PROPOSED

Species at Risk Act
Management Plan Series

Management Plan for the River Redhorse (*Moxostoma carinatum*) in Canada

River Redhorse

2016

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

About the *Species at Risk Act* Management Plan Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is "*to manage species of special concern to prevent them from becoming endangered or threatened*."

What is a species of special concern?

Under SARA, a species of special concern is a wildlife species that could become threatened or endangered because of a combination of biological characteristics and identified threats. Species of special concern are included in the SARA List of Wildlife Species at Risk.

What is a management plan?

Under SARA, a management plan is an action-oriented planning document that identifies the conservation activities and land use measures needed to ensure, at a minimum, that a species of special concern does not become threatened or endangered. For many species, the ultimate aim of the management plan will be to alleviate human threats and remove the species from the List of Wildlife Species at Risk. The plan sets goals and objectives, identifies threats, and indicates the main areas of activities to be undertaken to address those threats.

Management plan development is mandated under Sections 65–72 of SARA.

A management plan has to be developed within three years after the species is added to the List of Wildlife Species at Risk. Five years is allowed for those species that were initially listed when SARA came into force.

What's next?

Directions set in the management plan will enable jurisdictions, communities, land users, and conservationists to implement conservation activities that will have preventative or restorative benefits. Cost-effective measures to prevent the species from becoming further at risk should not be postponed for lack of full scientific certainty and may, in fact, result in significant cost savings in the future.

The series

This series presents the management plans prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as plans are updated.

To learn more

To learn more about the *Species at Risk Act* and conservation initiatives, please consult the SAR Public Registry.

Management Plan for the River Redhorse (*Moxostoma carinatum*) in Canada [Proposed]

2016

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PREFACE

Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress within five years. 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.

The Minister of Fisheries and Oceans is one of two competent ministers for the recovery of River Redhorse. Due to the presence of River Redhorse in the Trent Severn Waterway, the Minister of Environment and Climate Change Canada, the minister responsible for Parks Canada Agency, is also a competent minister under SARA. Fisheries and Oceans Canada has prepared this management plan as per section 65 of SARA. It has been prepared in cooperation with the Governments of Ontario and Quebec as well as the Ontario Freshwater Fish Recovery Team, as per section 66(1) of SARA.

Success in the management 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 management plan and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this management plan for the benefit of the River Redhorse and Canadian society as a whole.

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

AUTHORS

The management plan was prepared by Amy Boyko (Fisheries and Oceans Canada [DFO] Central and Arctic Region), Hugues Bouchard and Myriam Bourgeois (DFO Quebec Region), Henri Fournier and Nathalie Vachon (Ministère des Forêts, de la Faune et des Parcs [MFFP]) on behalf of DFO and Parks Canada Agency (PCA).

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STRATEGIC ENVIRONMENTAL ASSESSMENT

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. 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.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans 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 on non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

This management plan will clearly benefit the environment by promoting the conservation of the River Redhorse. The potential for the plan to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this plan will clearly benefit the environment and will not entail any significant adverse effects. The reader should refer to the following sections of the document in particular: Needs of the River Redhorse (Section 3.3); Threats (Section 4); Effects on other species (Section 9); and, Proposed implementation schedule (Section 10).

EXECUTIVE SUMMARY

In 2006, the River Redhorse was designated as Special Concern in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). It was listed on Schedule 1 of the *Species at Risk Act* in 2007. The COSEWIC designation was based on the species' highly disjunct and restricted range as well as its disappearance from three historical sites.

The River Redhorse is a member of the genus *Moxostoma* in the Catostomidae family. The River Redhorse is a large sucker, with adults generally measuring more than 500 mm in total length (TL); some specimens can exceed 700 mm TL. It has deeply plicate (folded) lips without transverse ridges. Even as adults, it may sometimes be confused with other suckers (particularly *Moxostoma* species) by those less experienced. However, there are several criteria that distinguish it from other species with which they live sympatrically in Quebec and Ontario.

The global range of the River Redhorse is restricted to North America where it is found in the Mississippi River drainage basin, Great Lakes/St Lawrence River system, and the Gulf Slope from Florida to Louisiana. This species has a disjunct distribution throughout most of its range in Canada. It occurs in southern Ontario (Grand River, Thames River), and eastern Ontario (Bay of Quinte, Trent River, Mississippi River, Madawaska, River, and throughout the Ottawa River system). It also occurs in southern and southwestern Quebec (Coulonge River, Gatineau River, Noire River, Ottawa River, and Richelieu River). The species is believed to be extirpated from the Ausable, Chateauguay, and Yamaska rivers, as it has not been identified during recent sampling events. Although River Redhorse has disappeared from some historical locations, it has been found at new sites in both Ontario and Quebec, likely as a result of increased sampling effort.

The River Redhorse is a long-lived species that requires a variety of interconnected habitats to complete all of its life stages. The preferred spawning habitat for the River Redhorse is moderate to large rivers with a moderate to swift current, riffle-run habitat, and clean gravel, cobble, or boulder substrate. Throughout the summer, it can be found in deeper, slower current areas with abundant aquatic vegetation, and softer substrates.

The principal threats affecting the future survival of the River Redhorse are habitat degradation through siltation, agricultural and urban pollution, and instream barriers such as dams, which restrict access to spawning areas and can change flow regimes during spawning periods. Other potential threats include the effects of climate change, invasive species, disease, and incidental harvest by anglers or the baitfish industry.

The long-term goal of this management plan is to maintain self-sustaining River Redhorse populations at current locations and restore self-sustaining populations at historical locations where feasible. Management should be directed towards conserving and improving the quality and quantity of habitat for known populations.

The following short-term management objectives (over the next 5-10 years) have been established to assist in achieving the goal of the management plan:

i. To understand the abundance and extent of existing populations;
ii. To improve our knowledge of the species' biology, ecology, and habitat requirements;

iii. To understand long-term population and habitat trends;
iv. To improve habitat conditions;
v. To evaluate and mitigate threats to the species and its habitat;
vi. To ensure the efficient use of resources in the management of the River Redhorse; and,
vii. To increase public awareness and engage private landowners and the public in conservation efforts to protect and manage the River Redhorse.

Management approaches to assist in meeting the objectives listed above have been organized into the following categories: Research; Monitoring and Assessment; Protection; Stewardship and Habitat Improvement; Management and Coordination; and, Outreach and Communication. Each approach also has several key actions that will be undertaken to obtain the desired outcome.

The development and implementation of management actions is being coordinated with other species at risk recovery teams throughout southern Ontario and Quebec as are ecosystem-based recovery initiatives, to ensure the proposed management actions do not adversely affect other species at risk within the range of River Redhorse.

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1. COSEWIC[1] species assessment information

Date of assessment: April 2006
Common name (population): River Redhorse
Scientific name: *Moxostoma carinatum*
COSEWIC status: Special Concern
Reason for designation: This freshwater fish species occurs in Ontario and Quebec, and although it has been collected at new locations in both provinces, sometimes in large numbers, this is thought to reflect the use of more effective sampling techniques such as boat electrofishing. It has likely disappeared historically from the Ausable, Chateauguay, and Yamaska rivers, since the use of boat electrofishing has failed to collect it recently. Threats to the species include habitat degradation (pollution, siltation), stream regulation that affects water flow (dams) and habitat fragmentation (dams). The Canadian range is highly fragmented and rescue effect is improbable because of the precarious conservation status in adjoining U.S. states.
Canadian occurrence: Ontario and Quebec
COSEWIC status history: Designated Special Concern in April 1983. Status re-examined and confirmed in April 1987 and in April 2006. Last assessment based on an update status report.

2. Species status information

The River Redhorse (*Moxostoma carinatum* Cope, 1870) has a global status rank of Apparently Secure (G4)[2] (NatureServe 2012). Within the U.S., the species is ranked between Endangered and Vulnerable (S1-S4), depending on the state (NatureServe 2012) (Table 1).

The national status rank for Canada is N2N3 and the sub-national status ranks are S2 in Ontario and S2S3 in Quebec (NatureServe 2012). River Redhorse has been assessed as Special Concern by COSEWIC (COSEWIC 2006) and is listed on Schedule 1 as Special Concern under the *Species at Risk Act* (SARA). In Quebec, it is designated as a vulnerable wildlife species under Quebec's *Act respecting threatened or vulnerable species* (Chapter E-12.01) and, in Ontario it is listed as Special Concern under Ontario's *Endangered Species Act, 2007* (S.O. 2007, Chapter 6) (OMNRF 2013).

[1] Committee on the Status of Endangered Wildlife in Canada.
[2] **G4/N4/S4** – **Apparently Secure**: Uncommon but not rare; some cause for long-term concern due to declines or other factors; **N3/S3** – **Vulnerable**: Vulnerable in the nation/state or province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation; **S2** – **Imperilled**: Imperilled in the state or province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state or province; **S1** – **Critically Imperilled**: Critically imperilled in the state or province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state or province. For more information on ranking see NatureServe.

Table 1. Canadian and U.S. national and provincial/state status for the River Redhorse (NatureServe 2012).

Canada and U.S. National Status (NX) and Provincial/State Status (SX)

Country	Region
Canada (N2N3)	Ontario (S2), Quebec (S2S3)
United States (N4)	Alabama (S4), Arkansas (S4), Florida (S1S2), Georgia (S2), Illinois (S2), Indiana (S3), Iowa (SNR), Kansas (S1S2), Kentucky (S4), Louisiana (S1S3), Michigan (S1), Minnesota (SNR), Mississippi (S3), Missouri (SNR), New York (S2), North Carolina (S2), Ohio (S3), Oklahoma (S1S2), Pennsylvania (S3S4), South Carolina (S1), Tennessee (S4), Virginia (S2S3), West Virginia (S3), Wisconsin (S2)

3. Species information

3.1 Species description

The following description is adapted from Jenkins (1970), Parker (1988), Jenkins and Burkhead (1993), and Scott and Crossman (1998), unless otherwise stated. The River Redhorse (Figure 1) is a relatively large fish, member of the family Catostomidae. Individuals are long-lived and may grow to impressive sizes, attaining total lengths of 80 cm and weights of over 10 kg. The oldest River Redhorse recorded in Canada was 28 years of age (Campbell 2001).

The River Redhorse is large-scaled, has a large, flat-topped head and a prominent, squarish snout. The dorsal and upper sides of its body are olive to olive-green in colouration, with a bronze overtone. Its sides are pale gold in colour, with the ventral side pale gold to milk white in colour. The snout hangs slightly over the lips, which have deep vertical grooves with no cross striations. Pectoral, pelvic, anal, and caudal fins are light orange to deep red, depending on maturity, and the caudal fin is deeply forked, with pointed tips. Some sexual dimorphism is present during the reproductive period. Males grow nuptial tubercles on the head, cheeks, snout, and anal and caudal fins, while females are slightly larger in body size and may have small nuptial tubercles on the anal fin only. In Canada, the tubercles begin growing in September-October and recede shortly after spawning in late May-mid/end of June.

The River Redhorse can be difficult to distinguish from other redhorse species with overlapping ranges in North America, as it appears morphologically similar to many of them (i.e., Black Redhorse [*M. duquesnei*], Copper Redhorse [*M. hubbsi*], Golden Redhorse [*M. erythrurum*], Greater Redhorse [*M. valenciennesi*], Shorthead Redhorse [*M. macrolepidotum*], and Silver Redhorse [*M. anisurum*]). However, adult River Redhorse are most often confused with the Shorthead Redhorse and Greater Redhorse (COSEWIC 2006). Several unique meristic and morphological features can be used to differentiate this species, including: tail colour (in live or freshly killed specimens only), number of scales in the lateral line, number of scales around the caudal peduncle, and lip morphology (COSEWIC 2006). The River Redhorse and Shorthead Redhorse have a red tail and 12 scales around the circumference of the narrow part of the caudal peduncle) and 42-47 scales are present in the lateral line (COSEWIC 2006). The

Greater Redhorse also has a red tail but has 15-16 caudal peduncle scales and 42-45 lateral line scales. The lips of the River Redhorse are grooved with no cross striations; the lower lip is three times thicker than the upper lip, and the bottom of the lower lip meets at an obtuse angle, almost forming a straight line in larger individuals. By comparison, the bottom half of the lower lip of the Shorthead Redhorse forms a slightly acute angle and has more cross striations. The most unique feature of the River Redhorse is the presence of molariform pharyngeal teeth, allowing it to crush molluscs and crustaceans. The only other co-occurring redhorse species in Canada with molariform pharyngeal teeth is the Copper Redhorse, which has 15-16 scales around the caudal peduncle. However, it has larger but fewer teeth and its pharyngeal apparatus is more robust than that of the River Redhorse (Jenkins 1970; Eastman 1977; Mongeau et al. 1986; French 1993; Massé and Leclerc 2008).

Figure 1. River Redhorse (*Moxostoma carinatum*). © J.R. Tomelleri.

3.2 Population and distribution

3.2.1 Distribution

Global distribution – The global range of the River Redhorse consists of many disjunct and fragmented populations throughout North America. Its range extends as far north as the Great Lakes basin and St. Lawrence River and as far south as northern Florida (Figure 2). In Canada, scattered populations exist throughout medium to large rivers in southern Ontario and southern Quebec. In the eastern U.S., small, fragmented populations are found throughout central and eastern parts of the Mississippi River system and the Gulf of Mexico continental slope between Louisiana and Florida (COSEWIC 2006).

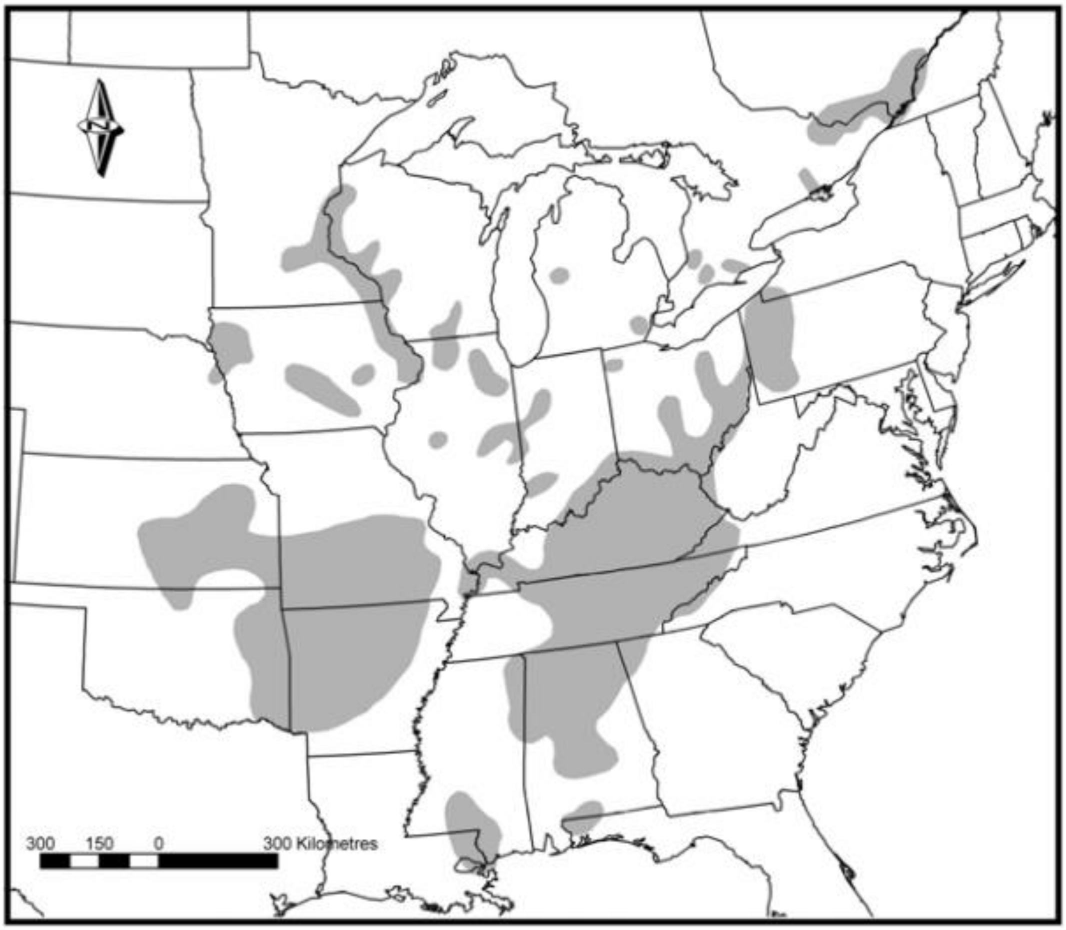

Figure 2. Global distribution of the River Redhorse. Modified from COSEWIC 2006.

Canadian distribution - Canadian populations of River Redhorse are located in southern and central Ontario and southern Quebec. Surveys with boat electrofishing equipment and seine nets have improved distribution information, but precise population estimates have been difficult to obtain because the species is highly mobile. Frequented areas undergo high rates of immigration and emigration (Campbell 2001).

Quebec – Prior to 1988, River Redhorse were reported in the Châteauguay, Yamaska, Ottawa, Richelieu, St. Lawrence, and St. François rivers (Parker 1988). It has been reconfirmed as present in the Ottawa, Richelieu and St. Lawrence Rivers (Figure 3). Although it has not been observed in the Châteauguay, Saint-François and Yamaska rivers since the 1960s, it bears noting that recent systematic surveys have not been conducted in these two rivers. Habitat degradation may have caused the extirpation of River Redhorse at these sites. See Section 3.2.2 Population size and trends for more details.

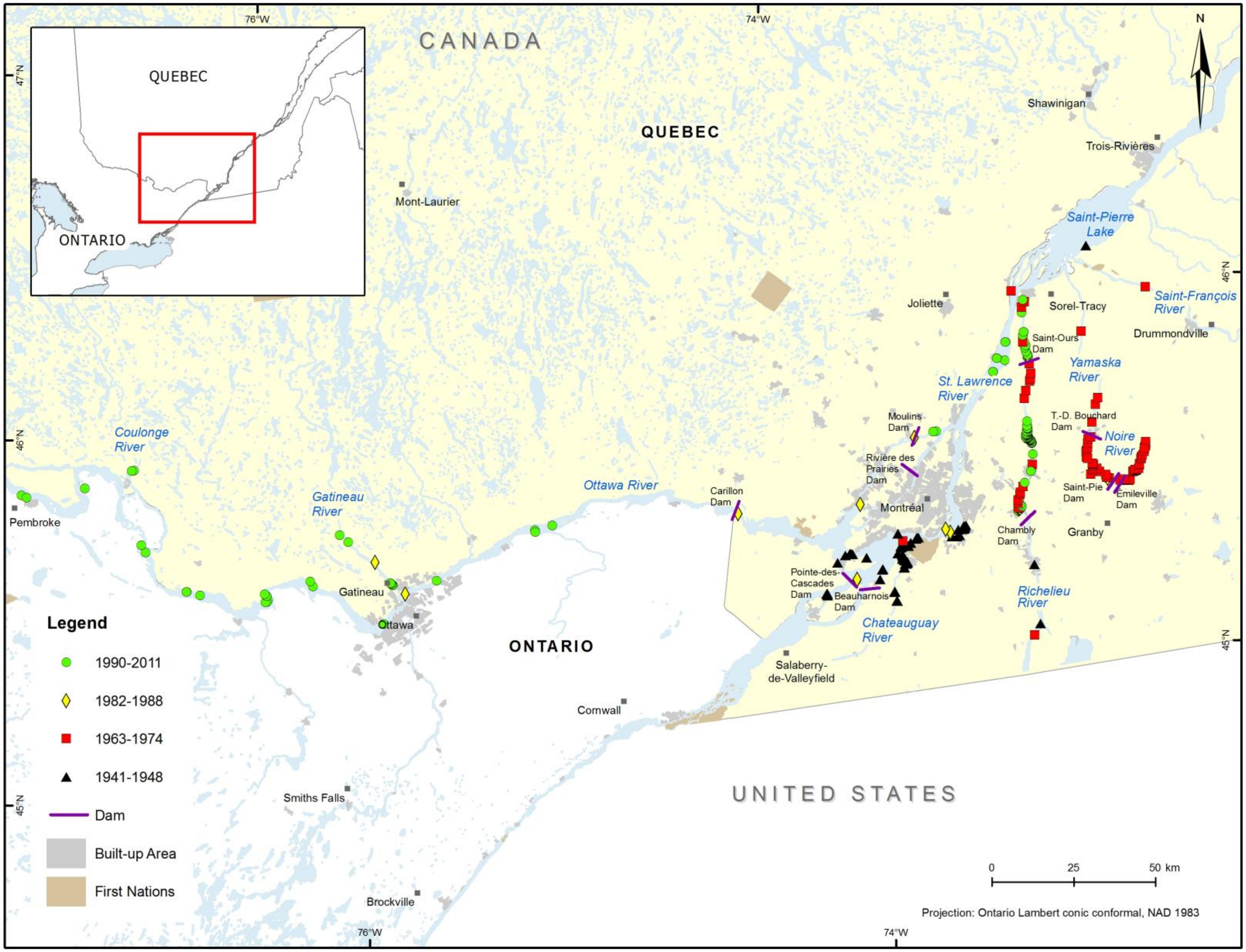

Figure 3. Distribution of River Redhorse in Quebec based on published and unpublished data (H. Fournier and N. Vachon, pers. comm. 2013) compiled by N. Vachon (MFFP).

Ontario - Surveys have discovered previously unknown River Redhorse populations in the Grand River in 1998, and the Thames River in 2003 (Figure 4a) (COSEWIC 2006). Recent (2002) surveys of the Ausable River have failed to confirm the species' presence in the watershed (N. Mandrak, DFO, unpubl. data). As the last specimen was collected in 1936, River Redhorse is currently presumed extirpated from this system (Parker 1988). In addition to the Grand and Thames rivers, populations have been confirmed in the Madawaska, Mississippi, Ottawa, and Trent rivers, as well as the Bay of Quinte (Lake Ontario) (Bay of Quinte individuals likely part of the Trent River population) (COSEWIC 2006) (Figure 4b). Voucher photographs or specimens are required to confirm a potential new population discovered in the Rideau River. Unconfirmed records have also been reported from Christie Lake, Echo Lake, Lake Simcoe, Rice Lake, the western end of Lake Erie, the Lake Huron-Lake Erie corridor (COSEWIC 2006), and the St. Lawrence River.

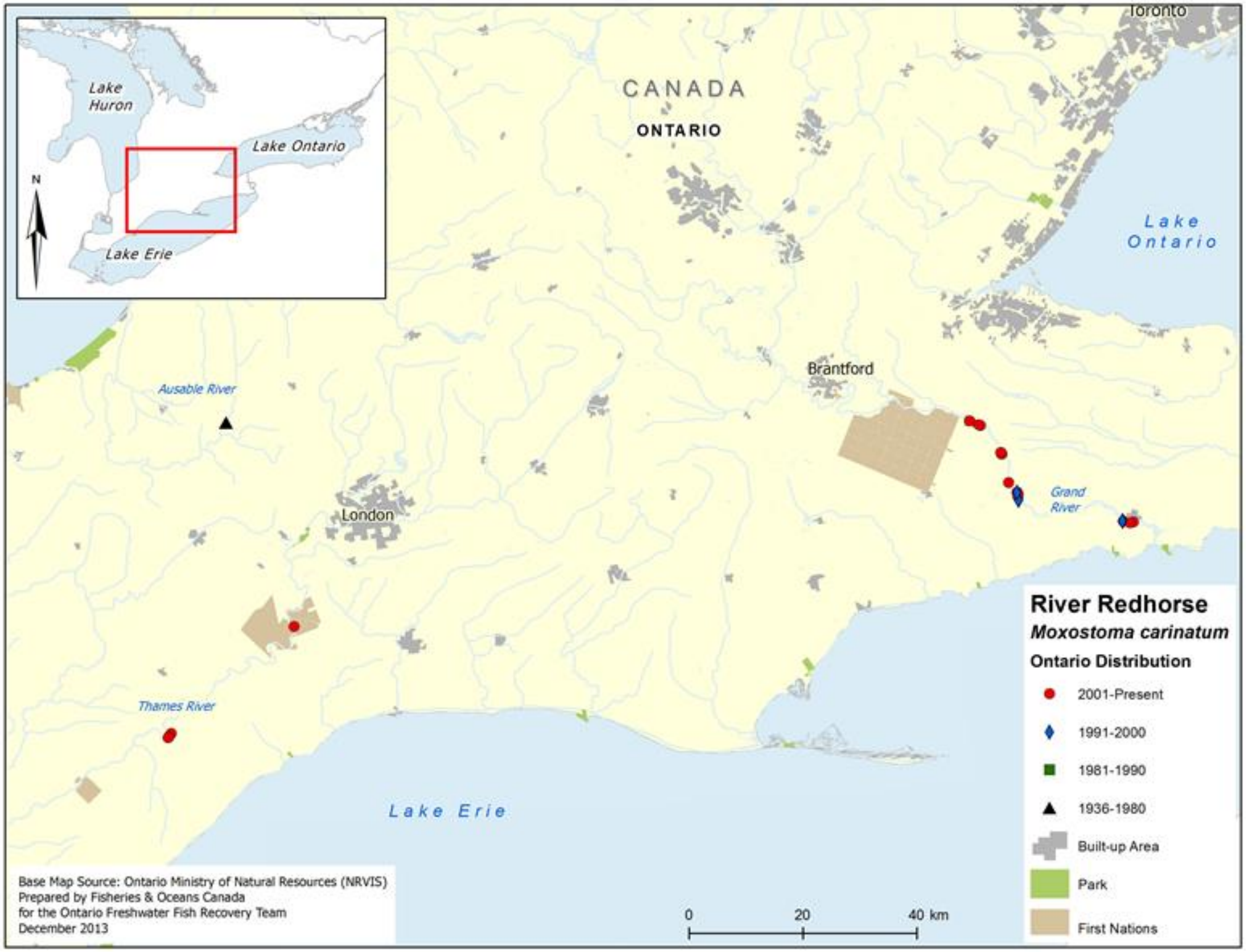

Figure 4a. Distribution of River Redhorse in southwestern Ontario.

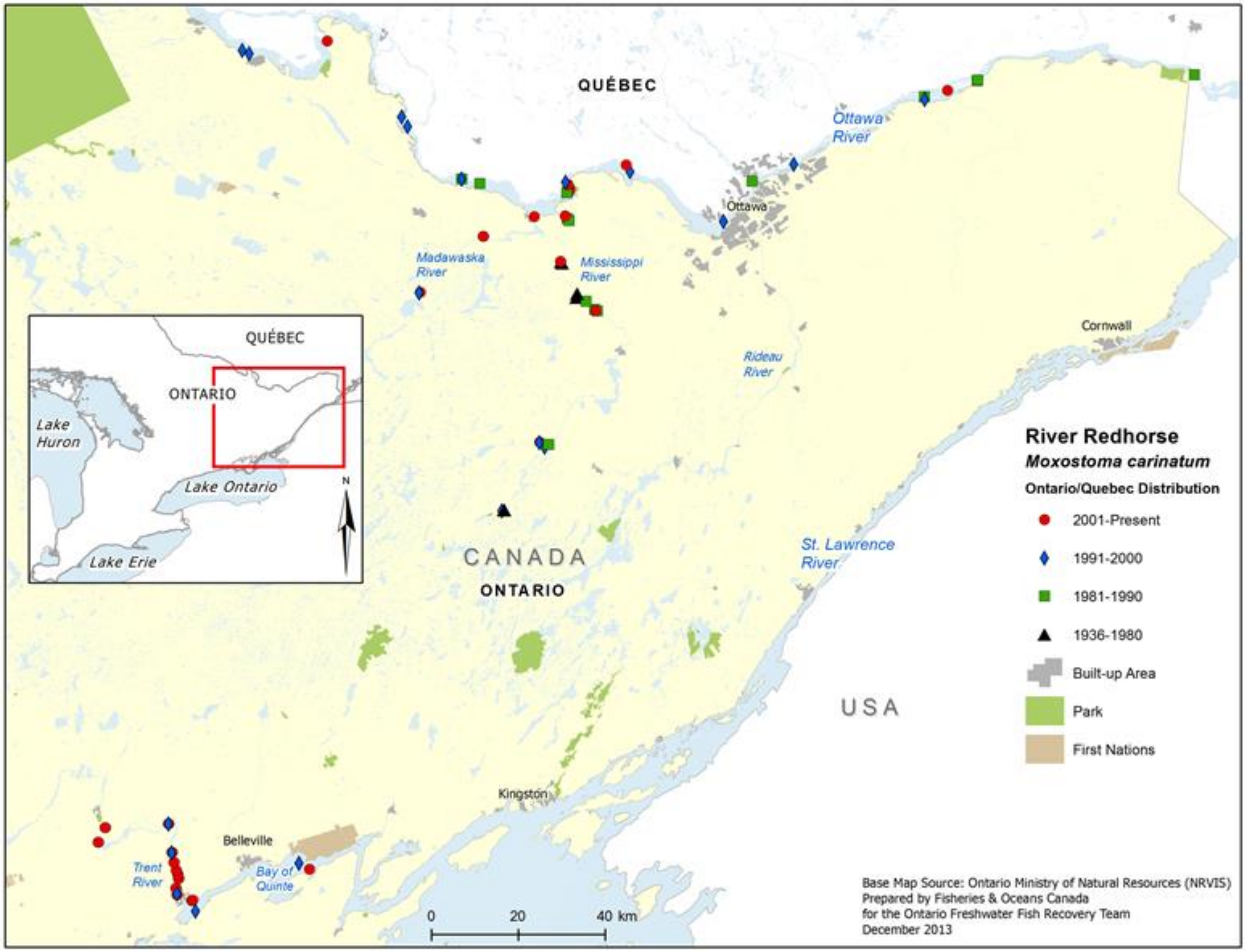

Figure 4b. Distribution of River Redhorse in eastern Ontario.

3.2.2 Population size and trends

Global population size and trends – Although accurate population estimates are currently unavailable, the global population is presumed to have declined in both numbers of populations and overall abundance since 1925 (Scott and Crossman 1998). Examination of bones found in middens left by First Nations and European fishery records from the early 20th century indicates that River Redhorse were historically present across a large area of southeastern North America, compared to the now discontinuous area of distribution (White and Trautman 1981; Cavender 1989; Scott and Crossman 1998). Current overall population sizes and trends are difficult to accurately quantify as the species has not been monitored regularly over time, with the exception of the Richelieu River in Quebec. Additionally, reliable identification of River Redhorse can be difficult, further confusing attempts to quantify population sizes and trends. River Redhorse are occasionally abundant in certain areas, but usually reported as uncommon or rare. The current global abundance is estimated at 10 000 individuals, given assumptions of 250+ occurrences with an average population size of 40 individuals (NatureServe 2012). Global populations over the short term are characterized as declining to stable, from +/-10% fluctuation to 30% decline (NatureServe 2012).

Canadian population size and trends – A precise estimate of current River Redhorse population trends in much of its Canadian range is unavailable as long-term standardized monitoring, using effective gear, has not occurred at many locations, and many fish inventories (especially older ones) only identify redhorse species to genus *Moxostoma* (Trautman 1981; Jenkins and Burkhead 1993; J. Farrell, Thousand Islands Biological Station, pers. comm. 2011). The exception is some locations in Quebec, where considerable expertise has been developed and where strict monitoring and recovery activities specific to the Copper Redhorse have yielded significant new knowledge about the River Redhorse (particularly its abundance relative to its conspecifics and its recruitment level), most notably in the Richelieu River. Studies indicate that spawning population sizes in Canada number in the hundreds to thousands of individuals (Campbell 2001), although it is believed that the Richelieu River population is larger than this (N. Vachon, MFFP, pers. comm. 2013).

Quebec

The presence of the River Redhorse in Quebec was first recorded in 1941 at the confluence of the Châteauguay River and Lake Saint-Louis. Available information, from which certain inferences can be made regarding trends in population status, suggests that River Redhorse populations present in the Ottawa and Richelieu rivers are stable. The species has declined significantly in the St. Lawrence River and has likely been extirpated from the Châteauguay (La Violette and Richard 1996), Yamaska, and Noire rivers due to habitat destruction (Moisan 1998).

Richelieu, Châteauguay, and Yamaska rivers: The most substantial information on population trends in Quebec comes from the Vianney-Legendre Fishway that bypasses the Saint-Ours Dam on the Richelieu River. Trap capture of adults is recurrent in the Vianney-Legendre Fishway. Young-of-the-year (YOY) have always been captured in the 12 years of redhorse recruitment monitoring in the Richelieu River, specifically in the Saint-Marc-sur-Richelieu and/or Saint-Ours regions, during the fall between 1997 and 2012. Total annual captures during these activities ranged from one to 191 YOY, which represents a relative abundance of 0.3 to 11.2% for the species compared to other *Moxostoma* (Vachon 1999a, b, 2002, 2007; 2010; N. Vachon, unpubl. data). The work accomplished over the past 30 years on the Copper Redhorse in the

Richelieu River, particularly population monitoring and recovery activities, has provided considerable new knowledge about the five redhorse species occurring in the river, including the juvenile stages. This work is complemented by monitoring studies on the Vianney-Legendre Fishway. Like its conspecifics, the River Redhorse spawns in the Chambly rapids and the downstream reach of the Saint-Ours Dam. Larvae disperse along the shallow shoreline areas to develop there. Areas of concentration are known and have been identified at such sites as the Saint-Marc-sur-Richelieu region and the grass beds surrounding the islands of Jeannotte and aux Cerfs in the Richelieu River. It is very difficult to tell Catostomidae species apart at the larval stage using external morphological criteria because there is much overlap between these criteria (Kay et al. 1994; Bunt and Cooke 2004). DNA analysis is a very effective tool (e.g., Lippé et al. 2004; Reid and Wilson 2006); however, in the first season of life, when individuals have reached the juvenile stage, it is possible to tell the species apart, at least the five sympatrically occurring conspecifics in Quebec, based on external morphological criteria (Vachon 1999a, 2003a). All of these activities have led to the conclusion that the Richelieu River has a relatively significant River Redhorse population and that the species' recruitment is constant due primarily to the recurring capture of YOY, more specifically in the Saint-Marc-sur-Richelieu region and in the downstream segment of the river from the Saint-Ours Dam to the mouth (Mongeau et al. 1986, 1992; Boulet et al. 1995; Boulet et al. 1996; Vachon 1999a, b, 2002; Fleury and Desrochers 2003, 2004, 2005, 2006; Vachon 2007; Leclerc and Vachon 2008; Desrochers 2009; Vachon 2010).

Intensive sampling surveys of the Yamaska River and its tributary, the Noire River, have failed to detect the River Redhorse. The presence of the species has not been reported since 1967 in the Yamaska River and 1987 in the Noire River. In the Châteauguay River, the species has not been found since 1948 (N. Vachon, pers. comm.). This river was last sampled in 1996 (La Violette and Richard 1996).

Ottawa River drainage: Sampling through the years has shown the species to be widely distributed throughout the Ottawa River and its tributaries (Pariseau et al. 2009; Pariseau 2012a; b; S. Reid, Ontario Ministry of Natural Resources and Forestry [OMNRF], unpubl. data; MFFP in Quebec, unpubl. data). River Redhorse has been confirmed in the Ottawa River from Holden Lake to Montebello (Haxton 2000b; MFFP, unpubl. data) and in the Des Milles Iles River (Moisan 1998; MFFP, unpubl. data). In addition, from upstream to downstream, River Redhorse can be found in the following widened sections of the Ottawa River: Upper and Lower Allumette Lake (Haxton 2000b; MFFP, unpubl. data; T. Haxton, OMNRF, pers. comm. 2006), Lac Coulonge (Haxton 2000a; Pariseau et al. 2009), Lac du Rocher Fendu (Chabot and Caron 1996; Haxton 1998), Lac des Chats (Haxton 2000b; MFFP, unpubl. data), Lac Deschênes (Pariseau et al. 2009; Pariseau 2012a), and Lac Dollard-des-Ormeaux (MFFP, unpubl. data). A 1998 – 1999 survey of Farmer's Rapids in the Gatineau River estimated the spawning population between 300 and 2100 individuals (Campbell 2001). A survey revealed spawning activity in Rivière Coulonge where 20 spawning specimens, including six females and 13 males, were caught (Pariseau et al. 2009). An individual was caught in Blanche River in Gatineau (Dubuc 1999). River Redhorse likely reproduce in other Ottawa River tributaries (particularly in Noire, Petite-Nation, and Rouge rivers) but surveys there were carried out too early in the season to verify this. Few surveys were completed in tributaries upstream from the first weir off the Ottawa River. A few catches were reported in the Gatineau River upstream of Chelsea, and one individual was apparently caught in the Réservoir Baskatong; however, this record remains unconfirmed as no voucher specimens are available. Surveys conducted in the Rivière du Lièvre with gillnets did not reveal the presence of this species (H. Fournier, MFFP, pers. comm. 2012).

St Lawrence River drainage: River Redhorse is relatively rare in the St. Lawrence River and was last observed in the 1970s (La Violette et al. 2003), until several individuals were identified in Lake Saint-Louis, approximately 10 km upstream of Montreal, in surveys between 1984 and 2004 (Moisan 1998; R. Dumas MFFP, pers. comm. 2006). It was often captured by commercial fisheries in Lake-Saint-Louis, Bassin de Lapraírie and Lake Saint-Pierre (Vladykov 1941, 1942). River Redhorse was found in the corridor from the Les Cèdres rapid section, upstream of Lake Saint-Louis to Saint-Nicolas, near Québec City, and Rivière Des Prairies (Moisan 1998; MFFP, unpubl. data).

Ontario

River Redhorse populations are present and appear to be stable in the Grand and Trent rivers and the Ottawa River drainage; however, this needs to be confirmed with trend through time data, which is currently lacking. Very small numbers have been found in the Thames River but the status of this population is unknown. The species has likely been extirpated from the Ausable River.

Ausable River: Two River Redhorse were collected from the Ausable River near Ailsa Craig in 1936. This area was sampled again during August 2002 (N. Mandrak, DFO, unpubl. data) and in 2004 (B. Upsdell, Ausable Bayfield Conservation Authority [ABCA], pers. comm. 2012) but no River Redhorse were captured. Additional surveys conducted by the ABCA in 2008 upstream of Ailsa Craig, near the mouth of the Little Ausable River, failed to detect the species (B. Upsdell, ABCA, pers. comm. 2012). River Redhorse has likely been extirpated from the Ausable River.

Thames River: Two River Redhorse were discovered in the Thames River in 2003 between Chatham and London, where the species was not known to occur previously (Edwards and Mandrak 2006) and a survey by DFO in 2005 located one juvenile and an adult (N. Mandrak, DFO, unpubl. data). Boat electrofishing surveys, conducted during the redhorse spawning period, at the Forks in London, Ontario, captured five species of redhorse, but no River Redhorse (Reid and Mandrak 2006).

Grand River: Previously unknown populations were first discovered in the Grand River during surveys in 1998 (COSEWIC 2006). Additional sampling between 2002 and 2003, and in 2007 yielded additional records near Caledonia, Cayuga, York, and Dunnville, 37 km downstream from Brantford (Clarke 2004; Reid et al. 2008; G. Buck, OMNRF, pers. comm. 2011).

Trent River/Bay of Quinte: The species was first recorded in the Trent River in 1997 when a single specimen was collected from the lower reaches. Since 1998, River Redhorse has been captured throughout a 50 km stretch in the lower river from Trenton to Hagues Reach hydroelectric station, and where the river joins Lake Ontario (J. Hoyle, OMNRF pers. comm. 2006). More than 314 River Redhorse have been captured from ten locations along the Trent River since 2001 (S. Reid, OMNRF, pers. comm. 2012).

One specimen was collected from the Bay of Quinte in 1997, representing the first confirmed record for Lake Ontario. Additional River Redhorse records have been collected during surveys in 1998 and 2001 from the Bay of Quinte, and since 2003, the OMNRF Lake Ontario Management Unit has identified River Redhorse during netting surveys; the species typically concentrates around the mouth of the Trent River, and 45 individuals were observed in trap nets from 2003 to 2012 (J. Hoyle, OMNRF, pers. comm., 2013).

Ottawa River drainage: Populations known to exist in the Ottawa and Mississippi rivers since before 1988 are still present and appear stable. Some surveys have revealed large groups of River Redhorse, indicating substantial breeding populations. A population also remains in the Mississippi River, with a survey conducted in 1998-1999 estimating the population at 633 ± 6.3 (Campbell 2001; S. Reid, OMNRF, unpubl. data).

River Redhorse was captured for the first time in the Madawaska River in 1992 when a single specimen was captured. The species' presence was re-confirmed in 1998 when OMNRF Nearshore Community Index Netting captured nine specimens near the confluence with the Ottawa River. Seven specimens were captured during the fall of 2001 and six more in 2002 during boat electrofishing (S. Reid, OMNRF, unpubl. data).

Unconfirmed records: There are several reports of River Redhorse captures outside its known range, but no voucher specimens are available to confirm these records. These include a single specimen captured from Lake Simcoe in 1978 during a fall trap-netting program by the Lake Simcoe Fisheries Assessment Unit, one specimen that was collected from Rice Lake, and more than 100 specimens caught in Christie Lake and Echo Lake in 1993 (COSEWIC 2006). Additional unconfirmed records outside the species' known distribution include seven specimens captured by the OMNRF between 1995-1998 and three specimens captured by DFO in 2004, from the St. Lawrence River, as well as 25 specimens from the Rideau Canal system (S. Reid, OMNRF, pers. comm. 2013, J. Barnucz, DFO, pers. comm. 2013).

Larval River Redhorse collections have been reported from western Lake Erie as well a number of locations along the Lake Huron-Lake Erie corridor (Chenal Ecarte, Chematogan Channel, Whitebread Drain, Dover Canal); however, due to the difficulty in reliable larval identification among redhorse species, these records are considered unconfirmed (COSEWIC 2006).

3.3 Needs of the River Redhorse

Habitat and biological needs

Spawn to hatch: The River Redhorse reaches sexual maturity at a later age and migrates upstream to spawn later in the year in northern (e.g., Canadian) populations compared to American populations in the south. Individuals become sexually mature in as short as 3-5 years in southern latitudes, but have been documented to require as many as 6-20 years to reach sexual maturity in Canadian populations (COSEWIC 2006). In the Richelieu River, spawners are 500 mm TL or larger in size and reach sexual maturity at an estimated age of approximately 10 years. Spawning begins around mid-June when the water temperature is between 12 and 18°C (Mongeau et al. 1986; T. Haxton, OMNRF, pers. comm. 2013). Adults migrate upstream to spawn for two weeks, usually between late May and late June (Comtois et al. 2004; Reid 2006b; Leclerc and Vachon 2008). Observations in the Vianney-Legendre Fishway show that River Redhorse migration activities begin around late May and are particularly intense in the first two weeks of June (Groupe conseil GENIVAR 2002; Fleury and Desrochers 2003, 2004, 2005, 2006; Leclerc and Vachon 2008; Desrochers 2009; N. Vachon, MFFP, unpubl. data). Spawning in American populations further south occurs at water temperatures between 18°-24°C and in northern populations when water reaches 17°-20°C (COSEWIC 2006).

Males have been reported to excavate very shallow and wide spawning redds (10-15 cm deep, 50-75 cm long), but it is unclear if these are deliberate excavations or merely artifacts of spawning behaviour (COSEWIC 2006). Eggs are deposited in sections of the riverbed containing gravel substrate, with clear fast running water, and usually hatch after 5-6 days depending on the temperature (Jenkins 1970; S. Reid, OMNRF, unpubl. data). After spawning, adults migrate downstream and no parental care is provided.

Preferred spawning habitat is described as riverine with moderate to swift riffle-run currents and clean coarse substrate (Mongeau et al. 1986; Parker 1988; Campbell 2001; Reid 2006b). Evidence suggests that population densities are approximately eight times greater in preferred locations than in regions with pools and impoundments (Yoder and Beaumier 1986). River Redhorse generally occupy large rivers in spring and migrate upstream to the upper reaches of larger tributaries to spawn (Scott and Crossman 1998). Appropriate flows must be maintained during spawning and during the incubation period or reproduction may not be successful (Jenkins and Burkhead 1993; Cooke and Bunt 1999).

The following conditions are all required for optimal spawning habitat:

- Riffle-run riverine habitat with cool, clear and fast-flowing water;
- Water less than 2 m in depth;
- Water surface current velocity (0.6 – 1.2 m/s) (Jenkins and Burkhead 1993);
- Clean, coarse substrate of boulder, cobble or gravel;
- Little to no submerged vegetation; and,
- Water temperatures between 17 and 24°C (Mongeau et al. 1986, 1992; Campbell 2001; COSEWIC 2006; Reid 2006a).

Young-of-the-Year: In the Richelieu River (Quebec), YOY have been found in abundance along vegetated shores with an average depth of 1.5 m (maximum depth < 3.0 m), a smooth slope of the littoral zone (< 20°) and substrate consisting mainly of fine sediment (silt, clay and sand) (Vachon 1999a). Analysis of the data does not provide more specific details about the habitat preferences of YOY River Redhorse.

Juveniles: According to Vachon (1999a), age 1+ River Redhorse are found in greater abundance in vegetated areas in the early spring. Moderate-sized streams or tributaries and backwater areas with slower currents have been suggested to provide suitable juvenile habitat (Jenkins 1970). Juvenile redhorse species (including River Redhorse) in the Trent River (Ontario) were collected in waters with low to moderate velocities in backwater areas, side channels and along the shoreline, and with, or close to, submersed aquatic vegetation (Reid 2008).

Adults: During non-spawning periods, habitat preferences are not as fully understood, but are slightly less limited. In Canada, adult River Redhorse have been reported from both rivers and lakes, although the species relies on riverine habitat to spawn. In Quebec, adults are clearly associated with rivers ranging in size from average to large (Mongeau et al. 1986, 1992). As long as water does not exceed 12 m in depth, non-spawning River Redhorse have been observed 10 km from the nearest rapids where spawning may have occurred. Summer habitat was characterized as riverine with slow currents, soft substrates, and abundant aquatic vegetation (Campbell 2001). In Quebec, where both River Redhorse and Copper Redhorse ranges overlap, post-spawning habitat of both species overlaps and consists of lowland rivers with channels of uniform depth (4 - 7 m), slow currents, abrupt banks with substrates of solid clay, sand and gravel, interspersed by rapids with suitable spawning habitat (Mongeau et al. 1992). Surveys of non-spawning adults in the Trent River also show trends towards deeper run/pool habitat (Reid 2006a). This is also consistent in the Grand River, where River Redhorse have been sampled from the lower section of the river downstream from the Caledonia Dam (Reid et al. 2008).

A healthy benthic environment is crucial for the River Redhorse. The adult diet consists primarily of benthic insect larvae such as mayflies (60%) and caddisflies (13%). Molluscs account for 19% of the species' diet, with scuds often being ingested as well (Mongeau et al. 1986). YOY feed mainly on microcrustaceans (47%), especially Chydoridae (water fleas) and harpacticoid copepods. Algae, particularly diatoms, as well as nematodes, make up a significant share of their diet. Age 1+ River Redhorse have a similar diet, except that they consume chironomid larvae in larger quantities (Vachon 1999a).

The limiting factor for habitat utilization is water turbidity, as the River Redhorse has a low tolerance for siltation (Yoder and Beaumier 1986; Reid 2006a). Although there is insufficient data to determine turbidity tolerance (Trebitz et al. 2007), the species is present in the lower Grand and Thames rivers, which are turbid (S. Reid, OMNRF, pers. comm. 2012). It is unclear whether the species is more impacted by suspended sediments in the water column or excessive sediment deposition on the substrate; however, it seems likely that high rates of silt deposition could affect the benthic organisms on which River Redhorse depend.

Ecological role

Members of the family Catostomidae are mid-trophic level benthivores that constitute a large amount of fish biomass in many rivers. At the ecological level, these species facilitate the transfer of matter and energy from the benthic food web to the pelagic food web (Cooke et al. 2005). Although juvenile River Redhorse have a diet that differs from that of adults, they forage on a wide variety of benthic prey (Mongeau et al. 1986; Vachon 1999a). In turn, juvenile River Redhorse can provide an important prey base for piscivorous fishes such as Largemouth Bass (*Micropterus salmoides*), Muskellunge (*Esox masquinongy*), Northern Pike (*E. lucius*), Smallmouth Bass (*M. dolomieu*), and Walleye (*Sander vitreus*) (COSEWIC 2006), as well as birds and mammalian predators (Cooke et al. 2005).

As the only redhorse species in Ontario with molariform pharyngeal teeth, the River Redhorse has been suggested as a suitable species for bio-control of invasive molluscs. Molluscs constitute close to 20% of the diet of the adult River Redhorse. In Quebec, the Copper redhorse eats molluscs for 90% of its diet.. The diet of other species, such as the Greater Redhorse, Shorthead Redhorse, and Silver Redhorse, consists primarily of insect larvae and crustaceans (Mongeau et al. 1986). It is unknown if River Redhorse consume species at risk molluscs such as the Hickorynut, (*Obovaria olivaria*), Wavyrayed Lampmussel (*Lampsilis fasciola*) or Round Pigtoe (*Pleurobema sintoxia*). The species has demonstrated the ability to crush the shells of invasive molluscs such as Zebra Mussel (*Dreissena polymorpha*) (Eastman 1977; French 1993).

Limiting factors

The River Redhorse has narrow habitat requirements, especially in terms of suitable spawning areas (e.g., riffle-run habitat with cool, clear, fast-flowing water and clean, coarse, substrates). A narrow range of conditions are required for successful incubation and hatching of eggs (Yoder and Beaumier 1986; Parker 1988; Scott and Crossman 1998; Campbell 2001) which include the maintenance of appropriate flows in suitable spawning areas described earlier. It is at the northern limit of its range in Canada, with low numbers and a disjunct distribution. Its narrow habitat requirements and small, fragmented populations leave it vulnerable to a wide range of pressures related to pollution, siltation, habitat destruction, and changes to flow regime (see section 4. Threats).

4. Threats

Known threats to the River Redhorse include increased turbidity and sediment loading as well as nutrient loading resulting from agricultural, urban, and industrial activities, causing stream eutrophication. Additional threats include instream barriers to migration such as dams and weirs without fish passage facilities. These threats create a cascade of negative effects on the population through habitat degradation, reduction and fragmentation, increased siltation and erosion, and loss of resources (e.g., food and nursery habitats). Suspected threats include the effects of climate change, aquatic invasive species, disease, and incidental harvest.

4.1 Threat assessment

Current and potential threats were assessed by the recovery team with input from experts from each province and are listed in Tables 2 and 3 for Ontario and Quebec populations, respectively. They are ranked based on their relative impact, spatial extent and expected severity and have been prioritized starting with the greatest perceived threat to the survival of the species (throughout their known current and historical ranges) based on the strongest evidence. There may be some variability in the severity and level of concern for some threats for individual populations. Threat assessment, particularly where evidence is limited, is an ongoing process linked to both species assessment and, where applicable, management. The threat classification parameters are defined as follows:

Extent – spatial extent of the threat in the species range/waterbody (widespread/localized);
Occurrence – current status of the threat (e.g., current, imminent, anticipated);
Frequency – frequency with which the threat occurs in the species range/waterbody (seasonal/continuous);
Causal Certainty – level of certainty that it is a threat to the species (High – H, Medium – M, Low - L);
Severity – severity of the threat in the species range/waterbody (H/M/L); and,
Overall Level of Concern – composite level of concern regarding the threat to the species, taking into account the five parameters listed above (H/M/L).

Table 2. Threat classification table for River Redhorse in Ontario.

Threat	Extent (widespread/localized)	Occurrence (current, imminent, anticipated)	Frequency (seasonal/continuous)	Causal certainty (high, medium, low)	Severity (high, medium, low)	Overall level of concern (high, medium, low)
Barriers to movement	Localized	Current	Continuous	High	High	High
Altered flow regimes	Localized	Current	Seasonal	High	High	High
Contaminants and toxic substances	Localized	Current	Continuous	High	High	Medium
Turbidity and sediment loading	Localized	Current	Continuous	High	High	Medium
Nutrient loading (Eutrophication)	Localized	Current	Continuous	High	High	Medium
Climate change	Widespread	Current/Imminent	Continuous	Low	Unknown	Medium
Habitat removal and alterations	Localized	Current	Continuous	High	Medium	Low
Aquatic invasive species and disease	Localized	Current/Imminent	Continuous	Low	Unknown	Low
Incidental harvest	Localized	Current/Imminent	Seasonal	Low	Low	Low

Table 3. Threat classification table for River Redhorse in Quebec.

Threat	Extent (widespread/localized)	Occurrence (current, imminent, anticipated)	Frequency (seasonal/continuous)	Causal certainty (high, medium, low)	Severity (high, medium, low)	Overall level of concern (high, medium, low)
Turbidity and sediment loading	Widespread	Current	Continuous	High	High	High
Nutrient loading (Eutrophication)	Widespread	Current	Continuous	High	High	High
Habitat removal and alterations	Widespread	Current	Continuous	High	High	High
Barriers to movement	Widespread	Current	Continuous	High	High	High
Altered flow regimes	Localized	Current	Seasonal	High	High	High
Contaminants and toxic substances	Widespread	Current	Continuous	High	High	High
Aquatic invasive species and disease	Widespread	Current/Imminent	Continuous	Medium	Medium	Medium
Climate change	Widespread	Current/Imminent	Continuous	Unknown	Unknown	Medium
Incidental harvest	Localized	Current/Imminent	Seasonal	Medium	Low	Low

4.2 Description of threats

Barriers to movement/Altered flow regimes: Locks, hydroelectric and flood control dams create instream barriers that alter stream flow and inhibit the upstream spawning-related movement of River Redhorse. Reid and Mandrak (2006) reviewed 46 dam-impact monitoring studies to assess impacts on catostomids species. River Redhorse declines were related to poor tailwater habitat conditions (Quinn and Kwak 2003) and the presence of dams blocking migration routes (Santucci et al. 2005).

As river reaches become more fragmented due to barriers, the persistence of River Redhorse within these reaches becomes less likely; River Redhorse abundance, adult sex ratio, and length and age distribution in the Trent River were negatively affected by decreasing river fragment length (Reid 2008). Additionally, the genetic diversity of individuals in the Trent River was lower when compared to populations in the Muskegon River (U.S.A.), an un-fragmented river of similar size to the Trent River (Reid 2008). Reid (2008) interpreted that river fragments less than 2 km in length are unlikely to support viable populations without immigration from other fragments. Barriers limit their ability to migrate to suitable habitat that is required at different life stages. Conditions are created that favour habitat generalists over other species (Reid 2004) by changing available habitat and making it difficult for the species to re-establish areas from which they were extirpated (Jenkins and Burkhead 1993). Barriers also change sedimentation patterns while restricting and altering river flow through the creation of pools and impoundments (Yoder and Beaumier 1986).

In Quebec, dams on the Yamaska, Noire, and Châteauguay rivers impede migration and fragment habitat. For over 30 years, the Saint-Ours Dam on the Richelieu River posed a major barrier to River Redhorse migration. Until the Vianney-Legendre Fishway was built in 2001, fish only had a limited window to cross the Saint-Ours Dam: two to three weeks on average, between early April and mid-May if hydrological conditions permitted. Population declines in the St. Lawrence River are also associated with the development of its extensive lift/lock system and a lack of fish passage facilities (Dumont et al. 1997). Multi-species fishways, such as the Vianney-Legendre Fishway at the Saint-Ours Dam, allow migration of River Redhorse (Groupe conseil GENIVAR 2002; Fleury and Desrochers 2003, 2004, 2005, 2006; Leclerc and Vachon 2008; Desrochers 2009).

Many River Redhorse spawning sites in the Ottawa River watershed are located downstream from watersheds regulated for hydroelectricity. This regulation can alter the flow regimes of rivers during the spawning period when the River Redhorse requires moderate to swift currents and clean substrate (COSEWIC 2006). Decreased flow rate during this period could lead to a reduction of available spawning grounds or water recession and egg mortality.

Dams may lead to increases in hypolimnetic discharge during reservoir release events (Reid et al. 2008). Such discharges, between post-spawn and pre-hatch periods, downstream of dams, displace eggs, cause suffocation from hypoxia, and mortality from temperature shock in early life stages (Clarkson and Childs 2000). Furthermore, crossing through turbines while migrating can also cause mortality.

Contaminants and toxic substances: Roads and urban areas can contribute contaminants to watersheds, including oil and grease, heavy metals, and chlorides (Dextrase et al. 2003); however, data are deficient on the effects of these on the River Redhorse.

Wastewater from cities, mills, and mines frequently contains substances such as chlorinated hydrocarbons, PCBs, polycylic aromatic hydrocarbons and heavy metals. Some of these chemicals are endocrine disrupters, known to cause reproductive and developmental problems in species related to the River Redhorse such as White Sucker (*Catostomus commersonii*) (e.g., Van Der Kraak et al. 1992; Fåhræus-van ree and Payne 2005) and potentially Copper Redhorse (Gendron and Branchaud 1997). Aravindakshan et al. (2004) confirmed and demonstrated the estrogenic effects on male Spottail Shiner (*Notropis hudsonius*), more than a third of which were intersex in those parts of the St. Lawrence River exposed to effluent from Montréal. Other research in the Ottawa River has also revealed effects likely caused by endocrine disruptors in the Walleye (*Sander vitreus*) (Picard-Aitken et al. 2007; H. Fournier, MFFP, pers. comm. 2012).

According to a survey of pesticide use in Ontario, the three most commonly used pesticides for agriculture between 2003-2008 were atrazine, glyphosate, and metolachlor (>100 000 kg) (Ontario Ministry of Agriculture Food and Rural Affairs 2010). These widely-used pesticides are known endocrine disrupters (Bretveld et al. 2006) with half-lives in aquatic ecosystems and sediment that can last for years (Environmental Protection Agency 2006). Fishes and other aquatic organisms are often more sensitive to these pesticides than terrestrial organisms (Giesy et al. 2000).

The level of contamination from toxic substances in the Richelieu and Yamaska rivers is also of concern (Berryman and Nadeau 1998, 1999). Many pesticides, including atrazine and metolachlor, have been detected in the Richelieu River. Some contaminants (PCBs, dioxins and furans) exceed the water quality criteria for the protection of aquatic life (Simoneau and Thibault 2009).

Turbidity and sediment loading: Sediment loading can negatively affect aquatic ecosystems by decreasing water clarity, silting up substrates, and aiding in the transportation of pollutants and nutrients. A natural process, erosion can nonetheless be increased by alterations of the shoreline (e.g., hardening) and human activities in the watershed (see below Habitat removal and alterations). Erosion brings with it an increase in turbidity and siltation of substrates (Vachon 2003b). For example, the trampling of banks and streambeds by livestock can destroy riparian vegetation. This, in turn, increases erosion, suspends sediments in the water column and reduces the depth profile of the river, allowing water to become too warm while destroying spawning and foraging habitat (Belsky et al. 1999). Fine sediments can also fill in spawning substrate and disrupt the entire food chain. Increased sediment and siltation in a waterbody can have indirect impacts on River Redhorse by negatively affecting the survival of molluscs and benthic invertebrates, its primary food sources (Vachon 2003b).

In Ontario, agricultural activities along the Mississippi River increase sediment and nutrient loads, consequently negatively affecting the availability of benthic prey (Campbell 2001). Despite elevated turbidity along the lower Grand River, a River Redhorse population occurs at this location; it is possible that although the water is turbid, the substrate is relatively silt free at River Redhorse locations. Turbidity and high nutrient loads in the lower Grand River basin from increased water use and sewage effluent from urban development is expected to increase as the surrounding population grows by 36% within the next 20 years (Ontario Ministry of Infrastructure 2012). In Quebec, increased agriculture and urbanization activities, which result in habitat deterioration including water quality, are the main contributing factors to explain the disappearance of the species in the Yamaska and Châteauguay rivers. The Richelieu River is still home to a large population of River Redhorse although water quality and habitat are also degraded, especially downstream (La Violette and Richard 1996; Moisan 1998; COSEWIC 2006; Simoneau and Thibaut 2009).

Nutrient loading (eutrophication): Nutrient input (phosphorus and nitrogen) leached from agricultural lands or from municipal or industrial sources may be very damaging to aquatic ecosystems. Impacts include increased algae and aquatic plant growth, increased turbidity, decreased available oxygen, and disruption of food webs (Bailey and Yates 2003) all of which would have a negative impact on the preferred habitat of River Redhorse. In Ontario, in the Thames River (where very few live River Redhorse have been detected), phosphorus levels at most sites in the watershed have shown a gradual downward trend since the 1970s. However, levels remain well above provincial guidelines of 30 µg/L for the protection of aquatic life (Thames River Recovery Team 2005 [TRRT]) with median total phosphorus concentration of 113 µg/L in the period from 2001-2006 (Ontario Ministry of the Environment and Climate Change 2009). Additionally, mean nitrite/nitrate levels in the Thames River were over the recommended limits from 1991-2000, and nitrate levels have shown an increasing trend in the watershed over the past 30 years (TRRT 2005).

Phosphorus levels in the Grand River exceed the provincial water quality objective at most locations. This has led to increased aquatic plant growth and decreased dissolved oxygen levels, particularly in the lower Grand River (Portt et al. 2007) where River Redhorse is found. The Grand River tributaries (Conestogo, Nith, and Speed rivers) all contribute significant inputs of suspended solids, phosphorus and nitrogen as a result of the intense agricultural activities and, in some cases, local geologic conditions present in those basins (Portt et al. 2007).

Similar degradation of water quality has been noted in some streams in Quebec where River Redhorse has been recorded. In the Yamaska River, phosphorus inputs from agricultural activities account for 67%, while another 25% are of urban origin. The median phosphorus concentration, measured at the mouth of the Yamaska River from 1998 to 2005, shows an improvement in recent years but remains quite high at 99 µg/L, three times the criterion for the prevention of eutrophication of 30 µg/L. The total average loads of phosphorus and nitrogen transported by the Yamaska River between 2001 and 2003, assessed at 310 and 7854 tonnes/year, respectively, are significantly higher than the estimated loads which would prevent eutrophication estimated at 65.2 and 2174 tons/year (Gangbazo and Le Page 2005; Gangbazo et al. 2005; Berryman 2008). The Richelieu River is also greatly affected by an increase in agricultural activities and urban development. It is estimated that 50% of phosphorus has an agricultural source. The total load of phosphorus transported by the Richelieu River, as assessed between 2001 and 2003, is 391 tons/year, which is higher than the estimated total load threshold of 346 tonnes/year which would prevent eutrophication (Gangbazo and Le Page 2005; Gangbazo et al. 2005).

Intensive livestock operations and sewage treatment plants are major potential point sources of nutrients. Improvements in water quality as a result of wastewater treatment have resulted in increases in the abundance and distribution of River Redhorse and other redhorse species in Ohio rivers (Yoder et al. 2005). Most Quebec and Ontario municipalities have sewage treatment systems that provide a preliminary treatment of wastewater. However, in the event of heavy precipitation or system breakdown, wastewater in some municipalities is evacuated into the natural environment without any treatment. Climate change could lead to more extreme weather conditions, which may increase the frequency of discharges of untreated waters from overflow structures.

Climate change – Global climate change is expected to cause many hydrogeological and thermal changes that will affect aquatic ecosystems throughout North America, including those in the Great Lakes and St. Lawrence basin (Lemmen and Warren 2004). By the year 2020, models predict warmer winters and summer “tropicalization” throughout the range of the River Redhorse. Such changes will cause increased rates of precipitation, increased snowmelt in spring, a rise in average water temperatures, accelerated erosion, increased runoff, and reduced annual stream flow in tributaries during low periods (Environment and Climate Change Canada 2001). Such effects are expected to put even greater stress on populations of species already at risk with fragmented habitats and other stressors (Bourque and Simonet 2008).

Habitat removal and alterations – Urbanization, industrialization and real estate development have brought significant changes in the riparian morphology and vegetation particularly in the St. Lawrence River and in other watercourses within the distribution of the River Redhorse. Backfilling, deforestation, the installation of riprap (which are rocks or other material used to armor shoreline structures against scour, water, or ice erosion), and the construction of walls and other infrastructure such as harbours, bridges and marinas have contributed to shoreline hardening and degradation of riparian and aquatic environments. A shoreline inventory conducted in 1995 revealed that 45% of the shoreline between Cornwall and l'Île d'Orléans was covered by a protective structure, be it a wall or riprap (Lehoux, 1996). Locally, the situation could be worse as demonstrated for Saint-Jean-sur-Richelieu (near Montreal) where the percentage of covered shorelines reaches 75% (CNC, 2008). Wave action from passing commercial and recreational vessels also contributes to bank erosion and shoreline receding, as demonstrated between Montreal and Sorel (Dauphin 2000). The extensive agricultural activities carried out in the lowlands of the St. Lawrence River resulted in increases in drainage capacity, channeling of watercourses, and loss of riparian vegetation which contributes noticeably to soil and bank erosion (for a review, see Roy, 2002). It is estimated that 50,000 km of watercourses were modified in Quebec between 1944 and 1986, an average of more than 1,000 km per year (MEQ, 2003).

Populations in the Trent River and Grand River are associated with large stretches of shallow habitat with swift current (Reid 2006a; Reid et al. 2008). As spawning occurs on riffles, destruction of gravel areas could have deleterious consequences on reproductive success. Disturbance of riffle areas during spawning and before eggs hatch would also impact survival. Given that young River Redhorse are dependent on aquatic vegetation, human alterations to the shoreline and destruction of aquatic vegetation could negatively affect their survival and, eventually, reproductive success.

Aquatic invasive species and diseases – At least 185 aquatic invasive species are known to be established in the Great Lakes region (Environment and Cimate Change Canada 2010) with the Zebra Mussel, Round Goby (*Neogobius melanostomus*), and Common Carp (*Cyprinus carpio*) having the greatest negative impact on the North American ecosystems to which they have been introduced.

Zebra Mussel consumption by River Redhorse would likely lead to more rapid bioaccumulation of toxins and malnutrition as observed in Freshwater Drum (French and Bur 1996). The tendency of Common Carp to uproot aquatic macrophytes during feeding increases turbidity in the water column (Lougheed et al. 1998), which could have negative impacts on the River Redhorse. However, the impact is likely to be low as Common Carp and River Redhorse have co-existed in river systems for more than 100 years. The presence of Round Goby is associated with the decline of small-bodied native benthic fishes (e.g., darters, sculpins) (Baker 2005). Round Goby may competitively interfere with River Redhorse due to their common food requirements. It is also possible that the species may consume River Redhorse eggs; although, literature on the diet of Round Goby indicates that fish egg consumption by the species is negligible (e.g., Taraborelli et al. 2010), and Round Goby individuals observed sitting on the nests of Walleye had no eggs in their stomachs, only mussels (J. Bowlby, OMNRF, pers. comm. 2013).

Additionally, three potential new invasive carp species, Bighead Carp (*Hypophthalmichthys nobilis*), Silver Carp (*H. molitrix*), and Black Carp (*Mylopharyngodon piceus*) (collectively known as Asian carps), could potentially pose a threat to River Redhorse and other native species in the Great Lakes and their tributaries. The presence of these species in the Great Lakes could result in declines in abundance of native fishes as a result of competition for food and habitat (Cudmore et al. 2011; Asian Carp Regional Coordinating Committee 2012).

In Quebec, two species of potentially competitive fish are well established in certain areas of the River Redhorse range. They are Round Goby, which has a strong presence in the St. Lawrence River, and Tench (*Tinca tinca*), which occurs in both the Richelieu River and the St. Lawrence River up to Québec City. Like the Round Goby, the Tench may compete with the River Redhorse for food (Vachon and Dumont 2000; Dumont et al. 2002; Masson et al. In preparation).

The overall impact of aquatic invasive plants on River Redhorse has not been investigated, but changes to vegetation communities will likely affect the species' food source – benthic communities.

Another concern is the potential impact of diseases, such as viral hemorrhagic septicemia (VHS), on River Redhorse. Currently, there are no known cases of VHS affecting the species (OMNRF's Lake Ontario Management Unit detected no trend in River Redhorse catches in the Bay of Quinte associated with the VHS outbreak in 2005 [J. Hoyle, OMNRF, pers. comm. 2013]), but it is affecting many other fish species and the list is growing. The disease is present in the Great Lake basin (lakes Erie, Huron and Simcoe and the lower reach of the Thames River) and the upper St. Lawrence River where it has caused several recent fish kills (Groocock et al. 2007). It has not yet been detected in the Ottawa River or in the St. Lawrence River downstream of Cornwall. However, it should be noted that habitat alterations such as artificialized flow regimes, eutrophication, increased temperature and habitat loss have frequently been linked to disease emergence in freshwaters. There is also growing evidence that future changes in climate and water storage and availability, and nutrient enrichment will influence water-related diseases (Johnson and Paull 2011).

Incidental harvest – The River Redhorse is not a legal baitfish in Ontario (OMNRF 2011) or Quebec; however, YOY or juveniles may be captured incidentally. As with most fisheries, the potential for incidental harvest exists, which is dependent on the distribution and intensity of baitfish harvest in relation to the distribution of River Redhorse and target (legally allowed) baitfishes. In Ontario, a substantial portion of harvest activity occurs in nearshore areas of lakes Huron, Erie, and Ontario, where River Redhorse do not occur. Baitfish harvest also occurs in tributaries of the Great Lakes, including those where River Redhorse may be found. Drake and Mandrak (2012) estimated that 1 out of 294 randomly-selected tributary harvest sites containing target baitfishes will also contain River Redhorse. A major study of the Ontario baitfish pathway uncovered a single River Redhorse during 68 baitfish purchases (a cumulative total of 16 886 fishes) in southern Ontario during August-October, 2007 and February 2008 (Drake 2011). No other redhorses were detected during sampling. The detection of a single River Redhorse indicates that individuals may fail to be removed from catches, should they be incidentally harvested. Overall, these results imply that the probability for incidental harvest and transfer throughout the baitfish pathway is low.

The deliberate targeting of adult River Redhorse by anglers (legal in Ontario) is considered to be of low impact compared to other threats due to a lack of interest in the species for sport fishing. However, a review of sucker conservation in North America has identified incidental angling and harvesting as a possible threat, as most people unfamiliar with ‘rough fish’ have difficulty distinguishing the River Redhorse from other redhorses and suckers (Cooke et al. 2005). Commercial harvest of all redhorse species is illegal in the Bay of Quinte and the St. Lawrence River; only impoundment gears are allowed in areas where fishermen might encounter redhorse species; if River Redhorse is encountered it can be released alive (J. Hoyle, OMNRF, pers. comm. 2013).

In Quebec, some ethnic communities target redhorses specifically in sport fishing, even though it is prohibited to catch and possess any suckers and redhorses in virtually the entire Copper Redhorse range, including a large portion of the Richelieu River and the St. Lawrence River.

5. Actions already completed or underway

Ontario
Ecosystem recovery strategies: Note that the recovery strategies referenced in this section are not “recovery strategies” as defined in SARA. An ecosystem-based recovery strategy for the Grand River is currently being implemented, and addresses the River Redhorse. The goal of this recovery strategy is “to conserve and recover fish species at risk in the Grand River, and to enhance the native fish community using sound science, community involvement, and habitat improvement measures.” Other ecosystem-based recovery strategies that overlap with the known distribution of River Redhorse are the Ausable River recovery strategy (Ausable River Recovery Team 2006) and the Recovery Strategy for the Thames River Aquatic Ecosystem (TRRT 2005). Initiatives, such as the Thames River Restoration Project, aim to improve habitat and water quality by reducing sediment and nutrient loads (TRRT 2005) and will be beneficial to River Redhorse populations. Most conservation measures in Ontario do not specifically address River Redhorse, but the species is included as a part of wider river restoration efforts by conservation authorities that include River Redhorse with other fish species. There are several projects in Ontario that do specifically address the River Redhorse. One such initiative involves an area along part of Mississippi River known to be used by River Redhorse for spawning that has been designated as a fish sanctuary (COSEWIC 2006).

The following is a summary of targeted research and/or management actions related to River Redhorse:

- Grand River distribution study: Throughout 2002 and 2004, as part of a graduate research program, distribution and spawning characteristics of River Redhorse within the Grand River watershed were investigated (Reid 2008)..

- Grand River redhorse study: Research conducted on the ecological interactions of the six redhorse species within the Grand River, including River Redhorse (2002-2004) (Clarke 2004).

- Trent River redhorse study: Research conducted on impacts of river fragmentation on distribution, demographics, and genetic population structure of redhorse species (1999-2004) (Reid 2008; OMNRF, unpubl. data).

- St. Lawrence River/Lake St. Francis surveys: The OMNRF Lake Ontario Management Unit conducts index gillnetting biennially in habitats suitable for River Redhorse. Identification of *Moxostoma* species was not taken to the species' level; however, this will be initiated beginning in 2013 (J. Hoyle, OMNRF, pers. comm. 2013).

- Ottawa River surveys: The OMNRF conducted Nearshore Community Index Netting from Rolphton to Arnprior (1997-2003), and from Lac des Chats to the Quebec border (mid-2000s) (K. Punt, OMNRF, pers. comm. 2013; S. Smithers, OMNRF, pers. comm., 2013).

- Status of species at risk in the Cornwall Area of Concern: In 2010, the Raisin River Conservation Authority undertook a project to determine the status of Bridle Shiner (*Notropis bifrenatus*), Cutlip Minnow (*Exoglossum maxillingua*), River Redhorse, Grass Pickerel (*Esox americanus vermiculatus*), and American Eel (*Anguilla rostrata*) in the Cornwall Area of Concern (Jacobs 2010).

- SAR habitat mapping: In 2010, the Rideau Valley Conservation Authority executed a Species at Risk Fish Habitat Mapping study to locate and conserve habitat for the Bridle Shiner, Pugnose Shiner (*Notropis anogenus*), and River Redhorse in the region (Rideau Valley Conservation Authority 2010).

- Up to 2009, the commercial fishery in Lake Ontario combined all sucker harvest. As of 2010, commercial harvesters on Lake Ontario chose to restrict their sucker harvest to White Sucker only, to avoid potential incidental harvest of River Redhorse (J. Bowlby, OMNRF, pers. comm.).

Quebec

Several initiatives, including some research, in Quebec have been undertaken that benefit threatened fishes. Since the River Redhorse is sympatric with the Copper Redhorse, the River Redhorse benefits from the protection and recovery measures put in place and the knowledge being gained through various works about this globally unique species. However, some measures are aimed at several species at risk, including the River Redhorse.

- The Vianney-Legendre Fishway built at the Saint-Ours Dam in 2001 restores free passage of fishes in the Richelieu River and provides access to the Chambly spawning grounds. Five species are impacted by this work: River and Copper redhorses, Lake Sturgeon (*Acipenser fulvescens*), American Shad (*Alosa sapidissima*), and American Eel.

- The Pierre-Etienne-Fortin Wildlife refuge located at Chambly Rapids, was established in 2002 to protect spawning areas of Copper and River redhorses as well as Channel Darter (*Percina copelandi*), by virtue of the *Regulation respecting the Pierre-Étienne-Fortin Wildlife Preserve*..

- Commercial fishing of River Redhorse has been prohibited since 1995. Protection of the islands of Jeannotte and aux Cerfs (Richelieu River at Saint-Marc-sur-Richelieu) ensures that natural shorelines and vegetated areas are conserved.

- The possible creation of a wildlife refuge will strengthen the protection of surrounding aquatic vegetation of islands of Jeannotte and aux Cerfs, an important rearing habitat for the five species of redhorses (Vachon 2002, 2007). In both these areas, namely the

Pierre-Étienne-Fortin Wildlife Preserve and the islands of Jeannotte and aux Cerfs, stewardship and awareness activities have been underway for several years. Initiatives for the protection of aquatic habitat and the improvement of water quality in the Richelieu River watershed are also underway and include the green and blue corridor project for the Richelieu River.

- Strategies to develop a joint action plan for the recovery of aquatic habitat in Lac St. Pierre are currently being considered.

- The MFFP (Ministère des Forêts, de la Faune et des Parcs) is still surveying the Ottawa River and its tributaries to identify the River Redhorse distribution and spawning sites. Other non-targeted monitoring has been conducted by the Réseau de suivi ichtyologique, which has resulted in River Redhorse records for the St. Lawrence since 1995.

- For close to 15 years, recruitment of redhorses in the Richelieu River has been monitored, with some exception, on an annual basis. This work, which targets primarily Copper Redhorse, generates considerable new knowledge about YOY (Vachon 1999a, b, 2002, 2007; 2010, unpubl. data).

- Lastly, follow-up and other work ongoing in the Vianney-Legendre Fishway are other sources of new information about the species (Groupe conseil GENIVAR 2002; Fleury and Desrochers 2003, 2004, 2005, 2006; Leclerc and Vachon 2008; Desrochers 2009; MFFP, unpubl. data).

6. Knowledge gaps

One of the biggest obstacles to River Redhorse conservation is a lack of basic ecological knowledge and understanding of life history. More information related to population size, distribution, spawning activities (frequency, habitat, period, behaviour), as well as demographic and habitat trends will better inform an effective management plan. Factors influencing the survival rate of eggs, larvae, and juveniles and successful recruitment also require further study, especially in Ontario where little is known regarding habitat associations. An improved understanding of the status and distribution of the less-studied and unconfirmed populations is required (e.g., Madawaska, Rideau, and Thames rivers). As targeted sampling of other Ontario rivers has not occurred for over 10 years, the status of other Ontario populations is uncertain. Standardized sampling protocols (e.g., gear, timing, effort) for River Redhorse (which should also be effective for Black Redhorse in Ontario rivers) need to be developed. Additionally, representative estimates of population size are required so that population viability analysis can be conducted in the future.

The general impacts of aquatic invasive species such as Common Carp, Round Goby, Tench, and Zebra Mussel, which may spread parasites, transmit diseases such as VHS and compete for food and habitat with endemic species, have been studied but their specific impacts on River Redhorse have not been thoroughly investigated through studies or literature review. Other, less well understood, threats include the impacts of sport or commercial fisheries, as well as the effects of climate change.

There is often a lack of interest or ability when it comes to identifying redhorse species (Jenkins and Burkhead 1993; J. Farrell, Thousand Islands Biological Station, pers. comm. 2011). At the larval stage, River Redhorse cannot be reliably distinguished due to meristic and morphological overlap (Kay et al. 1994; Bunt and Cooke 2004; Bunt et al. 2011), which complicates studies in the early developmental stages. However, this difficulty may be overcome through genetic analysis techniques that can be used to distinguish among different redhorse species (Lippé et al. 2004; Reid and Wilson 2006). Tools are available to reliably identify juveniles and adults on the basis of meristic and morphological criteria (Vachon 2003a; Massé and Leclerc 2008; Holm et al. 2009) but this requires experienced staff in the field and the laboratory, especially for YOY, which may be difficult to tell apart from certain conspecifics without a laboratory examination (N. Vachon, unpubl. data). Proper identification of River Redhorse is critical for their conservation (Clarke 2004).

7. Relevant federal and provincial fish habitat and fisheries management legislation

Federal - In Canada, SARA and the *Canadian Environmental Assessment Act 2012* (CEAA 2012) directly and indirectly address River Redhorse management. Section 79 of SARA states that environmental assessments must identify the effects of a project on all species listed at risk in the area. When the CEAA 2012 applies and a species at risk has been identified as a valued ecosystem component within the scope of the review pursuant to that Act, the environmental assessment will take into account any change that might be caused to aquatic species as defined in s.2(1) of SARA. Furthermore, under s.79 of SARA, during an environmental assessment of a project under CEAA 2012, the competent minister must be notified if the project will affect a listed wildlife species.

The River Redhorse is a species that supports a commercial, recreational, or Aboriginal (CRA) fishery; consequently, the Fisheries Act can be applied to protect a fishery against serious harm.

The habitat of River Redhorse may also be indirectly protected where it overlaps with the habitat of SARA-listed Endangered or Threatened species with identified critical habitat; Channel Darter critical habitat overlaps with River Redhorse habitat in the Gatineau, Richelieu and Trent rivers. In addition, the entire area of critical habitat identified for the Copper Redhorse covers grass beds of the Richelieu River and the St. Lawrence River (west of the Richelieu River to Île Sainte-Hélène and the Mille-Îles River) where the River Redhorse occurs.

Ontario – The River Redhorse has been listed under Ontario's *Endangered Species Act* as a Special Concern species; although the habitat of Special Concern species does not receive direct protection under the Act, the habitat of River Redhorse may receive indirect protection where it overlaps with the habitat of species listed as Threatened or Endangered.

In Ontario, River Redhorse habitat receives protection under the Provincial Policy Statement which prohibits development and site alteration in "Significant Wildlife Habitat (2.1.4(d)), which includes the "habitat of species of conservation concern" and specifically includes Special Concern species identified under the *Endangered Species Act*. River Redhorse habitat could also receive policy-level habitat protection when the provisions of the Provincial Policy Statement are applied to protect the habitats of co-occurring threatened and endangered species. Paragraph 2.1.3(a) of the *Provincial Policy Statement, 2005,* issued under s.3(1) of the *Planning Act* prohibits the development and site alteration in the "significant habitat of provincially-listed endangered species and threatened species". It should also be noted that according to s.2.1.7 of the Act, there is nothing in s.2.1 that restricts or limits the ability of existing agricultural uses to continue.

River Redhorse is indirectly protected under *Lakes and Rivers Improvement Act,* which addresses the construction and maintenance of dams, pipelines, channelization, and dredging activities, and the *Ontario Water Resources Act*, which prevents the deposition of harmful material into lakes and rivers as well as the removal of benthic or littoral material. The *Ontario Environmental Assessment Act* sets standards for the undertaking and application of decisions based on environmental assessments conducted in the province. Conservation authorities are also responsible for regulating and enforcing riparian development by the use of floodplain regulations under the *Conservation Authorities Act*.

The use of River Redhorse as baitfish is prohibited in Ontario (OMNRF 2011) and is not a legal commercial species (a restriction on all redhorse harvest is contained within the conditions of Ontario commercial fishing licences) (J. Hoyle, OMNRF, pers. comm. 2013).

Quebec – River Redhorse is indirectly and directly protected by several pieces of provincial legislation and regulations. Since October 2009, the River Redhorse has had vulnerable species status under *An Act Respecting Threatened or Vulnerable Species* (R.S.Q., chapter E-12.01), in force in Quebec. A River Redhorse protection plan was prepared (Direction générale de la protection de la faune 2011) and the species benefits from many protection and recovery activities targeting the Copper Redhorse.

The Act respecting the conservation and development of wildlife (chapter C-61.1) allows for the creation of wildlife preserves where “the conditions governing the use of the resources and the carrying on of recreational activities incidental thereto are fixed with a view to preserving the wildlife habitat or the habitat of a species of wildlife” (section 122). The Pierre- Étienne-Fortin Wildlife Preserve was created under this Act, in the Chambly Rapids, a spawning area, to protect several species at risk, including River Redhorse.

General protection of fish habitat is addressed in the *Environment Quality Act* (EQA), which prohibits the release or emission of contaminants into the environment that may harm wildlife on public and private lands. The EQA also regulates the development and implementation of the Politique de protection des rives, du littoral et des plaines inondables (Protection policy for lakeshores, riverbanks, littoral zones and floodplains) that aims to protect lakes and streams. Under *An Act Respecting Land Use Planning and Development*, minimum standards for development of municipal lands are set. The Agricultural Operations Regulation section of the EQA may also indirectly protect River Redhorse habitat as it prohibits free access of livestock to waterbodies and shorelines.

Use of all redhorses as bait has been prohibited since the 1980s and commercial fishing of Copper Redhorse and River Redhorse has been prohibited since 1995. With respect to the sport fishery, it is prohibited to catch and keep any suckers and redhorses from the Richelieu, Yamaska, and Noire rivers; this special regulation was extended to nearly the entire range of the Copper Redhorse in 2009 in the area 8 (*Quebec Fishery Regulations*, SOR/90-214 and SOR/2008-322). Lastly, capturing fishes for bait in the Richelieu River between the Chambly Dam and its mouth on the St. Lawrence has been prohibited since April 1, 2008.

8. Management

8.1 Goal

The long-term goal of this management plan is to maintain self-sustaining River Redhorse populations at current locations and restore self-sustaining populations at historical locations where feasible. Management should be directed towards conserving and improving the quality and quantity of habitat for known populations.

8.2 Objectives

The following short-term management objectives (over the next 5-10 years) have been established to assist in achieving the goal of the management plan:

i. To understand the abundance and extent of existing populations;
ii. To improve our knowledge of the species' biology, ecology, and habitat requirements;
iii. To understand long-term population and habitat trends;
iv. To improve habitat conditions;
v. To evaluate and mitigate threats to the species and its habitat;
vi. To ensure the efficient use of resources in the management of the River Redhorse; and,
vii. To increase public awareness and engage private landowners, first nations groups and the public in conservation efforts to protect the River Redhorse.

8.3 Actions

In an effort to meet the goal and objectives of the management plan, six categories of actions have been identified. These actions comprise the strategies required to protect, maintain and improve River Redhorse populations and habitat. Many of these actions can and should be performed in conjunction with other recovery and management teams dealing with individual species at risk and ecosystem-based approaches. Ensuring that River Redhorse is considered where feasible in surveys, outreach and educational efforts targeted at Endangered and Threatened species, will result in more efficient and cost-effective conservation efforts.

Management priorities have been assigned to six key categories as follows:

1. Research (biology, habitat requirements, and threat evaluation)
2. Monitoring and assessment (population distribution and habitat)
3. Protection
4. Stewardship and habitat improvement
5. Management and coordination
6. Outreach and communication

8.3.1 Research

Research is required to determine the habitat requirements for River Redhorse during non-spawning periods (i.e., nursery, juvenile, overwintering). An evaluation of the quality and quantity of habitat required to ensure the conservation of River Redhorse is also necessary.

The population dynamics of River Redhorse in Canada have not been well studied. Some research has been conducted on the age structure, mortality rate, age at maturity, and spatial structure of populations for River Redhorse populations in the Trent and Grand rivers (i.e., Reid

2006b, 2008; Reid et al. 2008). Other work carried out in the Richelieu River provided knowledge about the various aspects of adult and juvenile biology (habitat and reproduction period, sexual maturity, growth, food) (Mongeau et al. 1986, 1992; Vachon 1999a). However, this information is lacking for all Canadian populations. Such information is required for accurate monitoring of populations.

Standardized sampling protocols (i.e., gear, timing, effort) need to be developed for the long-term monitoring and assessment River Redhorse in Ontario and Quebec (ideally, these would also be effective for detecting Black Redhorse in Ontario). The development of such protocols should include a detectability analyses of gear types.

An analysis of the genetic structure of the species in Canada is required to help inform the Designatable Unit assessment conducted by COSEWIC; the collection of tissue from specimens to facilitate a genetic analysis should be incorporated into a standardized sampling protocol.

Research into threats to the species should focus on the extent, incidence, and severity of the currently known and imminent threats mentioned in previous sections. Identifying the specific impacts from threats, such as habitat removal and alteration, and contaminants and toxic substances at the population level will aid in identification of appropriate mitigation measures. Research should focus on effective dam removal when possible and how fishways can be built or retrofitted to accommodate the passage of redhorse species and other non-game fishes to increase habitat accessibility (Bunt et al. 1999). Research should also identify possible, new, and emerging threats such as the effects of incidental angling, VHS, and the effects of climate change to local and regional hydrology.

Actions:

1. Determine habitat requirements at various stages of the species' life cycle.
2. Determine the quality and quantity of habitat required to ensure the conservation of River Redhorse and to support the long-term management goal (see 8.1), and identify limiting habitats for the species.
3. Collect information on population dynamics of known populations (demographic structure, productivity, migration trends, and, recruitment rates) at all extant locations where such information is not available.
4. Identify the factors influencing the survival rate of eggs, larvae, and juveniles.
5. Assess the impacts of flow regulation on River Redhorse habitats and identify potential mitigations measures where necessary.
6. Conduct threat assessments at the population level to evaluate the severity of other known and potential threats that may affect survival. Determine ways to mitigate identified threats.
7. Develop standardized sampling protocols specific to River Redhorse for use during long-term population monitoring in Ontario and Quebec.
8. Determine genetic structure of Canadian populations to inform Designatable Unit assessment.

8.3.2 Monitoring and assessment

To prioritize future research, integrate habitat information, and coordinate conservation efforts, all available information on River Redhorse should be entered into existing provincial geo-referenced databases. Such information should be made easily accessible between organizations such as the MFFP, Natural Heritage Information Centre (NHIC) of the OMNRF, and other stakeholders concerned with species and fisheries management.

Due to its rarity, non-lethal capture methods are recommended for surveys. In Ontario, recommended effective gear types for detecting the species include boat electrofishing (Portt et al. 2008) and Nearshore Community Index Netting (NSCIN) (Willox et al. 1997). In Quebec, both seining and boat electrofishing have proven effective at detecting the species (N. Vachon, pers. comm. 2013). A standardized index population and habitat monitoring program, using sampling protocol developed specifically for River Redhorse (see 8.3.1 Research), should be coordinated with existing monitoring programs where possible. A long-term monitoring program will enable assessments of changes/trends in range, population distribution and abundance, key demographic characters, and changes/trends in habitat features, quality, and extent. Standard stream assessment protocols (e.g., habitat evaluation indexes) or other standardized techniques for fish habitat characterization should be used to describe areas that are important for River Redhorse. This will allow for scientifically valid comparisons of habitat requirements during known and unknowns periods in its life history. This will also allow a determination of habitat trends over time. Once established and identified, these habitats can be conserved, protected, and enhanced. It is recommended that proponents conducting work that may impact River Redhorse habitat, in areas where species presence is highly probable but unsupported by current data, conduct targeted surveys using standardized sampling techniques proven effective at detecting the species (see 8.3.1 Research).

Field and laboratory personnel should have appropriate fish identification training, including the identification of species at risk, such as provided by the MFFP on the identification of Catostomidae (Massé and Leclerc 2008) and Royal Ontario Museum (ROM) (a field key to the identification of redhorse species has been developed by the ROM and is provided during their fish identification courses). References, such as waterproof pocket guides, that identify distinguishing features of adult and juvenile redhorses (lip characteristics, fin ray and scale counts, fin colouration) should be made available to those conducting fish inventories in rivers inhabited by these species. It is also important to develop interest in species such as redhorses among research scientists so that special attention is given to them.

Actions:

1. Ensure that long-term monitoring of River Redhorse populations and habitat employs standardized sampling protocols during the collection and identification of the species and to collect habitat information.
2. Perform surveys through historical river reaches and current locations to confirm the species' extent.
3. Perform surveys at sites with areas of suitable habitat but lacking records (e.g., upper St. Lawrence River from Cornwall to Kingston, lower Thames River, Rideau River).
4. Consolidate River Redhorse data into existing provincial centralized databases, including habitat parameters, and publish the results.

8.3.3 Protection

Actions:

1. Employ mitigation measures for threats identified as a result of research undertaken in Section 8.3.1 (Research).
2. Promote awareness with municipal planning offices and planning officials to develop and adopt land and water management practices that minimize impacts to River Redhorse.

8.3.4 Stewardship and habitat improvement

Active promotion of stewardship activities will raise community support and awareness of conservation issues regarding the River Redhorse and increase awareness of opportunities to improve aquatic habitats and land management practices that affect aquatic ecosystems. Habitat improvement activities should be coordinated with existing groups and initiatives (e.g., ecosystem-based recovery programs), and direction, technical expertise/contacts, and information on financial incentives (e.g., existing funding opportunities for private landowners, ENGOs, and First Nations) should be made available.

Restoration efforts should be targeted to address the primary threats facing specific populations (and informed through population level threat assessments; see 8.3.1 Research, Action 6). For example, water-quality related threats such as sediment and nutrient loading are considered primary threats to populations in southwestern Ontario and southern Quebec, whereas, the presence of dams and flow regulation are threats to populations in the Trent and Ottawa rivers.

Important habitat, such as suitable spawning areas and other regions that fulfill requirements at other life stages, identified as a result of actions undertaken in Section 8.3.1 should be placed on a priority list of sites that would benefit from rehabilitation. Initiatives to restore habitat should give priority to areas where the species has been extirpated or are accessible to established populations, allowing for re-colonization.

Habitat accessibility can be enhanced through the removal of instream barriers (e.g., abandoned or obsolete dams) when possible. If such barriers cannot be removed, a fishway should be constructed and ineffective existing fishways retrofitted and monitored for several years to demonstrate their effectiveness in allowing the upstream and downstream migration of River Redhorse and other species at risk.

Restoration efforts through actions such as dam removal, planting riparian vegetation or instream additions of gravel should be overseen by qualified individuals and organizations (e.g., hydrogeological engineers, aquatic biologists).

Actions:

1. Promote and coordinate stewardship initiatives with stakeholders, First Nations, conservation groups, and interested landowners in areas where River Redhorse is extirpated, or to allow current populations to re-colonize historical sites. Ensure that information related to funding opportunities (e.g., federal/provincial funding programs) is made available.
2. Encourage the implementation of Best Management Practices relating to livestock management, the establishment of riparian buffers, nutrient and manure management , tile drainage, etc. at locations where the primary threats are related to water quality.
3. Create a prioritized list of current or potential habitats that would benefit from rehabilitation.
4. Create a prioritized list of instream barriers within River Redhorse habitats that could be removed (e.g., abandoned/obsolete dams).

5. Promote the retirement/protection of fragile lands upstream of and/or adjacent to River Redhorse habitats through Ecological Gift programs, easements, and tax incentives (e.g., Conservation Land Tax Incentive Program [CLTIP] [Ontario]).

8.3.5 Management and coordination

A coordinated strategy is recommended between researchers, single species, multi-species, and ecosystem-based recovery teams where River Redhorse are located. The results of current research on information such as habitat requirements should be assembled and consolidated in a reasonable time frame and made available for rapid integration with protection and restoration initiatives being undertaken by relevant stakeholders. Such an effort would enable groups, such as conservation authorities in Ontario or watershed organizations in Quebec, to share resources and information, and combine their efforts when implementing management actions. Species-focused initiatives could also be combined with efforts that integrate with watershed and water-source protection planning. Such a strategy would also aid communication with private interests, such as property owners and dam operators where River Redhorse habitat is located within such areas.

Actions:

1. Collaborate with, and share information among, relevant groups, First Nations, initiatives and recovery/management teams (e.g., ecosystem-based recovery teams [Ontario], watershed organizations and lake protection associations [Quebec], federal and provincial governments), to address management actions of benefit to River Redhorse.
2. Work with dam operators to ensure appropriate flow regimes and water depths during typical spawning periods.
3. Identify prospective partners and funding opportunities.

8.3.6 Outreach and communication

To the layperson, the superficial similarity between redhorses and carp or sucker species, such as White Sucker, may lead to incidental harvesting and has contributed to the belief that redhorses are common and widespread, serve no purpose, and can tolerate poor water conditions (Cooke et al. 2005).

To address issues caused by neglect, ignorance, and misunderstanding, it is important to challenge these common public perceptions. The River Redhorse should be included in existing communication and outreach programs for both ecosystem-based recovery, as well as Endangered and Threatened aquatic species to ensure the efficient use of resources, and to instil awareness of the need to protect freshwater fishes and ensure the health of freshwater ecosystems.

The impacts of incidental harvesting and angling can be minimized through outreach initiatives to assist in identification of redhorse species and other non-game and non-sport fish species. Public (e.g., anglers, conservation groups) awareness of the ecological role of native catostomids in cycling nutrients, providing a prey base for more popular game fishes and birds of prey, and the multiple pressures on their populations should be promoted. Sheets and posters for morphological identification of redhorse and sucker species should be made available online in Ontario. Sport fishing for redhorses and suckers is prohibited in a large area (zone 8) in Quebec; educational material and awareness campaigns should target anglers to help them better distinguish Common Carp from suckers and redhorses. . Some material has already been developed with this intent.

Actions:

1. Ensure River Redhorse is included in future communication and outreach programs for recovery of both ecosystem and Endangered and Threatened aquatic species, to create awareness of the need to protect freshwater fishes and ensure healthy aquatic ecosystems.
2. Develop and distribute educational materials providing key identification features that distinguish River Redhorse from other redhorses and sucker species to local anglers and conservation groups in Ontario; in Quebec, the focus of such materials should be on distinguishing Common Carp from redhorses and suckers as a whole.
3. Advise landowners adjacent to River Redhorse habitat of various tax incentive programs for conservation lands (e.g., Ecological Gifts Program, easements, CLTIP [Ontario]) to assist in River Redhorse conservation.

9. Effects on other species

River Redhorse habitat is shared by many other species, including multiple species at risk. The proposed management actions will benefit the environment in general. It is likely that implementation of the suggested management actions will benefit a wide variety of native species, including other co-occurring species at risk. Many of the stewardship and habitat improvement activities will be implemented through ecosystem-based recovery programs that have already taken into account the needs of other species at risk. No negative impacts on other species resulting from implementation of these management actions are expected.

10. Proposed implementation schedule

DFO encourages other agencies and organizations to participate in the conservation of the River Redhorse through the implementation of this management plan. Table 4 summarizes those actions that are recommended to support the management goals and objectives. While DFO has already commenced efforts to implement the plan such as; promotion of awareness with municipal planning officials and collaborating on the sharing of information with other management agencies, the performance of activities mentioned in the Management Plan, but not yet implemented by DFO will be subject to the availability of funding and other required resources (human resources, time, equipment etc.). Where appropriate, partnerships with specific organizations and sectors will provide the necessary expertise and capacity to carry out the listed action. However, this identification is intended to be advice to other agencies, and carrying out these actions will be subject to each agency’s priorities and budgetary constraints. Cooperation with the US may be warranted in implementing this management plan, but will be pursued on an “as needed basis” (e.g. collaborating on research). Under the Species at Risk Act (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress within five years.

Table 4. Implementation schedule.

Action	Objectives[3]	Priority	Threats addressed[4]	Participating agencies[5]		Approximate timeframe[6]
				Quebec	Ontario	
8.3.1 Research						
1. Identify habitat requirements	ii, iii	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
2. Assess quality/quantity of habitat	ii, iii, iv	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
3. Assess population dynamics	i, ii, iii	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
4. Identify factors influencing survival rate of eggs, larvae, juveniles	ii, iii, v	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
5. Assess impacts of flow regulation	iv, v	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
6. Assess threats	iv, v	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
7. Develop standardized sampling protocols for River Redhorse	i, ii, iii	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
8. Determine genetic structure of Canadian populations	i – iv	Necessary	All	DFO, MFFP, AI, NGOs, FN	DFO, OMNRF, CA, AI	2015-2020
8.3.2 Monitoring and assessment						

[3] See Sub-Section 8.2 (Objectives).
[4] See Section 4 (Threats).
[5] AI: Academic Institution; CA: Conservation Authority (Ontario); DFO: Fisheries and Oceans Canada; OMNRF: Ontario Ministry of Natural Resources and Forestry; PCA: Parks Canada Agency; FN: First Nations; MFFP : Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec; Non Governmental Organizations: NGOs (e.g., ZIP Committee, Fondation de la Faune du Québec, watershed organizations)
[6] Timeframes are subject to change in response to demands on resources.

Action	Objectives[3]	Priority	Threats addressed[4]	Participating agencies[5]		Approximate timeframe[6]
				Quebec	Ontario	
1. Ensure use of standardized sampling methods	i-iii	Necessary	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2015-2020
2. Conduct surveys – historical, current locations	i, iii	Necessary	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2015-2020
3. Conduct surveys – potential locations	i, iii	Necessary	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2015-2020
4. Consolidate data	All	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2015-2020

Table 4 (cont'd). Implementation schedule.

Action	Objectives	Priority	Threats addressed	Participating agencies		Approximate timeframe
				Quebec	Ontario	
8.3.3 Protection						
1. Mitigate threats	iv, v	Necessary	All	DFO, MFFP, PCA, NGOs, FN	DFO, OMNRF, PCA, CA	2015-2020
2. Identify potential seasonal sanctuaries	iv, v	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2015-2020
3. Promote awareness with municipal planning officials	iv, v	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2015-2020
8.3.4 Stewardship and habitat improvement						
1. Promote/coordinate stewardship activities	iv-vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2016-2021
2. Promote stewardship initiatives, encourage BMPs	iv-vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2016-2021
3. Create prioritized list of areas for rehabilitation	iv-vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2016-2021
4. Create prioritized list of instream barriers that could be removed	iv-vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2016-2021
5. Promote fragile land retirement	iv-vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2016-2021

Table 4 (cont'd). Implementation schedule.

Action	Objectives	Priority	Threats addressed	Participating agencies		Approximate timeframe
				Quebec	Ontario	
8.3.5 Management and coordination						
1. Collaborate and share information	vi	Necessary	All	DFO, MFFP, PCA	DFO, OMNRF, PCA, CA	2015-2020
2. Ensure maintenance of appropriate flow regimes	iv, v	Necessary	All	DFO, MFFP, PCA	DFO, OMNRF, PCA, CA	2015-2020
3. Identify potential partners and funding sources	vi, vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNR, CA	2015-2020
8.3.6 Outreach and communication						
1. Include River Redhorse in communication and outreach programs	vii	Beneficial	All	DFO, MFFP, NGOs, FN, OBV	DFO, OMNRF, CA	2016-2021
2. Develop and distribute educational materials	vii	Beneficial	All	DFO, MFFP, NGOs, FN, OBV	DFO, OMNRF, CA	2016-2021
3. Promote awareness of tax incentive programs	iv, v, vii	Beneficial	All	DFO, MFFP, NGOs, FN	DFO, OMNRF, CA	2016-2021

11. Associated plans

In Ontario and Quebec, the River Redhorse will benefit from a number of existing ecosystem-based recovery strategies that are being implemented in various parts of its range (see Section 5 for more detail).

Additionally, protection and recovery activities, recovery strategies, and management plans are currently being developed or are already in place for other species at risk with ranges that overlap the River Redhorse in Ontario and Quebec (e.g., Channel Darter [*Percina copelandi*], Eastern Sand Darter [*Ammocrypta pellucida*], Bridle Shiner, and Grass Pickerel, and Northern Madtom [*Noturus stigmosus*] and Pugnose Shiner in Ontario and Copper Redhorse in Quebec). Recovery initiatives implemented through these strategies will also benefit the River Redhorse.

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