Proposed

Species at Risk Act
Recovery Strategy Series

Recovery Strategy and Action Plan for the Eastern Pondmussel (*Ligumia nasuta*) in Canada

Eastern Pondmussel

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For copies of the recovery strategy and action plan, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the SAR Public Registry.

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Preface

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

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

The Minister of Fisheries and Oceans Canada is the competent minister under SARA for the Eastern Pondmussel and has prepared this recovery strategy and action plan, as per sections 37 and 47 of SARA. It has been prepared in cooperation with the Government of Ontario, Walpole Island First Nation, Environment and Climate Change Canada (CWS), Central Michigan University, University of Guelph, Bishop Mills Natural History Centre and the Lower Thames Valley Conservation Authority.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this recovery strategy and action 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 recovery strategy and action plan for the benefit of the Eastern Pondmussel and Canadian society as a whole.

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

Acknowledgments

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Executive summary

The Eastern Pondmussel is a medium-sized freshwater mussel with an average length of 70 mm. Its shell is slender and long, and bluntly pointed at the posterior end. The outside of the shell varies in colour from yellowish- or greenish-black in juveniles to dark brown or black in adults, with narrow green rays, concentrated at the posterior end of the shell. This species is considered imperilled (N2) in Canada where it has been assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada and listed as Endangered on Schedule 1 of the *Species at Risk Act*. The Canadian distribution is restricted to Ontario where it was once one of the most common species in the lower Great Lakes (lakes Erie and St. Clair) and connecting water channels. The current distribution of the species includes the delta area of Lake St. Clair, Lake Erie – including Cedar Creek (Long Point National Wildlife Area (LPNWA)) and Turkey Point Marsh in Long Point Bay as well as McGeachy Pond adjacent to Rondeau Bay, several coastal wetlands of Lake Ontario - Rouge River, Carruthers Creek, Lynde Creek, Consecon Lake, Pleasant Bay, East Lake, Wilton Creek/Hay Bay, and Lyn Creek in the upper St. Lawrence River drainage near the outlet of Lake Ontario.

The primary threat to Eastern Pondmussel populations, particularly in Lakes St. Clair and Erie, is the presence of the exotic Zebra Mussel. Other significant threats to Canadian populations include: turbidity and sediment loading, contaminants and toxic substances, nutrient loading, altered flow regimes, habitat removal and alterations, potential loss of fish hosts and the impact of climate change.

The population and distribution objectives for the Eastern Pondmussel are to return or maintain self-sustaining populations in the following locations where live animals currently exist: St. Clair River delta, Long Point Bay - including both Cedar Creek (LPNWA) and Turkey Point Marsh, Rouge River, Carruthers Creek, Lynde Creek, Trent River, Consecon Lake, Pleasant Bay, East Lake, Wilton Creek/Hay Bay, Lyn Creek and McGeachy Pond. The populations at these locations could be considered recovered when they demonstrate active signs of reproduction and recruitment throughout their distribution in each location such that populations are stable or increasing. In addition, threats at these locations would need to be reduced to 'low'.

Using available data, critical habitat has been identified for the Eastern Pondmussel in the following locations: Long Point Bay - including both Cedar Creek (LPNWA) and Turkey Point Marsh, Rouge River, Carruthers Creek, Lynde Creek, Consecon Lake, Pleasant Bay, East Lake, Wilton Creek/Hay Bay, Lyn Creek (including Golden Creek) and McGeachy Pond. Additional areas of potential critical habitat for this species in Lake St. Clair will be considered in collaboration with Walpole Island First Nation. A schedule of studies has been developed that outlines the necessary steps to obtain the information to further refine these critical habitat descriptions.

The recovery team has identified a variety of approaches that are necessary to ensure that the population and distribution objectives are met. These approaches have been organized into three categories: (1) Research and Monitoring; (2) Management and Coordination; and, (3) Communication and Outreach. Where possible, recovery efforts will be accomplished through cooperation with existing recovery programs for fish and mussel species at risk.

The action plan portion of this document provides the detailed recovery planning in support of the strategic direction set out in the recovery strategy section of the document. The plan outlines what needs to be done to achieve the population and distribution objectives, including

the measures to be taken to address the threats and monitor the recovery of the species, as well as the measures to protect critical habitat. Socio-economic impacts of implementing the action plan are also evaluated.

Recovery feasibility summary

Recovery of the Eastern Pondmussel is believed to be both biologically and technically feasible. The following feasibility criteria[1] have been met for the species:

1. *Individuals of the Eastern Pondmussel that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.*

    Yes. Reproducing populations exist in Lyn Creek, Long Point Bay and are believed to exist in the Lake St. Clair delta (as well as in other locations). These populations are available to improve the population growth rate and abundance. Any potential translocations would need to ensure genetic issues are investigated in advance.

2. *Sufficient suitable habitat is available to support these species or could be made available through habitat management or restoration.*

    Yes. The habitat that supports this species in the Lake St. Clair delta and those populations in Lake Erie -- Cedar Creek (LPNWA) and Turkey Point Marsh, is sufficient but of marginal quality due to the presence of dreissenid mussels (i.e. Zebra and Quagga mussels). The Lake St. Clair delta population is afforded some level of protection from human disturbance as well as urban/industrial development by the Walpole Island First Nation territory. The population of the Eastern Pondmussel in Lyn Creek appears to be of high quality due to water clarity, evidence of reproduction, and relatively undisturbed habitat; however, this has not been quantified. The lands adjacent to Lyn Creek are generally privately owned and there are no bridges or settlements along the stretch of river where these animals have been observed. For other locations within coastal wetlands of Lake Ontario, less is known, however the persistence of populations at these locations suggests that suitable habitat exists and could be enhanced through habitat restoration.

3. *The primary threats to the species or its habitats (including threats outside Canada) be avoided or mitigated.*

    Yes. With the exception of dreissenid mussels in the Great Lakes, significant threats to Eastern Pondmussel populations can be avoided or mitigated through recovery actions. Eliminating the impacts of dreissenid mussels on the Lake St. Clair or Cedar Creek (LPNWA) Eastern Pondmussel populations is not possible; however, it may be possible to establish more refuge sites in other locations, particularly within the Lake Ontario watershed.

4. *Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.*

    Yes. Recovery techniques that are necessary to recover Eastern Pondmussel populations do exist and have been demonstrated to be effective. For example, artificial propagation in the U.S. has been successful for a number of species (Hanlon 2000). In addition, host fish identification for the Eastern Pondmussel is underway in Canada and as hosts are identified it will be possible to artificially propagate juveniles of this species.

[1] Draft Policy on the Feasibility of Recovery, *Species at Risk Act* Policy. January 2005.

Table of contents

1. COSEWIC[2] species assessment information

Date of assessment: April 2007*
Common name (population): Eastern Pondmussel
Scientific name: *Ligumia nasuta* (Say, 1817)
COSEWIC status: Endangered
Reason for designation: This was one of the most common species of freshwater mussel in the lower Great Lakes prior to the invasion of the Zebra Mussel (*Dreissena polymorpha*) in the late 1980s. Zebra Mussels attach to the shells of native freshwater mussels in the hundreds or even thousands, causing the native mussels to suffocate or die from lack of food. Over 90% of historical records for the species are in waters that are now infested with Zebra Mussels and therefore uninhabitable. The species has declined dramatically and now occurs as two small, widely separated populations, one in the delta area of Lake St. Clair and one in a tributary of the upper St. Lawrence River. There is evidence that declines may be continuing at one location. Although Zebra Mussels appear to be declining in some areas, their impacts on this species may be irreversible if insufficient breeding adults have survived. Climate change is likely to cause a drop in water levels in the delta and further reduce the amount of habitat available to the mussel. Recent surveys in Lake St. Clair, which were conducted as a collaborative effort between Environment and Climate Change Canada and the Walpole Island First Nation, resulted in the identification of a significant refuge for this species within First Nation territory. The refuge is being managed by the First Nation for the protection of this and other aquatic species at risk with which it co-occurs.
Canadian occurrence: Ontario
COSEWIC status history: Designated Endangered in April of 2007. Assessment based on a new status report.

Note that since 2007, several new populations have been discovered (see below).

2. Species status information

Global status: The Eastern Pondmussel (*Ligumia nasuta* Say, 1817) is globally listed as apparently secure (G4; NatureServe 2012). In the U.S., the Eastern Pondmussel is considered apparently secure and occurs in Connecticut, Delaware, District of Columbia, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, and Virginia (NatureServe 2012). Table 1 lists the national (Canada and U.S.) and provincial status, as this species is known only from the lower Great Lakes region of Ontario in Canada. Although it is widespread in North America, the species has declined in many places, particularly in the Great Lakes (NatureServe 2012).

Canadian status: In Canada, the Eastern Pondmussel has a national ranking of N2 (nationally imperilled), and is designated as S1 in Ontario (NatureServe 2012). It was assessed as Endangered in 2007 by COSEWIC (COSEWIC 2007). It is listed as Endangered under the federal *Species at Risk Act* (SARA) and Ontario's *Endangered Species Act*, 2007.

Percent of global distribution and abundance in Canada: Estimates using data available prior to 2007 indicated that less than 2% of the species' global range is in Canada and this amounts to approximately 2.2 – 4.4% of the global abundance. This amounts to an approximate extent of occurrence of 3400 km^2 for the Eastern Pondmussel (COSEWIC 2007),

[2] Committee on the Status of Endangered Wildlife in Canada.

however, with the discovery of more recent populations these estimates could change. The largest population of Eastern Pondmussel is found in the St. Clair River delta and has an area of occupancy of approximately 44 km^2. A small population with an area of occupancy of approximately 1 km^2 occurs in Lyn Creek near Brockville, Ontario (COSEWIC 2007). In addition, populations of unknown sizes were recently found (2009–2013) at three locations in the Lake Erie watershed: Cedar Creek (LPNWA), Turkey Point Marsh (both located in Long Point Bay), and McGeachy Pond (adjacent to Rondeau Bay). Populations have also been recently discovered at several locations within the Lake Ontario watershed including: Rouge River, Carruthers Creek, Lynde Creek, Trent River, Wilton Creek/Hay Bay, Pleasant Bay, Consecon Lake and East Lake.

Table 1. Global, national and sub-national ranks for the Eastern Pondmussel (NatureServe 2012)

Rank	Jurisdiction rank*
Global (G)	G4 (2007)
National (N)	
Canada	N2
U.S.	N4
Sub-national (S)	
Canada	Ontario (S1)
U.S.	Connecticut (S1S2), Delaware (S1), District of Columbia (SNR), Maryland (S1S2), Massachusetts (S3), Michigan (SNR), New Hampshire (S1), New Jersey (S2), New York (S2S3), North Carolina (S1), Ohio (S1), Pennsylvania (S1), Rhode Island (S1), South Carolina (S2), Virginia (S3)

*For an explanation of G, N and S-ranks, see NatureServe (2012)

3. Species information

3.1 Species description

The Eastern Pondmussel is a medium-sized freshwater mussel. Its shell is slender and long, and one end is bluntly pointed (the posterior end). The outside of the shell varies in colour from yellowish- or greenish-black in juveniles to dark brown or black in adults. Narrow green rays, concentrated at the posterior end of the shell, are often visible in juveniles and light-coloured adults. More detailed information can be found in COSEWIC (2007).

3.2 Population and distribution

Global range: The Eastern Pondmussel's range is restricted to eastern North America (Figure 1) where it is found from the lower Great Lakes east through New York to New Hampshire and south, to South Carolina (COSEWIC 2007).

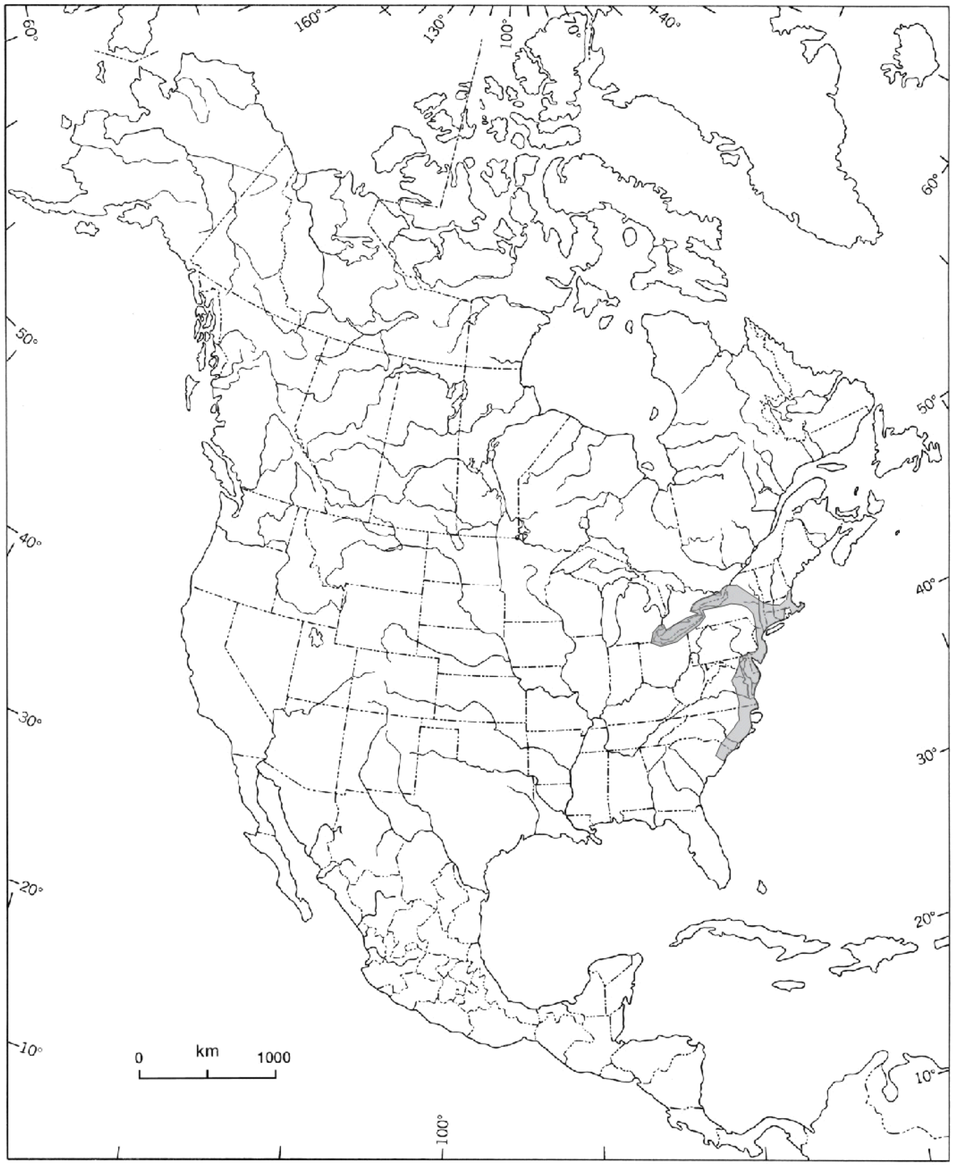

Figure 1. North American distribution (shaded area) of the Eastern Pondmussel (based on records from the Lower Great Lakes Unionid Database and data obtained from NatureServe and jurisdictional authorities)

Canadian range: In Canada, the Eastern Pondmussel is known only from the lower Great Lakes region of Ontario, where it occurred historically in the drainages of lakes St. Clair, Erie, and Ontario. At the time of publication of the status report, only two populations were thought to exist; these were known from the St. Clair River delta and Lyn Creek in the upper St. Lawrence River drainage, near the outlet of Lake Ontario (COSEWIC 2007) (Figures 2a,b). Recently, small populations have been found in Long Point Bay (Lake Erie drainage) at Cedar Creek (LPNWA) and Turkey Point Marsh and there is also an unconfirmed report of a single Eastern Pondmussel in Rondeau Bay (no voucher was taken), within the Provincial Park boundaries (J. Gilbert, MNRF, pers. comm. 2009). During surveys in 2011–12, the presence of Eastern Pondmussel was confirmed at several locations within wetland habitats of the Lake Ontario drainage (including Rouge River, Carruthers Creek, Lynde Creek, Pleasant Bay, East Lake and

Wilton Creek/Hay Bay (Brumpton *et al.* 2013)); During surveys in 2013, the species was also confirmed from Consecon Lake as well as the lower Trent River (S. Reid, MNRF, pers. comm.) and McGeachy Pond adjacent to Lake Erie near Rondeau Bay (T. Morris, DFO, pers. comm.). Given the recent discovery of these small populations, further sampling in similar wetland habitats throughout the lower Great Lakes may uncover additional remnant populations.

The range of the Eastern Pondmussel has been significantly reduced by ~93% (COSEWIC 2007) as it is believed to have been extirpated from much of its historical range in Lake Ontario (e.g., Bay of Quinte and Moira River), certain areas of Lake Erie (Niagara and Welland rivers, mouth of the Grand River, and at numerous locations in the shallow western basin, including Point Pelee, Pelee Island, Middle Sister Island, and East Sister Island). It also occurred in the Detroit River and Lake St. Clair (outside of the St. Clair delta region), but is now considered extirpated from these locations.

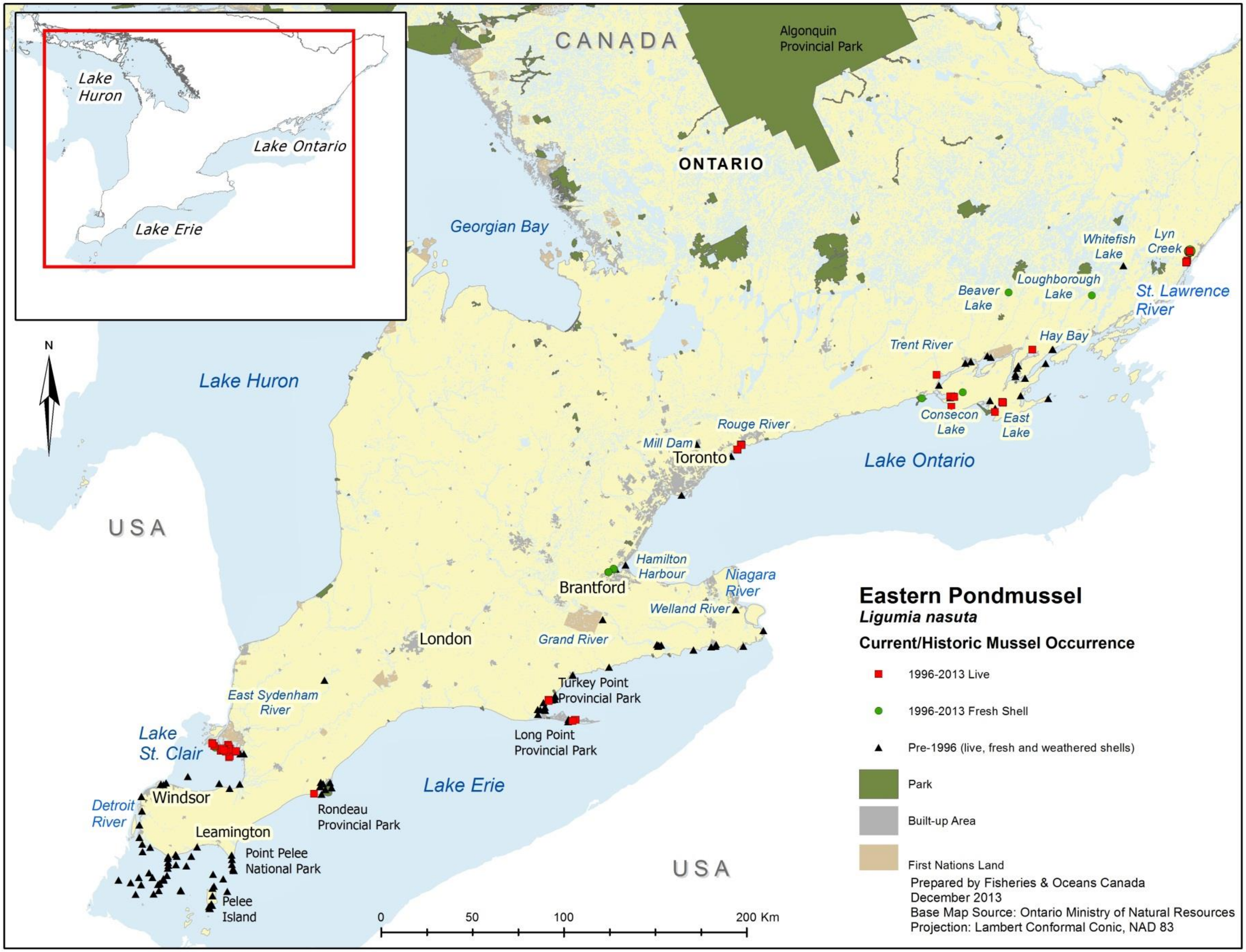

Figure 2(a). Current (1996–2013) and historic distribution (pre 1996) of the Eastern Pondmussel in Ontario

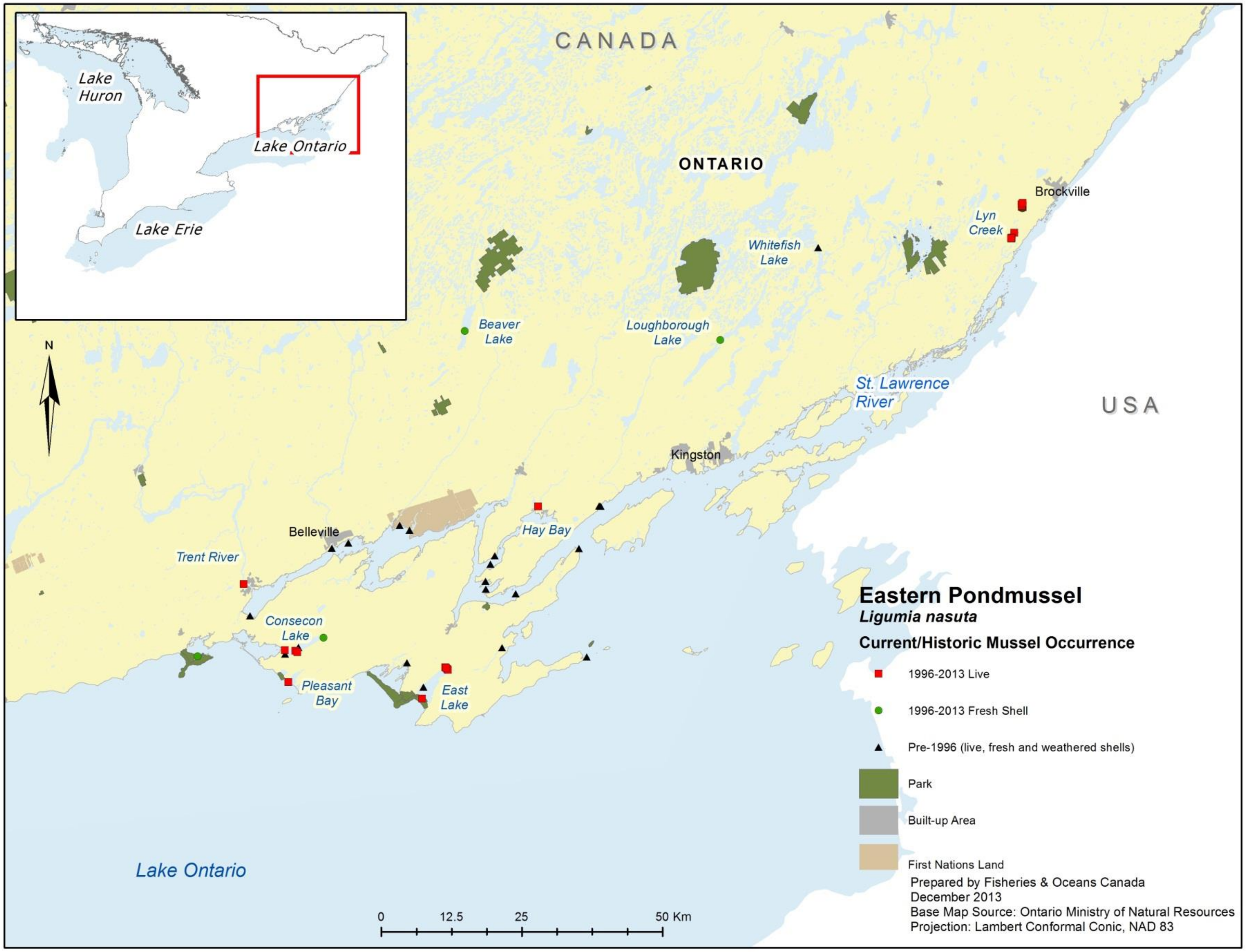

Figure 2(b). Current (1996–2013) and historic distribution (pre 1996) of the Eastern Pondmussel in eastern Ontario (close-up detail)

Canadian population size: The following descriptions of the known occurrence of Eastern Pondmussel in Canada were adapted from Bouvier and Morris (2011).

Lake St. Clair: Historic Eastern Pondmussel records exist for the offshore waters of Lake St. Clair and in the Detroit River. However, extensive unionid surveys have been conducted in Lake St. Clair since the invasion of the Zebra Mussel and no live Eastern Pondmussel have been detected. It is believed that the species has been extirpated from the offshore area of Lake St. Clair since 1994 (Nalepa et al. 1996). Additionally, unionid surveys in the Detroit River from 1997–98 did not find any live Eastern Pondmussel and it is assumed that it is no longer present in this system (Schloesser et al. 2006).

> *St. Clair River Delta*: The largest remaining population of Eastern Pondmussel can be found in the St. Clair River delta and most of the records are located within the Walpole Island First Nation territory. The first record of Eastern Pondmussel at this location is from 1965 when a fresh whole shell was recorded; the first live specimen was not detected until 1999. The delta represents a significant refuge site for native unionids, including the Eastern Pondmussel, from the Zebra Mussel invasion (Zanatta et al. 2002). Zanatta et al. (2002) surveyed numerous sites in the nearshore areas of Lake St. Clair from 1999 to 2001 and found live Eastern Pondmussel at 16 sites. In 2003 and 2005, Metcalfe-Smith et al. (2004) detected live Eastern Pondmussel at six of 15 sites surveyed in the Canadian waters of the delta. A total of 310 live Eastern Pondmussel have been detected in the St. Clair River delta since 1999.

Sydenham River: Only one record, from 1991, exists for Eastern Pondmussel in the Sydenham River. It is unknown whether this record consists of a live animal or a weathered or fresh shell.

Lake Erie: The species also historically flourished throughout Lake Erie and its connecting channels. Records exist for the Niagara and Welland rivers; the eastern and central basins of Lake Erie (Crystal Beach, Port Colborne, the mouth of the Grand River, Port Dover, Port Rowan, Long Point Bay, and Rondeau Bay); and, numerous locations from the western basin (Point Pelee, Pelee Island, Colchester, Middle Sister Island, East Sister Island, and Holiday Beach). Eastern Pondmussel was also found in the Detroit River at Windsor and Amherstburg. Many of these historical sites have been revisited subsequent to the invasion of Zebra Mussel and no live Eastern Pondmussel, and, in many cases, no live unionids, were found (COSEWIC 2007); however, since 2008 a few remnant populations have been detected within coastal wetland habitats of Lake Erie (see below)

> *Long Point Bay – Cedar Creek (LPNWA)*: In August 2008, three sites were sampled in Cedar Creek (small inlet located within the boundaries of the Long Point National Wildlife Area (NWA), resulting in the capture of 21 Eastern Pondmussel (J. Gilbert, MNRF, unpubl. data). In September of 2008, this area was revisited and another 23 individuals were detected (J. Gilbert, MNRF, unpubl. data).

> *Long Point Bay – Turkey Point Marsh*: Four live specimens were also collected from one site in Turkey Point Marsh (north shore of Long Point Bay) in the summer of 2008 (J. Gilbert, MNRF, unpubl. data). The records from Cedar Creek (LPNWA) and Turkey Point Marsh represent the first time since 1979 that live Eastern Pondmussel have been recorded in Lake Erie.

> *McGeachy Pond (adjacent to Rondeau Bay)*: In July 2013, four live Eastern Pondmussels were encountered with minimal search effort of 4.5 person-hours plus

some informal searching (T. Morris, DFO, unpublished data). There are no historic records for this location, however in the past, McGeachy Pond is believed to have been connected hydrologically to Rondeau Bay where the species was once known to occur.

Grand River: The first record of Eastern Pondmussel in the Grand River is from 1934 when three fresh shells were collected near Dunnville. Subsequent sampling yielded five fresh shells in 1963, approximately 1 km downstream of the original record. The most recent record of the species is from 1995 in McKenzie Creek, when one fresh valve was collected. Eastern Pondmussel has never been collected alive from this system.

Lake Ontario: Most of the Eastern Pondmussel records in the Lake Ontario watershed originated from the Bay of Quinte drainage including locations in the vicinity of Prince Edward County. These locations include the Moira River, Consecon Lake, East Lake, Hay Bay and Bay of Quinte proper (Figure 2b). The species was also found in scattered locations along the north shore of Lake Ontario, including the mouth of Pickering Creek, Hanlon's Point (near Toronto, Ontario), and Hamilton Harbour. In 1996, 14 live Eastern Pondmussels were recorded in Consecon Lake with no Zebra Mussel present in the lake at this time. However, the Consecon Lake site, along with numerous other historic Eastern Pondmussel sites were revisited in 2005, and all areas were found to be infested with Zebra Mussel and not a single live unionid (i.e. native freshwater mussel) was found (COSEWIC 2007). Since this time however, targeted and intensive sampling has demonstrated that in fact several small, isolated populations of Eastern Pondmussel persist within coastal habitats of Lake Ontario (but not within the lake proper), despite the presence of Zebra Mussels. In their sampling of 24 coastal wetlands of Lake Ontario in 2011–12, Brumpton *et al.* (2013) recorded from 1 to 17 live animals from each of the following locations: Rouge River, Carruthers Creek, Lynde Creek, Wilton Creek/Hay Bay, Pleasant Bay and East Lake; these surveys employed both clam-rake and visual-tactile searches (12 person-hours of each). Further sampling in 2013 at Consecon Lake resulted in the detection of five live animals, confirming that a remnant population of Eastern Pondmussel had in fact survived at this location (S. Reid, MNRF, pers. comm., July 2013); in addition, a single live individual was found during sampling of the lower Trent River near the outflow of Mayhew Creek in Trenton.

Mill Dam (Lake Ontario): Fifteen fresh whole shells were collected in 1860 from Mill Dam (near Markham, Ontario) which is located in the upper watershed of the Rouge River; this remains the only record of Eastern Pondmussel at this location.

Beaver Lake: No live Eastern Pondmussel have been detected in Beaver Lake (Lanark County); however, three fresh whole shells were discovered in 1998 and an additional weathered shell was discovered in the same area in 2006 (F. Schueler, Bishops Mills Natural History Centre [BMNHC], unpubl. data). This site has not been formally sampled but it was noted in 2006 that the lake was infested with Zebra Mussel (*Dreissena polymorpha*) (F. Schueler, BMNHC, pers. comm.); since that time a moderately fresh shell of the Eastern Pondmussel was found in a dreissenid-free lake nearby - Inglesby or White Lake (Schueler 2012).

Loughborough Lake: Loughborough Lake has not been formally sampled and only one known record of Eastern Pondmussel occurs at this location. One weathered valve (102 mm) and one weathered shell fragment were collected from the lake in 2009 at the Missouri Bridge (County Rd. 10) (F. Schueler, BMNHC, unpubl. data). It was noted at the time of collection that the area was infested with Zebra Mussel, however, inlets and tributaries of this large lake, and of nearby lakes, have not been investigated, and may contain dreissenid-free areas or marshes (Schueler 2012).

Whitefish Lake (Lake Ontario): In 1995, one weathered Eastern Pondmussel valve was collected in Whitefish Lake (part of the Lake Ontario portion of the Rideau Canal system). No further sampling has been conducted at this location. The Cataraqui portion of the Rideau Canal is infested with Zebra Mussels, but its inlets and tributaries, and nearby Frontenac Axis lakes, have not been explored, and may contain dreissenid-free areas or marshes that should be investigated (F. Schueler, BMNHC, pers. comm.).

Lyn Creek: Eastern Pondmussel were first detected in Golden Creek, a tributary of Lyn Creek (tributary of the upper St. Lawrence River) in 2005 when two fresh valves and one weathered whole Eastern Pondmussel were collected (F. Schueler, BMNHC, unpubl. data). In 2006, seven sites on Lyn Creek were sampled by means of an observational study and 42 live Eastern Pondmussel were recorded. Between 2007 and 2009, additional observational studies were completed at previously visited sites as well as new sites, and the presence of live individuals was noted at all but one location. In 2009, a formal timed-search survey completed at one site yielded ten live Eastern Pondmussel. An Eastern Pondmussel population is believed to inhabit an 8 km stretch of Lyn Creek. The lowest reaches of Lyn Creek, the Jones Creek estuary into which it empties, and other tributaries of this estuary have not been investigated and may contain dreissenid-free areas or marshes that support Eastern Pondmussel (Schueler 2012).Bouvier and Morris (2011) derived population estimates for all current Eastern Pondmussel populations in Canada (Table 2). The Great Lakes and connecting channels (i.e. open water areas) were not included in their estimates as the Eastern Pondmussel is believed to be extirpated from these areas. Refer to Bouvier and Morris (2011) for details on the methodology.

To date, it appears that there are 13 remaining populations of Eastern Pondmussel in Ontario. It is known to be currently distributed in the St. Clair River delta, Long Point Bay - Cedar Creek (LPNWA), and Turkey Point Marsh, and Lyn Creek (Fisheries and Oceans Canada [DFO] 2011) and has been recently confirmed within coastal wetlands of Lake Ontario at the following locations: the Rouge River, Carruthers Creek, Lynde Creek, Pleasant Bay, East Lake and Wilton Creek/Hay Bay (Brumpton *et al.* 2013). Furthermore, in 2013, the species was also confirmed from Consecon Lake and the lower Trent River (eastern Lake Ontario drainage) as well as McGeachy Pond adjacent to Lake Erie near Rondeau Bay. It is unknown whether populations are present at Beaver Lake or in the Grand River. The largest and most studied population is that of the Lake St. Clair delta area, the only population for which a population size could be estimated (Table 2). The population of Lyn Creek, discovered in 2006, is smaller (Schueler 2012) and is thought to occupy an 8 km stretch of the creek. However, the size of this population is not currently known. Population size estimates are not yet available for the populations found in Cedar Creek (LPNWA) or Turkey Point Marsh, which were discovered in 2008 (J. Gilbert, MNRF, pers. comm. 2009). The area of occupancy of Eastern Pondmussel for the five populations (known to exist prior to 2011) is provided in Table 2; population estimates for six recently discovered populations within Lake Ontario wetlands, are not included due to limited data (i.e. a single collection site).

Table 2. Population estimates for Eastern Pondmussel populations known to exist in Canada prior to 2011*

Population	Average total unionid density (#/m^2) (SE)	Eastern Pondmussel density (#/m^2) (SE)	Eastern Pondmussel area of occupancy (m^2)	Eastern Pondmussel estimated population size
St. Clair River delta	0.079 (± 0.105)	0.008 (± 0.006)	17 540 000	48 521 – 242 513
Long Point Bay				
Cedar Creek (LPNWA)	NA	NA	793 236	NA
Turkey Point Marsh	NA	NA	525 498	NA
Grand River	NA	NA	15 621	NA
Beaver Lake	NA	NA	5 470 211	NA
Lyn Creek	NA	NA	211 154	NA

(Table reproduced from Bouvier and Morris 2011)

*Populations discovered recently within Lake Ontario and Lake Erie wetlands (2011–13) are not included.
NA – information not available

The population trend for the Eastern Pondmussel is believed to be declining (COSEWIC 2007; NatureServe 2012) as the species was nearly eliminated by dreissenid mussels in Ontario. Ninety percent of the historical Eastern Pondmussel records occur in areas that are now infested with dreissenid mussels. The Eastern Pondmussel was once one of the most common species in the shallower areas of the lower Great Lakes and connecting water channels; however, due to the dreissenid invasion in the late 1980s, the largest remaining population of the Eastern Pondmussel in Canada persists in the St. Clair River delta. Overall, this species appears to be widely distributed throughout the delta but sparse in numbers (COSEWIC 2007). Densities appear to be declining in this area; however, this is difficult to determine as this area was not surveyed prior to 1999 (COSEWIC 2007). Population trends for Lyn Creek, McGeachy Pond, Cedar Creek (LPNWA), Turkey Point Marsh and seven coastal wetlands of Lake Ontario are currently unknown.

Populations of Eastern Pondmussel were ranked by Bouvier and Morris (2011), with respect to abundance and trajectory; the same ranking method was applied to newly discovered populations in 2011–2012 with data from Brumpton et al. (2013) (Table 3). Population abundance and trajectory were then combined to determine the population status (Table 3). A certainty level was also assigned to the population status, which reflected the lowest level of certainty associated with either population abundance or trajectory. Refer to Bouvier and Morris (2011) for further details on the methodology.

Table 3. Abundance index, population trajectory, and population status of Eastern Pondmussel populations in Canada

Population	Abundance index	Certainty*	Population trajectory	Certainty*	Population status	Certainty**
Great Lakes and connecting channels (open waters)	Extirpated	2	-	-	Extirpated	2
St. Clair River delta	Medium	1	Unknown	3	Poor	3
McGeachy Pond	Low	2	Unknown	3	Poor	3
Long Point Bay	Low	2	Unknown	3	Poor	3
Grand River	Unknown	3	Unknown	3	Unknown	3
Rouge River	Low	2	Unknown	3	Poor	3
Carruthers Creek	Low	2	Unknown	3	Poor	3
Lynde Creek	Low	2	Unknown	3	Poor	3
Pleasant Bay	Low	2	Unknown	3	Poor	3
Consecon Lake	Low	2	Unknown	3	Poor	3
East Lake	Low	2	Unknown	3	Poor	3
Wilton Creek/Hay Bay	Low	2	Unknown	3	Poor	3
Trent River	Low	2	Unknown	3	Poor	3
Beaver Lake	Unknown	3	Unknown	3	Unknown	3
Lyn Creek	Low	3	Unknown	3	Poor	3

(Table modified from Bouvier and Morris 2011 and updated with data from Brumpton et al. 2013, S. Reid unpublished and T. Morris unpublished)

*Certainty associated with abundance index or population trajectory is listed as: 1=quantitative analysis; 2=standardized sampling; 3=expert opinion.

**Certainty for population status reflects the lowest level of certainty associated with either abundance index or population trajectory.

3.3 Needs of the Eastern Pondmussel

Habitat and biological needs

Spawning: The reproductive biology of the Eastern Pondmussel is similar to that of most unionid mussels (adapted from Clarke 1981, Kat 1984 and Watters 1999). During spawning, males release sperm into the water and females living downstream filter the sperm out of the water with their gills. Once the ova are fertilized they are held until they reach a larval stage called the glochidium. Eastern Pondmussel is bradytictic (long-term brooder) such that it spawns in late summer, broods the glochidia over the winter and subsequently releases the glochidia in early spring (COSEWIC 2007). The female mussel releases the glochidia, which must attach to an appropriate host fish.

Females of this species use a visual display to attract their host fish and thus water clarity may be important for successful reproduction. According to Corey and Strayer (2006), the female positions herself upright in the substrate, with the valves gaping and the mantle exposed. White papillae ripple up and down the mantle margin in an uninterrupted, synchronized rippling, the appearance of which resembles a swimming amphipod. Complete down and back motions along the mantle margin were observed. When a fish strikes at the lure, the female expels her glochidia, which facilitates the attachment of the glochidia to the gills of the fish. Further development to the juvenile stage cannot continue without a period of encystment on the host. The dependency of unionids, including the Eastern Pondmussel, on a host fish for development may be a limiting factor for many mussel populations as any changes that affect the host also affect the mussels.

Encysted glochidia stage: The glochidia become encysted on the host and develop, but do not grow. Attachment times for the Eastern Pondmussel range from 11 to 32 days (depending on temperature) until they metamorphose into juveniles (McNichols et al. 2008). To date, three hosts for the Eastern Pondmussel have been identified: Brook Stickleback (*Culaea inconstans*), Pumpkinseed (*Lepomis gibbosus*) and Yellow Perch (*Perca flavescens*) (McNichols et al. 2008). Lab experiments suggest that the Yellow Perch is the preferred host, yielding significantly more juveniles (McNichols et al. 2008).

Juvenile: After metamorphosis, juveniles release themselves from the host and fall to the substrate to begin life as free-living mussels. Juveniles of most species of freshwater mussels live completely buried in the substrate where they feed on similar foods obtained directly from the substrate or from interstitial water (Yeager et al. 1994; Gatenby et al. 1997). Juvenile mussels remain buried until they are sexually mature, at which point they move to the surface for the dispersal/intake of gametes (Watters et al. 2001).

Adult: The Eastern Pondmussel (like all freshwater mussels) is a sedentary animal that buries itself partially or completely in the substrates of rivers or lakes. It is characterized as a lake-species (Bouvier and Morris 2011). It occurs in sheltered areas of lakes, in slack-water areas of rivers and in canals (Metcalfe-Smith et al. 2005; COSEWIC 2007); such habitats are typically found in coastal wetlands within the lower Great Lakes. It prefers substrates of fine sand and mud at water depths ranging from 0.3 to 4.5 m (COSEWIC 2007). In rivers, Eastern Pondmussel is restricted to the lowermost reaches (Strayer 1983). In Ontario, the St. Clair River delta population is found on substrates composed of over 95% sand at the transition zone between the emergent wetlands and the open waters of Lake St. Clair (COSEWIC 2007). The habitat in Lyn Creek (Eastern Ontario) was described by Schueler (2008, 2012) as free of Zebra Mussels, in slow moving areas over sand, silt and clay beds. Eastern Pondmussel habitat in Long Point Bay has yet to be quantified (J. Gilbert, MNRF, pers. com. 2009).

Adult Eastern Pondmussel have very limited dispersal abilities. Although adult movement can be directed upstream or downstream, studies have found a net downstream movement through time (Balfour and Smock 1995). The primary means for large-scale dispersal, upstream movement, and the invasion of new habitat or evasion of deteriorating habitat, is limited to the encysted glochidial stage on the host fish.

Adult freshwater mussels are filter-feeders that obtain nourishment by siphoning particles of organic detritus, algae and bacteria from the water column and, as recently shown, sediments (Nichols et al. 2005).

Ecological role: Freshwater mussels play an integral role in the functioning of aquatic ecosystems including water column and sediment processes (Vaughn and Hakenkamp 2001). They are sensitive indicators of the health of freshwater ecosystems, including water and habitat quality and especially the fish community on which they depend for successful reproduction.

The Eastern Pondmussel was historically a significant component of the Great Lakes mussel fauna, being the fourth most common species in the lower Great Lakes and connecting channels prior to 1990 (COSEWIC 2007). It is reasonable to assume that this species contributed significantly to the function of unionid communities in the Great Lakes ecosystem prior to the dreissenid invasion. Mussels are also important prey for a few species including the muskrat (*Ondatra zibethicus*) (Neves and Odom 1989), which results in a transfer of energy from the aquatic to the terrestrial environment. This may specifically be the case of the Eastern Pondmussel populations in the St. Clair River delta and Long Point Bay as they are found in areas near the preferred habitat of muskrats (wetland areas with abundant emergent vegetation) (NatureServe 2012).

Limiting factors: Factors involving reproduction and dispersal may be contributing limiting factors for the Eastern Pondmussel. Availability of host fish suitable for glochidial attachment may inhibit unionid population growth and dispersal and the time frame for glochidia attachment to host fish may be very limited. Effectively, large-scale dispersal is limited to the encysted glochidial stage on the host fish. Predation by fishes, mammals and birds can threaten mussel populations and may be inhibiting Eastern Pondmussel populations.

Water temperatures can also greatly impact the fitness and survivorship of freshwater mussels. Although limited research has been conducted with respect to water temperature and Eastern Pondmussel ecology, such effects have been well documented for other similar freshwater mussel species. For example, higher water temperatures: can lead to increased respiration and greater metabolic activity and therefore, may be physiologically stressful to mussels (Huebner 1981); can lead to reduced dissolved oxygen levels (Huebner 1981); and can adversely affect or reduce the survival of larval glochidia (Pandolfo et al. 2010). Fluctuations in stream thermal regimes have also been documented to affect the production of gametes (Galbraith et al. 2009), and limit reproductive output (Heinricher, and Layzer 1999).

4. Threats

4.1 Threat assessment

Table 4, adapted from Bouvier and Morris (2011), provides a summary of threats to four Eastern Pondmussel populations in Canada that were known to exist prior to 2011. Although threats to six recently discovered populations (2011–12) in coastal wetlands of Lake Ontario have yet to be evaluated, a summary of suspected threats to these populations is included following Table 4; for populations detected in 2013, no attempt has yet been made to summarize threats to these locations (McGeachy Pond and Consecon Lake). Known and suspected threats in the table were ranked with respect to threat likelihood and threat impact for each population. The threat likelihood and threat impact were then combined to produce an overall threat status. A certainty level was also assigned to the overall threat status, which reflected the lowest level of certainty associated with either threat likelihood or threat impact. See Bouvier and Morris (2011) for further details. Additional information is provided in the threat descriptions which follow the table.

Table 4. Threat assessment table

Threat Level for all locations in Canada (known prior to 2011*) where it is believed that a population of Eastern Pondmussel may exist resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty assigned to each Threat Level, which relates to the level of certainty associated with Threat Impact. Certainty has been classified as: 1= causative studies; 2=correlative studies; and 3=expert opinion. Gray cells indicate that the threat is not applicable to the location due to the nature of the aquatic system. Clear cells do not necessarily represent a lack of a relationship between a location and a threat; rather, they indicate that either the Threat Likelihood or Threat Impact was Unknown.

Threat	St. Clair River Delta	Long Point Bay**	Grand River	Beaver Lake
Exotic species	High (2)	High (2)	Medium (2)	High (2)
Turbidity and sediment loading	Medium (3	Medium (3)	High (2)	Medium (3)
Contaminants and toxic substances	High (3)	Medium (3)	High (2)	Unknown (3)
Nutrient loading	Medium (3)	Medium (3)	High (2)	Unknown (3)
Altered flow regimes			Medium (2)	
Habitat removal and alterations	Medium (3)	Medium (3)	High (2)	Medium (3)
Fish hosts	Medium (3)	Medium (3)	Medium (3)	Medium (3)
Predation and harvesting	Low (3)	Low (3)	Low (3)	Low (3)
Recreational activities	Low (3)	Low (3)	Low (3)	Low (3)

(Table modified from Bouvier and Morris 2011)

*Threats to populations recently discovered within Lake Ontario and Erie wetlands (2011–13) were not assessed; threats for Lyn Creek were assessed by Bouvier and Morris (2011) but were determined to be unknown due to lack of information.

**Long Point Bay includes both Cedar Creek (LPNWA) and Turkey Point occurrences; threats to the species within the Cedar Creek (LPNWA) will tend to be lower, as this area is located away from any cultural activities (which might include the threats mentioned above) and also appears to be less impacted by Zebra Mussels.

Note: The Threat Level represents a combination of the **current** Threat Impact and Threat Likelihood at a location. It **does not** reflect the potential impact a threat might have on a freshwater mussel population if it was allowed to occur in the future.

Although threats to recently discovered populations of Eastern Pondmussel within Lake Ontario wetlands have not been evaluated, some general comments on suspected threats at these six locations can be made. For several coastal wetland locations within Lake Ontario, some level of Zebra Mussel infestation was noted (Brumpton et al. 2013), thus the threat from this exotic species may be fairly high to these small populations. All coastal wetland locations are also likely to be effected to some degree by water level and flow alteration due to the influence of water level fluctuations within Lake Ontario. The three estuary wetlands (Rouge River, Carruthers Creek and Lynde Creek), occur within fairly urbanized watersheds and are likely susceptible to sediment loading, toxic substances (e.g., chloride) and nutrient loading. This is not the case for East Lake and Pleasant Bay where such threats would be less of a concern. The Wilton Creek/Hay Bay location, however may be susceptible to nutrient loading as this watershed is largely agricultural (S. Hogg, MNRF, pers. comm.). Further encroachment by development within the occupied areas of the Rouge River, Carruthers Creek, Lynde Creek and Wilton Creek/Hay Bay is unlikely as these areas are protected through their classification as provincially significant. Threats to populations detected in 2013 (McGeachy Pond, Consecon Lake and Trent River) have yet to be assessed, although dreissenid mussels are known to be present in Consecon Lake and may represent the greatest threat at this location; at McGeachy Pond, the presence of the Asiatic Clam (*Corbicula fluminea*) has been known since 2007 and may represent a potential threat to the population of Eastern Pondmussel.

Description of threats

The following brief descriptions emphasize the principal threats currently acting on Eastern Pondmussel populations throughout Ontario. Much of the information has been summarized from Bouvier and Morris (2011).

Exotic species: Zebra Mussel have decimated populations of freshwater mussels in the Lower Great Lakes by virtually eliminating historical habitat (Schloesser and Nalepa 1994; Nalepa et al. 1996). Over 90% of historical records for the Eastern Pondmussel – the most for any species of unionid in Canada – are from areas now infested with Zebra Mussel and are thus uninhabitable. Dreissenid mussels continue to threaten and limit the distribution of this species in the St. Clair River delta, Long Point Bay and coastal wetlands of Lake Ontario. Zebra Mussel have been shown to colonize unionids in large numbers and this has many negative effects on the unionids. The individual can no longer open and close its valves, which can limit movement, feeding and reproduction, and also increases the risk of predation and parasitism (Schloesser et al. 1996; Baker and Hornbach 1997). Due to the increased weight of Zebra Mussel on the unionid, the individual may become immobilized or dislodged and not have the ability to burrow back into the sediment. In addition, valves of unionids can become deformed via the tension created by the Zebra Mussel byssal threads (Schloesser et al. 1996). The Zebra Mussel has been shown to directly reduce available food sources in the water column due to its siphoning ability (Mackie 1991). The attachment of the Zebra Mussel can also directly prevent a unionid from feeding and reproducing by covering its siphons.

The results of an unpublished study on the impacts of Zebra Mussel on five species of native mussels in Lake St. Clair indicated that Eastern Pondmussel had the lowest rate of survival, and carried the heaviest load of Zebra Mussel relative to their size (COSEWIC 2007). Despite heavy infestations with Zebra Mussel in East Lake and nearby Consecon Lake and an apparent loss of live unionids, of any species, in 2005 and 2006 (COSEWIC 2007; Bouvier and Morris 2011), recent sampling has confirmed the existence of live Eastern Pondmussel in low numbers at both locations as well as within five other coastal wetlands of Lake Ontario (Brumpton et al. 2013). Although infestation rates may vary, Zebra Mussels remain a threat to all populations within coastal wetlands of Lake Ontario.

It is unlikely that Zebra Mussels could be introduced into the Lyn Creek drainage as the only standing waterbodies in the system are two small, wetland-surrounded ponds (Lambs Pond south of New Dublin and Lees Pond north of Lillies) with no boat access (BMNHC 2006). Standing waterbodies are required for successful dispersal of Zebra Mussel because it allows them to form a “source” population, where reproduction can occur; Zebra Mussel larvae (i.e.

veligers) must remain in the water column for several weeks to complete their development before settling. Natural dispersal of Zebra Mussel is passive and generally occurs downstream of the adult population during the larval stage via water currents. If there is no source population, Zebra Mussel cannot extend their populations downstream (Claudi and Mackie 1994). However, upstream movement of dreissenids is due largely to human activities. For example, Zebra Mussel can attach to boat bottoms, be transported in ballast water or bait buckets and be easily moved from one lake to another (Claudi and Mackie 1994). This is unlikely in Lyn Creek, as there is no boat access. In contrast, freshwater mussel populations in the Grand River are highly susceptible to Zebra Mussel, as the Grand River is heavily impounded. Infestation by Zebra Mussel of the Luther, Belwood, Guelph, or Conestogo reservoirs could have a significant impact on the freshwater mussel populations (Bouvier and Morris 2011).

Turbidity and sediment loading: High silt inputs can act to suffocate mussels by clogging gill structures and may also disrupt reproductive functions by decreasing the likelihood of encountering a suitable host fish (visual predators). Susceptibility to siltation varies from species to species and freshwater mussels have been shown to be only mildly tolerant of high silt conditions during periods of low flow (Dennis 1984).

In the Grand River, increased agricultural pressure (from 68% in 1976 to 75% in 1998) has affected water quality, resulting in increased turbidity and sediment loads; however, the effects of this increase will more greatly affect species found in the lower Grand River (WQB 1989; Bouvier and Morris 2011; COSEWIC 2006a), such as the Mapleleaf and Eastern Pondmussel. The presence of a low head dam near the mouth of the river at Dunnville is also known to contribute to degraded, turbid conditions within the lower 30 km reaches of the Grand River.

The St. Clair River delta, as a result of its protection through the Walpole Island First Nation territory (e.g., access restrictions), Lyn Creek, which is surrounded by relatively undisturbed habitat, and Cedar Creek (LPNWA), which is located in the Long Point NWA, are considered areas less at risk from this threat (Bouvier and Morris 2011). Of the recently confirmed locations within coastal wetlands of Lake Ontario, those part of estuary systems are likely impacted to some degree by sediment loading and turbidity (e.g., Rouge River, Carruthers Creek, Lynde Creek and Wilton Creek/Hay Bay).

Contaminants and toxic substances: The life history characteristics of freshwater mussels make them particularly sensitive to increased levels of sediment contamination and water pollution. Mussels are primarily filter feeders, while juveniles remain buried in the sediment feeding on particles associated with the sediment; in both cases filter feeding increases exposure to water and sediment-born contaminants. The glochidial stage appears to be particularly sensitive to heavy metals (Kellar and Zam 1990), ammonia (Mummert et al. 2003; Augspurger et al. 2003), acidity (Huebner and Pynnonen 1992), and salinity (Gillis 2011).

Gillis (2011) has shown that glochidia of the Wavyrayed Lampmussel (*Lampsilis fasciola*) were acutely sensitive to sodium chloride. Assuming that the salt sensitivity of the Eastern Pondmussel is comparable to that of the Wavyrayed Lampmussel, because their range is limited to southern Ontario, Canada's most road-dense and thus heavily salted region, chloride from road salt is a substantial threat to the early life stages. While natural water does buffer the toxic effects of chloride to the glochidia, chloride levels in mussel habitat have been reported at levels (>1300 mg/L) that are toxic to the Wavyrayed Lampmussel (Gillis 2011). Although federal water quality guidelines for the protection of aquatic life have been set at 120 mg/L for chronic exposure to chloride, this guideline may not be sufficiently protective of glochidia of some species at risk mussels in southern Ontario (CCME 2011). Further work by Todd and Kaltenecker (2012) suggest that long-term road salt use is contributing to increases in baseline chloride concentrations in at risk mussel habitats in southern Ontario that may affect recruitment of at-risk mussel populations.

The area surrounding the St. Clair River delta is clean and clear. The habitat of the Eastern Pondmussel in Lyn Creek appears to be of high quality with clear water and is relatively undisturbed as the lands adjacent to Lyn Creek are generally privately owned, and there are no bridges or settlements along the stretch of river where Eastern Pondmussel have been observed. Pollution is considered to be a low threat for the Lyn Creek population; however, due to the sensitivity of mussels to contaminants, water quality should be monitored. The areas in Long Point Bay where Eastern Pondmussel populations are found also appear to be have good water quality (J. Gilbert, MNRF, pers. comm. 2009).

In the Grand River, Mackie (1996) reported that anthropogenic stressors (e.g., sewage pollution) occurring below urban centres, were responsible for much of the harm to the freshwater mussel assemblage. The Grand River watershed has a population of approximately 780 000 people and is expected to increase by nearly 40% over the next 20 years (GRCA 1998; COSEWIC 2006a). Wastewater discharge is a major input in these urban areas and will only increase relative to population growth. A recent study that assessed the cumulative impacts of urban runoff and municipal wastewater effluent on freshwater mussels in the Grand River concluded that chronic exposure to multiple contaminants (e.g., ammonia, chloride and metals such Cu, Pb, and Zn) contributed to the decline of mussel populations in this watershed (Gillis 2012); the author also confirmed this negative impact through a follow up (unpublished) study which revealed the existence of a 'dead zone' immediately downstream of one wastewater treatment plant outfall near Kitchener where no live mussels were detected for several kilometers (P. Gillis, Environment and Climate Change Canada, pers. comm).

Nutrient loading: The primary concern of nutrient loadings for freshwater mussels relates to eutrophication effects, namely algal blooms that can result in oxygen depletion and algal toxins. A negative correlation was found between concentrations of phosphorus and nitrogen and Wavyrayed Lampmussel (*Lampsilis fasciola*) abundance in a variety of southwestern Ontario streams (Morris et al. 2008).

With the exception of the Grand River, where the threat level for this threat is considered high for Eastern Pondmussel due to agricultural activities, this threat is assigned a level of medium (unknown for Beaver Lake) (Table 4).

Altered flow regimes: Damming of the stream channel has been shown to detrimentally affect mussels in many ways. Reservoirs alter downstream flow patterns and disrupt the natural thermal profiles of the watercourse while impoundments act as physical barriers, potentially separating mussels from their host fish(es). Evidence has linked mussel extinction to construction and operation of dams in multiple rivers (Theler 1987; Layzer et al. 1993). Impoundments also act to increase water retention times, thereby making river systems more susceptible to invasion of invasive species, such as dreissenid mussels, and to changes in species composition, based on habitat changes. High flow conditions may result in dislodgement of adults and disruption of larval forms, while low flow can lead to low dissolved oxygen, silt accumulation, elevated temperatures and, at the extreme, desiccation. Freshwater mussels are particularly vulnerable to reductions in water depth as they are frequently found in very shallow water (10–20 cm) (Metcalfe-Smith et al. 2007). A significant negative correlation between mean annual stream flow and growth of a variety of freshwater mussel species has been demonstrated (Rypel et al. 2008), indicating the profound role impoundments and artificial flow manipulation may have on freshwater mussel assemblages. In contrast, it should be noted that dams/barriers constructed in the past, in wetland areas, can be beneficial for habitat enhancement by separating the unmanageable harm from off-site impacts (e.g., sedimentation or nutrient loading, invasive species etc.).

Habitat removal and alterations: Destruction of habitat through dredging, ditching, and other forms of channelization may compromise this species. River channel modifications, such as dredging, can result in the direct destruction of mussel habitat and lead to siltation and sand accumulation of local and downstream mussel beds. The construction of impoundments can lead to the fragmentation of habitat, altered water levels, habitat conversion, and the clearing of riparian zones, resulting in the loss of cover, increased rates of siltation and thermal shifts. These are all factors that can be deleterious to the Eastern Pondmussel survival in areas under development.

Fish hosts: Any factors that directly or indirectly affect host fish abundances and distributions may impact Eastern Pondmussel distributions. Unionids cannot complete their life cycle without access to the appropriate glochidial host. If host fish populations disappear or decline in abundance to levels below that which can sustain a mussel population, recruitment will no longer occur and the mussel species may become functionally extinct (functionally extinct in this case is defined as a population that is no longer viable, as a crucial part of their life cycle [in this case the host fish] has been removed) (Bogan 1993). Currently, lab experiments suggest that Yellow Perch is the preferred host for the Eastern Pondmussel (followed by Brook Stickleback and Pumpkinseed). Once functional host relationships have been confirmed in the field, follow-up studies on the host fish populations would then need to be completed to determine if access to glochidial hosts is a limiting factor for this mussel species in Ontario. Introduction of exotic species that may cause a decline in the host fish(es) may indirectly affect Eastern Pondmussel populations. For example, the introduction of the Round Goby (*Neogobius melanostomus*), has been shown to have negative effects on certain species of fish (e.g., Dubs and Corkum 1996); however, whether or not the Round Goby affects the host fish(es) of the Eastern Pondmussel is unknown.

Predation and harvesting: Freshwater mussels are known to be food sources for a variety of mammals and fishes (Fuller 1974). Predation of juvenile mussels by Common Carp have the potential to impact populations of Eastern Pondmussel, due to their high population densities within some coastal wetland habitats; the exclusion of Common Carp has also been used to facilitate wetland restoration within coastal marshes such as Coote's Paradise and could contribute to the recovery of the Eastern Pondmussel (Schueler 2012). Predation by muskrats in particular may be a limiting factor for the Eastern Pondmussel in the St. Clair River delta, and those of Long Point Bay because wetland areas with abundant emergent vegetation are the preferred habitat for muskrats (NatureServe 2012). Tyrrell and Hornbach (1998) are among those who have shown that muskrats are both size- and species-selective in their foraging, and can therefore significantly affect both the size structure and species composition of mussel communities. There have been several studies of muskrat predation on freshwater mussels (Neves and Odom 1989; Tyrell and Hornbach 1998), but these studies were not conducted in areas likely to support populations of the Eastern Pondmussel. However, since muskrats and the Eastern Pondmussel are found in very similar habitats in Ontario, there is an increased likelihood of predator/prey interactions which supports further study.

Harvesting mussels for human consumption could be a potential concern; however, to date, there are no reports of the harvest of Eastern Pondmussel for human consumption (Bouvier and

Morris 2011). Poaching of unionid mussels is suspected but unknown in its intensity or occurrence.

Recreational activities: Recreational activities that may impact mussel beds include (Bouvier and Morris 2011):

- Driving all-terrain vehicles (ATVs) through river beds
- Propellers on recreational boats and jet skis – propeller channels have been noted through the mussel beds in the St. Clair River delta
- Paddling action disturbance (kayaks, etc.) of the mussel bed

Metcalfe-Smith et al. (2000) observed that paddlers in shallow water often disturbed the riverbed creating the potential for dislodging mussels and promoting downstream transport. Increasing popularity of recreational activities such as canoeing may further increase stresses on unstable populations. Mehlhop and Vaughn (1994) found that “recreational activities” were contributing to the decline in many species of native freshwater mussels.

Climate change: Impacts of climate change on remaining populations of Eastern Pondmussel and other unionids in the Great Lakes are likely to be severe. The potential impact of climate variability and change on the Great Lakes ecosystem is a topic of considerable research effort at present. Although a clear warming trend is indicated, the climate models are variable. Likely responses of the Great Lakes to climate variability and change are discussed in an Environment and Climate Change Canada report on threats to water availability in Canada (Environment and Climate Change Canada 2004). According to one model, net basin supply (precipitation plus runoff minus evaporation) to the lower lakes shows large decreases, with Lake St. Clair showing a dramatic decrease. Other simulations show decreases or even slight increases, but there is general agreement that climate warming will cause lake levels to drop. Impacts of lower lake levels on remnant unionid communities clinging to survival in the shallow (1.5 m or less) “flats” area of the St. Clair River delta are likely to be significant. If the flats dry up, these communities would either be lost entirely or the mussels would move out of the flats and into deeper water where they would encounter high densities of Zebra Mussel and suffer high mortality rates (COSEWIC 2007). According to J. Gilbert (MNRF), a decrease in Lake Erie water levels would have a large, negative impact on the Eastern Pondmussel populations. Similar impacts would be expected to populations within coastal wetlands of Lake Ontario if water levels declined significantly.

5. Population and distribution objectives

The long-term recovery goal (> 20 years) is to prevent the extirpation of the Eastern Pondmussel in Canada and to promote its recovery by:

1. Protecting existing populations to prevent further declines
2. Restoring degraded populations to healthy self-sustaining levels by improving the extent and quality of habitat (where feasible)
3. Repatriating the Eastern Pondmussel in historically occupied habitats (where feasible), excluding areas where dreissenids have now made habitats unsuitable.

Given that much of the Great Lakes and its connecting channels have been devastated by the introduction of dreissenid mussels, these areas no longer provide suitable habitat for freshwater mussels (DFO 2011a). With the exception of some occupied coastal wetlands, these areas are currently excluded from the recovery goal for the Eastern Pondmussel; repatriating this species to the these areas of the Great Lakes is not currently feasible. If in the future it is determined that the restoration of suitable habitats in these locations is possible, the recovery goal will be revisited.

The population and distribution objectives for the Eastern Pondmussel are to return or maintain self-sustaining populations in the following locations where live animals currently exist:

1. St. Clair River delta
2. Long Point Bay - Cedar Creek (LPNWA) and Turkey Point Marsh
3. Rouge River
4. Carruthers Creek
5. Lynde Creek
6. Consecon Lake
7. Pleasant Bay
8. East Lake
9. Wilton Creek/Hay Bay
10. Lyn Creek
11. McGeachy Pond
12. Trent River

The populations at these locations could be considered recovered when they demonstrate active signs of reproduction and recruitment throughout their distribution in each location such that populations are stable or increasing. In addition, threats at these locations would need to be reduced to ‘low’. For example, dreissenid mussels would need to be absent or present at densities that do not threaten pondmussel populations. More quantifiable objectives will be developed once necessary surveys and studies have been completed.

Rationale: Very little is known about the Eastern Pondmussel and much information is required before the population and distribution objectives can be refined. Knowledge of population demographics (extent, abundance, trajectories and targets) is currently limited, remaining populations are small, and new populations continue to be discovered in coastal wetland areas of Lake Erie and Lake Ontario. Note that locations where live animals have not been recently confirmed (1996–present) have been excluded from the population and distribution objectives (e.g., Grand River, Beaver Lake).

6. Broad strategies and recovery actions

Recommended scale for recovery: Currently, a single-species recovery strategy and action plan (rather than one that takes a multi-species or ecosystem-based approach) is best suited for the Eastern Pondmussel. Its current range and distribution overlaps very little with other mussel species at risk found throughout southern Ontario. The Eastern Pondmussel population found in the St. Clair River delta is within the range of the existing draft Walpole Island Ecosystem Recovery Strategy (Walpole Island Heritage Centre 2002) and may receive some benefit from the implementation of this multi-species initiative.

6.1 Actions already completed or currently underway

Actions that are underway include surveys (for estimating abundance as well as presence), host fish identification experiments and genetic studies. Surveys for unionids, including the Eastern Pondmussel, in Lake St. Clair have been underway since 1997 (COSEWIC 2007). Information on the recently discovered populations are limited. Host fish identification experiments have begun at the University of Guelph, where three (*) of six fish species (Rock Bass [*Ambloplites rupestris*], Logperch [*Percina caprodes*], Johnny Darter [*Etheostoma nigrum*], Brook Stickleback*, Pumpkinseed*, and Yellow Perch*) examined produced Eastern Pondmussel juveniles (McNichols *et al.* 2008). The Eastern Pondmussel was included in a recent study investigating the evolution of active host-attraction strategies in freshwater mussels. Zanatta and Murphy (2006) found that the Eastern Pondmussel was more closely related to members of *Potamilus* and *Leptodea* genera than that of *Ligumia*. They therefore concluded that the Eastern Pondmussel should be reclassified into an existing or newly described genus.

6.2 Recovery and action planning

Three broad strategies were recommended to address threats to the species and meet the population and distribution objectives: 1) Research and Monitoring; 2) Management and Coordination; and 3) Communication and Outreach. Approaches are identified for each of the broad strategies. These approaches or activities are further divided into numbered recovery measures with priority ranking (high, medium, low), identification of the threat addressed and associated timeline (tables 5 and 6). Table 5 provides the implementation schedule for recovery measures led by DFO; Table 6 includes collaborative recovery measures undertaken jointly by DFO and its partners. More detailed narrative for recovery measures is included after the tables (Section 6.3). It should be noted that the activities identified in tables 5 & 6 meet the requirements of SARA, subsection 49(1)(d) - i.e. activities needed to address threats to the species, meet the population and distribution objectives or address monitoring requirements.

Implementation of these measures will be accomplished in coordination with relevant ecosystem-based recovery teams and other organizations. Of the broad strategies, higher priority will generally be given to the recovery measures identified for research and monitoring, as these data will be used to inform the other two strategies (i.e. Management and Coordination and Communication and Outreach).

Table 5. Implementation schedule: measures for the recovery of Eastern Pondmussel, to be led by Fisheries and Oceans Canada

#	Recovery measures	Priority	Threats addressed	Timeline*
Broad strategy: research and monitoring				
	Approach: research and monitoring - inventory			
1(a)	Conduct further surveys within the historical distribution of the Eastern Pondmussel to detect new populations (focus on historical records and unsampled coastal wetlands); determine extent and abundance of any new populations detected.	High	All	2016–2017
1(b)	Conduct intensive surveys to quantify distribution and abundance of extant populations with emphasis on newly discovered populations.	High	All	2016–2018
	Approach: research - habitat requirements			
2	Determine habitat requirements of all life stages of the Eastern Pondmussel.	High	All	2017–2019
	Approach: monitoring - host fish populations			
3(a)	Identify/confirm functional host fish species for Eastern Pondmussel.	Medium	Disruption of fish host	2016–2018
3(b)	Determine distribution and abundance of the identified host species.	Medium	Disruption of fish host	2018–2019
	Approach: monitoring - populations and habitat			
4(a)	Develop a mussel monitoring standard specific to lake and wetland habitats to be used in routine surveys to track changes in mussel populations.	High	All threats	2017–2018
4(b)	Establish routine quantitative surveys to monitor changes in the distribution and abundance of extant Eastern Pondmussel populations and exotic species in the area.	High	Exotic species	2018–2020
4(c)	Establish stations to monitor changes to Eastern Pondmussel habitat. This monitoring will complement and be integrated into the routine population surveys.	High	All habitat threats	2018–2020

(cont'd)

Table 5 (cont'd). Implementation schedule: measures for the recovery of Eastern Pondmussel, to be led by Fisheries and Oceans Canada

#	Recovery measures	Priority	Threats addressed	Timeline*
	Approach: monitoring/threat evaluation – exotic species monitoring			
5	Monitor the distribution and abundance of Zebra Mussel within currently occupied habitats (e.g., critical habitat areas). Quantify infestation rates for live mussels that are present and determine upstream limit of Zebra Mussels within tributaries of the lower Great Lakes occupied by Eastern Pondmussel.	High	Exotic species	2017–2019
	Approach: research - threat evaluation			
6(a)	Determine glochidia and juvenile sensitivity to environmental contaminants that populations of Eastern Pondmussel may be exposed to.	High	Changes in water quality	2018–2019
6(b)	Evaluate threats to habitat for all extant populations to guide local stewardship programs to improve conditions within critical habitat and other occupied habitats.	High	All threats	2016–2018
	Approach: research – feasibility of repatriation, population augmentation			
7(a)	Determine if existing populations should be augmented or repatriated into historical habitat.	High	Exotic species, disruption of host fish relationships	2018–2019
7(b)	Develop and implement genetically sound propagation guidelines for freshwater mussels.	High	Exotic species, disruption of fish host relationships	2018–2019

(cont'd)

Table 5 (cont'd). Implementation schedule: measures for the recovery of Eastern Pondmussel, to be led by Fisheries and Oceans Canada

#	Recovery measures	Priority	Threats addressed	Timeline*
Broad strategy: management and coordination				
	Approach: coordination of activities			
8	Promote and enhance expertise in freshwater mussel identification, biology, ecology, and conservation.	Medium	All	On-going
9(a)	Work with the recovery teams and relevant groups (e.g., conservation authorities and stewardship groups) to aid in implementation of all recovery actions.	High	All	On-going
Broad strategy: communication and outreach				
	Approach: communication and outreach			
12(a)	Mussel identification workshop that incorporates identification, biology, ecology, threats, and conservation of freshwater mussel species in Ontario over a two-day workshop.	High	All	On-going
12(b)	Encourage public support and participation in mussel recovery by developing awareness materials and programs. Will encourage participation in local stewardship programs to improve and protect habitat for Eastern Pondmussel.	Medium	All	2016–2019

*Timelines are subject to change in response to demands on resources and/or personnel and as new priorities arise.

Table 6. Collaborative recovery measures for Eastern Pondmussel, to be undertaken jointly by Fisheries and Oceans Canada, its partners, volunteer agencies, organizations and individuals

#	Recovery measures	Priority	Threats addressed	Timeline (short-, medium- or long-term)	Potential Partnerships*
Broad strategy: management and coordination					
	Approach: coordination of activities				
9(b)	Implement local stewardship programs to improve habitat conditions and reduce threats within critical habitat and other occupied habitats. Priorities and mitigation approaches to be informed through threat evaluation research.	High	All	Long term	Conservation Authorities
10(a)	Develop an implementation plan to respond to the direct threat of Zebra Mussel on vulnerable populations of Eastern Pondmussel in Lake St. Clair, Lake Erie and Lake Ontario.	High	All	Medium	Walpole Island First Nation, Conservation Authorities
10(b)	Work with municipal planning authorities so that they consider the protection of critical habitat for the Eastern Pondmussel within official plans.	High	All	Medium – Long term	Municipal and County Planning Departments, Conservation Ontario
10(c)	Investigate the integration of Eastern Pondmussel recovery and protection into existing watershed plans (particularly for areas subject to urban expansion within the Greater Toronto Area; e.g., Rouge River Watershed Plan). Threat evaluation research to inform priorities for individual populations at the watershed scale.	Medium	All	Medium	Conservation Authorities
10(d)	Support the development and implementation of legislation and policies at all levels of government that will aid in the protection of existing populations and enhance recovery of those populations.	Medium	All	Long term	All levels of government

(cont'd)

Table 6 (cont'd). Collaborative recovery measures for Eastern Pondmussel, to be undertaken jointly by Fisheries and Oceans Canada, its partners, volunteer agencies, organizations and individuals

#	Recovery measures	Priority	Threats addressed	Timeline Short-, medium-, or long-term	Potential Partnerships*
Broad strategy: communication and outreach					
	Approach: communication and outreach				
11(a)	Development of an overall communications plan to increase awareness and support for the protection and recovery of the Eastern Pondmussel. This communications plan will provide direction and coordination for all communications and outreach activities related to the species.	Medium	All	Medium	Conservation Authorities
11(b)	Once the host relationship has been confirmed in the field: Increase awareness within the angling community about the importance of the Yellow Perch (and other hosts as they are identified) as a host for the Eastern Pondmussel.	Low	Disruption of fish host relationships	Medium	Conservation Authorities, Angling groups
11(c)	Increase public awareness of the potential impacts of transporting/releasing exotic species (including baitfish).	High	Exotic species, disruption of fish host relationships	Medium – Long term	MNRF, Ontario Federation of Anglers and Hunters

*Conservation Authorities may include one or more of the following organizations that cover watersheds where Eastern Pondmussel currently occur: Lower Thames Region Conservation Authority, Long Point Region Conservation Authority, Toronto Region Conservation Authority, Central Lake Ontario Conservation Authority, Quinte Region Conservation Authority and Cataraqui Region Conservation Authority.

6.3 Narrative to support the recovery planning and implementation tables

1 (a-b): Further surveys are required to confirm the current distribution and abundance of the Eastern Pondmussel in Canada. All known extant populations require further sampling effort as most are represented by only one or a few sample locations without density information; similarly, additional sampling effort is required to detect new populations in areas with the greatest potential for harbouring undetected individuals (e.g., coastal wetland habitats of lakes Erie, Ontario or St. Clair with low dreissenid densities). Sampling methods to determine density and demographic information need to be quantitative and could be informed by the work of Metcalfe-Smith *et al.* (2007). A thorough understanding of all extant populations is necessary for the refinement of critical habitat as well as to inform effective recovery actions.

2: One of the key gaps in understanding the habitat requirements for this species relate to the early life – including spawning and fertilization, encysted glochidial as well as juvenile life stages. Research to better understand the differences in habitat for these life stages will help further refine the identification of critical habitat. The identification of critical habitat is a legal requirement under SARA and is one of the best tools for conserving Eastern Pondmussel populations.

3 (a–b): To determine if the Eastern Pondmussel is host limited, it is necessary to confirm the functional host fish(es) and then determine their distributions. The identification of host specificity in some mussel species requires that hosts be identified for local populations wherever possible. Once the Canadian host(s) have been identified, it is necessary to determine the distribution, abundance, and health of the host species.

4 (a–c) and 5: A network of monitoring stations should be established throughout the current range of the Eastern Pondmussel similar to that developed for freshwater mussels within the Sydenham River (Metcalfe-Smith *et al.* 2007). Mussel monitoring methods need to be developed that are specific to lake and wetland habitats where Eastern Pondmussels are found (current methods focus on riverine habitats). The results of the monitoring program will allow for assessment of the progress made towards achieving the recovery objectives/goals. Monitoring sites should be established in a manner so as to permit:

- Quantitative tracking of changes in mussel abundance and demographics (size, age, sex), or that of their hosts;
- Detailed analysis of habitat use and the ability to track changes in the use or availability; and,
- The ability to detect exotic species - monitoring stations should be set up in areas where there is a likely source location for establishment of dreissenids (e.g., reservoirs) to permit early detection of the invasive species. Monitoring of exotics in the St. Clair River delta, Cedar Creek (LPNWA) and elsewhere, will be conducted in close association with the managed refuge sites.

6(a): Some initial research has been completed on selected contaminants for early life stages of freshwater mussels – including chloride, ammonia and copper. However further work is required that is specific to the Eastern Pondmussel.

6(b): Although some preliminary work has been done on evaluating threats for some populations (refer to Section 4), little is known regarding threats to other populations (for example for recently discovered populations found along the Lake Ontario shoreline). More comprehensive threat evaluations for all extant populations will help inform stewardship programs to ensure the most efficient and effective use of limited resources while promoting an 'ecosystem approach' when warranted.

7 (a–b): Additional surveys may show that without direct intervention, some populations are unlikely to persist. One intervention may be to augment existing populations with individuals from a nearby stable population or by stocking with artificially reared juveniles. Research into the feasibility of augmentation for Canadian populations of Eastern Pondmussel has begun with the establishment of laboratory rearing procedures but should also include the identification of genetically suitable stocks for source populations.

8: Expertise in freshwater mussel identification, distribution, life history, and genetics is limited to a small number of biologists in Ontario. This capacity could be increased by training personnel (both within government as well as non-government organizations and First Nations groups with a conservation focus) and encouraging graduate and post-graduate research directed towards the conservation of freshwater mussels. Such efforts would enhance partnering opportunities to implement recovery measures for freshwater mussels.

9: Many of the threats affecting Eastern Pondmussel populations are similar to those that affect other aquatic species. Therefore, efforts to remediate these threats should be done in close connection with other recovery teams and relevant groups to eliminate duplication of efforts. Once threats have been evaluated for extant populations, the results will inform local stewardship programs for threat mitigation. As with other mussels, measures to improve habitat for the Eastern Pondmussel may include stewardship actions involving Best Management Practices (BMPs) for agricultural properties (Agriculture Canada and OMAFRA 1992–2011) and residential properties (School of Environmental Design and Rural Development 2007) within the catchment areas of the critical habitat identified.

10(a): If exotic species (Zebra Mussel or fish species that may affect the host fish[es]) are detected via routine monitoring practices, a coordinated plan should ensure a quick response. Dreissenid mussels in the St. Clair River delta and Long Point Bay cannot be eliminated; however, their presence in the delta can be monitored to determine if their numbers are increasing or decreasing. It is unlikely that dreissenid mussels will affect the Eastern Pondmussel population in Lyn Creek as there are only two standing waterbodies in the system (wetland surrounded ponds) with no boat access (BMNHC 2006). However, exotic fishes may impact the host fish relationship if they become established.

11 (a–c): A communications plan to increase awareness and support for the protection and recovery of the Eastern Pondmussel will provide overall direction for all outreach activities (such as 11(b) below).

Based on current research, the most likely preferred and functional host of the Eastern Pondmussel is the Yellow Perch (this species produced a significantly higher number of juvenile mussels than did Brook Stickleback and Pumpkinseed in lab studies). Outreach activities should be directed at promoting non-destructive sport-fisheries at locations and times when Yellow Perch may be infested with Eastern Pondmussel glochidia (March to

July); commercial and recreational fisheries are known to be sustainably managed by the MNRF and are currently not known to impede recovery of the Eastern Pondmussel. Other outreach activities that benefit the Eastern Pondmussel include the privately run BMNHC mussel identification course held in Eastern Ontario where several populations occur.

12 (a–b): Increasing freshwater mussel knowledge and identification can be assisted though the development of awareness material, such as the *Photo Field Guide to the Freshwater Mussels of Ontario* (Metcalfe-Smith et al. 2005) and the recently completed identification "app" - *Canadian Freshwater Mussel Guide* now available for free download from iTunes. In addition, an annual, hands-on mussel identification workshop is offered by DFO to government, agency, non-government organizations, Aboriginal peoples and the public. Increased public knowledge and understanding of the importance of the Eastern Pondmussel, and mussels in general, will play a key role in the recovery of this species.

7. Critical habitat

7.1 General identification of critical habitat for the Eastern Pondmussel

The identification of critical habitat for Threatened and Endangered species (on Schedule 1) is a requirement of the SARA. Once identified, SARA includes provisions to prevent the destruction of critical habitat. Critical habitat is defined under section 2(1) of SARA as:

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

SARA defines habitat for aquatic species at risk as:

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

Critical habitat for the Eastern Pondmussel has been identified to the extent possible, using the best information currently available. The critical habitat identified in this recovery strategy describes the geospatial areas that contain the habitat necessary for the survival or recovery of the species. The current areas identified may be insufficient to achieve the population and distribution objectives for the species. As such, a schedule of studies has been included to further refine the description of critical habitat (in terms of its biophysical functions/features/attributes as well as its spatial extent) to support its protection.

7.2 Information and methods used to identify critical habitat

Using the best available information, critical habitat has been identified using a 'bounding box' approach for extant populations of Eastern Pondmussel in Long Point Bay, Rouge River, Carruthers Creek, Lynde Creek, Consecon Lake, Pleasant Bay, East Lake, Wilton Creek/Hay

Bay, Lyn Creek and McGeachy Pond; additional areas of potential critical habitat within the St. Clair River delta region will be considered in collaboration with Walpole Island First Nation.

This approach requires the use of essential functions, features, and attributes for each life stage of this species to identify patches of critical habitat within the 'bounding box', which is defined by occupancy data for the species. Life stage habitat information was summarized in chart form using available data and studies referred to in Sections 3.3 (Habitat and biological needs). The 'bounding box' approach was the most appropriate, given the limited information available for this species and the lack of detailed habitat mapping for these areas. This approach and the methods used to identify reaches of critical habitat are consistent with the approaches recommended by DFO (2011b) for freshwater mussels.

Within Lyn Creek, an ecological classification system was used in the identification of critical habitat. The MNRF's Aquatic Landscape Inventory System (ALIS version 1) (Stanfield and Kuyvenhoven 2005) was used as the base unit for defining reaches within riverine systems. The ALIS system employs a valley classification approach to define river segments with similar habitat and continuity on the basis of hydrography, surficial geology, slope, position, upstream drainage area, climate, landcover and the presence of instream barriers, all of which are believed to have a controlling effect on the biotic and physical processes within the catchment. Therefore, if the species has been found in one part of the ecological classification, it would be reasonable to expect that it would be present in other spatially contiguous areas of the same valley segment. Within all identified river segments (i.e., valley segments), the width of the habitat zone is defined as the area from the mid-channel point to bankfull width on both the left and right banks. Critical habitat for the Eastern Pondmussel in Lyn Creek was therefore identified as the reach of river that includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present; segments or reaches were excluded only when supported by robust data indicating species absence and/or unsuitable habitat conditions. Current occupancy for this species was defined by recent records of live individuals (and/or fresh shells) from 1996 onward; this is the point in time when systematic surveys of freshwater mussel communities in southern Ontario began. Unoccupied ALIS segments with suitable habitats were also included when limited sampling had occurred (i.e., the species was assumed to be present). Within Lyn Creek, a short reach of river upstream of the occupied ALIS segment was included as critical habitat; beyond this point a small waterfall blocks upstream movement.

Within lacustrine waters, critical habitat was identified, based on the 'bounding box' approach and refined using: 1) National Oceanic and Atmospheric Administration (NOAA) bathymetry data; and 2) MNRF's provincial wetland mapping (Wetland Unit data from Land Information Ontario [LIO] (2011)). For the Long Point Bay locations, the NOAA 1 m depth contour was used to delineate the area within which critical habitat is found as all records were contained within this shallow region of the outer bay. Locations where provincial wetland mapping was directly used in the delineation include the Rouge River, Carruthers Creek, Lynde Creek, Pleasant Bay and Wilton Creek/Hay Bay. For these more confined locations, the critical habitat extent was identified as all contiguous wetland polygons identified as either marsh or open water; areas classified as treed wetlands (i.e. swamp) were excluded. For more information on the provincial wetland classification, refer to LIO (2011). For coastal wetlands directly influenced by lake levels, high-water mark elevations above sea level were also used (International Great Lakes Datum 1985) to help incorporate annual variability in water levels.

7.3 Identification of critical habitat: biophysical function, features and their attributes

Table 7 summarizes the limited available knowledge of the functions, features and attributes for each life stage of the Eastern Pondmussel (refer to Section 3.3 Needs of the Eastern Pondmussel for full references). Areas within which critical habitat is found must be capable of supporting one or more of these habitat functions. *Note that not all attributes in Table 7 must be present for a feature to be identified as critical habitat.* If the features as described in Table 7 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table. All attributes may be used to help inform management decisions for the recovery and/or protection of habitat.

Table 7. Essential functions, features, and attributes of critical habitat for each life stage of the Eastern Pondmussel (lacustrine and riverine populations)

Life stage	Function	Feature(s)	Attribute(s)*

Spawning and fertilization (time period unknown)
 	
Bradytictic (long-term brooder) such that it spawns in late summer, broods the glochidia over the winter and subsequently releases the glochidia in early spring.
	Reproduction	Sheltered areas (e.g., wetlands) of lakes, in slack-water areas of streams and channels with sand, silt, mud and/or clay substrates present.	• Attributes assumed to be same as for adults (see below)
			• Contaminants levels below the following thresholds:
			  • Long-term chloride levels < 120 mg/L – (CCME 2011)
			  • Mean concentrations of < 0.3 mg/L total ammonia as N at pH 8; for protection of all life stages of freshwater mussels (Augspurger et al. 2003)
			• Copper levels < 3 µg/L (CCME 2005) should protect sensitive glochidia (Gillis et al. 2008).

Encysted glochidial stage (up to 89 days, depending on temperature) on host fish until drop off (March – July)	Development on host for encystment	Same as above with host fish(es) present	• Attributes assumed to be same as for adults (see below) • Presence of host fish(es) (e.g., Yellow Perch, Brook Stickleback and Pumpkinseed). • Clear water (for attracting host) • Dissolved oxygen (DO) levels sufficient to support host (DO > 47% saturation at temperatures from 0–25°C; PWQO [1994] for protection of warmwater species) • Summertime water temperatures reach ~27°C (range unknown) for successful development
Adult/Juvenile	Feeding Cover	Sheltered areas (e.g., wetlands) of lakes, in slack-water areas of streams and channels with sand, silt, mud and/or clay substrates present	• Adequate water level (sufficient to prevent stranding and increased predation) • Supply of food (plankton: bacterial, algae, organic detritus, protozoans) • Dreissenids absent or in low abundance • Maintenance of an "environmental thermal regime"** (gamete production and development)

*Note that not all attributes must be present for a feature to be identified as critical habitat.

**Maintenance of an 'environmental thermal regime' requires that water temperatures are maintained within the limits of natural variability (daily or seasonal) such that lifecycle processes are completed without impacting the fitness of the organism.

Studies to further refine knowledge on the essential functions, features and attributes for various life stages of the Eastern Pondmussel are described in Section 7.5 (Schedule of studies to identify critical habitat).

7.4 Identification of critical habitat: geospatial

Using the best available information, critical habitat has been identified for Eastern Pondmussel populations in the following waterbodies:

1. Long Point Bay: Cedar Creek (LPNWA) and Turkey Point Marsh
2. Rouge River
3. Carruthers Creek
4. Lynde Creek
5. Consecon Lake
6. Pleasant Bay
7. East Lake
8. Wilton Creek/Hay Bay
9. Lyn Creek (including Golden Creek)
10. McGeachy Pond

The areas delineated on the following maps (Figures 3 to 11) represent the extent of critical habitat that can be identified at this time (July 2013). Additional areas of potential critical habitat within the Lake St. Clair/Walpole Island area will be considered in collaboration with Walpole Island First Nation. Note that for riverine areas delineated (e.g., Lyn Creek), the entire 'bankfull' channel is included (e.g., from the top of the riverbank on one side of the channel to the top of the riverbank on the other); this supports long-term channel forming discharges important in maintaining in-stream habitat conditions required by freshwater mussels. For lacustrine populations, habitats extending up to the annual high water mark are included. *Using the 'bounding box' approach, critical habitat is not comprised of all areas within the identified boundaries, but only those areas where biophysical features/attributes are present and are capable of supporting one or more habitat functions* (refer to Table 7). *Note that permanent anthropogenic structures that may be present within the delineated areas (e.g., marinas, navigation channels) are specifically excluded; it is understood that maintenance or replacement of these features may be required at times.* Brief explanations for the areas within which critical habitat is found are provided below.

Table 8 below provides the geographic coordinates that situate the boundaries within which critical habitat is found for the Eastern Pondmussel; these points are indicated in Figures 3 to 11.

Table 8. Coordinates locating the boundaries within which critical habitat is found for the Eastern Pondmussel*

	Coordinates† locating areas of critical habitat				
Location (species)	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**
Long Point Bay Cedar Creek (LPNWA)	80° 9' 18.708" W 42° 36' 17.663" N	42° 33' 1.012" N 80° 2' 24.730" W	42° 30' 52.981" N 80° 7' 44.866" W	42° 33' 38.369" N 80° 16' 59.554" W	
Long Point Bay (Turkey Point Marsh	42° 40' 5.802" N 80° 20' 20.536" W	42° 39' 49.720" N 80° 23' 39.220" W			
Rouge River	43° 48' 0.289" N 79° 7' 48.321" W	43° 47' 55.676" N 79° 7' 2.997" W	43° 47' 24.054" N 79° 7' 13.896" W	43° 47' 46.825" N 79° 7' 54.644" W	
Carruthers Creek	43° 50' 3.654" N 78° 59' 53.486" W	43° 49' 51.746" N 78° 58' 56.377" W	43° 49' 37.362" N 78° 58' 57.114" W	43° 49' 38.648" N 78° 59' 18.797" W	43° 49' 58.402" N 78° 59' 59.262" W
Lynde Creek	43° 51' 16.189" N 78° 58' 33.335" W	43° 51' 55.866" N 78° 57' 25.539" W	43° 50' 43.262" N 78° 56' 52.383" W	43° 50' 40.686" N 78° 57' 17.294" W	
Consecon Lake	44° 0' 3.347" N 77° 31' 23.944" W	44° 1' 17.357" N 77° 25' 23.245" W	44° 0' 29.606" N 77° 24' 44.875" W	43° 59' 0.705" N 77° 31' 13.906" W	
Pleasant Bay	77° 31' 27.335" W 43° 56' 47.635" N	77° 29' 17.525" W 43° 58' 2.696" N	77° 28' 39.895" W 43° 57' 23.486" N	77° 30' 33.804" W 43° 56' 4.836" N	
East Lake	77° 14' 17.737" W 43° 54' 38.764" N	77° 9' 38.868" W 43° 57' 7.220" N	77° 9' 11.911" W 43° 56' 17.756" N	77° 12' 35.215" W 43° 53' 7.991" N	
Wilton Creek/Hay Bay	44° 9' 14.321" N 76° 58' 30.303" W	44° 9' 32.357" N 76° 54' 57.658" W			
Lyn Creek (including Golden Creek)	44° 35' 4.885" N 75° 45' 46.373" W	44° 31' 4.857" N 75° 48' 35.353" W			
McGeachy Pond	42° 15' 56.471" N 81° 56' 46.845" W	42° 15' 47.197" N 81° 57' 5.725" W	42° 15' 45.089" N 81° 56' 27.223" W		

*Riverine habitats are delineated to the midpoint of channel of the uppermost stream segment(s) and lowermost stream segment.
†All coordinates obtained using map datum NAD 83

Long Point Bay

Cedar Creek (LPNWA): The area within which critical habitat is found has been identified as the contiguous waters and wetlands of the outer portions of Long Point Bay which includes the National Wildlife Area (Long Point Unit) and is bounded by Sawlog Ridge to the west. This area extends from the high-water mark down to the 1 m depth contour (Figure 3a). The high-water mark elevation for Lake Erie is 174.62 m above sea level (International Great Lakes Datum 1985) and may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Erie.

Turkey Point Marsh: The area within which critical habitat is found has been identified as the contiguous waters and wetlands south of the dyke (P1) and is bounded by the marina near St Williams to the west (P2) (Figure 3b). This area extends from the high-water mark down to the 1 m depth contour. The high-water mark elevation for Lake Erie is 174.62 m above sea level (International Great Lakes Datum 1985) and may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Erie.

Rouge River: The area within which critical habitat is found has been identified as all contiguous waters and wetlands (marsh and open water classes) of the Rouge River estuary up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). This includes all occasionally exposed lands lying between the high-water mark and the water's edge of the Rouge River wetland and which may vary with water level fluctuations in Lake Ontario (Figure 4). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario.

Carruthers Creek: The area within which critical habitat is found has been identified as all contiguous waters and wetlands (marsh and open water classes) of the Carruthers Creek estuary up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). This includes all occasionally exposed lands lying between the high-water mark and the water's edge of the Carruthers Creek wetland and which may vary with water level fluctuations in Lake Ontario (Figure 5). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario.

Lynde Creek: The area within which critical habitat is found has been identified as all contiguous waters and wetlands (marsh and open water classes) of the Lynde Creek estuary up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). This includes all occasionally exposed lands lying between the high-water mark and the water's edge of the Lynde Creek wetland and which may vary with water level fluctuations in Lake Ontario (Figure 6). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario.

Consecon Lake: The area within which critical habitat is found has been identified as all contiguous waters and wetlands of Consecon Lake (Figure 7), up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario.

Pleasant Bay: The area within which critical habitat is found has been identified as all contiguous waters and wetlands of Pleasant Bay up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). This includes all occasionally exposed lands lying between the high-water mark and the water's edge of the Pleasant Bay wetland and which may vary with water level fluctuations in Lake Ontario (Figure 7). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario.

East Lake: The area within which critical habitat is found has been identified as all contiguous waters and wetlands of East Lake (Figure 8), up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario. The area within which critical habitat is found for East Lake includes the creek that flows into East Lake from downstream of Highway 10.

Wilton Creek (Hay Bay): The area within which critical habitat is found has been identified as all contiguous marsh and open water classes of the Wilton Creek wetland of inner Hay Bay and up to the high-water mark elevation for Lake Ontario at 75.32 m above sea level (International Great Lakes Datum 1985). This includes all occasionally exposed lands lying between the high-water mark and the water's edge of the Wilton Creek wetland and which may vary with water level fluctuations in Lake Ontario (Figure 9). The high-water mark may extend to areas that are dry due to low water levels and may extend higher where coastal wetlands exist and habitat function is connected to Lake Ontario.

Lyn Creek (including Golden Creek): The area within which critical habitat is found in Lyn Creek is currently identified as the reach from a point approximately 200 m downstream of the highway 401 bridge upstream to the beginning of the rocky, higher gradient reach just downstream of the waterfall on the Golden Creek tributary just east of the town of Lyn (Figure 10). This critical habitat description includes the entire 'bankfull' channel and represents a total reach of approximately 8 km in length.

McGeachy Pond: The area within which critical habitat is found has been identified as all contiguous waters and wetlands of McGeachy Pond (Figure 11), a small body of water located approximately 1 km west of the town of Erieau on Rondeau Bay. This includes habitat areas up to the high-water mark (seasonally wetted) and may extend to areas that are dry due to low water levels.

Note: Areas of critical habitat identified at these locations may overlap with critical habitat identified for other co-occurring species at risk (e.g., Eastern Sand Darter [*Ammocrypta pellucida*] and Pugnose Shiner [*Notropis anogenus*]); however, the specific habitat requirements within these areas may vary by species.

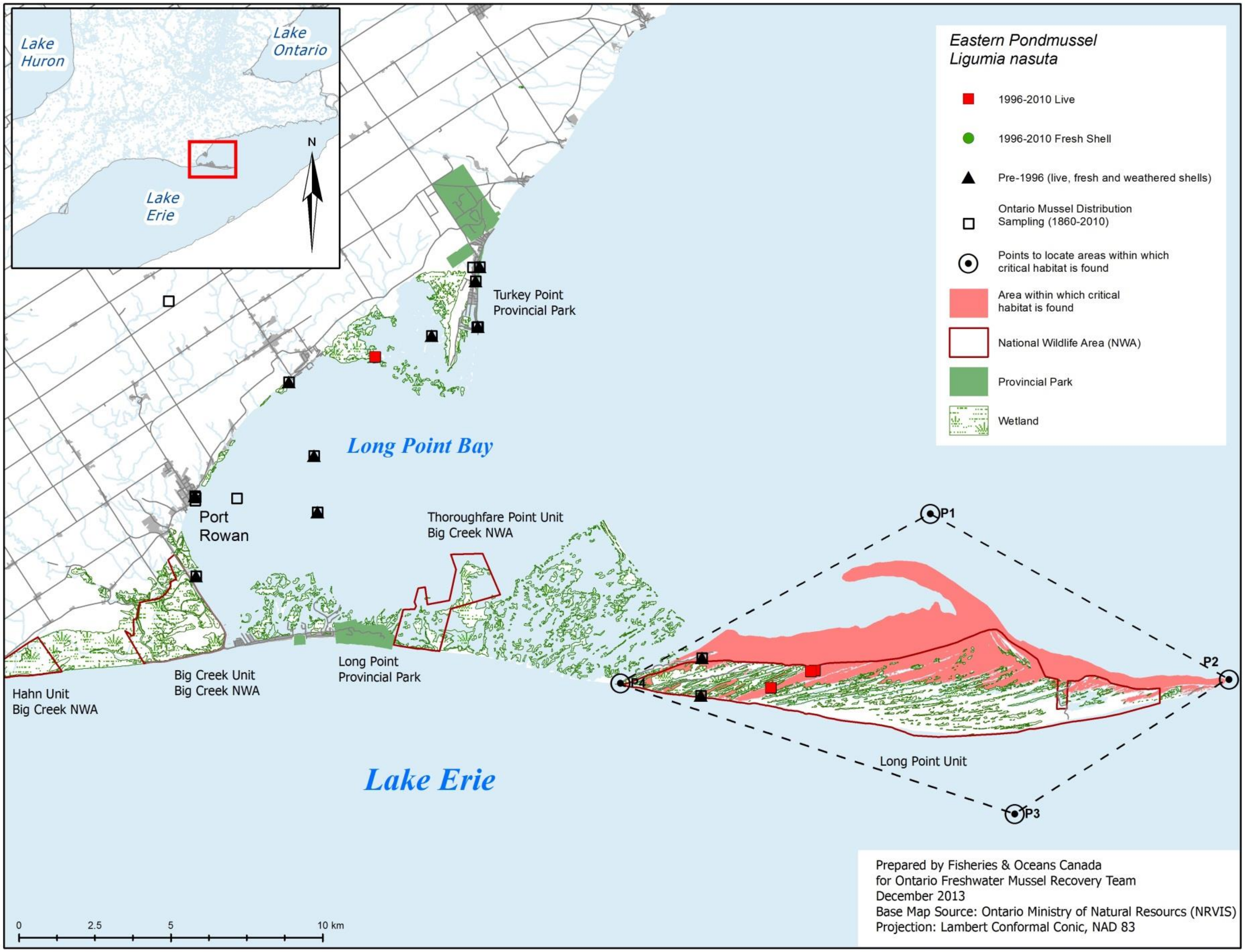

Figure 3(a). Area within which critical habitat is identified for the Eastern Pondmussel in Cedar Creek (LPNWA).

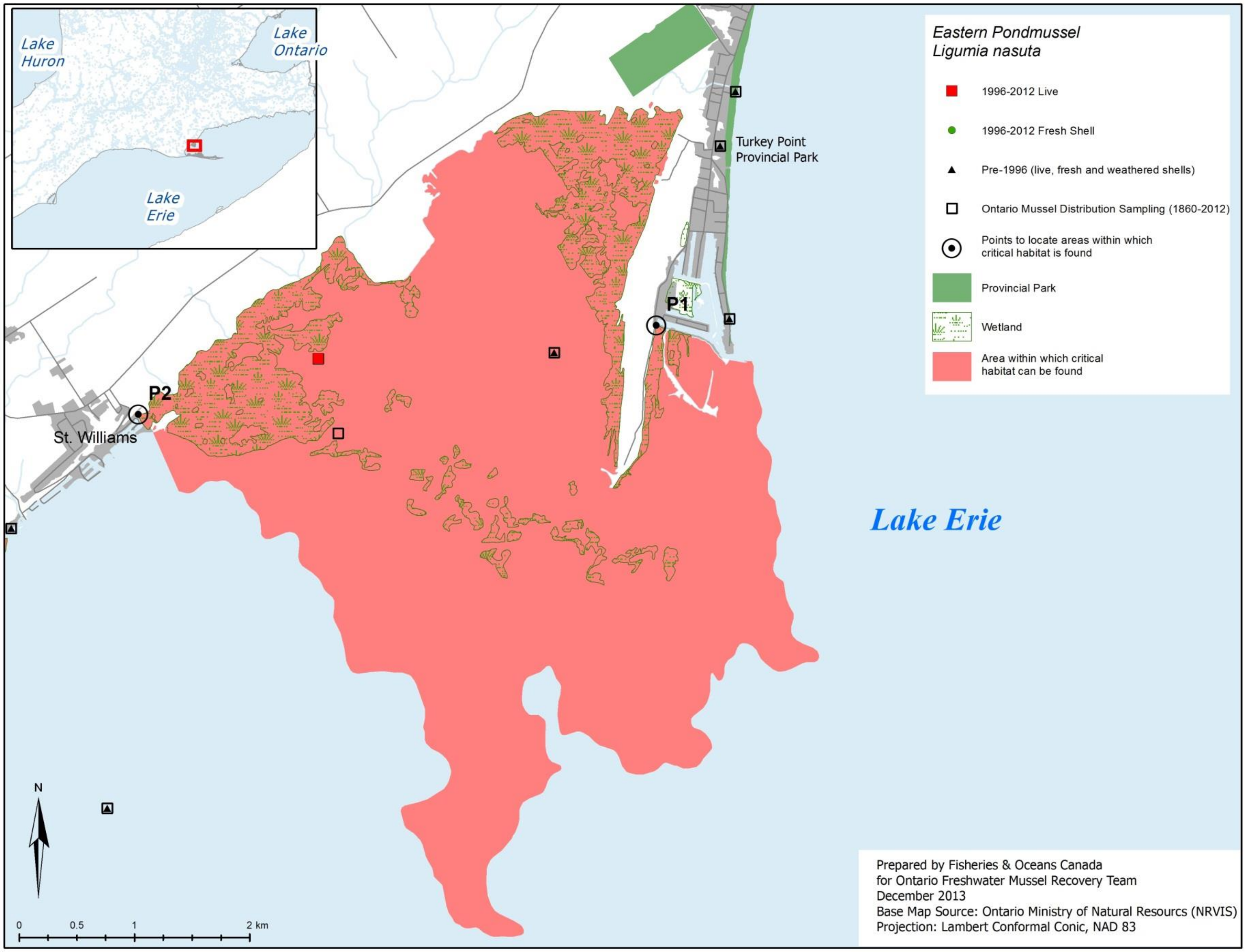

Figure 3(b). Area within which critical habitat is identified for the Eastern Pondmussel in Turkey Point Marsh.

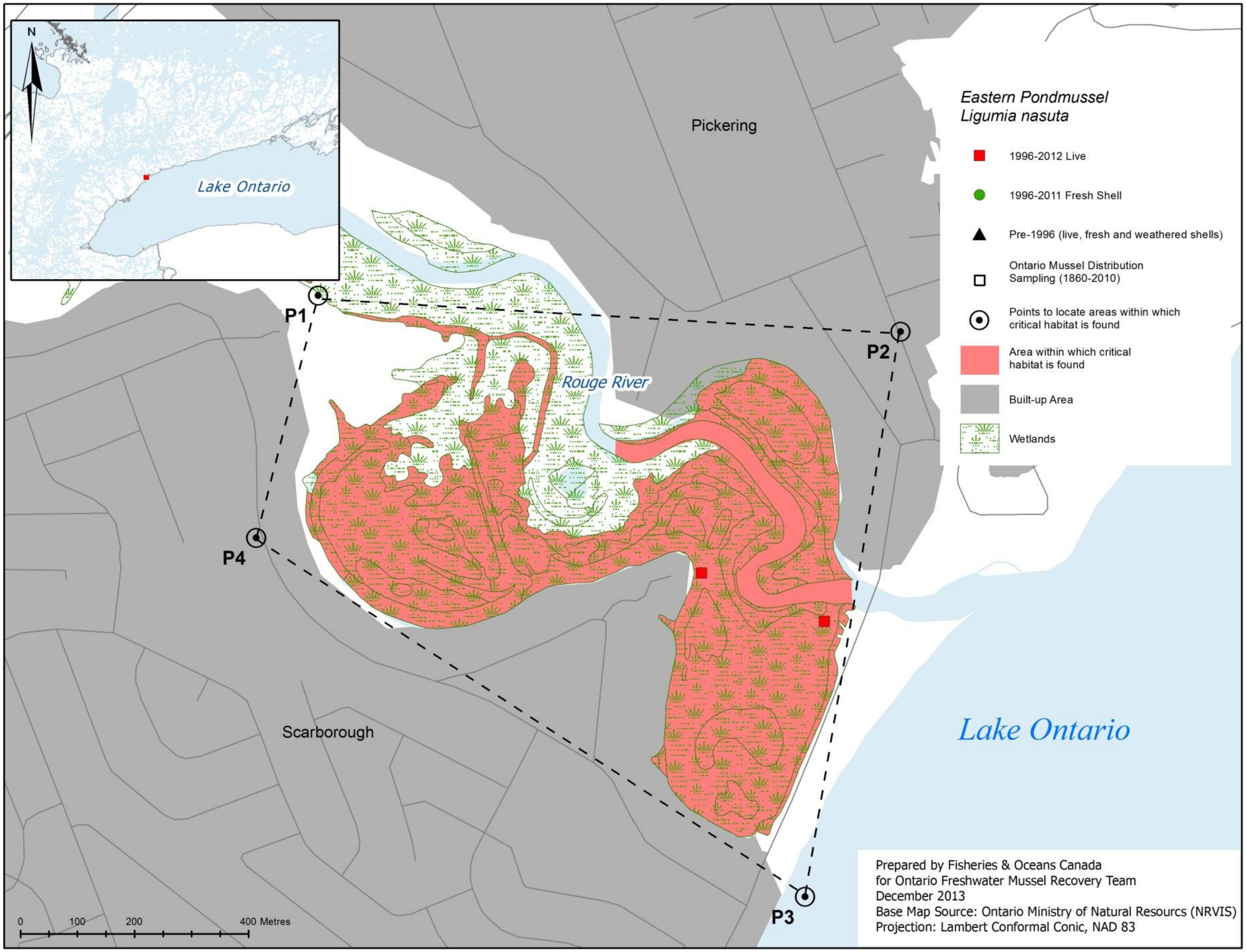

Figure 4. Area within which critical habitat is identified for the Eastern Pondmussel in the Rouge River.

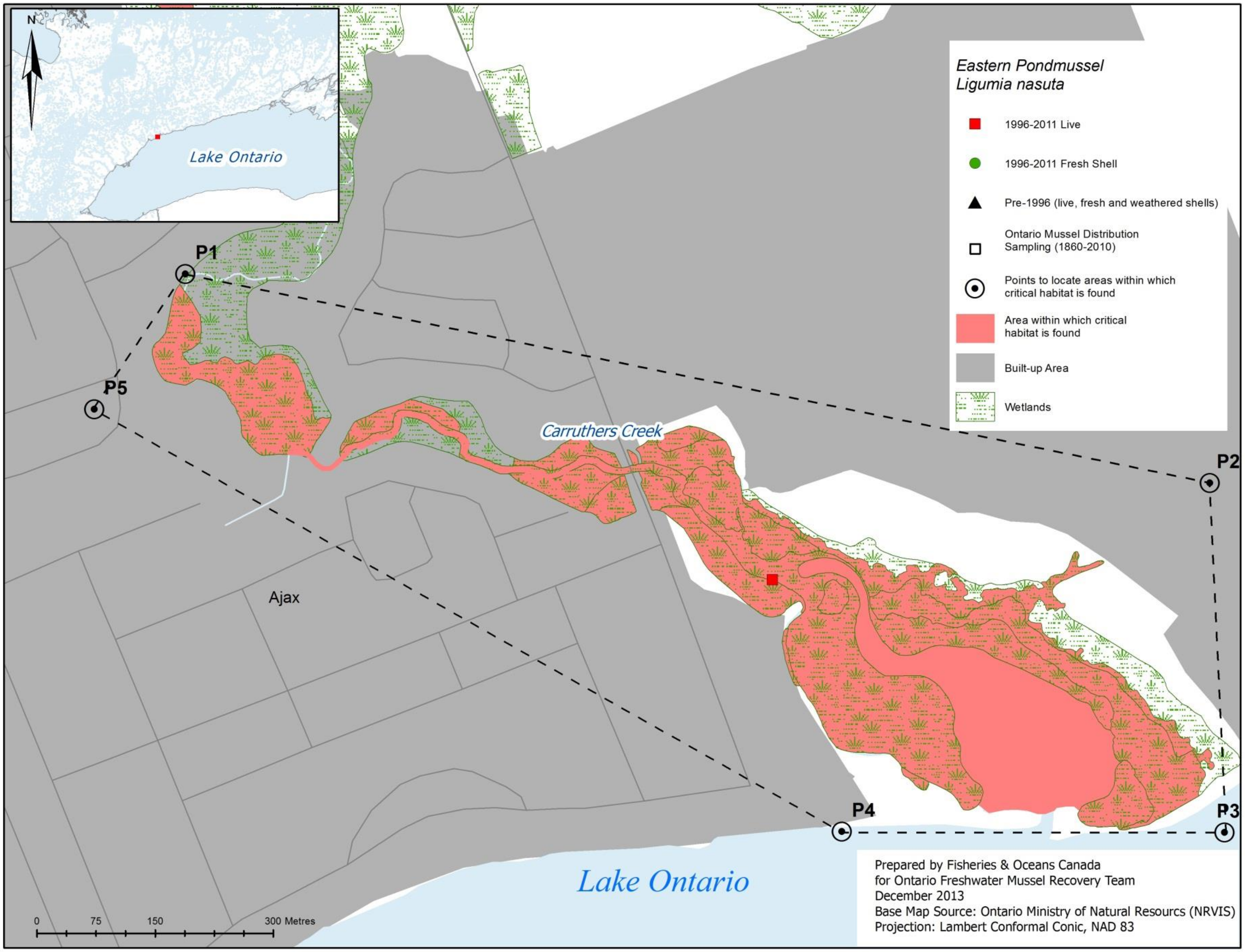

Figure 5. Area within which critical habitat is identified for the Eastern Pondmussel in Carruthers Creek.

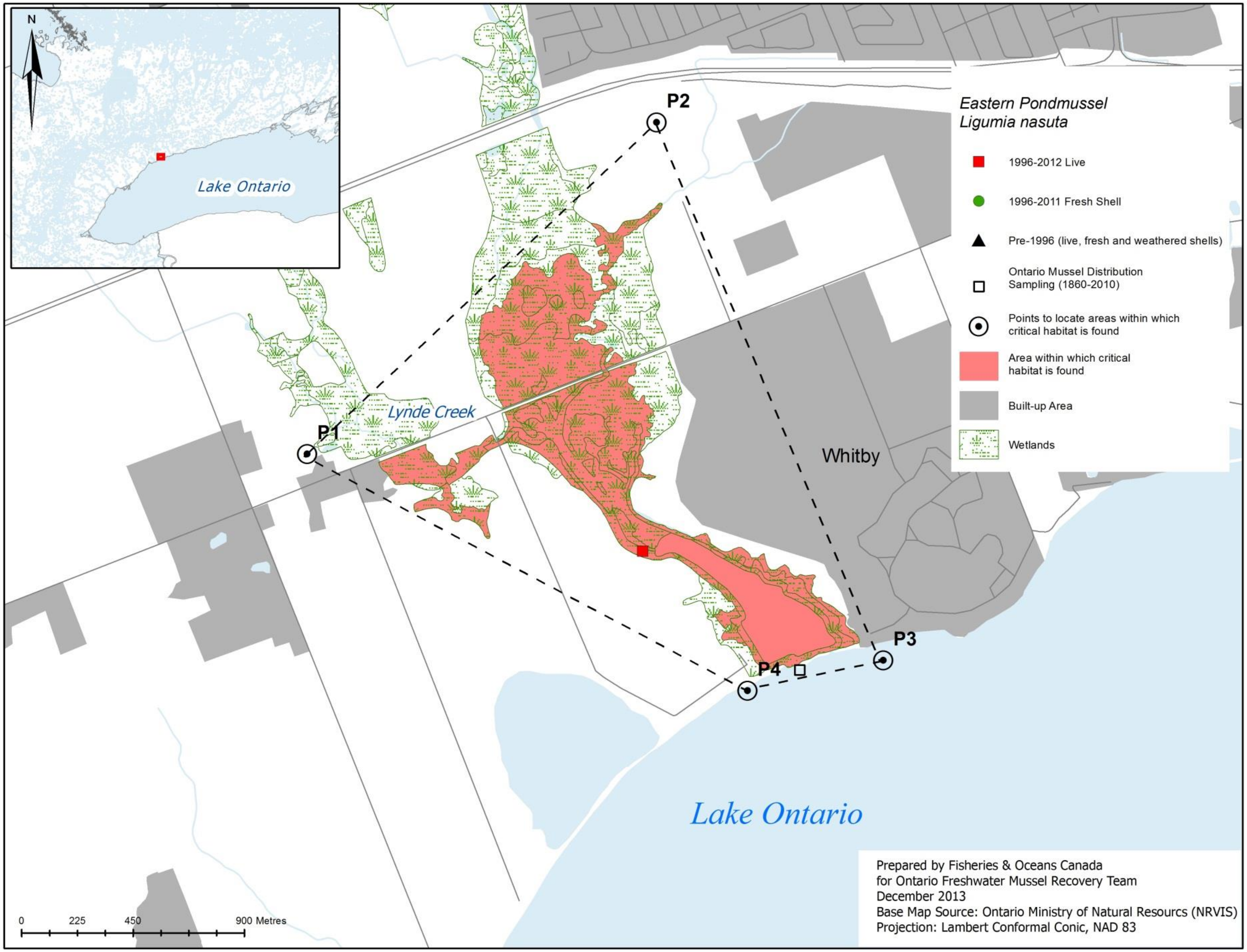

Figure 6. Area within which critical habitat is identified for the Eastern Pondmussel in Lynde Creek.

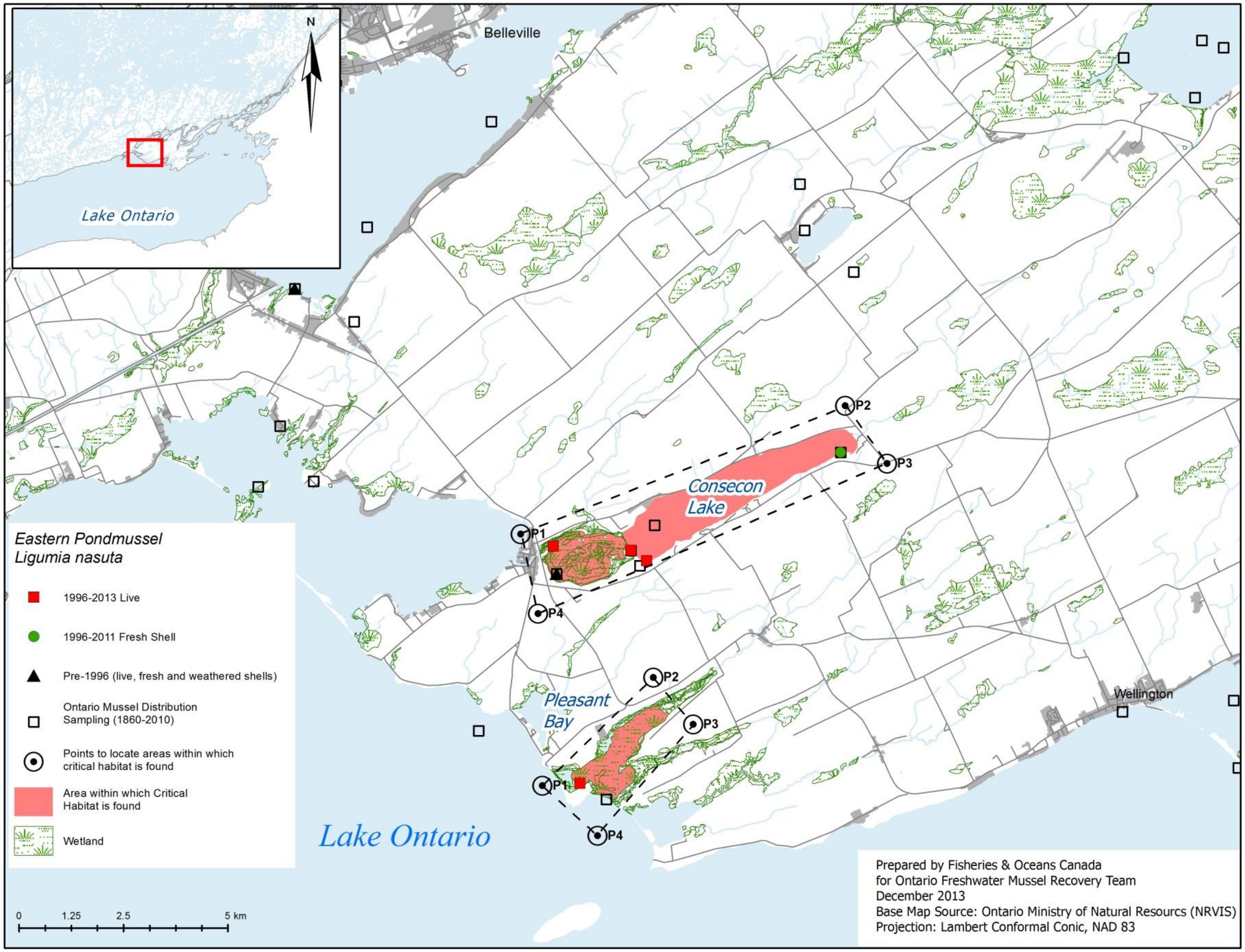

Figure 7. Area within which critical habitat is identified for the Eastern Pondmussel in Consecon Lake and Pleasant Bay.

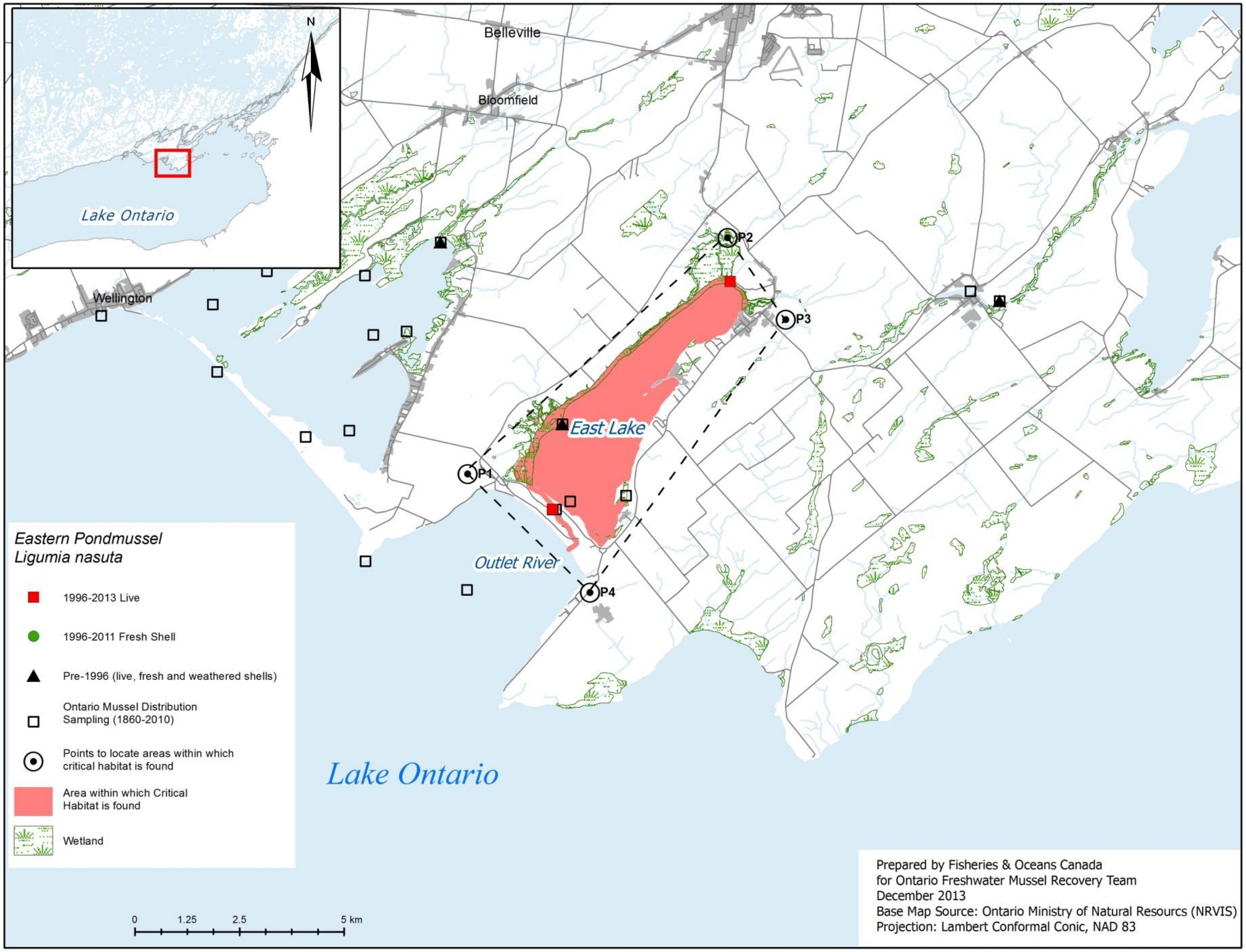

Figure 8. Area within which critical habitat is identified for the Eastern Pondmussel in East Lake.

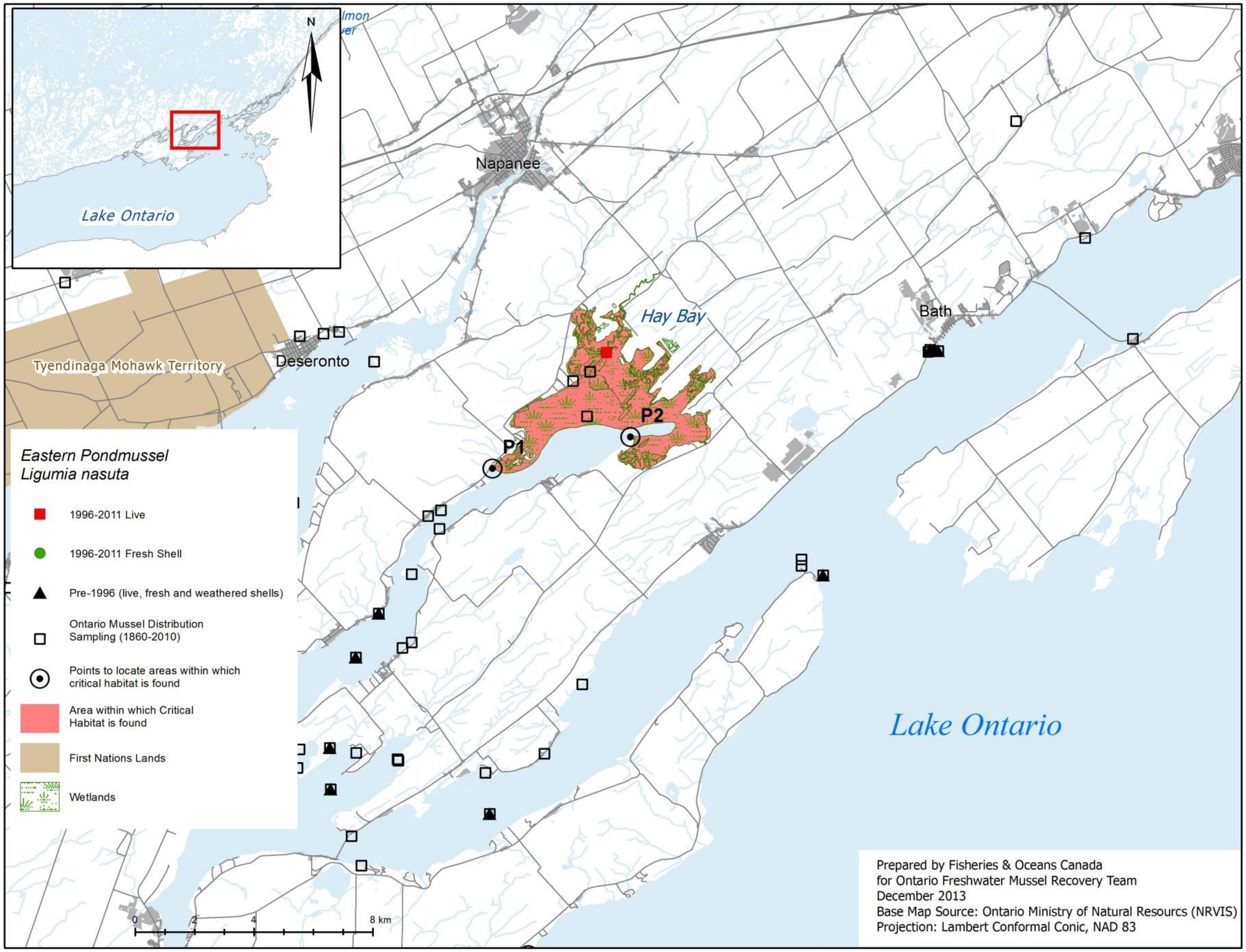

Figure 9. Area within which critical habitat is identified for the Eastern Pondmussel in Wilton Creek (Hay Bay).

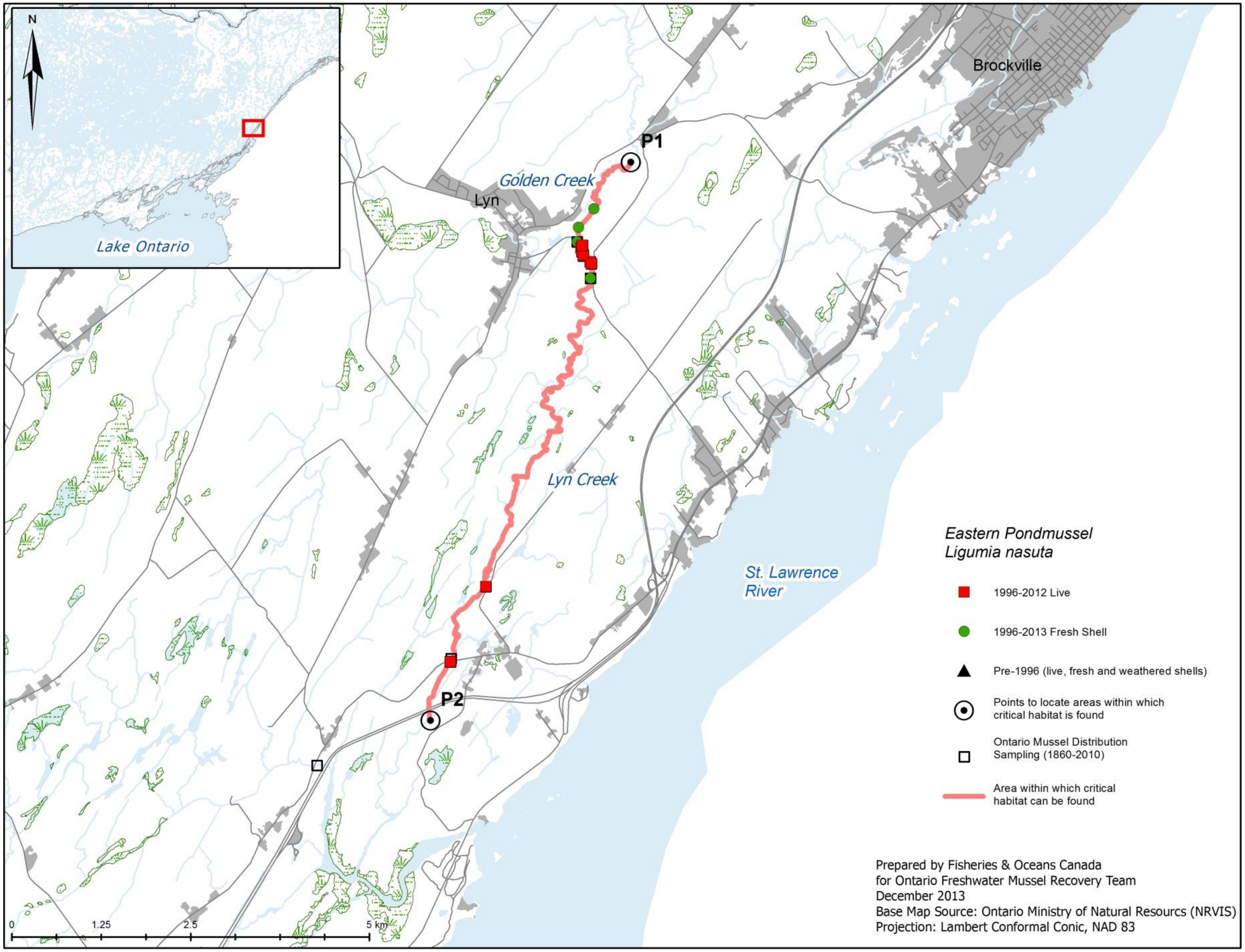

Figure 10. Area within which critical habitat is identified for the Eastern Pondmussel in Lyn Creek (including Golden Creek).

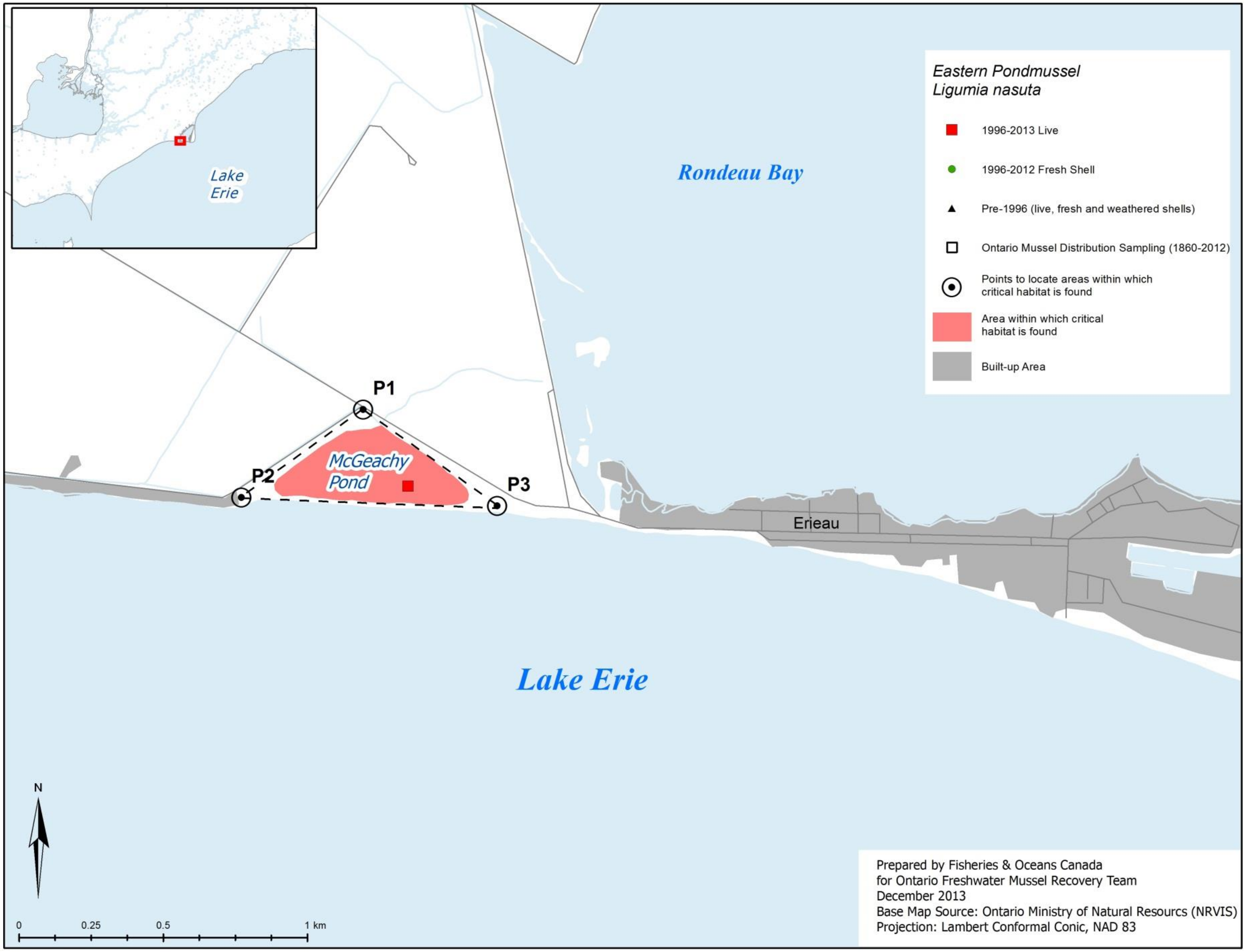

Figure 11. Area within which critical habitat is identified for the Eastern Pondmussel in McGeachy Pond.

The identification of critical habitat within Cedar Creek (LPNWA) and Turkey Point Marsh, coastal wetlands of Lake Ontario (including Rouge River, Carruthers Creek, Lynde Creek, Wilton Creek/Hay Bay and Pleasant Bay), Consecon Lake, East Lake, Lyn Creek and McGeachy Pond will ensure that currently occupied habitat is protected, until such time as critical habitat is further refined according to the schedule of studies laid out in Section 7.5. (Schedule of studies to identify critical habitat). The schedule of studies outlines activities necessary to refine the current critical habitat descriptions at confirmed extant locations as well as address locations with limited information (e.g., Beaver Lake, Grand River). Critical habitat descriptions will be refined as additional information becomes available to support the population and distribution objectives.

7.5 Schedule of studies to identify critical habitat

This recovery strategy includes an identification of critical habitat to the extent possible, based on the best available information. Further studies are required to refine critical habitat identified for the Eastern Pondmussel and to support the population and distribution objectives for this species. The activities listed in Table 9 are not exhaustive and it is likely that the process of investigating these actions will lead to the discovery of further knowledge gaps that need to be addressed.

Table 9. Schedule of studies to identify critical habitat

Description of activity	Outcome/Rationale	Timeline*
Conduct mussel population surveys in areas of known and potential occurrence.	Determine the spatial extent of remaining population locations to identify baseline data required for the identification of critical habitat. Determine if adults and juveniles are occurring in the same locations.	2016–2018
Assess and characterize habitat conditions in occupied areas (e.g., flow, substrate, water clarity and quality).	Refine features and attributes of critical habitat for remaining populations.	2016–2018
Determine any life stage differences in habitat use.	Determine critical habitat at different life stages (adult vs. juvenile mussel vs. glochidia).	2017–2019
Survey and identify areas of suitable but unused habitat within the historical range of the Eastern Pondmussel.	Determine why there is no longer Eastern Pondmussel in these areas (e.g., lack of host fish[es], water quality).	2018–2020
Determine/confirm functional host fish species.	Determine host for the glochidia (parasitic larvae) to juvenile transformation.	2016–2018
Conduct host fish population surveys (and collect associated habitat information) within the range of the Eastern Pondmussel if current data does not exist.	Determine range and abundance of suitable host fish(es) (may help determine why Eastern Pondmussel no longer occurs in certain areas). Collection of habitat information will provide insight into presence/absence of various host species at different locations.	2018–2019

(cont'd)

Table 9 (cont'd). Schedule of studies to identify critical habitat

Description of activity	Outcome/Rationale	Timeline*
Determine areas of overlap between mussel and host habitat.	Identify sites that may be suitable for potential relocations and/or reintroductions.	2018–2020
Based on collected information, review population and distribution objectives. Determine amount, configuration and description of critical habitat required to achieve these objectives if adequate information exists.	Refinement of population and distribution objectives, as well as amount, configuration and description of critical habitat to meet these objectives.	Ongoing

*Timelines are subject to change in response to demands on resources and/or personnel and as new priorities arise.

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

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For the critical habitat of the Eastern Pondmussel, it is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat, and subsection 58(2) for locations found within protected areas (i.e. national parks, marine protected areas, migratory bird sanctuaries and wildlife areas).

The Eastern Pondmussel, like most mussel species, is sensitive to a wide variety of stressors. Therefore, the activities described in Table 10 are neither exhaustive nor exclusive, and have been guided by the general threats described in Section 4 (Threats). The absence of a specific human activity does not preclude, or fetter the Department's ability to regulate it pursuant to SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition since it is destruction of critical habitat that is prohibited. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation is applied where it is reliable and available. In every case, where information is available, thresholds and limits are associated with attributes to better inform management and regulatory decision-making. However, in many cases the knowledge of a species and its critical habitat may be lacking, and in particular, information associated with a species' or habitat thresholds of tolerance to disturbance from human activities, is lacking and must be acquired.

Table 10. Human activities likely to result in the destruction of critical habitat for Eastern Pondmussel. The pathway of effect for each activity is provided as well as the potential links to the biophysical functions, features and attributes of critical habitat.

Activity	Effect-Pathway	Function affected	Feature affected	Attribute affected
Siltation and turbidity: Work in or around water with improper sediment and erosion control (e.g., installation of bridges, pipelines, culverts), overland runoff from ploughed fields, run-off from urban and residential development, use of industrial equipment, cleaning or maintenance of bridges or other structures without proper mitigation.	Improper sediment and erosion control or mitigation can cause increased turbidity and sediment deposition, changes in preferred substrates, and impairment of feeding and reproductive functions.	Reproduction Feeding Cover Development on host for encystment	Sheltered areas (e.g., wetlands) of lakes, in slack-water areas of streams and channels with sand, silt, mud and/or clay substrates present Presence of host fish(es)	• Summertime water temperatures • Water clarity • Substrates of sand silt, mud and clay • Presence of host fish species • Food supply • Maintenance of an environmental thermal regime
Unfettered livestock access to waterbodies.	When livestock have unfettered access to waterbodies damage to shorelines, banks and watercourse bottoms can cause increased erosion and sedimentation, affecting turbidity and water temperatures.			
Removal or cultivation of riparian vegetation.	Agricultural lands, particularly those with little riparian vegetation and without tile drainage, allow large inputs of sediments to the watercourse.			

(cont'd)

Table 10 (cont'd). Human activities likely to result in the destruction of critical habitat for Eastern Pondmussel

Activity	Effect-Pathway	Function affected	Feature affected	Attribute affected
Water quality: Over-application of fertilizer and improper nutrient management (e.g., organic debris management, wastewater management, animal waste, septic systems and municipal sewage). Introduction of high levels of chloride through activities such as excessive salting of roads in winter.	Improper nutrient management can cause nutrient loading of nearby waterbodies. Elevated nutrient levels (phosphorous and nitrogen) can cause increased turbidity causing harmful algal blooms, changing water temperatures, and reduced DO levels. Mussel survival rates are closely related to DO levels. Low DO may also cause mortality of warm water fish hosts, thereby disrupting mussel reproductive cycles. Recent evidence has shown that juvenile mussels are among the most sensitive aquatic organisms to ammonia toxicity. Chloride levels have shown recent inclines due to an increased use of road salt. High chloride levels can cause direct mortality of sensitive glochidia.	Reproduction Feeding Cover Development on host for encystment	Sheltered areas (e.g., wetlands) of lakes, in slack-water areas of streams and channels with sand, silt, mud and/or clay substrates present Presence of host fish(es)	• Summertime water temperatures • Water clarity • Presence of host fish species • Food supply • Contaminant levels – chloride and ammonia • Dissolved oxygen (DO) levels sufficient to support host • Maintenance of an environmental thermal regime

(cont'd)

Table 10 (cont'd). Human activities likely to result in the destruction of critical habitat for Eastern Pondmussel

Activity	Effect-Pathway	Function affected	Feature affected	• Attribute affected
Water quantity: Water-level management (e.g., through dam operation) or water extraction activities (e.g., for irrigation), that causes dewatering of habitat or excessive flow rates; large increases in impervious surfaces from urban and residential development.	High flow conditions (and 'flashier' flows) can cause dislodgement and passive transport of mussels from areas of suitable habitat into areas of lesser or marginal habitat. Low flows can result in depressed DO levels, desiccation, elevated temperatures and stranding. Host fish may also be impacted, thereby disrupting reproduction. Altered flow patterns can affect habitat availability (e.g., by 'dewatering' habitats) in creeks and rivers, sediment deposition (e.g., changing preferred substrates), and water temperatures.	Same as above	Same as above	• Adequate water level • Summertime water temperatures • Food supply • DO levels sufficient to support host • Presence of host fish species • Substrates of sand silt, mud and clay • Maintenance of an environmental thermal regime
Decline of host fish: Excessive removal of host fish (through either commercial* or recreational harvest) or indirect means (e.g., damming activities) may prevent fish movement.	Any activities that affect the host species' abundance, movements, or behaviour during the period of encystment or release may disrupt the reproductive cycle of this mussel.	Development on host for encystment	Same as above	• Presence of host fish species
Urbanization: Over application or misuse of herbicides and pesticides. Release of urban and industrial pollution into habitat (including the impact of stormwater runoff from existing and new developments).	Introduction of toxic compounds (e.g., high chloride levels from stormwater runoff) into habitat used by these species can change water chemistry affecting habitat and host fish availability or use, especially during sensitive life stages (glochidia, juvenile).	Reproduction Cover Development on host for encystment	Same as above	• Presence of host fishes • Contaminants levels – chloride, ammonia, and copper

(cont'd)

Table 10 (cont'd). Human activities likely to result in the destruction of critical habitat for Eastern Pondmussel

Activity	Effect-Pathway	Function affected	Feature affected	Attribute affected
Physical habitat loss/modification: • Dredging • Grading • Excavation	Changes in bathymetry, shoreline and channel morphology caused by dredging and nearshore grading and excavation can move mussels, alter preferred substrates, change water depths, change flow patterns potentially affecting turbidity, nutrient levels and water temperatures.	Reproduction Cover Feeding Development on host for encystment	Same as above	• Summertime water temperatures • Water clarity • Presence of host fish species • Food supply • Substrates of sand silt, mud and clay • Maintenance of an environmental thermal regime • Adequate water level
Placement of material or structures in water (e.g., groynes, piers, infilling, partial infills, jetties)	Placing material or structures in water reduces habitat availability (e.g., the footprint of the infill or structure is lost). Placing of fill can cover preferred substrates for mussels and their host fish.			
Construction of dams and/or barriers	Dams/barriers can result in direct loss of habitat or fragmentation, which can limit the reproductive capabilities of mussels by eliminating or decreasing the number of hosts available.			
Recreational activities:	Can affect number and health of available host fishes.	Reproduction Cover Feeding Development on host for encystment	Same as above	• Presence of host fish species • Substrates of sand silt, mud and clay • Water clarity • Dreissenids absent or in low abundance
Excessive baitfish collection (either recreational or commercial); baitfish releases.	Spread aquatic invasive species (boats, bait buckets).			
Use of motor vehicles (e.g., 4x4 trucks, ATVs) in the river.	Disrupt substrate, dislodge mussels.			

*Commercial fisheries, some of which target Yellow Perch and Pumpkinseed, exist within locations of critical habitat (Bay of Quinte and Prince Edward County area, as well as Lake Erie), however these harvests have been ongoing for some time and are known to be sustainably managed by the MNRF. As such, these fisheries are currently not a concern for the recovery of the Eastern Pondmussel.

In future, threshold values for some stressors may be informed through further research. For some of the above activities, BMPs may be enough to mitigate threats to the species and its habitat; however, in some cases, it's not known if BMPs are adequate to protect critical habitat and further research is required.

7.7 Proposed measures to protect critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. It is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

8. Socio-economic evaluation of the action plan

The *Species At Risk Act* requires that the action plan component of the recovery document[3] include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1)(e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. Its intent is to inform the public and to guide decision making on implementation of the action plan by partners.

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

It is important to note that the socio-economic evaluation only applies to the detailed recovery measures. The setting of population and distribution objectives and the identification of critical habitat are science-based exercises and socio-economic factors were not considered in their development.

[3] The "action plan component of the recovery document" will simply be referred to as "action plan" from this point forward.

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

Policy baseline

The policy baseline consists of the protection under the *Species at Risk Act* for the Eastern Pondmussel (the species was listed under SARA in 2013), along with continued protection under Ontario's *Endangered Species Act, 2007.* Other legislation that may provide direct or indirect habitat protection for the Eastern Pondmussel includes existing provincial legislation[4] and the federal *Fisheries Act*. The policy baseline also includes any recovery actions that were implemented prior to and after the Eastern Pondmussel was listed under SARA. These recovery actions included various projects[5] funded by the federal government and province of Ontario.

Socio-economic benefits of implementing this action plan

Some of the benefits of recovery actions required to return/maintain self-sustaining populations of the Eastern Pondmussel outlined in this action plan are difficult to quantify but would generally be positive. Efforts to implement recovery actions would complement other recovery efforts for other wetland fishes such as the Pugnose Shiner, Lake Chubsucker and Grass Pickerel.

Some of the unquantifiable non-market benefits mentioned in the second paragraph of this evaluation would be enjoyed by the Canadian public as a result of implementing the recovery actions contained in the action plan. The implementation of local stewardship programs to improve habitat conditions and reduce threats within critical habitat and other occupied habitats will help to improve wetland habitat and help lead to a healthier ecosystem. A healthier ecosystem could result in benefits such as better water quality.

The benefits of implementing the recovery actions contained in the action plan are anticipated to be low.

Socio-economic costs of implementing this action plan

The majority of the recovery activities identified in this action plan are short-term (2016–2019), medium term or ongoing. Most of these activities focus on research, monitoring, engagement, education, and management to reduce threats and to inform and promote species recovery. Some of the actions are one-time projects (e.g., research and monitoring), likely funded from existing federal government resources. Implementation of local stewardship actions could be supported by programs such as the Government of Canada's Habitat Stewardship Program. In addition, most programs require a level of direct or in-kind support costs from applicants as

[4] Examples of other provincial legislation that provide habitat protection include considerations under Section 3 of Ontario's *Planning Act* which prohibits development and site alteration in the significant habitat of endangered species and protection under the *Lakes and Rivers Improvement Act* in Ontario.

[5] Projects include fish host research and fish host survey work.

matching funds[6]. The costs (direct and in-kind) associated with these short-term actions are estimated to be low[7] and spread over the next five years[8].

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

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

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

The Canadian public will benefit from the implementation of the action plan through expected non-market benefits associated with recovery and protection of the species and its habitat. Recovery actions that improve wetland habitat will help lead to a healthier ecosystem. This has additional benefits to Canadians such as improvements to water quality.

9. Measuring progress

The overall success of implementing the recommended recovery approaches will be evaluated primarily through routine population (distribution and abundance) and habitat (quality and quantity) surveys and monitoring (refer to implementation schedule – Table 5, recovery measures #1 and #4). During the next five years, focus will be placed on completing recovery actions identified as “high priority” for the Eastern Pondmussel. Reporting on *implementation* of the action plan components, under s. 55 of SARA, will be done by assessing progress towards achieving the broad strategies/approaches outlined in this document. Reporting on the ecological and socio-economic impacts of the action plan, under s. 55 of SARA, will be done by assessing the results of monitoring the recovery of the species and its long term viability, and by assessing the implementation of the action plan.

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[6] For example, matching funds for the Habitat Stewardship Program can come from landowners and/or provincial funding programs. This helps leverage additional support for recovery actions.

[7] Low costs are defined as less than $1 million annually.

[8] Future expenditures cannot be determined in great detail as it is expected these activities would continue to be funded through existing government funding, including the Habitat Stewardship Program, where support is determined on a priority basis and based on availability of resources.

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11. Recovery team members

The following members of the Ontario Freshwater Mussel Recovery Team were involved in the development of the recovery strategy and action plan for the Eastern Pondmussel:

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Dr. Gerry Mackie	University of Guelph
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Kelly McNichols	Fisheries and Oceans Canada
Dr. Todd Morris (Co-chair)	Fisheries and Oceans Canada
Dr. Scott Reid	Ontario Ministry of Natural Resources
Dr. Frederick Schueler	Bishop Mills Natural History Centre
Dr. Astrid Schwalb	University of Waterloo
John Schwindt	Upper Thames River Conservation Authority
Shawn Staton (Co-chair)	Fisheries and Oceans Canada
Valerie Towsley	Lower Thames River Conservation Authority
Mari Veliz	Ausable Bayfield Conservation Authority
Dr. Daelyn Woolnough	Central Michigan University
Dr. Dave Zanatta	Central Michigan University

Appendix A: Effects on the environment and other species

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 and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's[9] (FSDS) goals and targets.

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

This combined recovery strategy and action plan will clearly benefit the environment by promoting the recovery of the Eastern Pondmussel. In particular, it will encourage the protection and improvement of coastal wetland habitats in the lower Great Lakes. These limited wetland habitats support species at risk from many other taxa (including birds, reptiles, fishes and plants) and thus the implementation recovery actions for the Eastern Pondmussel will contribute to the preservation of biodiversity in general. The potential for these recovery actions to inadvertently lead to adverse effects on other species was considered. The SEA concluded that the implementation of this document will clearly benefit the environment and will not entail any significant environmental effects.

[9] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1