, Grand River Watershed Fisheries Management Plan) and public education programs that have resulted in increased awareness of species at risk, and improvements to habitat and water quality throughout the Black Redhorse range in Ontario.

Complementary Recovery strategies, action plans, and management plans

Several recovery strategies, action plans, and management plans have been developed for aquatic species at risk that are found in watersheds occupied by Black Redhorse. It is expected that many of the recovery actions identified in the single and multi-species ecosystem-based documents listed below will benefit Black Redhorse populations; many of these recovery actions are underway.

Ecosystem-based recovery strategies and action plans for watersheds occupied by Black Redhorse are:

- “Recovery Strategy for Species at Risk in the Ausable River 2005 to 2010: An Ecosystem Approach” (Ausable River Recovery Team 2006), which includes direct consideration of the Black Redhorse
- “Action Plan for the Ausable River in Canada: An Ecosystem Approach” (DFO 2018a)
- “Recovery Strategy for Fish Species at Risk in the Grand River in Canada” (Portt et al. 2007), which includes direct consideration of the Black Redhorse
- “Recovery Strategy for the Thames River Aquatic Ecosystem” (Thames River Recovery Team 2005), which includes direct consideration of the Black Redhorse
- “Recovery Strategy for Fish Species at Risk in the Essex-Erie Region in Canada: An Ecosystem Approach” (Essex-Erie Recovery Team 2008), which includes specific consideration of the Black Redhorse from the extirpated Catfish Creek location

Single and multi-species federal recovery strategies, action plans, and management plans for species that occupy watersheds where Black Redhorse is found include, but are not limited to, the following species:

- River Redhorse
- Eastern Sand Darter (*Ammocrypta pellucida*)
- Pugnose Shiner (*Notropis anogenus*)

[7] Ontogeny is the development of an organism from the earliest life stages to maturity.

- Northern Riffleshell (*Epioblasma rangiana*)
- Snuffbox (*Epioblasma triquetra*)
- Round Pigtoe (*Pleurobema sintoxia*)
- Salamander Mussel (*Simpsonaias ambigua*)
- Rayed Bean (*Villosa fabalis*)
- Rainbow (*Villosa iris*)
- Round Hickorynut (*Obovaria subrotunda*)
- Kidneyshell (*Ptychobranchus fasciolaris*)
- Wavy-rayed Lampmussel (*Lampsilis fasciola*)

Asian Carp Program

The Asian Carp Program was established by DFO in 2013 and focuses on the early detection of Asian carps, including the Grass Carp, Silver Carp (*Hypophthalmichthys molitrix*), Bighead Carp (*H. nobilis*), and Black Carp (*Mylopharyngodon piceus*). Sampling efforts are focused in areas where Asian carps are most likely to become established within the Great Lakes and its watersheds. Many of these locations are in or near watersheds occupied by Black Redhorse. The program has been successful in detecting and removing Grass Carp from the Grand River. Black Redhorse has also been incidentally captured at several locations through these sampling efforts, including the Grand, Maitland, Sauble, Bayfield, and Ausable rivers (Marson et al. 2014, 2016, Colm et al. 2018, Marson et al. 2018, Colm et al. 2019a, b).

7.2 Measures to be taken to implement the recovery strategy

The recovery measures presented in this recovery strategy and action plan outline the current understanding of what needs to be done to promote the recovery of Black Redhorse, including achieving population and distribution objectives and addressing threats. The measures are meant to facilitate the recovery planning process by identifying activities that can be undertaken by DFO as well as other jurisdictions, organizations, and individuals committed to Black Redhorse recovery. DFO strongly encourages all Canadians to participate in the conservation of Black Redhorse by undertaking measures outlined in this recovery strategy and action plan. DFO recognizes the important roles of the species experts and its member organizations and agencies in the implementation of measures for this species. Recovery teams typically consist of members from provincial and federal governments, Indigenous groups, conservation authorities, academic institutions, environmental organizations, and community members.

This recovery strategy and action plan builds upon many successful activities already underway, while at the same time recognizing that other measures need to be undertaken or enhanced. It is acknowledged that recovery measures, and the manner in which they are conducted, are adaptively managed; that is, as new information and techniques become available, they are considered and incorporated as appropriate into the program methodology, potentially changing these measures and their relative priority.

Four broad strategies were identified to address threats to the species and meet the population and distribution objectives: 1) inventory and monitoring; 2) management and coordination; 3) stewardship and outreach; and 4) research. Approaches are identified for each of the broad strategies and further divided into numbered recovery measures, with priority ranking (high, medium, and low), identification of the threats addressed, and associated timelines (tables 4 to 6). Implementation of these measures will be dependent on a collaborative approach in which DFO is a partner in recovery efforts, but cannot implement the measures alone. Implementation

of this recovery strategy and action plan is subject to the appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Table 4 identifies the measures to be undertaken by DFO to support the recovery of Black Redhorse. Table 5 identifies the measures to be undertaken collaboratively between DFO and its partners, other agencies, organizations, and/or individuals. As all Canadians are invited to join in supporting and implementing this recovery strategy and action plan, table 6 identifies the measures that represent opportunities for other jurisdictions, organizations, or individuals to lead for the recovery of the species. If your organization is interested in participating in one of these measures, please contact the Species at Risk Ontario and Prairie office. A narrative (section 7.3) is included when further explanation of specific approaches is warranted.

Federal funding programs for species at risk that may provide opportunities to obtain funding to carry out some of the outlined activities include the Habitat Stewardship Program for Species at Risk, the Aboriginal Fund for Species at Risk and the Canada Nature Fund for Aquatic Species at Risk.

Table 4. Measures to be undertaken by Fisheries and Oceans Canada.

#	Recovery measure	Broad strategy	Approach	Priority[8]	Threat(s) or concern(s) addressed	Timeline[9]
1	Establish fixed sampling locations to monitor changes to Black Redhorse habitat. This monitoring will complement, and be integrated into, population surveys and will also act as an early warning system for invasive species detection.	Inventory and monitoring	Habitat assessment	High	Invasive species and determining habitat trends	Ongoing
2	Work with ecosystem recovery teams and other relevant groups to aid in the implementation of recovery actions.	Management and coordination	Coordination of activities	High	All threats	Ongoing
3	Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of invasive/introduced species.	Management and coordination	Coordination of activities	Low	Invasive species	3 to 5 years

[8] “Priority” reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "High" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "Medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "Low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

[9] Timeline reflects the amount of time required for the measure to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.

Table 5. Measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners.

#	Recovery measure	Broad strategy	Approach	Priority[10]	Threat(s) or concern(s) addressed	Status/ timeline[11]	Partner(s)
4	Conduct further surveys within the current and historical distribution of Black Redhorse to determine the extent, abundance and demographics of known populations. Establish long-term quantitative surveys to monitor changes in the distribution and abundance of extant populations.	Inventory and monitoring	Population assessment (occupied and historical locations)	High	Determine population trends and refine population and distribution objectives	Medium to long-term	Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry (OMNDMNRF), Ontario Ministry of Environment, Conservation and Parks (MECP) conservation authorities
5	Conduct surveys to detect new populations; determine the extent and abundance of any new populations detected.	Inventory and monitoring	Population assessment (potential new locations)	Low	Refine population and distribution objectives	Medium to long-term	OMNDMNRF, MECP, conservation authorities

[10] ”Priority” reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "High" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "Medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "Low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

[11] “Status/timeline” separates measures into three categories based on the projected length of time it will take to accomplish them:

- “Short-term” equals 1 to 2 years
- “Medium-term” equals 3 to 5 years
- “Long-term” equals >5 years

#	Recovery measure	Broad strategy	Approach	Priority[10]	Threat(s) or concern(s) addressed	Status/ timeline[11]	Partner(s)
6	Communicate species information (distribution, status, threats, habitat requirements, etc.) and encourage all levels of government and conservation authorities to protect habitats that are important to the Black Redhorse and facilitate recovery in their legislation, policies, official plans, and watershed plans.	Management and coordination	Coordination of activities	High	All threats	Medium to long-term	All levels of government, conservation authorities
7	Encourage the removal or modification of dams within the portions of the watershed occupied by this species, or between reaches currently occupied and those that could potentially be utilized. If upstream access for non-indigenous invasive species is an issue, Black Redhorse transfers should be considered.	Management and coordination	Coordination of activities	Medium	Natural system modifications	Long-term	All levels of government
8	Promote stewardship (for example, riparian buffers) and facilitate access to funding sources among landowners, Indigenous groups and other interested parties (for example, anglers).	Stewardship and outreach	Habitat improvement/ awareness	High	All threats	Long-term	Landowners, Indigenous groups, angling groups, environmental non-governmental organizations (ENGO's)

#	Recovery measure	Broad strategy	Approach	Priority[10]	Threat(s) or concern(s) addressed	Status/ timeline[11]	Partner(s)
9	Increase public awareness of the potential impacts of invasive species and how to prevent the spread (for example, avoiding transporting/releasing invasive species [including baitfish]).	Stewardship and outreach	Awareness	Medium	Invasive species	Ongoing	OMNDMNRF, MECP, Ontario Federation of Anglers and Hunters (OFAH)
10	Provide a Black Redhorse information package (outlining identification and biology) to commercial baitfish harvesters and possibly recreational anglers. Request avoidance of occupied habitats, and the release and reporting of any Black Redhorse captured.	Stewardship and outreach	Awareness	Low	Biological resource use	Ongoing	OMNDMNRF, MECP, OFAH, angling groups
11	Deliver fish identification courses to fisheries biologists, technicians, and other resource managers.	Stewardship and outreach	Awareness	Medium	Improve overall awareness	Ongoing	OFAH
12	Encourage all-terrain vehicle (ATV) operators to keep vehicles out of streams.	Stewardship and outreach	Awareness	Low	Human intrusion	Ongoing	OMNDMNRF, conservation authorities
13	Identify pollution sources (for example, wastewater and/or stormwater management facilities) and their relative and cumulative effects.	Research	Threat evaluation	High	Pollution and nutrient loading	Long-term	Conservation authorities, provincial government, academia
14	Investigate the impacts that climate change and severe	Research	Threat evaluation	Low	Climate change and	Long-term	Conservation authorities,

#	Recovery measure	Broad strategy	Approach	Priority[10]	Threat(s) or concern(s) addressed	Status/ timeline[11]	Partner(s)
	weather are having on Black Redhorse, and evaluate the potential impacts of projected climate change scenarios on the species and its habitat.				severe weather		provincial government, academia
15	Conduct a risk assessment on the impact of invasive or non-native species on Black Redhorse. Evaluate and consider the risk posed to Black Redhorse populations from non-native stocking programs (for example, Brown Trout).	Research	Threat evaluation	Low	Invasive species	Long-term	Conservation authorities, provincial government, academia
16	Evaluate the likelihood, and impacts of human intrusions (for example, incidental harvest) on Black Redhorse populations (for example, angler surveys).	Research	Threat evaluation	Low	Biological resource use	Long-term	Conservation authorities, provincial government, academia
17	Study the impact of land-use pressures in the Grand and Thames River watersheds. Investigate the impact of natural system modifications (for example, altered flow, barriers, groundwater withdrawal) on Black Redhorse populations.	Research	Threat evaluation	High	Natural system modifications	Long-term	Conservation authorities, provincial government, academia
18	Investigate the potential to use fish ladders to connect fragmented populations of Black Redhorse.	Research	Threat evaluation	Low	Natural system modifications	Ongoing	Conservation authorities, provincial

#	Recovery measure	Broad strategy	Approach	Priority[10]	Threat(s) or concern(s) addressed	Status/ timeline[11]	Partner(s)
							government, academia
19	Examine the feasibility of rearing Black Redhorse for threat analysis and potentially species repatriations in areas of suitable habitat where the species has been extirpated (for example, Catfish Creek) or historical locations where natural recolonization has not occurred, if warranted.	Research	Population augmentation/ repatriation	Low	Knowledge gaps	Ongoing	Conservation authorities, provincial government, academia

Table 6. Measures that represent opportunities for other jurisdictions, organizations or individuals to lead.

#	Recovery measure	Broad strategy	Approach	Priority[12]	Threat(s) or concern(s) addressed	Potential jurisdictions or organizations
20	Implement local stewardship programs to improve habitat conditions and reduce threats within critical habitat and other occupied habitats. Priorities and mitigation approaches to be informed through threat evaluation research.	Stewardship and outreach	Habitat improvement	High	All threats	Conservation authorities
21	Address watershed-scale stressors to Black Redhorse populations and their habitat in cooperation with existing relevant aquatic ecosystem recovery teams.	Stewardship and outreach	Threat reduction/ mitigation	High	All threats	Conservation authorities
22	Encourage public support and participation by developing awareness materials and programs.	Stewardship and outreach	Awareness	Medium	All threats	Conservation authorities
23	Determine the physiological tolerance thresholds of Black Redhorse with respect to various water quality parameters (for example, nutrients, contaminants, temperature), as well as the impact of other pertinent pollutants emitted from treatment plants (for example, pharmaceutical pollutants) and agricultural practices, and check against existing standards.	Research	Threat evaluation	Medium	Knowledge gaps	Conservation authorities, provincial government, academia

[12] "Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "High" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "Medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "Low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

#	Recovery measure	Broad strategy	Approach	Priority[12]	Threat(s) or concern(s) addressed	Potential jurisdictions or organizations
24	Monitor nutrient levels and potentially other parameters (for example, pharmaceutical pollutants, pesticides) in Black Redhorse occupied waters exposed to wastewater treatment plant emissions and agricultural farming practices, during key phases of their life cycle.	Research	Threat evaluation	Low	Nutrient loading	Conservation authorities, provincial government, academia

7.3 Narrative to support the implementation table

Broad strategy 1: inventory and monitoring

Habitat assessment (measure 1): Monitoring surveys should be conducted at fixed sampling locations within watersheds where Black Redhorse is known to occur that will investigate changes in habitat conditions over time. These surveys will inform threat assessments for this species and observed trends may be beneficial when assessing the trajectory of populations and the feasibility of their recovery.

Population assessment (measures 4 and 5): Further surveys are required to confirm the current distribution and abundance of Black Redhorse in Canada. Site selection should be directed through the identification and mapping of the distribution and extent of suitable habitat in southwestern Ontario. A thorough understanding of all extant populations is necessary for the refinement of critical habitat identification, as well as to inform effective recovery actions. Long-term monitoring is required to determine population trajectories and to evaluate the effectiveness of recovery efforts. Watersheds where Black Redhorse historically occurred, but has not recently been detected, should also be revisited and surveyed using appropriate capture methods. For example, Black Redhorse has not been detected in the Lower Thames River since 2003, and uncertainty persists over the status of the species in Gully Creek. Targeted sampling efforts in these watersheds could help to determine if they are currently occupied by Black Redhorse. The identification of previously unknown Black Redhorse populations would help guide stewardship, monitoring, and protection initiatives. Furthermore, it could lead to the identification of additional critical habitat.

Broad strategy 2: management and coordination

Coordination of activities (measures 2, 3, 6, 7): Many of the threats affecting Black Redhorse populations are similar to those that affect other aquatic species. Therefore, efforts to remediate these threats should be done in close connection with other recovery teams and relevant groups to eliminate duplication of efforts. Recovery strategies for the Ausable, Thames, and Grand rivers include consideration of the Black Redhorse; hence, a coordinated, cohesive approach between these teams and other relevant management teams that maximizes opportunities to share resources and information is necessary. Similarly, working relationships with Indigenous groups, municipal planners, and wastewater treatment facility operators, for example, will help to provide further protection and/or restoration of Black Redhorse populations.

Broad strategy 3: stewardship and outreach

Habitat improvement and threat reduction/mitigation (measures 8, 20, 21): The threats and degree of habitat degradation occurring at extant sites should be evaluated to determine if they pose immediate or long-term risks of extirpation. Where specific habitat restoration activities or threat mitigation options are achievable, they should be implemented and monitored for success. Supporting stewardship activities, such as planting, establishing riparian buffers, restricting livestock access to streams, preventing untreated or under-treated sewage or manure run-off into waterways, and minimizing chemical and fertilizer applications to lands adjacent to waterways, would maintain or improve water quality in Black Redhorse habitats. Best management practices (BMPs) represent a good tool to provide clear direction for improved methods of operation for industries, including agricultural land-use practices. To be effective, BMPs should target the primary threats affecting critical habitat. Once threats have been

evaluated for extant populations, the results will inform local stewardship programs by identifying threat mitigation approaches that are appropriate for a given location. As with other fishes, measures to improve habitat for Black Redhorse may include stewardship actions involving BMPs for agricultural properties (OMAFRA 2019) and residential properties (Caldwell and Landman 2013) within the catchment areas of the critical habitat identified. For more information on BMPs see Ontario Ministry of Agriculture, Food and Rural Affairs, Best Management Practice Series. The stewardship activities outlined here represent a non-exhaustive selection of activities that can be encouraged within these predominantly agricultural watersheds to help reduce the impacts of terrestrial practices on aquatic ecosystems.

Awareness (measures 9 to 12, 22): Public participation in the recovery process for Black Redhorse is essential, as the primary threat to its populations is the diffuse non-point source inputs of pollutants relating to the general agricultural and urban activities within these watersheds. Recovery cannot occur without the full participation of local citizens and landowners. Workshops and/or awareness material highlighting BMPs that prevent or mitigate threats to Black Redhorse should be made available to Ontario residents. Once threats have been evaluated, the results will inform local stewardship programs focused on threat mitigation. Measures to improve habitat for Black Redhorse may include stewardship actions involving BMPs for agricultural and residential properties within the catchment areas of the critical habitat identified.

It is important that Canadian residents are informed on the impacts of the spread of invasive species. Ways to prevent the spread should be highlighted through education and outreach initiatives. Efforts to encourage members of the public to use existing invasive species reporting systems should also be completed.

The Black Redhorse shares several physical characteristics with other fish species found in Ontario and may be commonly misidentified. It is important that individuals who are conducting fisheries work in Ontario are familiar with the species identification and biology. Fish identification courses should continue to be delivered by species experts around the province.

An angler awareness campaign should be undertaken to educate anglers regarding the two redhorse species that are considered to be at risk in Ontario, to encourage the live release of all redhorse species caught and to discourage targeting redhorse species. The difficulty in identifying Black Redhorse and River Redhorse means that most anglers would not be able to distinguish them from other redhorse species. Hence, the campaign would, in effect, discourage the taking of all redhorse species. There are no estimates of the harvest of Black Redhorse and River Redhorse by commercial bait harvesters. Such an estimate would be difficult to obtain, especially given the difficulty of identifying juvenile redhorse to the species level. To reduce the probability of harvesting, an information package should be distributed with bait fish licenses for the areas occupied by this species. This package should include a description and photograph/drawing of the species, identify the reaches that it occupies, describe its preferred habitats, and ask bait harvesters to avoid them.

Broad strategy 4: research

Threat evaluation (measures 13 to 18, 23, 24): A variety of potential threats to Black Redhorse populations have been identified (COSEWIC 2015, Bouvier et al. 2021). Many of these threats can be classified as widespread and chronic (table 3) and represent general ecosystem threats affecting a myriad of other aquatic species. Research needs include defining thresholds for water quality parameters (for example, nutrients, turbidity, contaminants),

investigating the impacts of climate change and severe weather, invasive species, and incidental harvest, as well as determining land-use pressures (for example, wastewater treatment) to explore the impacts of groundwater withdrawal. This will inform our understanding of allowable harm and destruction of critical habitat. The status, certainty, and cumulative effects of these threats should be confirmed throughout the species' distribution to ensure that appropriate recovery actions are undertaken.

Population augmentation/repatriation (measure 19): Repatriation efforts to re-establish viable populations of Black Redhorse need to consider the following:

i. prior to developing repatriation plans, it is necessary to conduct intensive sampling and confirm that Black Redhorse are no longer present (this would not be the case when developing augmentation plans)

ii. the success of repatriations will depend on an understanding of the species' habitat needs and on a sufficient quantity of suitable habitat being available at the repatriation site; surveys need to be undertaken to characterize current habitat conditions and identify appropriate actions to improve degraded habitats (if habitat requirements are poorly understood, then studies of habitat use will need to be undertaken)

iii. repatriations should not be considered until the causal factors that led to extirpation are understood and addressed

iv. source populations to support repatriations need to be identified; ideally source populations possess a high level of genetic diversity and genetic composition developed under similar historical conditions and selection pressures as the repatriation site (where possible, source populations within the same watershed are preferred)

v. removal of individuals from source populations should not negatively affect the status of these populations

vi. the preferred method of repatriation (for example, adult transfer versus captive-reared) needs to be determined; if captive rearing is the preferred option, propagation and rearing methods, as well as an appropriate rearing facility will need to be identified

vii. to successfully establish self-sustaining populations and preserve the genetic composition, the number of individuals to be repatriated, appropriate life stages, and the frequency and duration of supplemental stockings need to be determined

viii. monitoring is required to ensure that newly established populations are viable, that the stocking rate is appropriate, and habitat conditions remain suitable

ix. all proposed repatriations associated with this strategy will involve the preparation of a repatriation plan that will address the logistical and ecological aspects discussed above, as well as stakeholder implications

Repatriations should follow the American Fisheries Society Guidelines for Introductions of Threatened and Endangered Fishes and the National Code on Introductions and Transfers of Aquatic Organisms.

8 Critical habitat

8.1 Identification of Black Redhorse critical habitat

8.1.1 General description of Black Redhorse critical habitat

Critical habitat is defined in SARA as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species." [section 2(1)]

Also, SARA defines habitat for aquatic species as "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [section 2(1)]

For Black Redhorse, critical habitat is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life-cycle processes and to work towards achieving the species' population and distribution objectives.

This recovery strategy and action plan identifies critical habitat for Black Redhorse as run, riffle or pool areas in streams with slow to moderate flow for juveniles and moderate flow for adults within the Sauble River, Saugeen River, Maitland River (including Blyth Brook and Hopkins Creek), Bayfield River, Ausable River (including Little Ausable), Thames River (including Middle Thames River, Waubuno Creek, North Thames River, Fish Creek, Fanshawe Lake, Wye Creek, Stoney Creek, Medway Creek and Lower Thames River), and Grand River (including Conestogo River, Cedar Creek, Forwell Creek, Four Wells Lake, Laurel Creek, Nith River, Mount Pleasant Creek, and Big Creek).

It is unknown if the critical habitat identified in this recovery strategy and action plan is sufficient to achieve the species' population and distribution objectives. The schedule of studies (section 8.2) outlines the research required to acquire more detailed information about the critical habitat identified to achieve the species' population and distribution objectives.

8.1.2 Information and methods used to identify critical habitat

Using the best available information, critical habitat was identified based on an ecological classification system, the Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry's (OMNDMNRF) Aquatic Landscape Inventory System (ALIS, version 1) (Stanfield and Kuyvenhoven 2005). The ALIS system employs a valley segment classification approach to define river segments with similar habitat and continuity on the basis of hydrography, surficial geology, slop, position, upstream drainage area, climate, land cover and the presence of instream barriers, all of which are believed to have a controlling effect on the biotic and physical processes with the catchment. Therefore, if the species has been found in one part of a valley segment, it would be reasonable to expect that it would be present in other spatially contiguous areas of the same valley segment. Within all identified river segments (that is, valley segments), the width of the habitat zone is defined as the area from the mid-channel point to bankfull[13]

[13] From the top of the riverbank on one side of the channel to the top of the riverbank on the other.

width on both the left and right banks. Critical habitat for Black Redhorse was, in most cases (exceptions are described in section 8.1.3), identified as the reach of rivers that includes all contiguous ALIS segments from the uppermost stream segment with the species present[14] to the lowermost stream segment with the species present; segments or reaches were excluded only when supported by robust data indicating the species absence and/or unsuitable habitat conditions. Unoccupied ALIS segments with suitable habitats located adjacent to, or between, occupied segments were also included, up to a maximum of five, when limited sampling had occurred (that is, the species was assumed to be present).

8.1.3 Identification of critical habitat

Geographic information

The areas delineated in figures 4 to 15 represent the extent of critical habitat that can be identified at this time. Note that the areas delineated include the entire bankfull stream width.

For Black Redhorse, critical habitat is found in the Sauble River, Saugeen River, Maitland River (including Blyth Brook and Hopkins Creek), Bayfield River, Ausable River (including Little Ausable), Thames River (including Middle Thames River, Waubuno Creek, North Thames River, Fish Creek, Fanshawe Lake, Wye Creek, Stoney Creek, Medway Creek, and Lower Thames River), and Grand River (including Conestogo River, Cedar Creek, Forwell Creek, Four Wells Lake, Laurel Creek, Nith River, Mount Pleasant Creek, and Big Creek) (table 7; figures 4 to 15). The locations of the critical habitat's functions, features, and attributes have been identified using the bounding box approach. The bounding box was delineated using the ALIS segments which contained species records and/or suitable habitat. Critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical features and the functions they support occur, as described in table 8.

Note that permanent anthropogenic structures that may be present within the delineated areas are specifically excluded; it is understood that maintenance or replacement of these features may be required at times[15].

Sauble River: The areas within which critical habitat is found within the Sauble River represents a stretch of river approximately 3 km long beginning just downstream of Sauble Falls Parkway (Sauble Falls) and continuing downstream to the outlet at Lake Huron (figure 4).

Saugeen River: The areas within which critical habitat is found within the Saugeen River represents a stretch of river approximately 4 km long beginning at Denny's Dam (Southhampton) and continuing downstream to the outlet at Lake Huron (figure 5).

Maitland River and tributaries: The areas within which critical habitat is found within the Maitland River and its tributaries are described below; this represents a total river reach of approximately 91 km in length (figure 6).

[14] Species present = sites with live animals from 1999 onward.
[15] Note that, depending on the type of maintenance or replacement, it is encouraged that an application for a permit be submitted before work is conducted, to assess potential impacts to adjacent critical habitat.

- Maitland River: In the Maitland River beginning approximately 1 km downstream of B Line Road in Wingham and continuing downstream to the outlet at Lake Huron.

- Blyth Brook: In Blyth Brook beginning approximately 50 m upstream of the Base Line bridge (south of Auburn) and continuing downstream to its confluence with the Maitland River.

- Hopkins Creek: In Hopkins Creek beginning approximately 800 m upstream of the Maitland Line bridge (Holmesville) and continuing downstream to its confluence with the Maitland River, including the north branch upstream to the headwaters.

Bayfield River: The areas within which critical habitat is found within the Bayfield River represents a stretch of river approximately 24 km long beginning approximately 1 km downstream of Airport Line (near Clinton) and continuing downstream to the outlet at Lake Huron (figure 7). An unoccupied ALIS segment was included in critical habitat at the upstream extent due to the close proximity of a recent record.

Ausable River and the Little Ausable River: The areas within which critical habitat is found within the Ausable River and the Little Ausable River are described below; this represents a total river reach of approximately 47 km in length (figure 8).

- Ausable River: In the Ausable River, there are two areas of critical habitat, one in the upper Ausable River and other in the lower Ausable River. The critical habitat was not continuous throughout the Ausable River, based on the distance between these two areas and an adequate amount of sampling conducted. The upper Ausable River critical habitat represents a stretch of river approximately 33 km long beginning approximately 300 m downstream of S Road (near Huron Park) and continuing downstream to approximately 800 m downstream of New Ontario Road. The lower Ausable River, including the Ausable River Cut, critical habitat represents a stretch of river approximately 11 km long beginning at Kennedy Line in Thedford and continuing downstream to the outlet at Lake Huron.

- Little Ausable River: The Little Ausable River represents a stretch of river approximately 4 km long beginning approximately 1 km upstream of Maquire Road in Ailsa Craig and continuing downstream to its confluence with the Ausable River.

Thames River and tributaries: The areas within which critical habitat is found within the Thames River and tributaries are described below; this represents a total river reach of approximately 212 km in length (figures 9 to 12). The critical habitat was not continuous throughout the Thames River based on the distance between the upper and lower areas and an adequate amount of sampling conducted in between.

- Thames River/Middle Thames River (including Waubuno Creek): In the Thames River, beginning at the confluence of the Middle Thames River and continuing downstream to approximately 2.6 km downstream of Highway 402; in the Middle Thames River, beginning approximately 0.5 km upstream of 29 Line (near Holiday) and continuing downstream to the confluence with the Thames River; and, in Waubuno Creek, beginning approximately 0.5 km upstream of 29 Line (near Holiday) and continuing downstream to its confluence with the Thames River (figure 9).

- North Thames River and tributaries (Fish Creek, Wye Creek, Stoney Creek, Medway Creek): In the North Thames River, beginning just upstream of the 26 Line bridge (Fullarton) and continuing downstream to its confluence with the main stem of the Thames River; in Fish Creek, beginning approximately 0.5 km upstream of 142 Road (near Prospect Hill) and continuing downstream to its confluence with the North Thames River; in Wye Creek, beginning approximately 0.5 km upstream of Rebecca Road and continuing downstream to its confluence with the North Thames River, including Fanshawe Lake; in Stoney Creek, beginning at Highbury Avenue North, and continuing downstream to its confluence with the North Thames River; and, in Medway Creek, beginning at Richmond Street in Arva and continuing downstream to its confluence with the North Thames River (figure 10).

- Lower Thames River: In the Lower Thames River, beginning approximately 2 km downstream of Simpson Road and continuing downstream to the bridge at Highway 7 (Clachan Road) southeast of Bothwell. The critical habitat downstream extent was delineated by the physiographical change from sand plain to clay plain, cutting off a large ALIS segment. An unoccupied ALIS segment was included in critical habitat at the upstream extent due to the close proximity of a recent record (figure 12).

Grand River and tributaries: The areas within which critical habitat is found within Grand River and tributaries is described below; this represents a total river reach of approximately 321 km in length (figures 13 to 15).

- Grand River: In the Grand River, beginning approximately 3 km south of Elora and continuing downstream to Sutor Road (near Cayuga).

- Conestogo River: In the Conestogo River, beginning approximately 1.9 km downstream of the Temperance Road bridge (Hawkesville) and continuing downstream to the confluence at the Grand River in Conestogo.

- Cedar Creek, Forwell Creek, Four Wells Lake, Laurel Creek: In Cedar Creek, beginning approximately 90 m downstream of Northfield Drive West (Waterloo) and continuing downstream to the confluence with Forwell Creek. In Forwell Creek, beginning approximately 710 m downstream of Northfield Drive West and continuing to the confluence at Laurel Creek. In Four Wells Lake and connecting channels, continuing downstream to the confluence at Forwell Creek, east of King Street North in Waterloo. In Laurel Creek, beginning at the confluence with Forwell Creek and continuing downstream to the confluence with the Grand River, at Bridge Street East in Kitchener.

- Nith River: In the Nith River, beginning approximately 2.7 km upstream of the Huron Road bridge (Haysville) and continuing downstream to the confluence at the Grand River in Paris.

- Mount Pleasant Creek: In Mount Pleasant Creek, beginning approximately 1 km downstream of Old Greenfield Road (Brantford), and continuing downstream to the confluence with the Grand River.

- Big Creek: In Big Creek, beginning at the headwaters and continuing downstream to the confluence with the Grand River.

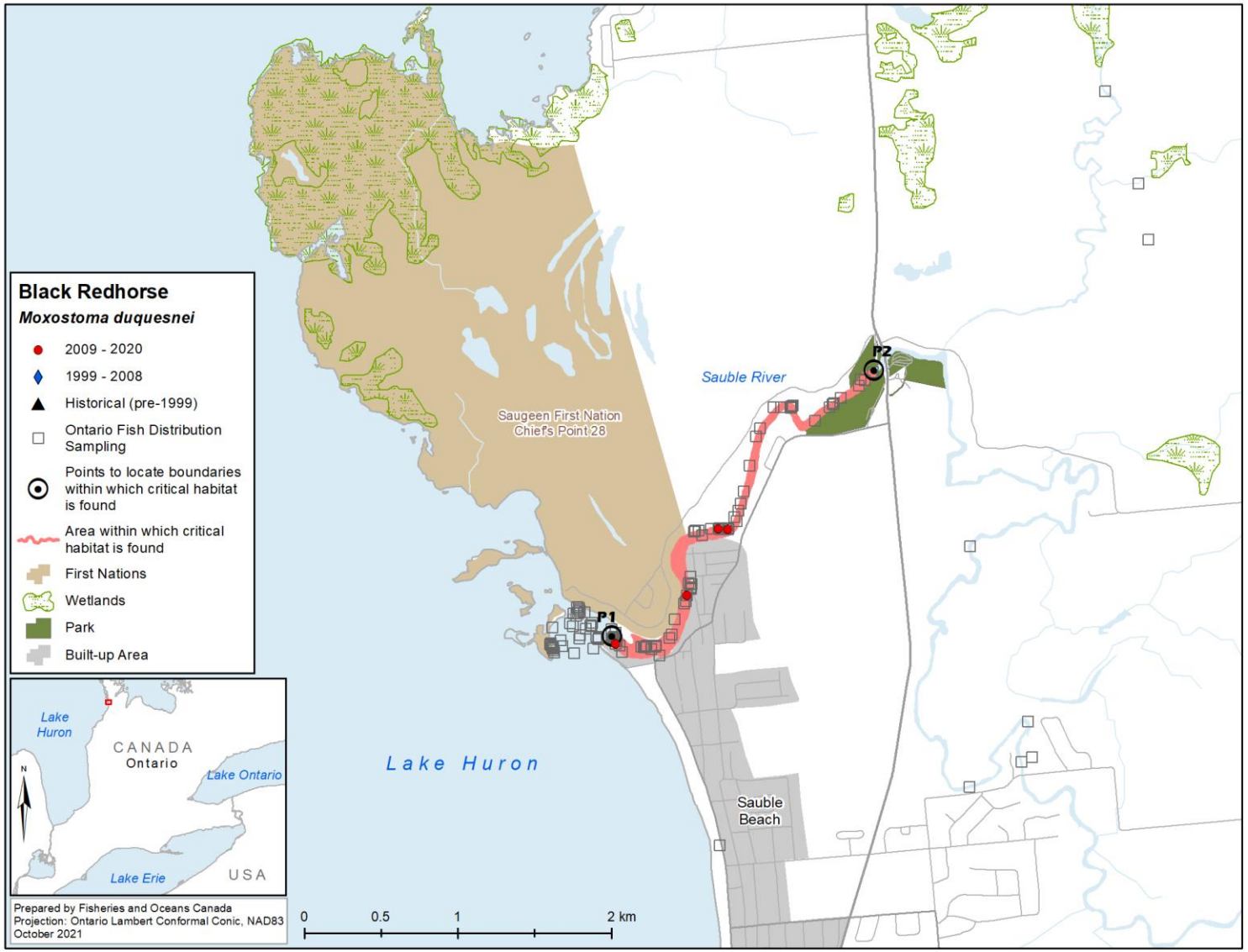

Figure 4. Areas within which critical habitat is found for Black Redhorse in the Sauble River. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

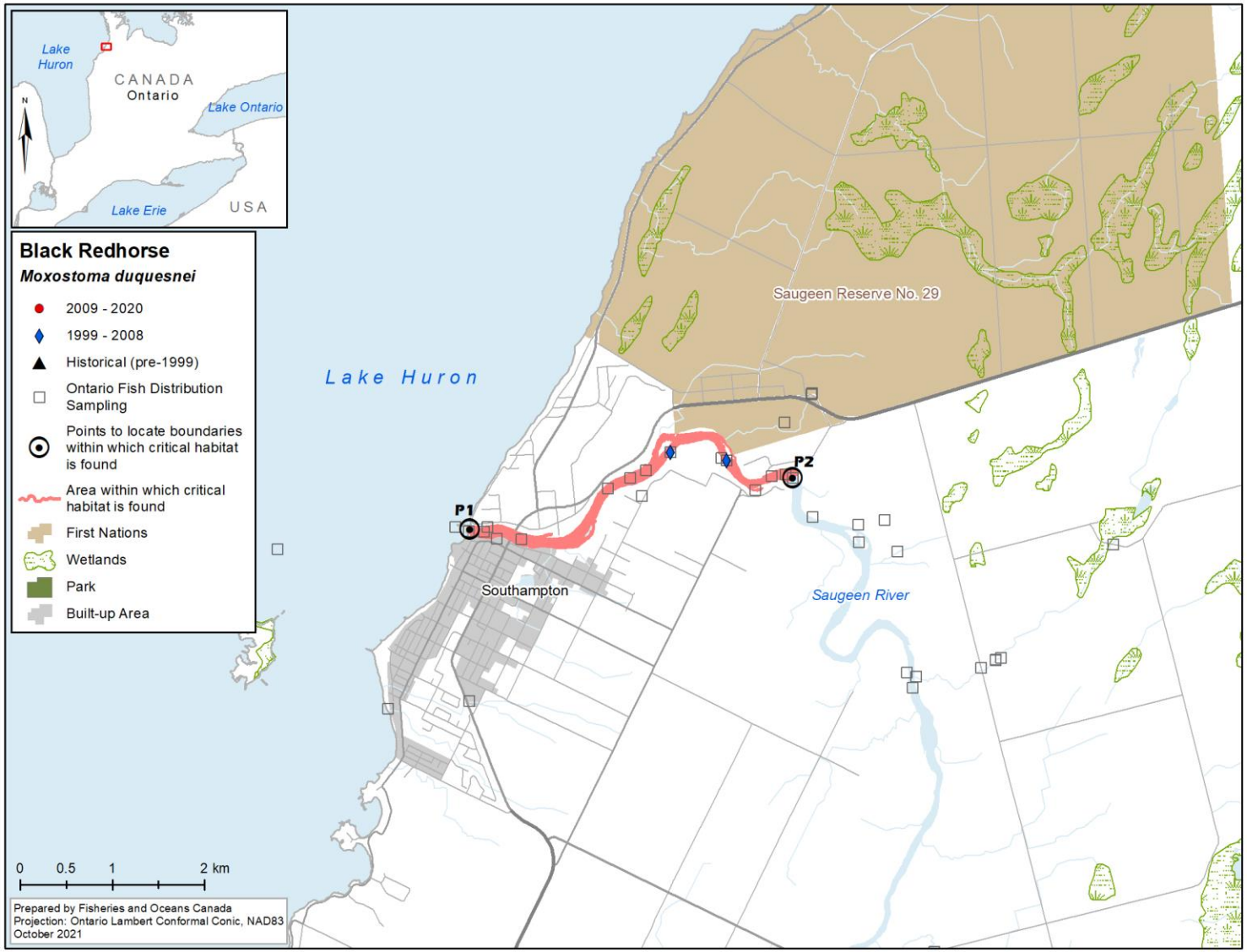

Figure 5. Areas within which critical habitat is found for Black Redhorse in the Saugeen River. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

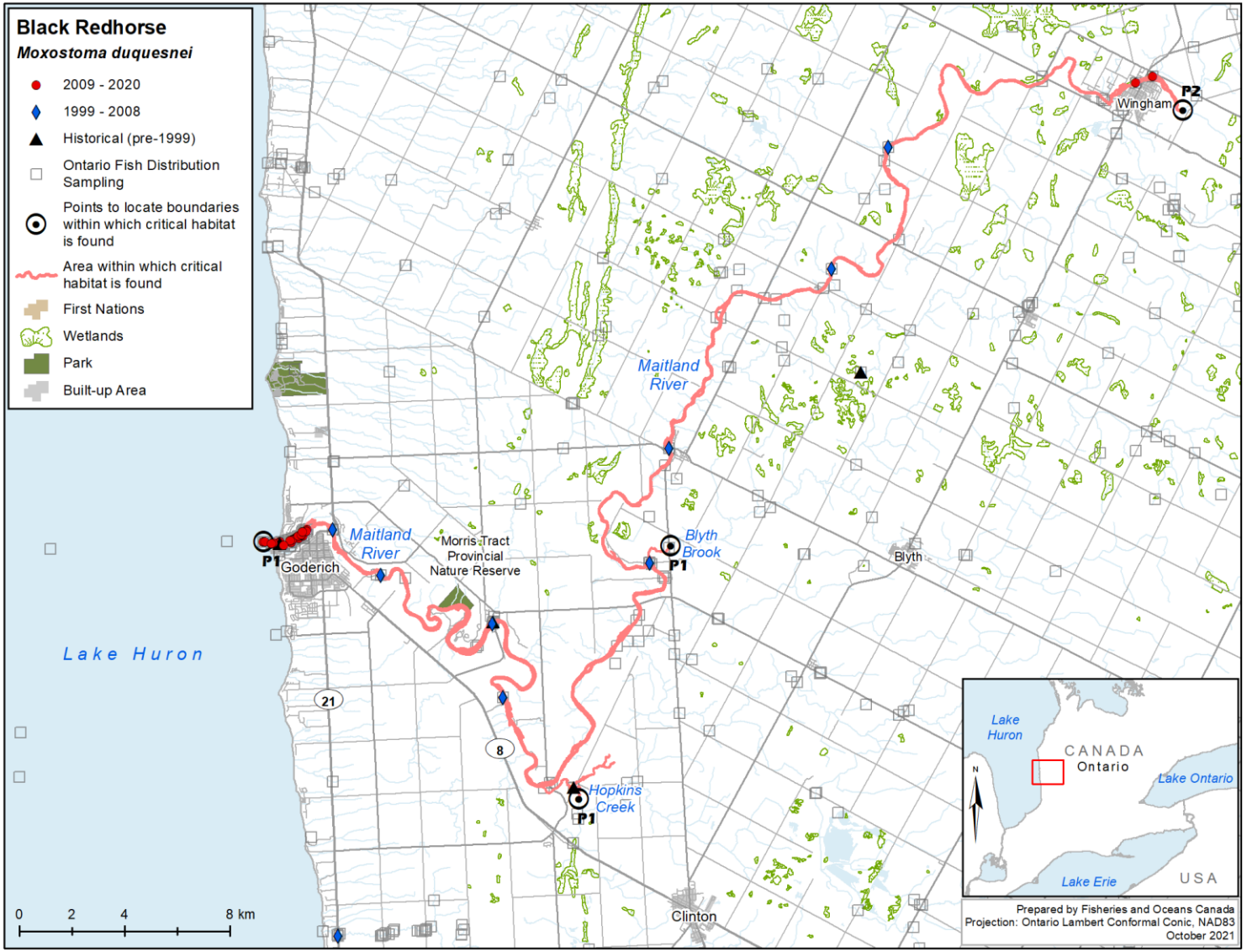

Figure 6. Areas within which critical habitat is found for Black Redhorse in the Maitland River. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

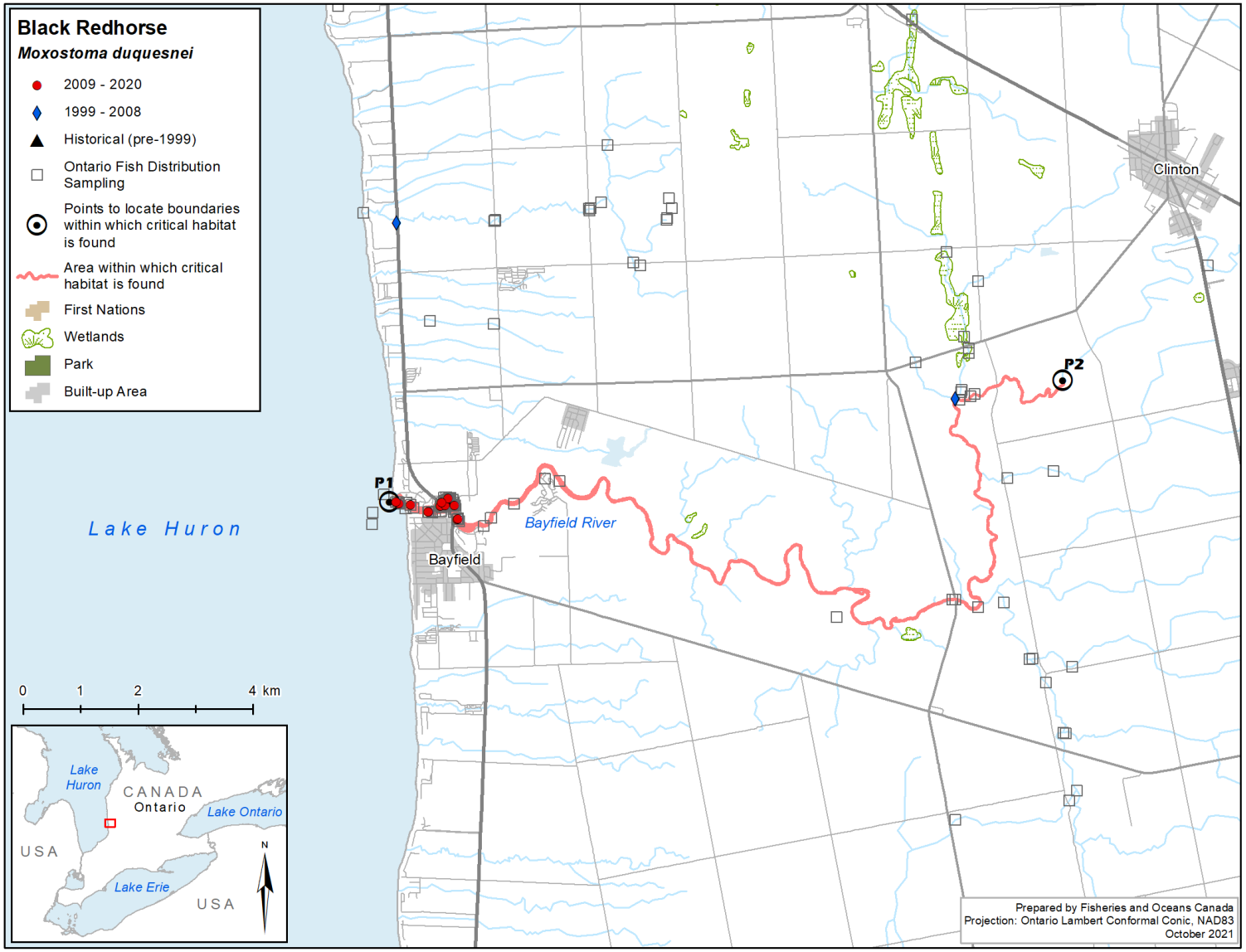

Figure 7. Areas within which critical habitat is found for Black Redhorse in the Bayfield River. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

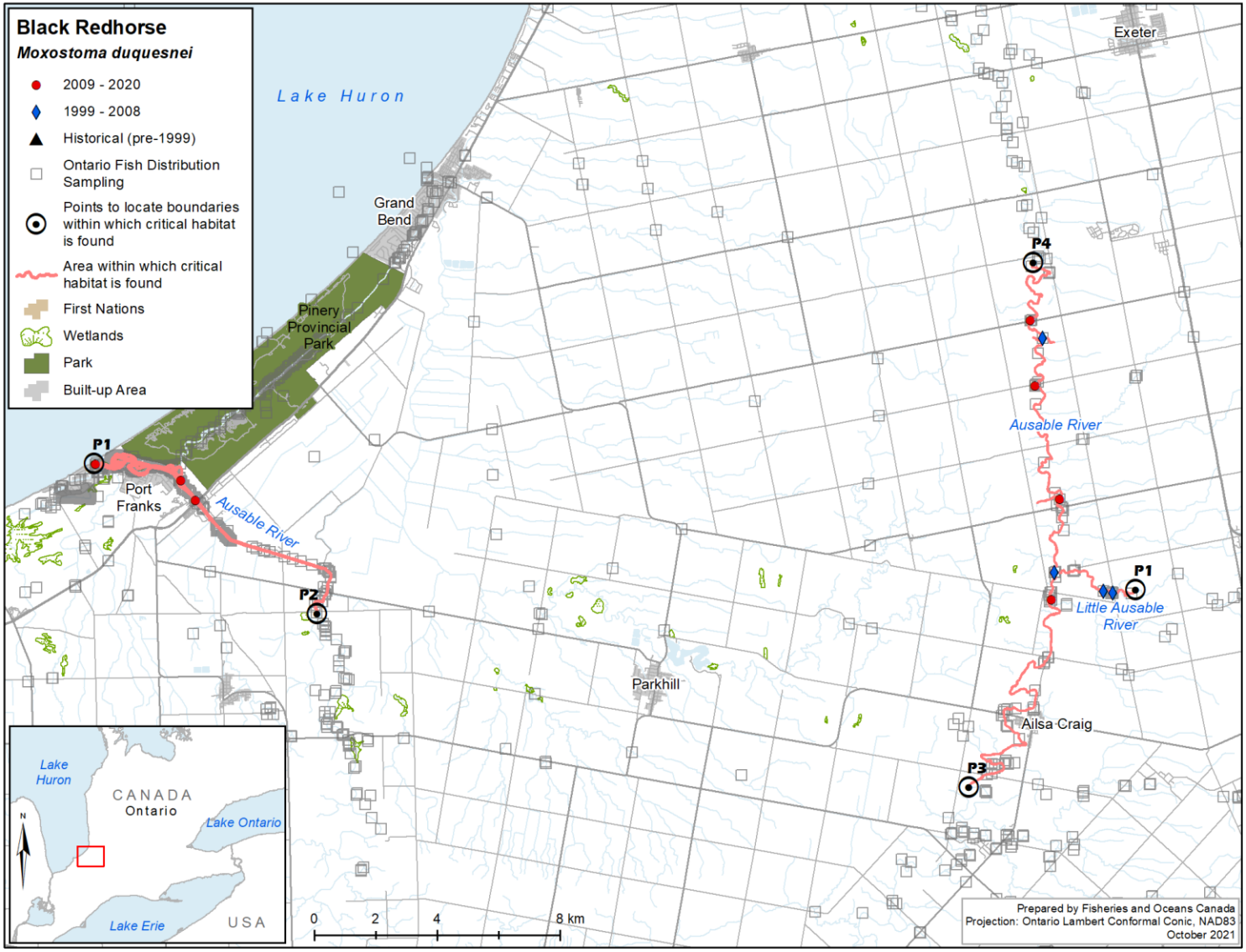

Figure 8. Areas within which critical habitat is found for Black Redhorse in the Ausable and Little Ausable rivers. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

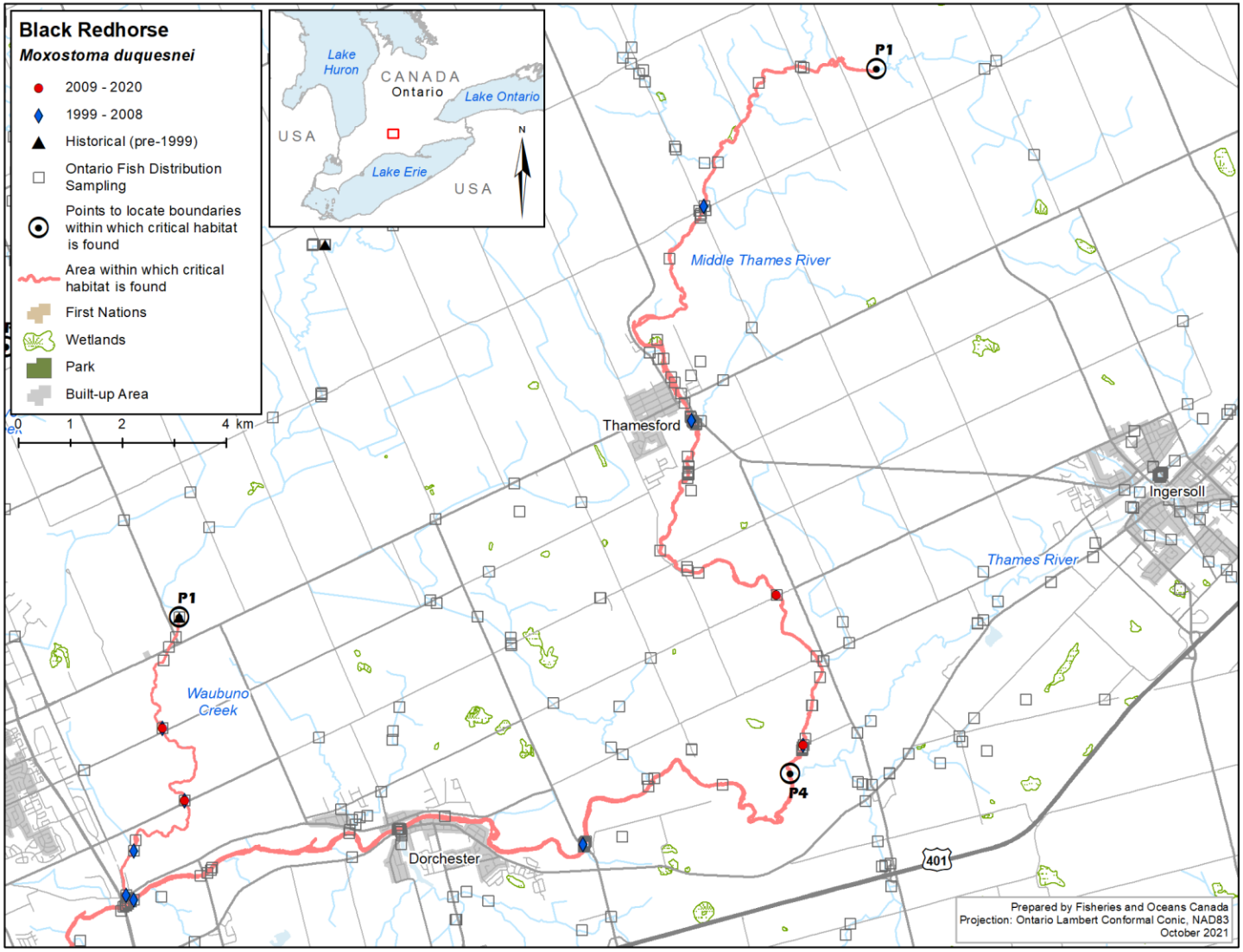

Figure 9. Areas within which critical habitat is found for Black Redhorse in Waubuno Creek, Middle Thames River, and Thames River. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

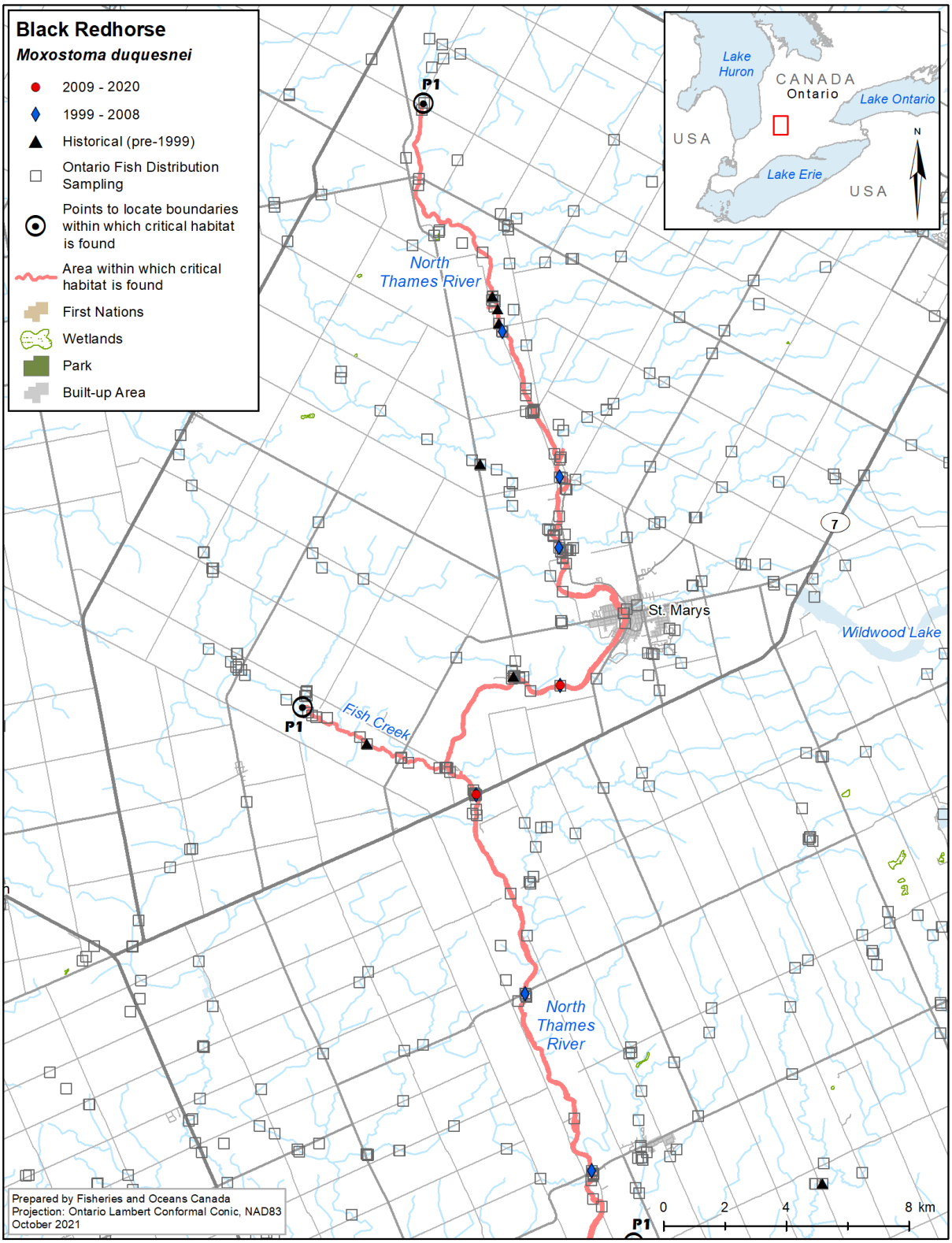

Figure 10. Areas within which critical habitat is found for Black Redhorse in the North Thames River and tributaries. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

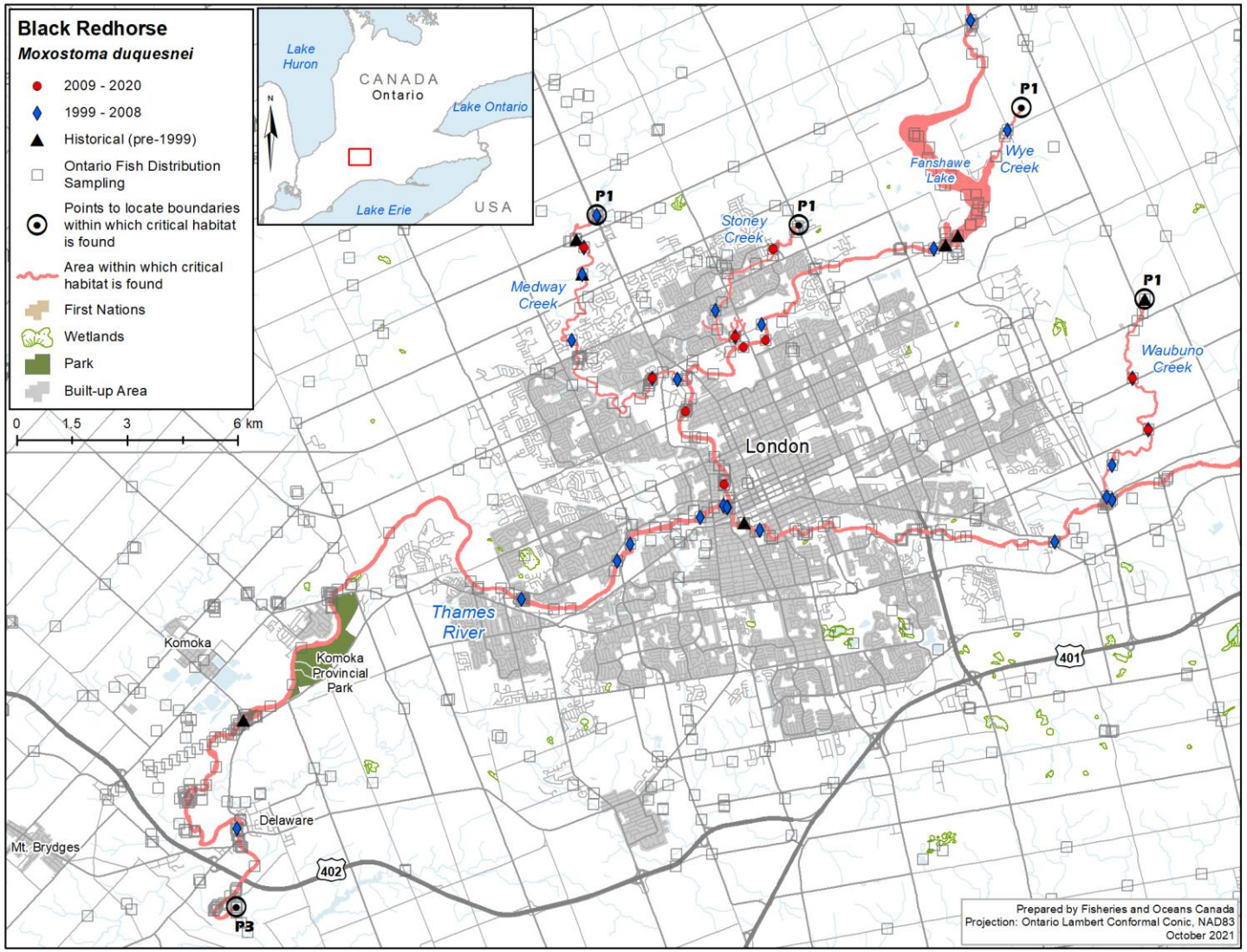

Figure 11. Areas within which critical habitat is found for Black Redhorse in the Thames River and tributaries (London area). Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

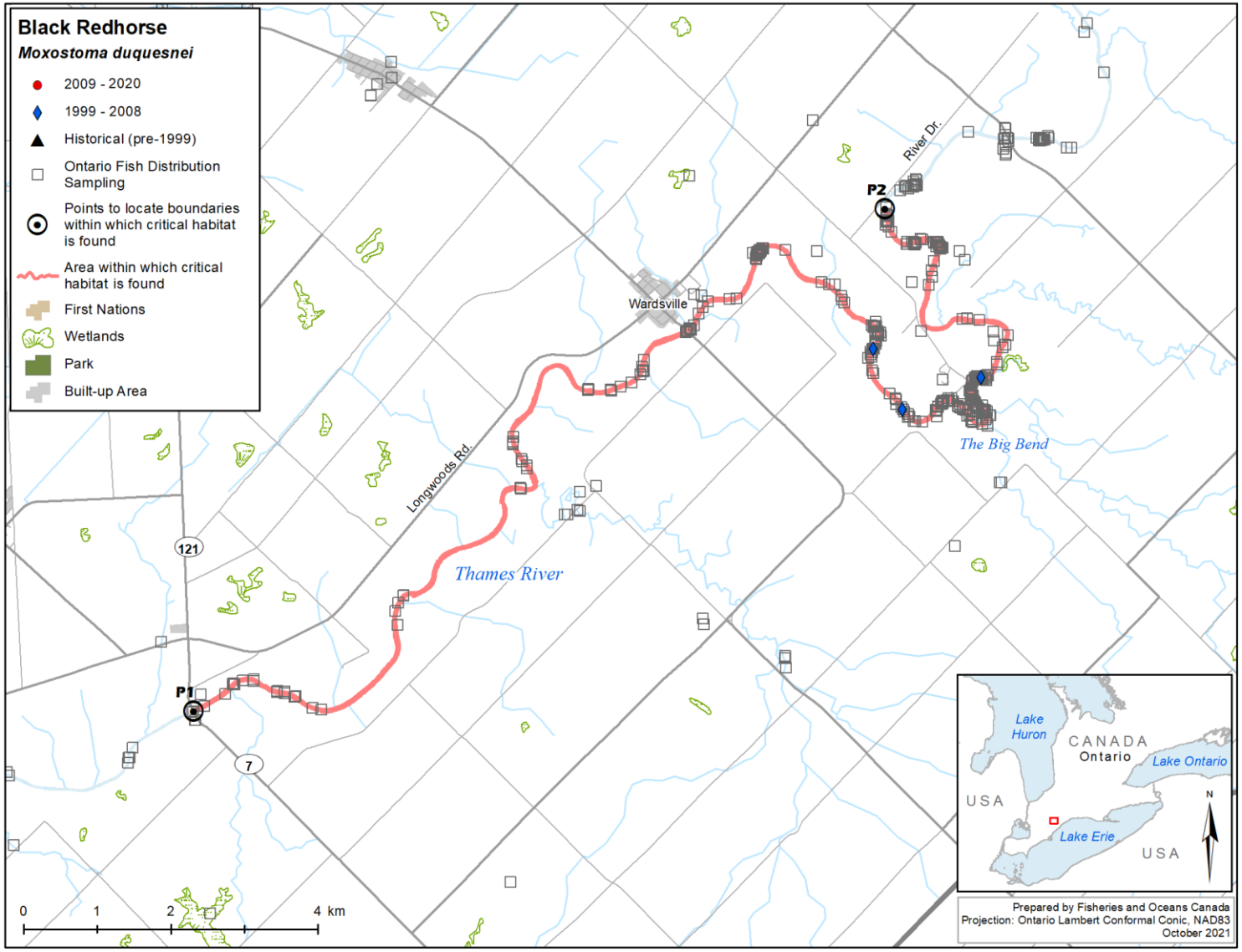

Figure 12. Areas within which critical habitat is found for Black Redhorse in the Lower Thames River. Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

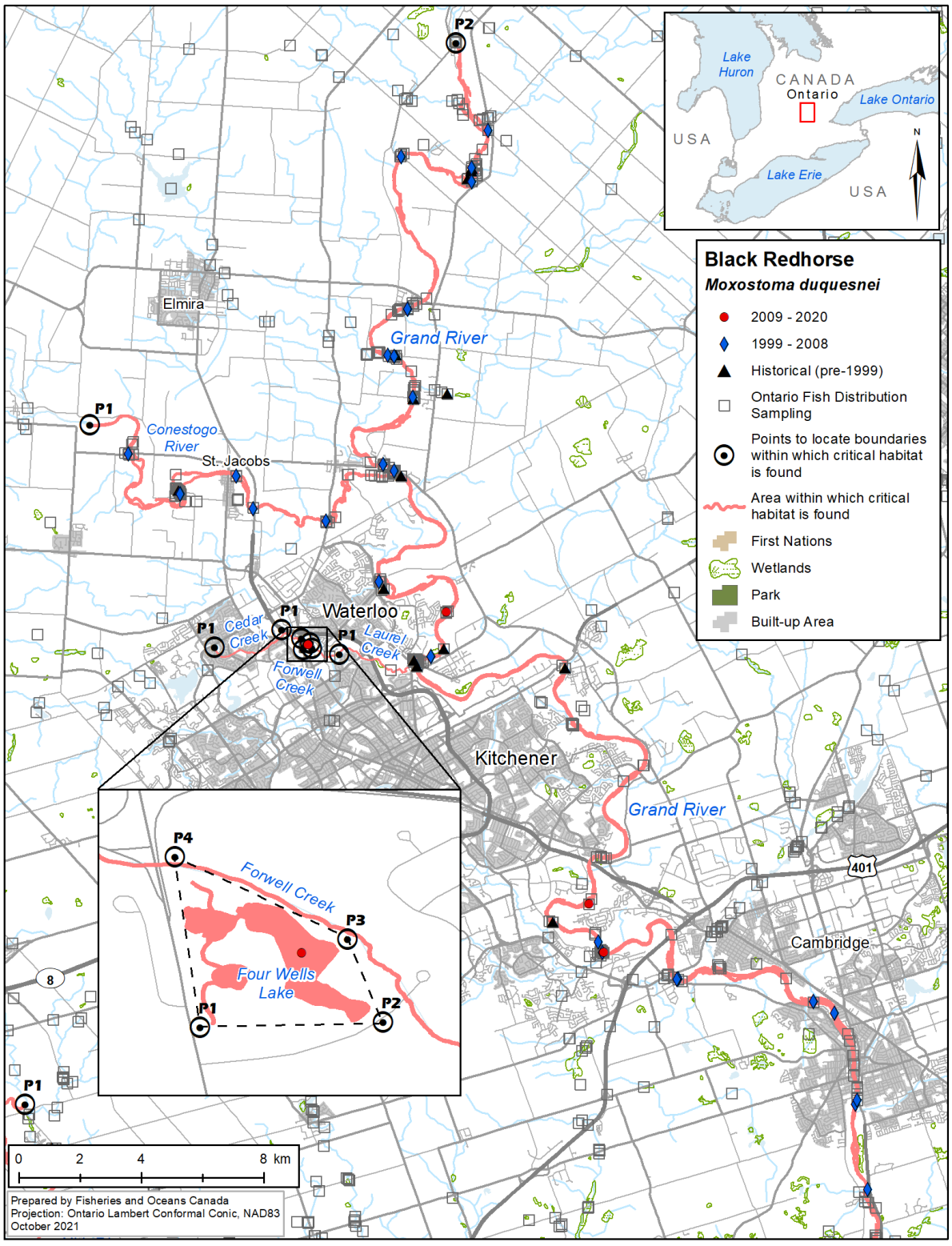

Figure 13. Areas within which critical habitat is found for Black Redhorse in the Grand River including the Conestogo River, Cedar Creek, Forwell Creek, Four Wells Lake, and Laurel Creek (Waterloo, Kitchener, Cambridge area). Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

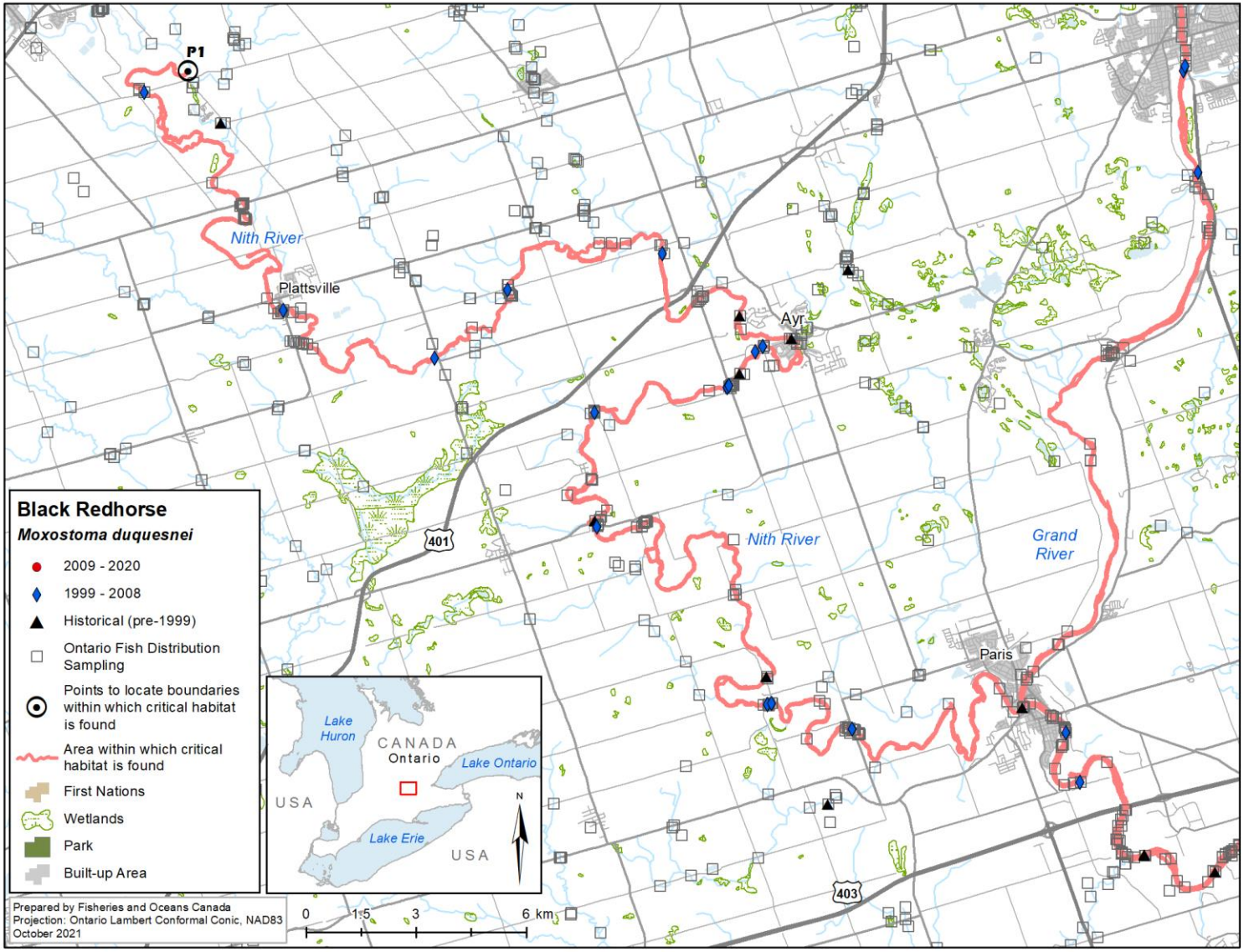

Figure 14. Areas within which critical habitat is found for Black Redhorse in the Grand and Nith rivers (Plattsville-Paris area). Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

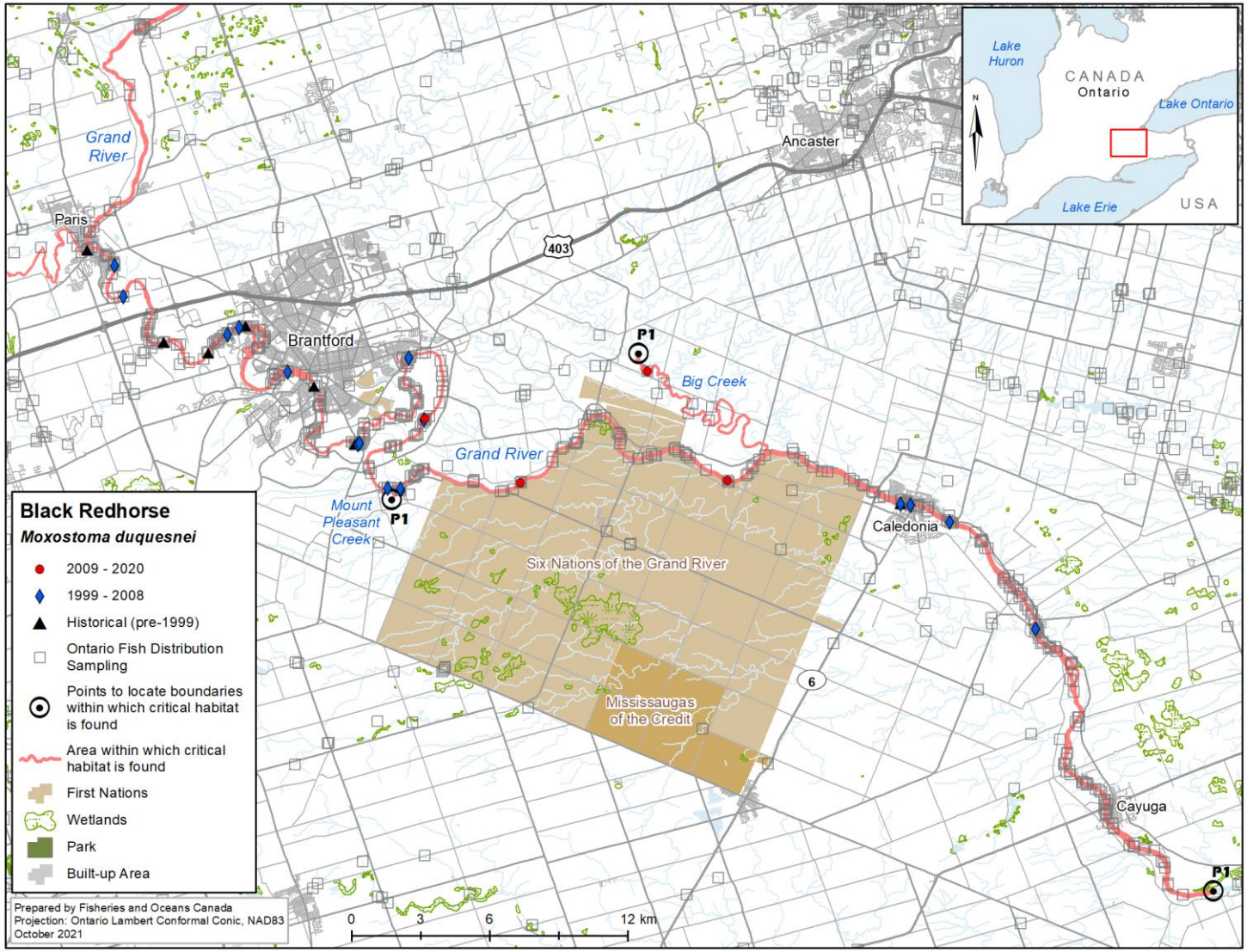

Figure 15. Areas within which critical habitat is found for Black Redhorse in the Grand River, Mount Pleasant Creek, and Big Creek (Paris-Cayuga area). Locations of historic (pre-1999) and current (1999 to 2020) Black Redhorse occurrences are also indicated.

Table 7. Coordinates locating the boundaries within which critical habitat is found for Black Redhorse in Canada[ab].

Location	Point 1	Point 2	Point 3	Point 4
Sauble River	44.661603, -81.278973	44.676438, -81.256366		
Saugeen River	44.501002, -81.373675	44.504541, -81.329240		
Maitland River	43.749172, -81.732638	43.882367, -81.289440		
Blyth Brook	43.741700, -81.540782			
Hopkins Creek	43.656527, -81.589552			
Bayfield River	43.569826, -81.709828	43.584107, -81.563961		
Ausable River	43.233959, -81.904850	43.187198, -81.818221	43.128144, -81.560659	43.280965, -81.525460
Little Ausable River	43.183631, -81.490407			
Middle Thames River	43.114775, -80.944813			
Waubuno Creek	43.026499, -81.115703			
North Thames River	43.411533, -81.214621			
Fish Creek	43.236514, -81.275091			
Wye Creek	43.074649, -81.153366			
Stoney Creek	43.048853, -81.229174			
Medway Creek	43.053604, -81.296043			
Thames River	42.608044, -81.834606	42.665466, -81.716930	42.889488, -81.426395	42.994000, -80.973957
Grand River	42.855175, -79.577937	42.898867, -79.640210	42.913246, -79.807056	43.662770, -80.451091
Conestogo River	43.557328, -80.607875			
Cedar Creek	43.490005, -80.562964			
Forwell Creek	43.494008, -80.535467			
Four Wells Lake	43.487883, -80.527269	43.48799, -80.523677	43.489612, -80.524381	43.49122, -80.527762
Laurel Creek	43.485827, -80.512981			
Nith River	43.359566, -80.649784			

Location	Point 1	Point 2	Point 3	Point 4
Mount Pleasant Creek	43.086994, -80.229543			
Big Creek	43.137949, -80.093167			

[a] Riverine habitats are delineated to the midpoint of channel of the uppermost stream segment(s) and lowermost stream segment
[b] All coordinates obtained using map datum NAD 83

Biophysical functions, features, and attributes

Table 8 summarizes the best available knowledge of the functions, features, and attributes for each life stage of the Black Redhorse (refer to section 4.3 “Needs of the species” for full references). Note that not all attributes in table 8 must be present in order for a feature to be identified as critical habitat. If the features as described in table 8 are present and capable of supporting the associated functions, the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

Table 8. General summary of the biophysical functions, features, attributes of critical habitat necessary for the Black Redhorse’s survival or recovery (table adapted from Bouvier et al. 2021).

Life stage	Function[16]	Features[17]	Attributes[18]
Spawning (occurs in late spring)	Spawning	Shallow riffles over cobble substrate	• Shallow riffles with cobble substrate, depths of 0.12 to 0.37 m
Egg to juvenile	Nursery Feeding Cover	Shallow runs, riffles and pools with aquatic vegetation Preference for groundwater seepages	• Shallow pools, slow to moderate flow with substrate size ranging from gravel to cobble substrate • Presence of aquatic vegetation
Adult (from age 1: onset of sexual maturity)	Feeding Cover	Streams with lower gradient	• 0.6 to 2.5 m depth, with stream gradient of 1.2 to 1.5 m/km

[16] Function: A life-cycle process of the listed species taking place in critical habitat (for example, spawning, nursery, rearing, feeding, and migration).

[17] Feature: Features are the essential structural component that provides the requisite function(s) to meet the species’ needs. Features may change over time and are usually comprised of more than one part, or attribute. A change or disruption to the feature or any of its attributes may affect the function and its ability to meet the biological needs of the species.

[18] Attribute: Attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species’ life processes.

Life stage	Function[16]	Features[17]	Attributes[18]
All life stages	All functions	Reaches of rivers with suitable water quality parameters	• Adequate levels of dissolved oxygen • Adequate food supply • Maintenance of environmental thermal regime

Summary of critical habitat relative to population and distribution objectives

Using the best available information, critical habitat has been identified for Black Redhorse populations in the following watercourses (figures 4 to 15):

1. Sauble River
2. Saugeen River
3. Maitland River and tributaries
4. Bayfield River
5. Ausable River and tributaries
6. Thames River and tributaries
7. Grand River and tributaries

These are areas that, based on current best available information, the Minister of Fisheries and Oceans considers necessary to partially achieve the species' population and distribution objectives required for the survival and recovery of the species. Additional critical habitat may be identified in future updates to the recovery strategy and action plan.

8.2 Schedule of studies to identify critical habitat

Further research is required to refine the understanding of the functions, features, and attributes of the currently identified critical habitat necessary to support the species' population and distribution objectives and protect the critical habitat from destruction. The schedule of studies required to refine critical habitat identification is outlined in table 9.

Table 9. Schedule of studies to refine critical habitat.

Description of study	Rationale	Timeline[19],[20]
Conduct studies to determine the habitat requirements for each life stage of the Black Redhorse (in particular, the habitat requirements for successful spawning and seasonal habitat needs).	Habitat requirements of the Black Redhorse outside the Grand River watershed are poorly understood. Determining the habitat requirements for each life-stage will ensure that all necessary features and attributes of critical habitat for this species will be identified for the entire life-history of the species.	3 to 5 years
Determine flow requirements for YOY and adult fish.	Will help to refine functions, features, and attributes of critical habitat.	3 to 5 years

[19] Timeline reflects the amount of time required for the study to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.
[20] Timelines are subject to change in response to demands on resources and/or personnel and as new priorities arise.

Description of study	Rationale	Timeline[19],[20]
Based on collected information, review population and distribution objectives. Determine amount, configuration, and description of critical habitat required to achieve these objectives, if adequate information exists.	Refinement of recovery objectives and critical habitat description to meet these objectives.	Ongoing

Activities identified in this schedule of studies will be carried out through collaboration between DFO, the provincial government of Ontario, conservation authorities, Indigenous groups, and other relevant groups and land managers. Note that many of the individual recovery approaches will help to address some of the information requirements listed above.

8.3 Examples of activities likely to result in the destruction of critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a final recovery strategy and/or action plan and included in the Species at Risk Public Registry. For Black Redhorse critical habitat, it is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

The following examples of activities likely to result in the destruction[21] of critical habitat (table 10) are based on known human activities that are likely to occur in and around critical habitat and would result in the destruction of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive and has been guided by the threats described in section 5. The absence of a specific human activity from this table does not preclude or restrict the Department's ability to regulate that activity under SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition, and does not mean the activity will inevitably result in destruction of critical habitat. Every proposed activity must be assessed on a case-by-case basis and site-specific mitigation will be applied where it is reliable and available. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision-making. However, in many cases, knowledge of a species and the thresholds of tolerance of its critical habitat to disturbance from human activities is lacking and must be acquired.

[21] Destruction occurs when there is a temporary or permanent loss of a function of critical habitat at a time when it is required by the species.

Table 10. Examples of activities likely to result in the destruction of critical habitat.

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Pollution	Release of urban and industrial pollution into habitat (including the impact of stormwater run-off from existing and new developments). Introduction of high levels of chloride through activities such as excessive salting of roads in winter.	Introduction of toxic compounds (for example, metals, salts, pesticides, pharmaceuticals, flame retardants) can change water quality affecting habitat availability or use, and prey availability.	Spawning Nursery Feeding Cover	Reaches of rivers with suitable water quality parameters	• Adequate levels of dissolved oxygen • Adequate food supply • Maintenance of environmental thermal regime
Pollution	Over-application or misuse of herbicides and pesticides.	Same as above	Same as above	Reaches of rivers with suitable water quality parameters Shallow runs, riffles, and pools with aquatic vegetation	• Presence of aquatic vegetation • Adequate levels of dissolved oxygen • Adequate food supply
Pollution	Over-application of fertilizer and improper nutrient management (for example, organic debris management, wastewater management, animal waste [livestock grazing], septic systems and municipal sewage).	Improper nutrient management can cause nutrient loading of nearby waterbodies. Elevated nutrient levels (phosphorous and nitrogen) can cause harmful algal blooms, changing water temperatures, and reduced dissolved oxygen levels. The availability of prey species can also be affected if prey are sensitive to organic pollution.	Same as above	Reaches of rivers with suitable water quality parameters Shallow runs, riffles, and pools with aquatic vegetation Preference for groundwater seepages	• Shallow pools, slow to moderate flow with gravel to cobble substrate (0.12 to 2.5 m depths) • Adequate levels of dissolved oxygen • Adequate food supply

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
					• Maintenance of environmental thermal regime
Pollution	Work in or around water with improper sediment and erosion control (for example, installation of bridges, pipelines, and culverts), overland run-off from ploughed fields, unfettered livestock access to waterbodies, run-off from urban and residential development, use of industrial equipment, cleaning or maintenance of bridges or other structures.	Improper sediment and erosion control or mitigation can cause increased turbidity and sediment deposition, changes in preferred substrates, and impairment of feeding and reproductive functions.	Same as above	Same as above	Same as above
Invasive species introductions	Introduction of invasive species (for example, from boats moving between waterbodies without being cleaned, and baitfish releases).	Invasive species may affect critical habitat by altering the nature of the habitat (for example, Grass Carp, should it become established, may deplete aquatic vegetation increase turbidity levels, and Zebra Mussel may alter the benthic substrate). Round Goby may be a potential competitor for food resources and introduced salmonid species (for example, Brown Trout) may prey upon juvenile Black Redhorse.	Same as above	Reaches of rivers with suitable water quality parameters Shallow runs, riffles, and pools with aquatic vegetation	• Presence of aquatic vegetation • Adequate levels of dissolved oxygen • Adequate food supply • Maintenance of environmental thermal regime

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Human intrusion (recreational activities)	ATVs, canoeing, kayaking, and wading.	Human activities including ATVs, canoeing, kayaking, and wading may damage habitats (for example, dislodging substrate, trampling aquatic vegetation) within localized areas.	Same as above	Shallow runs, riffles, and pools with aquatic vegetation	• Shallow pools, slow to moderate flow with gravel to cobble substrate (0.12 to 2.5 m depths)
Natural system modifications (dams and water management/ use)	Construction and operations of dams, weirs, and culverts. Water-level management (for example, through dam operation) that causes dewatering of habitat or excessive flow rates.	The installation of structures that restrict fish passage can limit the movement of individuals, fragment populations, and restricting access to important habitat areas. Barriers can alter water levels upstream and downstream, affecting habitat availability. Rapid, repeated, and prolonged changes in water flow (increases or decreases) and releases of cold hypolimnetic water can have a negative effect on Black Redhorse habitat, especially spawning habitat. Large changes (rapid or prolonged) in water flow can cause significant sediment deposition (for example, changing preferred substrates) or changes in prey abundance.	Same as above	Reaches of rivers with suitable water quality parameters Shallow runs, riffles, and pools with aquatic vegetation Preference for groundwater seepages	• Shallow pools, slow to moderate flow with gravel to cobble substrate (0.12 to 2.5 m depths) • Adequate levels of dissolved oxygen • Adequate food supply • Maintenance of environmental thermal regime
Natural system modifications (dams and water	Withdrawal of groundwater for municipal and industrial use and surface water	Water extraction can affect surface water levels and flow and groundwater inputs into streams and rivers, affecting habitat availability, the oxygenation of	Same as above	Same as above	Same as above

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
management/ use)	extraction activities (for example, for irrigation).	substrates, prey abundance, water temperature, and quality.			
Natural system modifications (other ecosystem modifications)	Large increases in impervious surfaces from urban and residential development resulting in shoreline hardening.	Changing shoreline morphology can result in altered flow patterns, change sediment depositional areas, cause erosion, and alter turbidity levels. Hardening of shorelines can reduce organic inputs into the water and alter water temperatures.	Same as above	Same as above	Same as above
Natural system modifications (other ecosystem modifications)	Placement of material or structures in water (for example, groynes, piers, infilling, jetties), dredging, grading, and excavation.	Placing material or structures in water reduces habitat availability (for example, the footprint of the infill or structure is lost). Placement of fill can cover preferred substrates, aquatic vegetation, and underwater structure. Changes in bathymetry and shoreline morphology caused by dredging and near-shore grading and excavation can remove (or cover) preferred substrates, change water depths, and change flow patterns, potentially affecting turbidity, nutrient levels, water temperatures, and migration.	Same as above	Same as above	• Presence of aquatic vegetation • Shallow pools, slow to moderate flow with gravel to cobble substrate (0.12 to 2.5 m depths) • Adequate levels of dissolved oxygen • Adequate food supply

9 Evaluation of the socio-economic costs and benefits of the action plan

SARA requires that an action plan component of the recovery document[22] include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1) (e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective, as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. Its intent is to inform the public and to guide decision-making on implementation of the action plan by DFO and its partners.

The protection and recovery of species at risk can result in both benefits and costs. The Act recognizes that "wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons" (SARA 2003). Self-sustaining and healthy ecosystems with their various elements in place, including species at risk, contribute positively to the livelihoods and the quality of life of all Canadians. A review of the literature confirms that Canadians value the preservation and conservation of species. Actions taken to preserve a species, such as habitat protection and restoration, are also valued. In addition, the more an action contributes to the recovery of a species, the higher the value the public places on such actions (Loomis and White 1996, DFO 2008). Furthermore, the conservation of species at risk is an important component of the Government of Canada's commitment to conserving biological diversity under the International Convention on Biological Diversity. The Government of Canada has also made a commitment to protect and recover species at risk through the Accord for the Protection of Species at Risk. An estimate of the costs and benefits associated with this action plan are described below.

This evaluation does not address the socio-economic impacts of protecting critical habitat for the Black Redhorse. Under SARA, DFO must ensure that critical habitat identified in a recovery strategy or action plan is legally protected within 180 days of the final posting of the recovery document. Where an Order will be used for critical habitat protection, the development of the Order will follow a regulatory process in compliance with the Cabinet Directive on Regulation, including an analysis of any potential incremental impacts of the Order that will be included in the Regulatory Impact Analysis Statement. As a consequence, no additional analysis of the critical habitat protection has been undertaken for the assessment of costs and benefits of the action plan.

9.1 Policy baseline

The policy baseline consists of the protection under SARA for Black Redhorse, along with continued protection under Ontario's *Endangered Species Act, 2007*. Other legislation that may provide direct or indirect habitat protection for the Black Redhorse includes the federal *Fisheries Act* and provincial legislation[23]. The policy baseline also includes any recovery actions that were

[22] That is, tables 4 to 6 and section 9

[23] Examples of other provincial legislation that provide habitat protection include, but may not be limited to, considerations under section 2.1.7 of the Provincial Policy Statement (2020) under Ontario's *Planning Act*, which prohibits development and site alteration in habitat of endangered and threatened species,

implemented prior to and after Black Redhorse was listed under SARA. These recovery actions included various projects[24] funded by the federal government and province of Ontario. Further information related to actions already completed can be found in section 7.1 of this report. This evaluation does not address past recovery efforts as they are not considered incremental costs.

9.2 Socio-economic costs

The recovery measures in this plan are grouped under four broad strategies: inventory and monitoring, management and coordination, stewardship and outreach, and research. Costs would be incurred by the lead agencies to implement the measures listed in the action plan, and by partners who choose to participate in the recovery measures. Some measures are ongoing, whereas others occur once or twice. The present value of the costs of implementing the recovery measures in this plan are anticipated to be less than $250, 000 over a five-year period[25]. Implementation of the actions is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Costs would be incurred by the federal government to implement the activities listed in the action plan. In-kind costs, such as volunteer time, providing expertise and equipment, would be incurred as a result of implementing activities listed in the action plan. Costs (including in-kind support) could be incurred by the province of Ontario and conservation authorities.

Long-term recovery activities will be developed through a cooperative approach following discussions between other agencies, levels of government, stewardship groups and stakeholders allowing for consideration of costs and benefits during the process.

9.3 Socio-economic benefits

Some of the benefits of recovery actions required to ensure viable and stable populations of Black Redhorse and to return the species to its full historical distribution outlined in this action plan are difficult to quantify but would generally be positive. If implemented, local stewardship programs to improve habitat conditions and reduce threats within critical habitat could help to improve riverine habitat and lead to healthier watersheds through improved water quality. Some unquantifiable non-market benefits would be enjoyed by the Canadian public as a result of implementing the recovery actions contained in the action plan. Research (Rudd et al. 2016) found that Canadian households had positive and significant willingness to pay values for recovery actions that led to improvements for little known species at risk in southwestern Ontario.

In the absence of information on biological outcomes of the measures identified in the action plan, it is not possible to estimate the incremental benefits that can be directly attributed to the implementation of the recovery measures.

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except in accordance with provincial and federal requirements, as well as protection under the *Lakes and Rivers Improvement Act* in Ontario.

[24] Where recovery actions for several species at risk (whose distributions partly overlap with Black Redhorse) have been implemented.

[25] The present value of the total incremental costs of the action plan was estimated with a discount rate of 7% over the five-year period.

9.4 Distributional impacts

Governments and conservation authorities will incur the majority of costs of implementing the action plan.

The Canadian public will benefit from the implementation of the recovery strategy and action plan through expected non-market and ecosystem benefits associated with recovery and protection of Black Redhorse and its habitat. Recovery actions that improve riverine habitat will help lead to healthier watersheds with benefits such as improved water quality.

10 Measuring progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. A successful recovery program will achieve the overall aim of recovering populations to a state where they are stable or increasing and demonstrably secure with low risk from known threats. Progress towards meeting these objectives will be outlined in a report on the progress of recovery strategy implementation.

Performance indicators:

1. Continued presence of Black Redhorse within its current distribution by 2026
2. Population trajectories in Sauble, Saugeen, Maitland, Bayfield, Ausable, Thames, and Grand rivers determined to be stable or increasing
    - Monitoring stations established by 2026 to allow for determination of population trajectories
3. Activities outlined in the schedule of studies for the full identification of critical habitat completed within the proposed timelines
4. Status of Black Redhorse in the Saugeen River, Gully Creek, Cedar Creek, Forwell Creek, Laurel Creek, and Four Wells Lake determined by 2026
5. Black Redhorse detected in formerly unoccupied sites within historical range by 2031 (that is, evidence of expansion)

Reporting on the ecological and socio-economic impacts of the recovery strategy and action plan (under section 55 of SARA) will be done by assessing the implementation of the recovery strategy and action plan after five years. Many measures in this recovery strategy and action plan will increase our understanding of the species, its status, and the threats it faces, and, over time, will contribute to monitoring Black Redhorse in Canada. This monitoring information will be used to report on the performance indicators and progress towards recovery in future reports on the progress towards recovery strategy implementation.

The broader ecological impacts of the implementation of this recovery strategy and action plan have been considered in its development. To report on the ecological impacts of implementation (under section 55 of SARA), monitoring data for other ecological components have been identified, and include water quality and quantity monitoring data for the watersheds where the species is found, where it exists. Additionally, other sensitive species with ranges that overlap that of Black Redhorse (for example, Eastern Sand Darter, Pugnose Shiner) could be monitored to track their trajectories and to document changes to overall fish community composition and abundance.

Reporting on the socio-economic impacts of the recovery strategy and action plan (under section 55 of SARA) will be done by collecting data on the costs incurred to implement it.

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Appendix A: effects on the environment and other species

In accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals (2010), *Species at Risk Act* (SARA) recovery planning documents incorporate strategic environmental assessment (SEA) considerations throughout the document. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This combined recovery strategy and action plan will clearly benefit the environment by promoting the recovery of the Black Redhorse. In particular, it will encourage the protection and improvement of riverine habitats within the Great Lakes watershed. These habitats support species at risk from many other taxa (including birds, reptiles, mussels and plants) and, thus, the implementation of recovery actions for the Black Redhorse will contribute to the preservation of biodiversity in general. The potential for these recovery actions to inadvertently lead to adverse effects on other species was considered. The SEA concluded that the implementation of this document will clearly benefit the natural environment and will not entail any significant adverse environmental effects. For further information, the SEA document serves as a helpful reference, particularly the following sections: Description of the species' needs, Description of threats, and Strategic direction for recovery.

Appendix B: record of cooperation and consultation

Recovery strategies and action plans are to be prepared in cooperation and consultation with other jurisdictions, organizations, affected parties and others as specified in sections 39 and 48 of the *Species at Risk Act* (SARA). Fisheries and Oceans Canada has utilized a process of species expert/subject matter expert review to seek input to the development of this recovery strategy and action plan. Information on participation is included below.

Subject matter expert reviewers

Name	Affiliation
Crystal Allan	Grand River Conservation Authority
David Andrews	Fisheries and Oceans Canada
Sarah Parna	Ontario Ministry of the Environment, Conservation and Parks
Scott Reid	Ontario Ministry of Natural Resources and Forestry

In addition, consultation on the draft recovery strategy and action plan occurred through letters sent to potentially impacted Indigenous groups. Additional stakeholder, Indigenous groups, and public input was sought through the publication of the proposed document on the Species at Risk Public Registry from July to September 2021. No comments were received during this period.