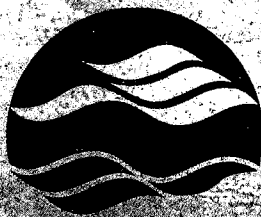


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COSEWIC
Assessment and Status Report
on the
Round Pigtoe
Pleurobema sintoxia
in Canada

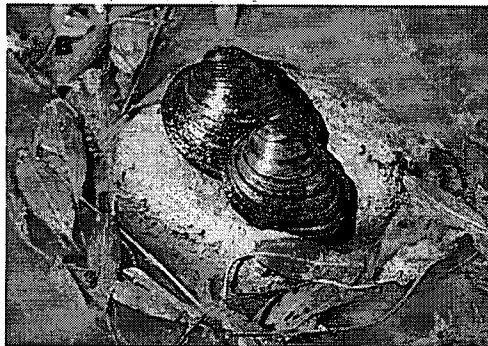
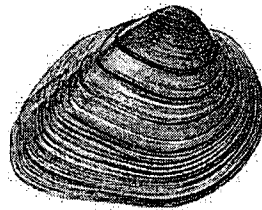
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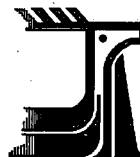
Round Pigtoe
Pleurobema sintoxia

in Canada



ENDANGERED
2004

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA



COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: (819) 997-4991 / (819) 953-3215
Fax: (819) 994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
<http://www.cosewic.gc.ca>

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le pleurobème écarlate (*Pleurobema sintoxia*) au Canada.

Cover illustration:

Round pigtoe — line drawing of the external features of the shell (reproduced with permission from Burch 1975). Photograph of live specimens collected from the Sydenham River near Dawn Mills (photographer J.L. Metcalfe-Smith).

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COSEWIC Assessment Summary

Assessment Summary – May 2004

Common name

Round pigtoe

Scientific name

Pleurobema sintoxia

Status

Endangered

Reason for designation

Species limited to a small area of occupancy in the Lake St. Clair and three watersheds in southern Ontario with continuing declines in habitat area, extent and quality. Threats include urban, industrial and agricultural development and irreversible impacts from zebra mussels in Lake St. Clair, with potential threats from introduction of zebra mussels in impoundments in the Sydenham River.

Occurrence

Ontario

Status history

Designated Endangered in May 2004. Assessment based on a new status report.



COSEWIC
Executive Summary

Round Pigtoe
Pleurobema sintoxia

Species information

The Round Pigtoe, *Pleurobema sintoxia* (Rafinesque, 1820) is a medium to large freshwater mussel (maximum length in Canada ~130 mm) that is usually somewhat rectangular in shape. The shell is relatively thick and solid with a roughened surface. It may be tan in colour in juveniles but darkens to a characteristic deep reddish brown with age.

Distribution

The Round Pigtoe was historically distributed from New York and Ontario in the east to South Dakota, Kansas and Oklahoma in the west and south to Arkansas and Alabama. In Canada, it was known from the Niagara, Detroit, Grand, Thames and Sydenham rivers as well as Lake Erie and Lake St. Clair. Large river populations have declined in the upper Midwest, but many populations survive in tributaries of the Mississippi and Ohio rivers. In Canada, it is extant in the Grand, Thames and Sydenham rivers and Lake St. Clair.

Habitat

The Round Pigtoe appears to be a habitat generalist. It may be found in small, medium-sized and large rivers with moderate flows on mixed substrates of gravel, cobble, boulder, sand and mud. In Lake Erie and Lake St. Clair, it occurs in shallow (<1 m) nearshore areas with firm sandy substrates. In large rivers it is often found at depths greater than 3 m.

Biology

The Round Pigtoe has separate sexes, but males and females look alike. The lifespan is unknown, but other members of the Subfamily Ambleminae tend to be long-lived (30 years or more). Like other freshwater mussels, the Round Pigtoe is parasitic on fish during its larval stage. The breeding season lasts from early May to July, and the larvae are released by the female before winter. Once released, the larvae must attach to the gills of an appropriate fish host and form a cyst. After a period of time, the larvae transform into juveniles that drop off the fish and fall to the substrate to begin life.

as free-living mussels. Several fishes known to be hosts for the Round Pigtoe in the U.S. also occur in the mussel's range in Canada (Bluegill, Spottfin Shiner, Bluntnose Minnow, Northern Redbelly Dace). Round Pigtoes, like all freshwater mussels, feed on bacteria and algae that they filter from the water with their gills.

Population sizes and trends

The Round Pigtoe is a widely distributed but uncommon species throughout its range. There is evidence that the species was once more abundant in many systems, especially large rivers, than it is now. It has been lost from the Niagara and Detroit rivers and the offshore waters of Lake Erie and Lake St. Clair due to impacts of the Zebra Mussel, *Dreissena polymorpha*. Small remnant populations still occur in a few nearshore areas in Lake Erie and Lake St. Clair where Zebra Mussel densities are lower. The Round Pigtoe is represented by only a few relic specimens in the Grand and Thames rivers, but appears to be reproducing in the Sydenham River and the delta area of Lake St. Clair.

Limiting factors and threats

The Round Pigtoe has been lost from most of its former range in the Great Lakes due to impacts of the Zebra Mussel, and the remaining Canadian population in the St. Clair delta may be at risk. Populations in the Grand and Thames rivers have been nearly extirpated, probably due to the combined effects of municipal and industrial pollution and agricultural impacts in these heavily populated watersheds. The population in the Sydenham River is small and there is evidence that recruitment may be declining. This population is at risk from intensive agriculture and associated heavy loadings of silt and nutrients.

Special significance of the species

There are 31 species in the genus *Pleurobema*, but only *P. sintoxia* has a range that extends into Canada. The Round Pigtoe is also the only member of the genus that is considered to be stable throughout most of its North American range. The genera *Pleurobema* and *Epioblasma* are the most critically imperiled unionid taxa. Thus, even the most common members of these taxa must be protected in order to prevent the extinction of the genera.

Existing protection or other status designations

The Round Pigtoe is listed as endangered in Iowa and Pennsylvania, threatened in Minnesota, special concern in Michigan and Wisconsin, and a species of special interest in Ohio, and is therefore afforded some protection in these states. There is no specific protection for the Round Pigtoe in Ontario or Canada at the present time.



COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS (AFTER MAY 2004)

Species	Any indigenous species, subspecies, variety, or geographically or genetically distinct population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

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

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

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994.



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

COSEWIC Status Report

on the

Round Pigtoe
Pleurobema sintoxia

in Canada

2004

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SPECIES INFORMATION

Name and classification

Scientific name: *Pleurobema sintoxia* (Rafinesque, 1820)
English common name: Round Pigtoe
French common name: Pleurobème écarlate

The recognized authority for the classification of aquatic molluscs in the United States and Canada is Turgeon et al. (1998). The currently accepted classification of this species is as follows:

Phylum Mollusca
Class Bivalvia
Subclass Palaeoheterodonta
Order Unionoida
Superfamily Unionacea
Family Unionidae
Subfamily Ambleminae
Genus *Pleurobema*
Species *Pleurobema sintoxia*

Parmalee and Bogan (1998) provide a complete list of synonyms for this species. *Pleurobema sintoxia* had been known as *P. coccineum* until recently. *Pleurobema sintoxia* was reintroduced as the scientific name of the Round Pigtoe when it was discovered that the name *sintoxia* was first proposed for the species by Rafinesque in 1820. The reintroduction of *sintoxia* is in the interest of proper nomenclature (Oesch 1995). Ortmann (1919) recognized two subspecies of the Round Pigtoe – a river form (form *coccineum*) and a Great Lakes form (form *pauperculum*).

The taxonomy of the genus *Pleurobema* remains contentious. Strayer and Jirka (1997) consider *P. sintoxia* to be part of the *P. cordatum* (Ohio Pigtoe) species complex of closely related species or ecophenotypes – also including *P. plenum* (Rough Pigtoe) and *P. rubrum* (Pyramid Pigtoe) – that are found throughout the Ohio River drainage and in parts of the Mississippi and Great Lakes basins. Other taxonomists consider *P. sintoxia* to be a unique species. It is generally agreed that rigorous genetic, anatomic, and conchological studies are required to resolve the status of these taxa (A. Bogan pers. comm. Sept 2002).

Description

The Round Pigtoe (Figure 1) is a medium to large sized freshwater mussel that is highly variable in morphology depending on habitat type. The river form is compressed, flattened, solid, and usually somewhat rectangular, but often oval or elongated. *Pleurobema sintoxia* was first described by Rafinesque in 1820. The type locality is the Mahoning River near Pittsburgh, Pennsylvania. The following description of the species

A

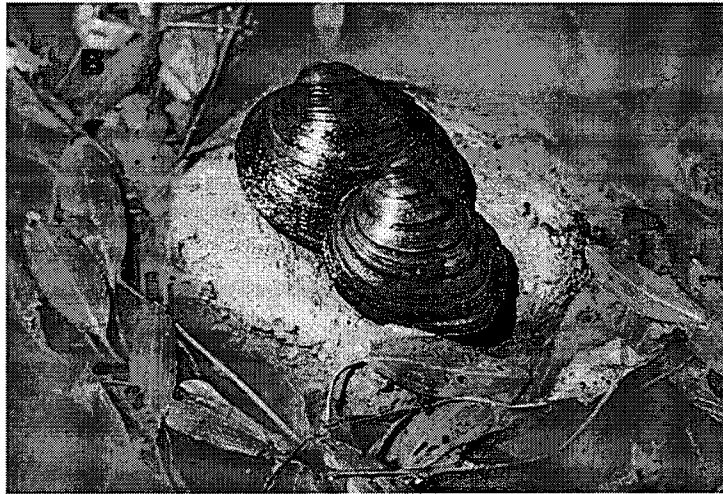
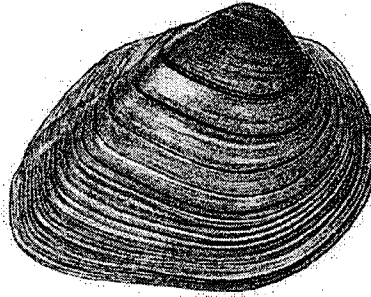


Figure 1. (A) Line drawing of the external features of the shell of *Pleurobema sintoxia*. Reproduced with permission from Burch (1975). (B) Photograph of live specimens collected from the Sydenham River near Dawn Mills, Ontario in 1999 (Photo credit: J.L. Metcalfe-Smith, NWR).

was adapted from Clarke (1981), Oesch (1995), Strayer and Jirka (1997), and Parmalee and Bogan (1998). The beaks are compressed, slightly elevated, turned forward, and slightly extending beyond the hinge line. Sculpture consists of a few coarse, irregular ridges curving upward along the beak. The anterior end is rounded; the posterior end is squarely truncated; and the posterior ridge is rounded, ending in a blunt point. There are two stout, rectangular, serrated pseudocardinal teeth in the left valve and one in the right valve – the latter having a low, roughened linear tooth anteriorly and dorsally. The lateral teeth – two in the left valve and one in the right – are straight, moderately high, and finely serrated. The interdentum is wide; the beak cavity is very shallow; and muscle scars are deep. The surface is roughened with concentric rest lines. The periostracum in juveniles is dull tan in colour with distinct green rays that fade as the surface darkens to a deep reddish brown or black with age. The nacre is white or various shades of pink.

According to Parmalee and Bogan (1998), *P. sintoxia* reaches a maximum length of 110 - 120 mm in medium-sized rivers. Clarke (1981) reports a maximum length of 90 mm in Canada; however, the authors have regularly collected animals >100 mm in length from rivers in southwestern Ontario. The Great Lakes form of *P. sintoxia* is generally smaller, rarely exceeding 75 mm in length (Strayer and Jirka 1997). The lake form is also more inflated and the beaks are full, elevated, and project forward well beyond the hinge line.

In Canada the Round Pigtoe may be confused with the Wabash Pigtoe (*Fusconaia flava*) (Figure 2). The main features distinguishing *F. flava* from *P. sintoxia* are a lower and more centrally located beak, deeper lateral sulcus, and deeper beak cavity in *F. flava* (Clarke 1981, Oesch 1995, Strayer and Jirka 1997). The lake form of *P. sintoxia* is somewhat similar to *Obovaria olivaria*, but has flatter valves, a duller periostracum, and is less likely to have coloured rays (Strayer and Jirka 1997).

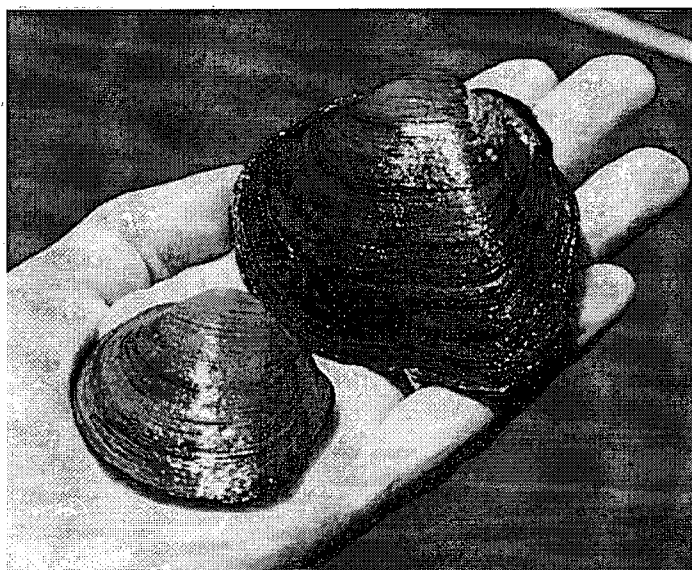


Figure 2. *Pleurobema sintoxia* (lower left) with *Fusconaia flava* (upper right) for comparison. Note the deeper sulcus on *F. flava*. Both specimens collected from the Sydenham River near Croton, Ontario in 2002 (photo credit: D. Zahatta, NWRI).

DISTRIBUTION

Global Range

The Round Pigtoe was once widely distributed from New York and Ontario west to South Dakota, Kansas and Oklahoma, and south to Arkansas and Alabama (Figure 3). It occurred in Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, New York, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, West Virginia, Wisconsin, and Ontario. The current distribution of

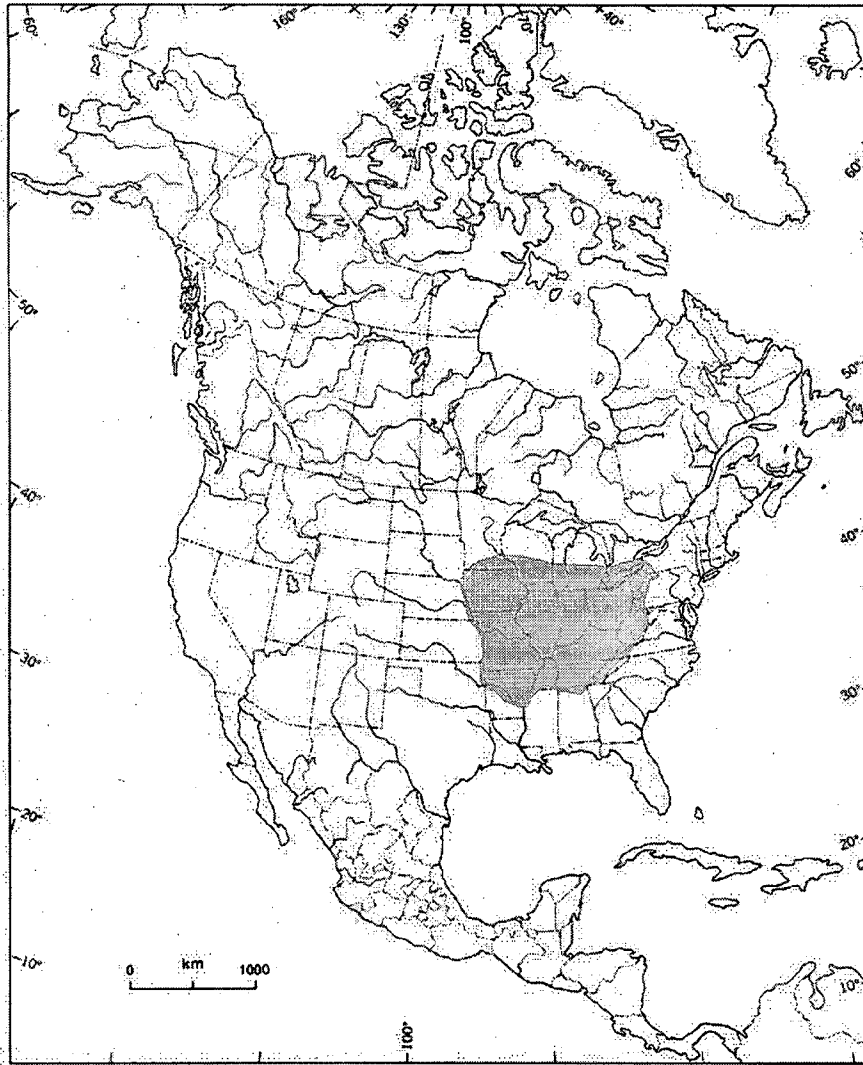


Figure 3. North American distribution of *Pleurobema sintoxia* (based on information provided by jurisdictions).

the Round Pigtoe is similar to the historical range. Although large river populations have for the most part disappeared from the upper Midwest, many populations still survive in tributaries of the Mississippi and Ohio rivers.

Canadian Range

In Canada *P. sintoxia* is only known from southern Ontario. The National Water Research Institute's Lower Great Lakes Unionid Database was used to identify occurrence records for *P. sintoxia* in Ontario. At the time of writing, the database consisted of approximately 7600 records for 40 species collected from nearly 2400 sites in the lower Great Lakes drainage basin since 1860 (see Metcalfe-Smith et al. 1998a for

a detailed description of the database and its data sources). The Round Pigtoe was historically collected from the Niagara, Detroit, Grand, Thames, and Sydenham rivers, as well as Lake Erie and Lake St. Clair. The earliest record of the species in Canada is one fresh whole shell collected in 1885 from the Grand River at Caledonia by J. Townsend (specimen held by the Canadian Museum of Nature; cat. no. 002417). Figure 4 shows the historical distribution of the Round Pigtoe in Ontario, based on 84 records collected between 1885 and 1995. The current distribution of the species, based on 57 records (live animals and shells) collected between 1997 and 2002, is shown in Figure 5. Live specimens were most recently collected from the Sydenham River in the summer of 2002.

Populations of *P. sintoxia* in the Niagara and Detroit rivers, Lake Erie and Lake St. Clair have been mostly lost due to impacts of the Zebra Mussel (*Dreissena polymorpha*). Small, isolated pockets of surviving animals may still be found in some nearshore areas that offer refuge from infestation by Zebra Mussels. For example, *P. sintoxia* was recently found alive in Metzger Marsh on the Pennsylvania shore of western Lake Erie (Nichols and Amberg 1999) and in the St. Clair delta area of Lake St. Clair (Zanatta et al. 2002). Results from a 2001 survey of the Niagara River showed that no live unionids of any species were found. The Long Point sites have not been re-surveyed in recent years, so we assume that the species still occurs there. A reproducing population still persists in the Sydenham River and small, possibly senescent, populations occur in the Middle Thames and Grand rivers (Metcalf-Smith et al. 1998b, 1999 and unpublished data). Overall, the Round Pigtoe has been lost from about 54% of its former range (in terms of extent of occurrence) in Canada; the historical extent of occurrence was 26,592 km² and the current EO is 12,360 km², with an estimated area of occupancy of about 15 km².

HABITAT

Habitat Requirements

The Round Pigtoe is typically found in medium-sized to large rivers (van der Schalie 1938; Strayer 1983; Parmalee and Bogan 1998), but also occurs in Lake Erie and Lake St. Clair (Clarke 1981; Strayer and Jirka 1997). Ortmann (1919) reported collecting the river form of this species "going up far into the headwaters" of the upper Allegheny system, and found the lake form "in a few feet of water upon pure sand" in Presque Isle Bay, Lake Erie. In smaller rivers, the Round Pigtoe may often be found deeply buried in mixtures of gravel, cobble, and boulder substrates, in or below riffles with moderate flows (Ortmann 1919; Gordon and Layzer 1989; Parmalee and Bogan 1998). In larger rivers, it is found in mud, sand and gravel substrates at depths greater than 3 m, but may occur in shallows on sand or gravel bars (Gordon and Layzer 1989). In southeastern Michigan, it was found to be especially abundant in medium to large streams away from the lake plain (Strayer 1983). In Lake St. Clair, *P. sintoxia* currently occupies shallow (<1 m) nearshore areas with firm, sandy substrates (Zanatta et al. 2002).

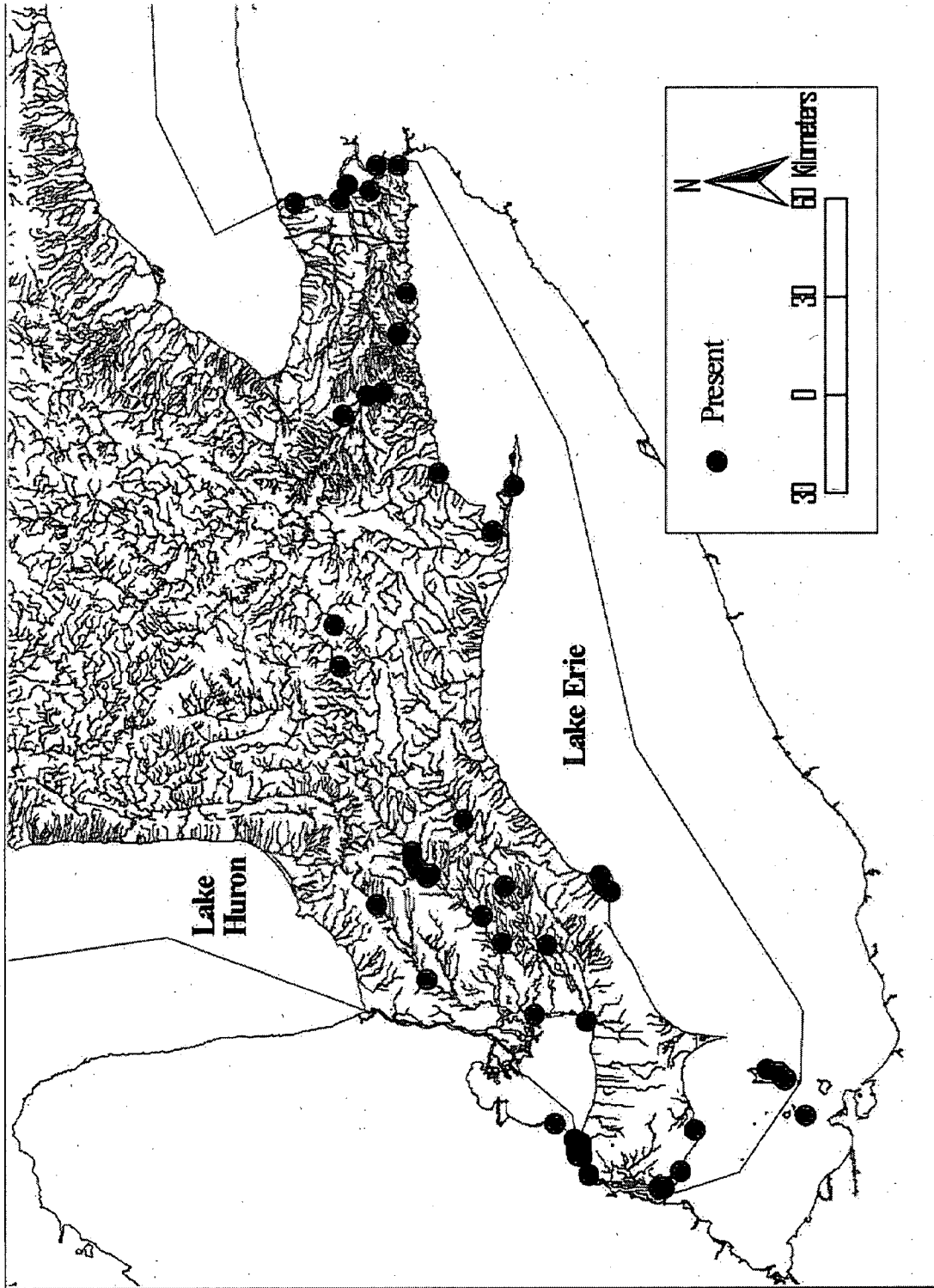


Figure 4. Historical (1885-1995) distribution of *Pleurobema sintoxia* in Ontario (based on records from the Lower Great Lakes Unionid Database).

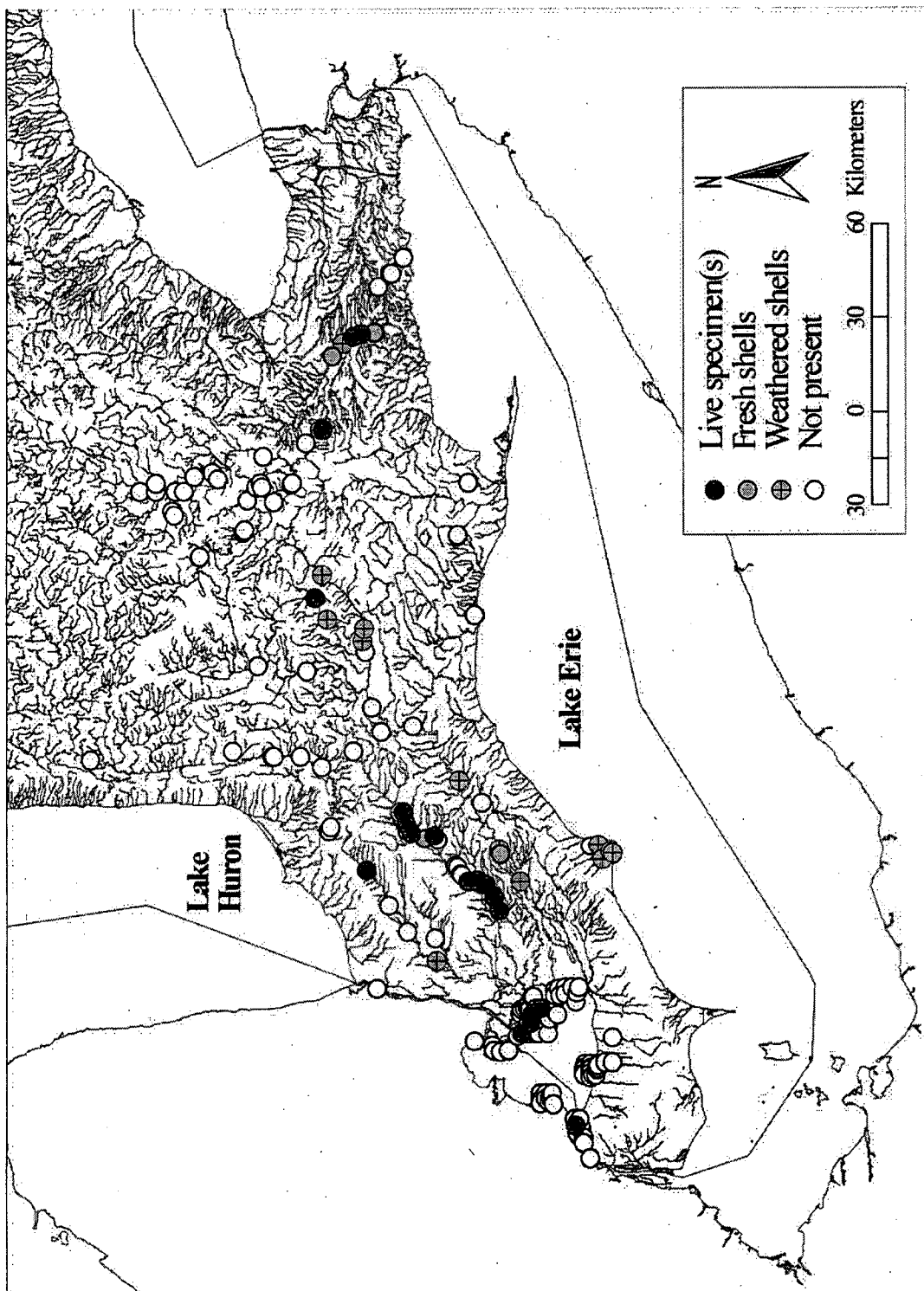


Figure 5. Current (1997-2002) distribution of *Pleurobema sintoxia* in Ontario (based on records from the Lower Great Lakes-Unionid Database).

The habitat preferences of juvenile mussels are believed to be different from those of adults, but there have been few studies on this topic (Gordon and Layzer 1989). The juvenile life stage is certainly more vulnerable than the adult stage, because juveniles have no control over the habitat into which they are released by their host and may die quickly in unsuitable habitats. The glochidial (larval) stage is the most vulnerable and specialized life stage, because the glochidia must successfully attach to an appropriate host in order to complete their metamorphosis to the juvenile stage.

Trends

Habitats for *P. sintoxia* and other unionids in Lake Erie, Lake St. Clair, and the Detroit and Niagara rivers have been largely destroyed by the Zebra Mussel. Native mussel communities were virtually extirpated from the offshore waters of western Lake Erie by 1990 (Schloesser and Nalepa 1994) and the offshore waters of Lake St. Clair and the Detroit River by 1994 (Nalepa et al. 1996; Schloesser et al. 1998). The mussel communities of Lake Erie were already in decline, probably due to a general decline in water quality over the past 40 years (Nalepa et al. 1991), but Lake St. Clair and the Detroit River still supported abundant and diverse mussel assemblages as recently as 1986 (Nalepa and Gauvin 1988) and 1992 (Schloesser et al. 1998), respectively. Unionids continue to survive in some nearshore areas with very shallow water, a high degree of connectivity to the lake (which ensures access to host fishes), and harsh conditions for Zebra Mussels (high water temperatures and considerable wave action in summer; ice scour in winter). However, such "refugia" are rare, and most of the unionid habitat in the Great Lakes has been permanently lost.

Agriculture is believed to be the main cause of the destruction of mussel habitat across North America (Strayer and Fetterman 1999). Since agriculture accounts for 75-85% of land use in the Grand, Thames and Sydenham River basins, it is likely that agricultural impacts (e.g., runoff of sediment, nutrients and pesticides, increased water temperatures due to loss of riparian vegetation, destruction of habitat by tractor crossings and cattle) have contributed to the deterioration of mussel habitat in these rivers. Municipal and industrial pollution may be responsible for the greater loss of mussel habitat in the heavily populated Grand and Thames River watersheds than in the primarily agricultural Sydenham River watershed (Metcalf-Smith et al. 2003).

Protection/ownership

Land ownership along the reaches of the Sydenham, Grand, and Thames rivers where *P. sintoxia* occurs is mainly private. Most of the lands are in agricultural use, including cash crops, pastures and woodlots. There are only two publicly owned properties in the Sydenham River watershed that are somewhat protected from development, i.e., 50 acres of forest owned by Mosa Township and 17 acres owned by the St. Clair Region Conservation Authority. In the Thames River watershed, there are 21 natural areas (Conservation Areas, E.S.A.'s, Provincial Nature Reserves, etc.) covering over 6200 ha; however, little of the area along the reach where this species occurs is protected (Thames River Background Study Research Team 1998).

Protected areas along the Grand River are too small to have any significance for the protection of this species (Peter Mason, Grand River Conservation Authority, pers. comm. October 2002).

The population of *P. sintoxia* in the Canadian waters of the St. Clair delta, is located entirely within the territory of the Walpole Island First Nation. The area is largely undisturbed and is likely to remain so in the future. The Walpole Island Heritage Centre is aware of the presence of *P. sintoxia* within their territory, and of the national significance of the population.

BIOLOGY

General

The basic life history of the freshwater mussel is applicable to the Round Pigtoe, and is described briefly as follows (adapted from Kat 1984, Watters 1999, and Nedeau et al. 2000): during spawning, males release sperm into the water and females living downstream filter the sperm out of the water with their gills. Ova are fertilized in a specialized region of the female gills, called marsupia, where they are held until they reach an intermediate larval stage termed the glochidium. The female mussel then releases the glochidia, which must attach to an appropriate host and become encapsulated. The glochidia remain attached and are nourished by the host's body fluids until they metamorphose into juveniles. The juveniles then break free of the capsule and fall to the substrate to begin life as a free-living mussel. The proportion of glochidia surviving to the juvenile stage is estimated to be as low as 0.000001%. Mussels overcome the extremely high mortality associated with this life cycle by producing large numbers of glochidia – often more than a million.

Reproduction

Pleurobema sintoxia is believed to be sexually dioecious, but is not sexually dimorphic. The lifespan of *P. sintoxia* has not yet been determined, but other members of the Subfamily Ambleminae are known to live for more than 30 years (Stansbery 1967). Age to maturity for this species is not known, but the juvenile stage for most unionids lasts 2-5 years. The Round Pigtoe is a short-term brooder (tachytictic) with the breeding season lasting from early May to late July in Wisconsin (Parmalee and Bogan 1998). The glochidia are subovate, without hooks, measuring 150 µm in both height and width according to Clarke (1981) and 160 µm according to Hoggarth (1993). The lack of hooks suggests that they are gill parasites. The known host fishes for this mussel are the Bluegill (*Lepomis macrochirus*), Spottfin Shiner (*Cyprinella spiloptera*), Bluntnose Minnow (*Pimephales notatus*), Northern Redbelly Dace (*Phoxinus eos*), and Southern Redbelly Dace (*Phoxinus erythrogaster*) (Hove 1995). All of these fishes, except for the Southern Redbelly Dace, occur commonly throughout *P. sintoxia*'s range in Canada and may therefore serve as glochidial hosts in Canadian waters.

Movements/dispersal

In the adult form, freshwater mussels are basically sessile; movement is limited to a few metres of the lake or river bottom. The only time that significant dispersal can take place is during the parasitic phase. Infected host fishes can transport the larval unionids into new habitats, and can replenish depleted populations with new individuals. Dispersal is particularly important for genetic exchange between populations (Nedeau et al. 2000). There is little opportunity for gene flow between Canadian populations of Round Pigtoe and American populations found in tributaries of Lake Erie and Lake St. Clair due to the presence of Zebra Mussels in the lakes and the distance host fish would need to travel. All Canadian riverine populations are geographically isolated from American populations; thus, there is little chance that individuals from American populations could bolster the Canadian populations or repopulate the Canadian range if the Canadian populations should disappear.

Nutrition and Interspecific Interactions

Round Pigtoes, like all species of freshwater mussels, are filter feeders as adults. Their primary food sources are bacteria, algae, particles of organic detritus, and some protozoans (Nedeau et al. 2000). Food availability may be a limiting factor for the Lake St. Clair population due to the presence of high densities of Zebra Mussels, which are also filter-feeders. During the parasitic larval stage, glochidia feed on the body fluids of the host.

POPULATION SIZES AND TRENDS

United States

Ortmann (1919) gives an overview of the distribution and abundance of *P. sintoxia* across its range in the United States at the turn of the 20th century. The Round Pigtoe was widely distributed in Pennsylvania, being "especially abundant" in the upper Allegheny, but less so in the Monongahela drainage where some smaller creeks had become polluted. It was also found in a Lake Erie tributary in Pennsylvania. The species was said to be found "all over the state" of Ohio, mainly in smaller streams in both the Ohio River and Lake Erie drainages. It was abundant in the headwaters of the Monongahela River in West Virginia; it occurred in the Great Lakes drainage in southern Michigan; and it was common in Indiana in both the Ohio and Great Lakes drainages. In Kentucky, it occurred historically in the Ohio River and most of its major tributaries (lower Tennessee and Cumberland, Green, Salt, upper Cumberland, Kentucky and Licking rivers and Tygarts Creek; R. Cicerello, Kentucky State Nature Preserves Commission, pers. comm. October 2002). In Tennessee, the Round Pigtoe was historically found in the Cumberland, Duck, Holston, and Tennessee rivers (Parmalee and Bogan 1998). Ortmann (1919) also mentions records from the western part of *P. sintoxia*'s range in Iowa, Missouri, Kansas, and northern Arkansas – possibly extending into Oklahoma. This information indicates that *P. sintoxia* was widely distributed and common in many parts of its range in the past.

Recent information suggests that the current distribution and abundance of the Round Pigtoe in the U.S. is generally the same as it was historically, although declines seem evident in a number of areas. In Pennsylvania, it is still known from 12 locations in the Allegheny River basin, 14 locations in the French Creek basin, and two locations in the Lake Erie drainage (R. Evans, Pennsylvania Natural Diversity Inventory, pers. comm. September 2002). In New York, it remains widespread in the Allegheny River basin, but populations in the Niagara River basin are likely gone (D. Strayer, Institute of Ecosystem Studies, pers. comm. September 2002). There are several records throughout West Virginia (although nowhere in any abundance) in the Monongahela River and Little Kanawha River drainages, the Elk River, Kanawha River, Ohio River, and Middle Island Creek (J. Clayton, West Virginia Department of Natural Resources, pers. comm. September 2002). In Michigan, *P. sintoxia* is fairly widespread throughout the state in both the Great Lakes and Ohio River drainages, although it is seldom common where it occurs (P. Marangelo, The Nature Conservancy – Michigan Chapter, pers. comm. September 2002). *Pleurobema sintoxia* is not a common species in Indiana and Illinois, but it remains widespread throughout these states in the Mississippi and Ohio River drainages (K. Cummings, Illinois Natural History Survey, pers. comm. September 2002). In Kentucky, *P. sintoxia* still inhabits the Ohio River where it is neither widespread nor abundant, the upper Green River and its major tributaries, the Rolling Fork River (a Salt River tributary), the upper Cumberland River's major tributaries, and the Big Sandy River. Most of these populations are isolated by impoundments or polluted river segments, and evidence of recent recruitment is lacking for some streams (R. Cicerello, Kentucky State Nature Preserves Commission, pers. comm. October 2002). In Tennessee, the Round Pigtoe is now apparently restricted to the Cumberland, Big South Fork Cumberland, and Stones rivers (Parmalee and Bogan 1998). The Round Pigtoe was found in the Tennessee River in the Muscle Shoals region (Tennessee and Alabama) in the early 20th century and up to the late 1970s, but not during surveys in the late 1990s (Garner and McGregor 2001). It was collected live again in this area in 2001 (J. Garner, Alabama Division of Wildlife and Freshwater Fisheries, pers. comm. September 2002). *Pleurobema sintoxia* is relatively common in Missouri, where it is found in 13 major drainages; however, there is no evidence of recruitment in many basins. The Missouri Department of Conservation has 359 records of *P. sintoxia* in its database of collections made from 1977-1999, 79% of which were for live or fresh dead specimens (S. Bruenderman, Missouri Department of Conservation, pers. comm. September 2002). A small population of the Round Pigtoe exists in the Red River drainage of Oklahoma (Vaughn et al. 1997). *Pleurobema sintoxia* has not been seen in recent extensive surveys of rivers in Iowa, although it was reported from the state historically (D. Woolnough, Iowa State University, pers. comm. October 2002).

Great Lakes and Connecting Channels

As mentioned earlier, Ortmann (1919) recognized both a river form and a Great Lakes form of *P. sintoxia*. He reported the lake form as being rare in Presque Isle Bay, Lake Erie. The Round Pigtoe has not been found alive in recent years in Presque Isle Bay or in Thompson Bay (the outer harbour of Presque Isle Bay) where other unionids have persisted despite the Zebra Mussel invasion (Schloesser and Masteller 1999,

E. Masteller, Penn State University at Erie Pennsylvania, pers. comm. July 2002). *Pleurobema sintoxia* was found during surveys of Lake Erie between 1913 and 1960, and 40 live specimens were collected from Put-in-Bay, Ohio in 1970 (Kokai 1976). More recently, the Round Pigtoe was represented by only weathered and fresh dead shells at 4 of 33 sites surveyed along the southwest shore and around the Bass Islands in 1998 (Ecological Specialists 1999). Sixteen species of unionids were collected from the western basin of Lake Erie between 1930 and 1982 (Nalepa et al. 1991). *Pleurobema sintoxia* was present in 1951-52, but not in 1961, 1972, 1973, or 1982. By 1991, the entire unionid community had been virtually eliminated by the Zebra Mussel – only four specimens of two species were found alive (Schloesser and Nalepa 1994). Although the species was recorded historically from Rondeau Bay on the north shore of Lake Erie, only old weathered shells were found during a 2001 survey, along with evidence of heavy Zebra Mussel infestation (Zanatta and Woolnough unpublished data). The only location where *P. sintoxia* appears to be extant in Lake Erie is Metzger Marsh, near Toledo, Ohio. The Round Pigtoe was one of 20 species found alive in the marsh in 1996 (Nichols and Amberg 1999). Surveys of seven other marshes near Metzger Marsh in 2000 produced few live mussels, none of which were *P. sintoxia* (Ecological Specialists 2001).

Pleurobema sintoxia was recorded from the Detroit River in the early 20th century by La Rocque and Oughton (1937) and through museum specimens collected by Bryant Walker in 1934 that are currently housed at the University of Michigan Museum of Zoology. More recently, 14 live *P. sintoxia* were collected from three stations in the river in 1982-83 (Schloesser et al. 1998). Following the Zebra Mussel invasion, Schloesser et al. (1998) collected 11 live *P. sintoxia* from six stations in 1992 and two live specimens from just one station in 1994. Based on the results of surveys conducted in 1997-98, it is now believed that *P. sintoxia* has been extirpated from the Detroit River (Schloesser et al. unpublished data).

There are nine historical records for *P. sintoxia* from the Niagara River. Nothing is known about the historical abundance of this species in the river. A survey was conducted in the Niagara River in the summer of 2001 for the New York Power Authority. Many recently spent shells of *P. sintoxia* were found, but no living specimens. According to the consultant responsible for the survey, "There were Zebra Mussels everywhere" (K. Schneider, Stuyvesant Falls, NY, pers. comm. November 2002). No further details about the survey could be disclosed, but it seems likely that *P. sintoxia* has been extirpated from the Niagara River.

The Round Pigtoe still persists in Lake St. Clair. Zebra Mussels are believed to have invaded the lake in 1986 (Hebert et al. 1989). Twenty-nine sites in the offshore waters of Lake St. Clair were surveyed for unionids in 1986, 1990, 1992, and 1994 (Nalepa and Gauvin 1988). One live *P. sintoxia* was recorded in 1986 (0.36% of the unionid community); two specimens were found in 1990 (0.81% of the community); and none were found in either 1992 or 1994. However, 42 Round Pigtoes measuring 31-95 mm in shell length (Figure 6) were found alive during recent surveys of nearshore areas around the lake. Zanatta et al. (2002) surveyed 95 nearshore sites and found live unionids at 33 sites, all but two of which were in shallow areas (< 1m) with sandy

substrates within an 8 km² area near the St. Clair delta. The Round Pigtoe represented only 1.8% of the overall community by abundance (42 of 2356 live unionids). It was found at only three sites off Squirrel Island where it was relatively abundant, representing 70% of 20 unionids (6 spp.) at one site, 48% of 29 unionids (7 spp.) at the second site, and 8% of 36 mussels (8 spp.) at the third site. Quantitative sampling in 2001 yielded density estimates of 0.005, 0.022 and 0.022 Round Pigtoes/m² at these sites. Sampling was repeated in 2003 and densities were found to have declined at all three sites, i.e., 0, 0.009 and 0.017 mussels/m², respectively (Metcalf-Smith et al., unpublished data) The St. Clair delta has been identified as a possible refuge for unionids from impacts of the Zebra Mussel (Zanatta et al. 2002).

Canadian Rivers

Pleurobema sintoxia has been reported from the Grand, Thames, and Sydenham rivers in Ontario. Metcalf-Smith et al. (1998b, 1999) surveyed 74 sites on the Grand, Thames, Sydenham, Ausable, and Maitland rivers in 1997, 1998 and 2002 to determine the conservation status of rare species of freshwater mussels in southwestern Ontario. They used the timed-search technique, which they have shown to be the most efficient method for detecting rare species (Metcalf-Smith et al. 2000a), with an intensive sampling effort of 4.5 person-hours (p-h)/site. Sites that were known to support rare species (including *P. sintoxia*) in the past were targeted. Results of these and other recent surveys were compared with the historical data to determine population trends for the Round Pigtoe. This species was not found in the Ausable or Maitland rivers in the lower Lake Huron drainage, nor did it occur there historically.

Pleurobema sintoxia was first collected from the Grand River in 1885 near Caledonia by J. Townsend and it was collected again in 1890 near Cayuga by J. Macoun; both specimens are held by the Canadian Museum of Nature in Aylmer, Quebec. The species has been encountered regularly in the lower reaches of the river (downstream of Brantford) since that time, e.g., by Oughton in 1934-35 (ROM collection), Stansbery and Stein in 1963 (Ohio State University Museum of Zoology collection), and Kidd (1973). Metcalf-Smith et al. (2000b) surveyed 95 sites in the river between 1995 and 1998, and found only one live *P. sintoxia* at each of three sites. Fresh shells were collected from an additional three sites, all in the lower mainstem of the river below Brantford. The Round Pigtoe accounted for 0.18% of the 1688 unionids collected during 4.5 p-h timed search surveys at 24 of these 95 sites. A site near York where one live *P. sintoxia* was found in 1998 was resurveyed in 2002 using 4.0 p-h of search effort, and 10 more live specimens were found (Metcalf-Smith and Zanatta, unpublished data). Shell lengths of live *P. sintoxia* collected from the Grand River during the most recent surveys range from 55-101 mm (Figure 6). The small number of specimens found, and especially the lack of small specimens, suggests that reproduction rates may be declining.

There are six records of the Round Pigtoe from the Thames River between 1934 and 1995. Specimens or shells (no information available for 4 of the records) were collected at widely separated sites from Woodstock in the upper reaches to Chatham

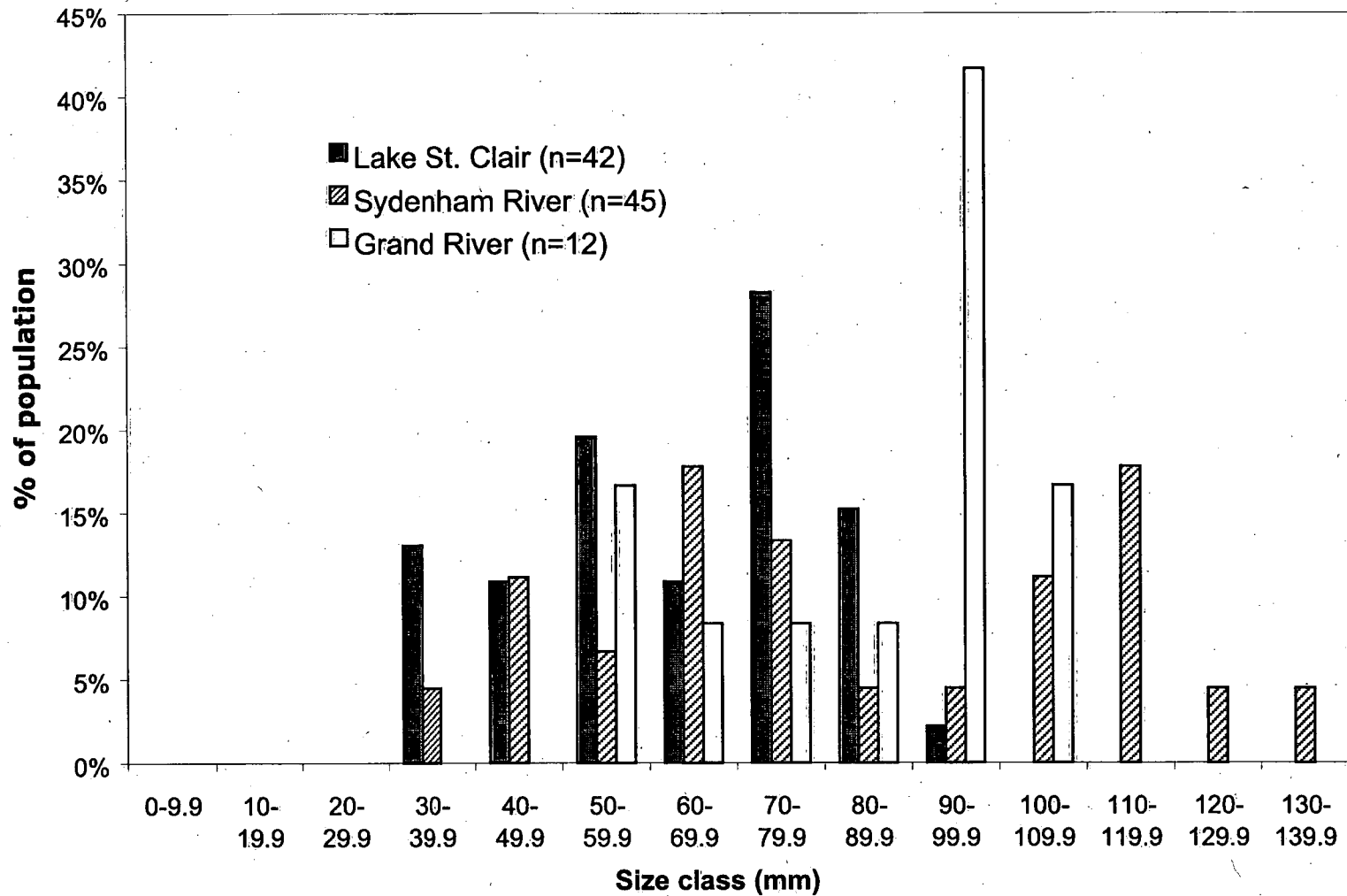


Figure 6. Size frequency distribution for live specimens of *Pleurobema sintoxia* found in Lake St. Clair, the Sydenham River, and the Grand River between 1997 and 2002.

near the mouth to the Middle Thames River near Thamesford. This information suggests that the species was once broadly distributed, although rare, in the Thames River. Only two live specimens of *P. sintoxia* were found during timed search surveys of 16 sites in the Thames River drainage in 1997-98. Both specimens were found at a site on the Middle Thames River upstream of Thamesford and both were very large (95 and 115 mm) by Clarke's (1981) standards (max. shell length of 100 mm reported for Canadian waters). The Round Pigtoe accounted for 0.11% of the community by abundance (a total of 1890 mussels were collected). It is likely that these specimens are remnants of a dying population. Weathered shells were found at an additional eight sites on the river between Thamesford and Chatham (~ 150 km reach), lending further support to the premise that the population was larger and more widespread in this river historically.

The Round Pigtoe appears to have always been a rare member of the unionid community of the Sydenham River. It was first collected from the river in 1929 by R. Cain at a site near Alvinston (specimen held by the ROM). Stein and associates (Ohio State University) collected 2 live specimens and 16 fresh whole shells from a site near Florence in 1965 and 4 live specimens and 4 fresh whole shells from a site below Alvinston in 1967. Clarke (1973) reported it alive at three of 11 sites he surveyed in 1971 but did not provide information on abundance. Clarke (1992) also surveyed 16 sites in the river in 1991 and found a total of 5 live *P. sintoxia* at two sites. Metcalfe-Smith et al. (1998b, 1999) conducted 4.5 p-h timed search surveys at 17 sites on the river in 1997-1998, and an 18th site was surveyed in 2002 (Metcalfe-Smith and Zanatta, unpublished data). Twenty-two Round Pigtoes were found alive at six of these sites, representing 0.93% of the 2359 unionids collected from the river. Only 1-2 specimens/site were observed in the East Sydenham River, but 14 live animals were collected from a site near Warwick on Bear Creek. Relative abundance in terms of catch-per-unit-effort (CPUE) was similar to that reported in the past, i.e., 0.22-0.44 specimens/p-h (except for 3.0/p-h at the site in Bear Creek) vs. 0.20-0.66 specimens/p-h between 1965 and 1991. Quantitative (quadrat) surveys were also conducted at 10 sites on the Sydenham River between 1999 and 2002, and 23 *P. sintoxia* were found alive at six of these sites (Metcalfe-Smith and Zanatta 2003). Density estimates ranged from 0.01 to 0.13 per m². Shell lengths of the 45 live Round Pigtoes observed at 7 different sites in a ~75 km reach of the East Sydenham River between Rokeby and Dawn Mills and one site in the north branch of the river ranged from 30 to 133 mm (Figure 6), suggesting that recruitment is occurring. However, quantitative sampling at an additional five sites in 2003 yielded only 3 more animals and a closer examination of the shell length data showed that the Round Pigtoe is successfully reproducing at only one or two sites on the river (Metcalfe-Smith and Zanatta, unpublished data).

Table 1 summarizes the available information on frequency of occurrence and relative abundance of *P. sintoxia* in various locations in Canada and the United States. The species was found at about 25% of sites surveyed (range 2-60%), representing 1.5% on average (range 0.1-5.1%) of the total number of mussels collected. The Round Pigtoe could be described as a broadly distributed but uncommon species that is seldom, if ever, abundant.

Table 1. Frequency of occurrence and relative abundance of *Pleurobema sintoxia* in various locations in the United States and Ontario.

River/Lake	State/ Province	Frequency of occurrence, as % of sites surveyed (# sites)	Relative abundance, as % of community	Year of survey
Red River drainage	OK	-	2.7%; 1.8%	1997 ^a
Green River	KY	-	1.8%	1990-91 ^b
Barren River	KY	-	0.6%	1990-91 ^b
St. Joseph River	OH	35% (40)	-	1938-75 ^c
Muskingum River	OH	-	0.1%; 0.2%	1992 ^d
Clinton River	MI	15.8% (76)	5.1%	1977-78 ^e
Clinton, Huron, and Raisin Rivers	MI	34.7% (75)	-	1980 ^f
upper Blanchard River	OH	45.5% (11)	2.2%	1994-96 ^g
Black and Pine Rivers	MI	21.7% (23)	-	1982-83 ^h
Lake St. Clair	ON, MI	3.4% (29)	0.4%	1986 ⁱ
Lake St. Clair	ON, MI	9.1% (33)	1.8%	1999-2001 ^j
Sydenham River (timed search method)	ON	35.3% (18)	0.9%	1997-98, 2002 ^{k, l}
Sydenham River (quadrat search method)	ON	60% (10)	0.6%	1999-2002 ^l
Thames River	ON	6.3% (16)	0.1%	1997-98 ^k
Grand River	ON	12.5% (24)	0.2%	1997-1998 ^k
Lake Erie (Western Basin)	OH, MI, ON	-	0.3%	1951-52 ^m
Lake Erie (Put-in-Bay)	OH	-	5.2%	1970 ⁿ
Detroit River	ON, MI	17.6% (17)	1.1%	1982-83 ^o
Detroit River	ON, MI	41.2% (17)	0.7%	1992 ^o
Detroit River	ON, MI	11.1% (9)	3.4%	1994 ^o

^aVaughn et al. (1997), ^bCochran and Layzer (1993), ^cClark (1977), ^dWatters (1993-1994), ^eStrayer (1980), ^fStrayer (1983), ^gHoggarth et al. (2000), ^hHoeh and Trdan (1985), ⁱNalepa and Gauvin (1988), ^jZanatta et al. (2002), ^kMetcalfe-Smith et al. (1998, 1999), ^lMetcalfe-Smith et al. (unpublished data), ^mNalepa et al. (1991), ⁿKokai (1976), ^oSchloesser et al. (1998).

LIMITING FACTORS AND THREATS

The introduction and spread of the exotic Zebra Mussel (*Dreissena polymorpha*) throughout the Great Lakes drainage has led to dramatic declines of native freshwater mussels in colonized areas. Zebra Mussels have infested 63% of sites where *P. sintonia* was known to occur prior to 1990 (Metcalf-Smith et al. 1998b). The Zebra Mussel invasion of Lake St. Clair, Lake Erie and the Detroit and Niagara rivers has led to the reduction or elimination of *P. sintonia* and other native mussel species from these waters (e.g., Schloesser and Nalepa 1994, Nalepa et al. 1996, Schloesser et al. 1998). Zebra Mussels may threaten the population of Round Pigtoes that still survives in the delta area of Lake St. Clair, as it is not known if the unionid community is stable or if the process of extirpation by Zebra Mussels is just slower in this area (Zanatta et al. 2002). Zebra Mussels are unlikely to endanger the other significant population of *P. sintonia* in Ontario, i.e., the population in the Sydenham River, because the river is not navigable by boats and has few impoundments that could support a permanent colony. Nevertheless, the reservoirs at Coldstream and Strathroy in the headwaters of the East Sydenham River are of some concern. Potential colonization of the Grand and Thames rivers with Zebra Mussels continues to be a major worry, because large sections of these rivers are impounded. In fact, Zebra Mussels have recently been found in the Fanshawe and Springbank reservoirs on the Thames River (S. Hohn, Upper Thames River Conservation Authority, September 2003).

Anthropogenic stressors such as high loadings of sediment, nutrients and toxic compounds originating from urban and agricultural sources are potential problems in southwestern Ontario where *P. sintonia* occurs. Siltation resulting from intensive agriculture has fouled many of the sand and gravel riffles in rivers inhabited by this species. Tile drains, cattle access to streams, and the reduction or elimination of riparian buffer strips have all contributed to this problem. Nutrient loadings through the application of fertilizers and the discharge of municipal sewage can have detrimental effects on rare fauna. Pesticides from farms and chlorides from winter road salting can also impact the benthic fauna (Jacques Whitford Environment Limited 2001).

Pleurobema sintonia is a commercially valuable species. It was historically used in the pearl button industry and it may now be taken for the cultured pearl industry (Oesch 1995). According to Busby and Horak (1993), *P. sintonia* is one of 12 commercially valuable species in Kansas. Baker (1993) notes that there has recently been a shift in market demand from the large washboards, *Megaloniaias nervosa*, to the Mapleleaf (*Quadrula quadrula*), Threeridge (*Amblema plicata*) and pigtoes (*Fusconaia* and *Pleurobema* spp.). Overharvesting has seriously depleted mussel stocks in the U.S.A., and the commercial harvest been closed in many states (e.g., Anderson et al. 1993 for Indiana). There was a short-lived mussel fishery on the Grand River in the early 1900s (Detweiler 1918), but there is no commercial harvesting of mussels in Canada at the present time. A request was made in the 1990s for a license to commercially harvest mussels from the Thames River, but the request was withdrawn before it could be considered (A. Dextrase, Ontario Parks, Ontario Ministry of Natural Resources, pers. comm. August 2003). Poaching is a potential threat if there are further closures, stricter regulations and/or stiffer fines associated with commercial musseling in the U.S.

The most significant natural controls on the size and distribution of mussel populations are the distribution and abundance of their host fishes, and predation. Unionids can not complete their life cycle without access to their 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 (Bogan 1993). As noted earlier (section on Biology), several fishes known to be glochidial hosts for the Round Pigtoe in the United States also occur throughout the mussel's range in Canada (Bluegill, Spotfin Shiner, Bluntnose Minnow and Northern Redbelly Dace) and are therefore likely hosts in Ontario. Laboratory testing and field confirmation is required to identify the functional host(s) with certainty.

Freshwater mussels are known to be food sources for a variety of mammals and fish (Fuller 1974). Predation by muskrats (*Ondatra zibethicus*), in particular, may be a limiting factor for some mussel species. Tyrrell and Hornbach (1998) and others 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. However, heavy-shelled mussels like *P. sintoxia* may escape predation because they are too difficult to open. During their study of muskrat predation on 34 species of mussels in the St. Croix and Mississippi rivers in Minnesota and Wisconsin, Tyrrell and Hornbach (1998) observed that the Round Pigtoe was one of the least preferred prey species. Watters (1993-94) compared the composition of the mussel community at two sites in the lower Muskingum River in Ohio with the composition of shells in nearby muskrat middens. The Round Pigtoe was too rare to be considered in the study, but the closely related Ohio Pigtoe (*P. cordatum*) was one of two dominant species that were underrepresented in muskrat middens. It appears that muskrats are unlikely to be a significant limiting factor for the Round Pigtoe in Ontario. Raccoons (*Procyon lotor*) are another potential predator. Although we are not aware of any studies on raccoon predation, we have observed raccoons feeding on mussels in the field and there is anecdotal information from the farming community in the Sydenham River watershed that the recent adoption of conservation tillage practices has led to an explosion in the raccoon population.

SPECIAL SIGNIFICANCE OF THE SPECIES

There are 31 species in the genus *Pleurobema* (recognized by Williams et al. 1993), but only *P. sintoxia* has a range that extends into Canada. Fifteen species of *Pleurobema* are either listed or are candidates for listing under the U.S. Endangered Species Act (USFWS 2002). Some of these species are already presumed to be extinct. *Pleurobema sintoxia* is the only member of the genus that is listed as "currently stable" by the American Fisheries Society (Williams et al. 1993), although this information is now ten years old. The entire genus is disappearing rapidly, mostly due to habitat alteration from the construction of impoundments. The genera *Pleurobema* and *Epioblasma* are the most critically imperiled taxa of unionids – the protection of even the most common members of these taxa is necessary to ensure that the genera

remain extant. The presence of rare mussel species is indicative of healthy waters, as the rarest species are often the most sensitive to habitat alteration. The continuing decline or disappearance of rare species is a warning of the continuing degradation of our freshwater resources.

EXISTING PROTECTION OR OTHER STATUS

Pleurobema sintoxia is listed as common (G4) in North America (Natureserve.org 2003). However, it is presently listed as endangered in Iowa (Cummings and Mayer 1992) and Pennsylvania (R. Evans, Pennsylvania Natural Diversity Inventory, pers. comm. September 2002), threatened in Minnesota (M. Davis, Minnesota Dept. of Natural Resources, pers. comm. September 2002), special concern in Michigan (P. Marangelo, The Nature Conservancy – Michigan Chapter, pers. comm. September 2002) and Wisconsin (W. Smith, Natural Heritage Inventory Program, pers. comm. September 2002) and as a species of special interest in Ohio (Cummings and Mayer 1992). It is therefore afforded some protection in these states. The Round Pigtoe is not currently listed or proposed for listing under the U.S. Endangered Species Act, nor is it listed in the IUCN Red Book. Sub-jurisdictional (state and provincial) ranks for the species are shown in Figure 7.

Ontario is one of six provinces that have stand-alone Endangered Species Acts (B.T. Fowler, Co-Chair, Lepidopterans and Molluscs Specialist Subcommittee, COSEWIC, pers. comm. August 2002). Species designated as endangered are protected from willful destruction under these Acts. Seven species of freshwater mussels that are listed as endangered by COSEWIC, namely, the Rayed Bean (*Villosa fabalis*), Wavy-rayed Lampmussel (*Lampsilis fasciola*), Northern Riffleshell (*Epioblasma torulosa rangiana*), Snuffbox (*Epioblasma triquetra*), Mudpuppy Mussel (*Simpsonias ambigua*), Kidneyshell (*Ptychobranthus fasciolaris*) and Round Hickorynut (*Obovaria subrotunda*), are found only in the Province of Ontario. None of these species has been listed as endangered by Ontario, so they do not benefit from provincial legislation at this time.

The Round Pigtoe population in Lake St. Clair is located entirely within the territory of the Walpole Island First Nation (WIFN). Special user permits are required to access First Nation territory and waters, which limits human disturbance in the area. The WIFN has no specific policy protecting the species at risk within their territory, but their philosophy is: "To preserve, enhance, and maintain a mutual respect, to continue a beneficial dependency upon the environment, and endeavor to co-exist with Mother Nature and protect this relationship" (C. Jacobs, Walpole Island Heritage Centre, pers. comm. October 2001). The Walpole Island Heritage Centre has been notified about the presence of the population of *P. sintoxia* in their territory.

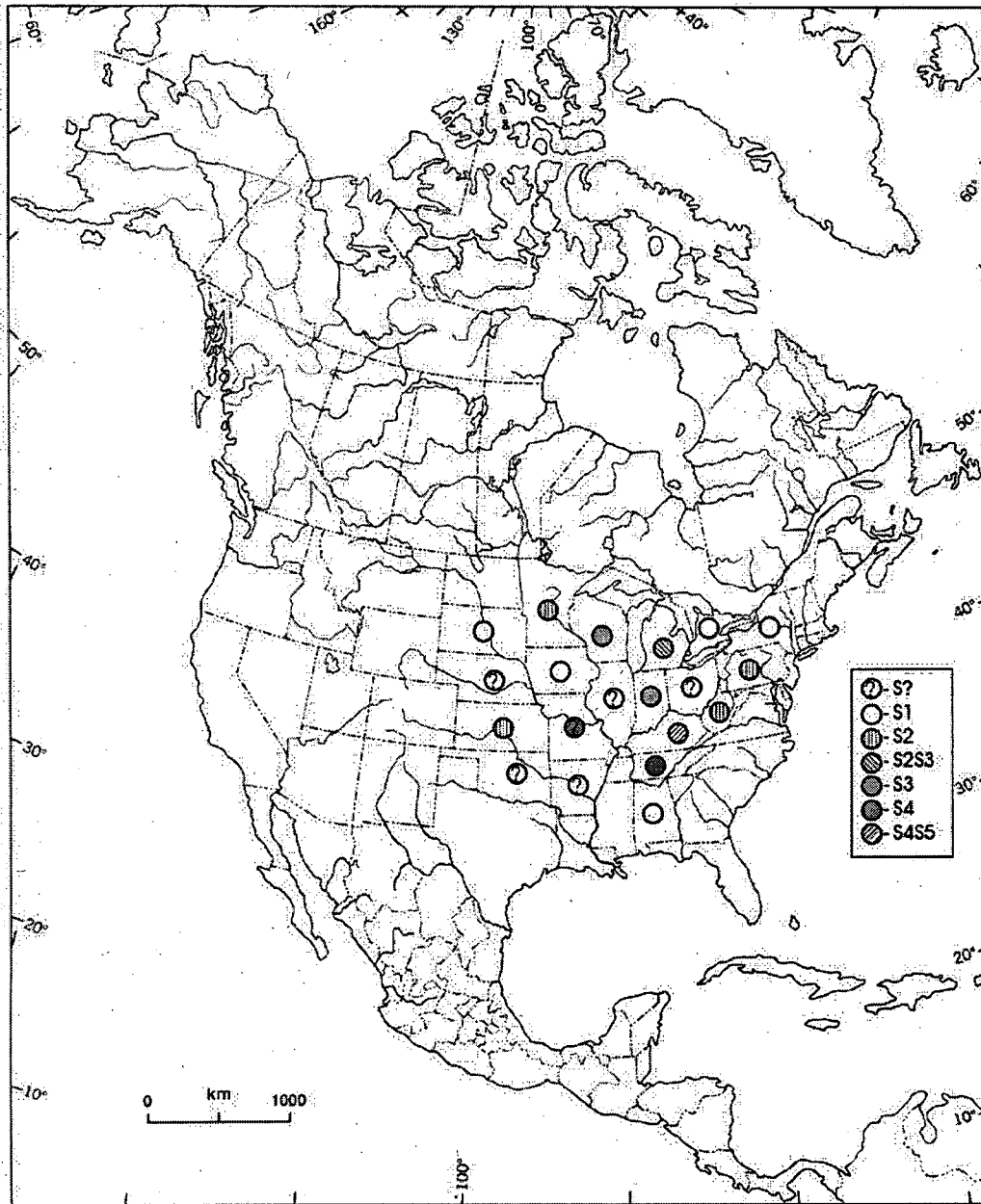


Figure 7. State and provincial conservation priority ranks (S-ranks) for *Pleurobema sintoxia*.

The federal Fisheries Act may represent the most important legislation protecting mussel habitat in Canada. Freshwater mussels are considered to be shellfish and, as such, are included in the definition of "fish" under this Act. Collection of live mussels is considered "fishing" and therefore falls under the Ontario Fishery Regulations made under the federal Fisheries Act. Threatened and endangered species in Ontario receive

policy level protection from development and site alteration through the Provincial Policy Statement under the provincial Planning Act. The Ontario Lakes and Rivers Improvement Act (prohibiting the impoundment or diversion of watercourses that would lead to siltation) and the voluntary Land Stewardship II program of OMAFRA (which is designed to reduce the erosion of agricultural lands) also protect mussel habitat. Stream-side development in Ontario is managed through flood plain regulations enforced by local Conservation Authorities. Land ownership along the reaches of the Sydenham, Grand, and Thames rivers where *P. sintoxia* occurs is mainly private and most of the land is in agricultural use (Protection/ownership in the section on Habitat).

SUMMARY OF STATUS REPORT

Pleurobema sintoxia historically occurred in 19 states and the province of Ontario. In the United States, it was found throughout the Mississippi and Ohio River systems. It also occurred in Lake Erie, Lake St. Clair, and their drainages. There are few data available on historical abundance, but Ortmann (1919) described the species as "abundant" in many locations throughout its range at the turn of the 20th century. In contrast, most jurisdictions currently describe the species as uncommon and never abundant, with evidence of recruitment lacking in some streams in Kentucky and Missouri. In Canada, the Round Pigtoe was historically found in the western basin of Lake Erie, Lake St. Clair, and the Niagara, Detroit, Grand, Thames, and Sydenham rivers. It has been lost from Lake Erie, the Niagara and Detroit rivers, and the offshore waters of Lake St. Clair due to impacts of the Zebra Mussel. A significant population was discovered in shallow waters of the St. Clair delta in Lake St. Clair in 1999, but it is not certain that this population will continue to co-exist with the Zebra Mussel. The Round Pigtoe has declined in the Grand and Thames rivers, with only small numbers of large - presumably relic - specimens left. Declines in the Grand River may be reversible, since many other mussel species have recolonized the lower river as a result of significant improvements in water quality over the past 25 years. The healthiest population of *P. sintoxia* in Canada is in the Sydenham River, where the species is relatively rare (representing about 1% of the mussel community by abundance) but shows signs of continuing recruitment at one or two sites.

The Round Pigtoe is currently listed as endangered in Iowa and Pennsylvania, threatened in Minnesota, special concern in Michigan and Wisconsin, and a species of special interest in Ohio, and is therefore afforded some protection in these states (it is not federally listed in the U.S.). Most land along the reaches of the Thames, Grand, and Sydenham rivers where *P. sintoxia* was found alive in recent years is privately owned and in agricultural use. The population of *P. sintoxia* in the St. Clair delta is located within the territory of the Walpole Island First Nation. The area is undeveloped and is under the control of the First Nation, which means there is excellent potential for protecting the population from human disturbance. However, it may not be possible to protect it indefinitely from the Zebra Mussel. The most significant threats to the continued existence of the Round Pigtoe in Canada are Zebra Mussels and agricultural impacts.

TECHNICAL SUMMARY

Pleurobema sintoxia

Round Pigtoe

Range of occurrence: Southwestern Ontario

Pleurobème écarlate

Extent and Area information	
<ul style="list-style-type: none"> • <i>Extent of occurrence (EO)(km²)</i> : By drawing polygons in Arcview, historical EO was 26,592 km², the current EO is 12,360 km² 	Lake St. Clair, Sydenham River, Middle Thames River, Lower Grand River ~12,400 km ²
<ul style="list-style-type: none"> • <i>Specify trend in EO</i> 	Decline (~54%)
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in EO?</i> 	No
<ul style="list-style-type: none"> • <i>Area of occupancy (AO) (km²)</i> 	8 km ² in Lake St. Clair delta, 0.5 km reach of Bear Creek/North Sydenham River (~0.01 km ²), 75 km of East Sydenham River (~2 km ²), 0.5 km reach of Middle Thames River (~0.02 km ²), 45 km reach of lower Grand River (~5 km ²). Total = ~15 km ² .
<ul style="list-style-type: none"> • <i>Specify trend in AO</i> 	Decline
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in AO?</i> 	No
<ul style="list-style-type: none"> • <i>Number of known of inferred locations</i> 	5
<ul style="list-style-type: none"> • <i>Specify trend in #</i> 	Decline
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in number of locations?</i> 	No
<ul style="list-style-type: none"> • <i>Specify trend in area, extent or quality of habitat</i> 	Decline
Population information	
<ul style="list-style-type: none"> • <i>Generation time (average age of parents in the population)</i> 	Unknown (estimate 10 years)
<ul style="list-style-type: none"> • <i>Number of mature individuals</i> 	Unknown
<ul style="list-style-type: none"> • <i>Total population trend:</i> 	Declining
<ul style="list-style-type: none"> • <i>% decline over the last/next 10 years or 3 generations</i> 	Unknown
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in number of mature individuals?</i> 	No
<ul style="list-style-type: none"> • <i>Is the total population severely fragmented?</i> 	Yes, no mixing between populations in different watersheds
<ul style="list-style-type: none"> • <i>Specify trend in number of populations</i> 	Decline
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in number of populations?</i> 	No
<ul style="list-style-type: none"> • <i>List each population and the number of mature individuals in each:</i> 	Total population ~200,000 but # of mature individuals unknown
Threats (actual or imminent threats to populations or habitats)	
<ul style="list-style-type: none"> - Zebra Mussels (invasive species). - Habitat loss and degradation due to agricultural impacts (siltation, nutrient loading, loss of riparian vegetation), urbanization, and municipal and industrial pollution. 	
Rescue Effect (immigration from an outside source)	
<ul style="list-style-type: none"> • <i>Status of the outside population(s)?</i> 	None
<ul style="list-style-type: none"> • <i>Is immigration known or possible?</i> 	Largely stable
<ul style="list-style-type: none"> • <i>Would immigrants be adapted to survive in Canada?</i> 	No
<ul style="list-style-type: none"> • <i>Is there sufficient habitat for immigrants here?</i> 	Likely (genetic testing required)
<ul style="list-style-type: none"> • <i>Is rescue from outside populations likely?</i> 	No
Quantitative Analysis	

Status and Reasons for Designation

<p>Status: Endangered</p>	<p>Alpha-numeric code: A2ace; B2ab(i,ii,iii,iv)</p>
<p>Reasons for Designation: Species limited to a small area of occupancy in the Lake St. Clair and three watersheds in southern Ontario with continuing declines in habitat area, extent and quality. Threats include urban, industrial and agricultural development and irreversible impacts from zebra mussels in Lake St. Clair, with potential threats from introduction of zebra mussels in impoundments in the Sydenham River.</p>	
<p align="center">Applicability of Criteria</p> <p>Criterion A (Declining Total Population): population size reduction estimated from 54% decline in extent of occurrence (and probably area of occupancy), continuing declines in quality and extent of habitat, and effects of introduced taxa (Endangered, A2a,c,e).</p> <p>Criterion B (Small distribution, and decline or fluctuation): qualifies for threatened under B1 (Extent of Occurrence < 20,000 km²) but Endangered for the following criteria: species has a small area of occupancy (<15 km²), population is severely fragmented and there are continuing declines in: Extent of Occurrence; Area of Occupancy; area, extent and quality of habitat; number of locations (Endangered B2a,b(i-iv)).</p> <p>Criterion C (Small Total Population Size and Decline): number of mature individuals unknown</p> <p>Criterion D (Very Small Population or Restricted Distribution): qualifies for Threatened under D2, small area of occupancy.</p> <p>Criterion E (Quantitative Analysis): unable to estimate probability of extinction.</p>	

ACKNOWLEDGEMENTS

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LITERATURE CITED

- Anderson, R.M., T. Stefanavage and T. Flatt. 1993. Why did Indiana halt commercial mussel harvest in 1991? Pp. 19-24 *in* K.S. Cummings, A.C. Buchanan, and L.M. Koch (eds.) Conservation and Management of Freshwater Mussels. Proceedings of the Upper Mississippi River Conservation Committee Symposium, St. Louis, Missouri, October 1992. Illinois Natural History Survey, Champaign, Illinois.
- Baker, P.M. 1993. Resource management: A shell exporter's perspective. Pp. 69-71 *in* K.S. Cummings, A.C. Buchanan, and L.M. Koch (eds.) Conservation and Management of Freshwater Mussels. Proceedings of the Upper Mississippi River Conservation Committee Symposium, St. Louis, Missouri, October 1992. Illinois Natural History Survey, Champaign, Illinois.
- Bogan, A.E. 1993. Freshwater bivalve extinctions (mollusca: Unionoida): A search for causes. *American Zoologist* 33:599-609.
- Busby, W.H. and G. Horak. 1993. Unionid mussels in Kansas: Overview of conservation efforts and harvest regulations. Pp. 50-55 *in* K.S. Cummings, A.C. Buchanan, and L.M. Koch (eds.) Conservation and Management of Freshwater Mussels. Proceedings of the Upper Mississippi River Conservation Committee Symposium, St. Louis, Missouri, October 1992. Illinois Natural History Survey, Champaign, Illinois.
- Clark, C.F. 1977. The freshwater naiads of Ohio, Part 1: St. Joseph River of the Maumee. *Sterkiana* 65-66: 14-36.
- Clarke, A.H. 1973. On the distribution of Unionidae in the Sydenham River, southern Ontario, Canada. *Malacological Review* 6:63-64.
- Clarke, A.H. 1981. The Freshwater Molluscs of Canada. National Museums of Canada, Ottawa. 446 pp.
- Clarke, A.H. 1992. Ontario's Sydenham River, an important refugium for native freshwater mussels against competition from the zebra mussel *Dreissena polymorpha*. *Malacology Data Net* 3(1-4): 43-55.
- Cochran, T.G. II, and J.D. Layzer. 1993. Effects of commercial harvest on unionid habitat use in the Green and Barren Rivers, Kentucky. Pp. 61-65 *in* K.S. Cummings, A.C. Buchanan, and L.M. Koch (eds.) Conservation and Management of Freshwater Mussels. Proceedings of the Upper Mississippi River Conservation Committee Symposium, St. Louis, Missouri, October 1992. Illinois Natural History Survey, Champaign, Illinois.
- Cummings, K.S., and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey Manual 5. 194 pp.

- Detweiler, J.D. 1918. The pearly fresh-water mussels of Ontario. Contributions to Canadian Biology, Supplement to the 7th Annual Report, Fisheries Branch, Department of Naval Service. pp. 75-91.
- Ecological Specialists. 1999. Final report: Unionid survey in the Western basin of Lake Erie near the Bass Islands and southwest shore. Prepared by Ecological Specialists, Inc., St. Peters, Missouri, for the Ohio Division of Wildlife - Department of Natural Resources, Columbus, Ohio and the U.S. Fish and Wildlife Service, Reynoldsburg, Ohio. 22 pp.
- Ecological Specialists. 2001. A unionid survey of Lake Erie coastal marshes in Ohio. Prepared by Ecological Specialists, Inc., St. Peters, Missouri, for the Ohio Biological Survey, Columbus, Ohio. 16 pp.
- Fuller, S.L.H. 1974. Clams and mussels (Mollusca: Bivalvia). *In* Pollution Ecology of Freshwater Invertebrates. Edited by C.W. Hart, Jr., and S.L.H. Fuller. Academic Press, New York.
- Garner, J.T. and S.W. McGregor. 2001. Current status of freshwater mussels (Unionidae, Margaritiferidae) in Muscle Shoals area of Tennessee River in Alabama (Muscle Shoals revisited again). *American Malacological Bulletin* 16(1/2): 155-170.
- Gordon, M.E., and J.B. Layzer. 1989. Mussels (Bivalvia: Unionoidea) of the Cumberland River: review of life histories and ecological relationships. Biological Report 89(15). U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. vii + 99 pp.
- Hebert, P.D.N., B.W. Muncaster, and G.L. Mackie. 1989. Ecological and genetic studies on *Dreissena polymorpha* (Pallas): a new mollusc in the Great Lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 46:1587-1591.
- Hoeh, W.R., and R.J. Trdan. 1985. Freshwater mussels (Pelecypoda: Unionidae) of the major tributaries of the St. Clair River, Michigan. *Malacological Review* 18:115-116.
- Hoggarth, M.A. 1993. Glochidial functional morphology and rarity in the Unionidae. Pp. 76-80 *in* K.S. Cummings, A.C. Buchanan, and L.M. Koch (eds.) Conservation and Management of Freshwater Mussels. Proceedings of the Upper Mississippi River Conservation Committee Symposium, St. Louis, Missouri, October 1992. Illinois Natural History Survey, Champaign, Illinois.
- Hoggarth, M.A., D.L. Rice, and T.L. Grove. 2000. The correlation of mussels with fish in the upper Blanchard River in Hardin and Hancock counties, Ohio, with special regard to the rayed bean (*Villosa fabalis*). Pp. 19-26 *in* R.A. Tankersley, D.I. Warmolts, G.T. Watters, B.J. Armitage, P.D. Johnson, and R.S. Butler (eds.) Freshwater Mollusk Symposia Proceedings. Ohio Biological Survey, Columbus, Ohio.
- Hove, M.C. 1995. Host research on round pigtoe glochidia. Triannual Unionid Report (8):8.
- Jacques Whitford Environment Limited. 2001. Sydenham River Recovery Project: Synthesis and analysis of background data. Report to the Sydenham River Recovery Team. 50 pp.
- Kat, P.W. 1984. Parasitism and the Unionacea (Bivalvia). *Biological Reviews* 59:189-207.

- Kidd, B.T. 1973. *Unionidae of the Grand River drainage, Ontario, Canada*. M.Sc. thesis, Carleton University, Ottawa, ON.
- Kokai, F.L. 1976. Variations in aperture characteristics of eighteen species of unionidae from Lake Erie. *Bull. of the Am. Malacol. Union* 1976:12-15.
- La Rocque, A., and Oughton, J. 1937. A preliminary account of the Unionidae of Ontario. *Can. J. Res.* 15D:148-155.
- Metcalfe-Smith, J.L., J. Di Maio, S.K. Staton, and G.L. Mackie. 2000a. Effect of sampling effort on the efficiency of the timed search method for sampling freshwater mussel communities. *Journal of the North American Benthological Society* 19(4):725-732.
- Metcalfe-Smith, J.L., J. Di Maio, S.K. Staton and S.R. de Solla. 2003. Status of the freshwater mussel communities of the Sydenham River, Ontario, Canada. Environment Canada. *The American Midland Naturalist* 150: 37-50.
- Metcalfe-Smith, J.L., G.L. Mackie, J. Di Maio, and S.K. Staton. 2000b. Changes over time in the diversity and distribution of freshwater mussels (Unionidae) in the Grand River, southwestern Ontario. *Journal of Great Lakes Research* 26(4):445-459.
- Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and N.M. Lane. 1998a. Selection of candidate species of freshwater mussels (Bivalvia: Unionidae) to be considered for national status designation by COSEWIC. *Canadian Field-Naturalist* 112(3):425-440.
- Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie and I.M. Scott. 1999. Range, population stability and environmental requirements of rare species of freshwater mussels in southern Ontario. Environment Canada, NWRI, Burlington, ON. NWRI Contribution No. 99-058.
- Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and E.L. West. 1998b. Assessment of the current conservation status of rare species of freshwater mussels in southern Ontario. Environment Canada, NWRI, Burlington, ON. NWRI Contribution No. 98-019.
- Metcalfe-Smith, J.L. and D.T. Zanatta. 2003. Development of a monitoring program for tracking the recovery of endangered freshwater mussels in the Sydenham River, Ontario: Report on Activities in Year 1 (2002-03). Environment Canada, NWRI, Burlington, ON. AEIRB Branch Technical Note No. 03-001.
- Natureserve.org. 2003. Natureserve Homepage: A Network Connecting Science with Conservation. Web site: <http://www.natureserve.org>
- Nalepa, T.F. and J.M. Gauvin. 1988. Distribution, abundance, and biomass of freshwater mussels in Lake St. Clair. *Journal of Great Lakes Research* 14(4):411-419.
- Nalepa, T.F., D.J. Hartson, G.W. Gostenik, D.L. Fanslow, and G.A. Lang. 1996. Changes in the freshwater mussel community of Lake St. Clair: from Unionidae to *Dreissena polymorpha* in eight years. *Journal of Great Lakes Research* 22(2):354-369.
- Nalepa, T.F., B.A. Manny, J.C. Roth, S.C. Mozley, and D.W. Schloesser. 1991. Long-term decline in freshwater mussels (Bivalvia: Unionidae) of the western basin of Lake Erie. *Journal of Great Lakes Research* 17(2):214-219.

- Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. The Freshwater Mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine. 118 pp.
- Nichols, S.J. and J. Amberg. 1999. Co-existence of zebra mussels and freshwater unionids: population dynamics of *Leptodea fragilis* in a coastal wetland infested with zebra mussels. *Canadian Journal of Zoology* 77:423-432.
- Oesch, R.D. 1995. Missouri Naiades. A Guide to the Mussels of Missouri. Missouri Department of Conservation, Jefferson City, MO. 270 pp.
- Ortmann, A.E. 1919. A monograph of the naiades of Pennsylvania, Part III. Systematic account of the genera and species. *Memoirs of the Carnegie Museum*, Vol. VIII, No. 1. Carnegie Institute, Pittsburgh, Pennsylvania. 384 pp.
- Parmalee, P.W. and A.E. Bogan. 1998. The freshwater mussels of Tennessee. University of Tennessee Press, Knoxville, TN. 384 pp.
- Schloesser, D.W. and T.F. Nalepa. 1994. Dramatic decline of unionids in offshore waters of western Lake Erie after infestation by the Zebra Mussel, *Dreissena polymorpha*. *Canadian Journal of Fisheries and Aquatic Sciences* 51:2234-2242.
- Schloesser, D.W., W.P. Kovalak, G.D. Longton, K.L. Ohnesorg, and R.D. Smithee. 1998. Impact of zebra and quagga mussels (*Dreissena* spp.) on freshwater unionids (*Bivalvia*: *Unionidae*) in the Detroit River of the Great Lakes. *American Midland Naturalist* 140:229-313.
- Schloesser, D.W. and E.C. Masteller. 1999. Mortality of unionid bivalves (*Mollusca*) associated with dreissenid mussels (*Dreissena polymorpha* and *D. bugensis*) in Presque Isle Bay, Lake Erie. *Northeastern Naturalist* 6(4):341-352.
- Stansbery, D.H.. 1967. Growth and longevity of Naiads from Fishery Bay in western Lake Erie. *American Malacological Union Annual Reports* 1967:10-11.
- Strayer, D.L. 1980. The freshwater mussels (*Bivalvia*: *Unionidae*) of the Clinton River, Michigan, with comments on man's impacts on the fauna, 1870-1978. *The Nautilus* 94(4):142-149.
- Strayer, D.L. 1983. The effects of surface geology and stream size on freshwater mussel (*Bivalvia*: *Unionidae*) distribution in southeastern Michigan, U.S.A. *Freshwater Biology* 13:253-264.
- Strayer, D.L., and A.R. Fetterman. 1999. Changes in the distribution of freshwater mussels (*Unionidae*) in the Upper Susquehanna River basin, 1955-1965 to 1996-1997. *American Midland Naturalist* 142:328-339.
- Strayer, D.L., and K.J. Jirka. 1997. The pearly mussels of New York State. *Memoirs of the New York State Museum* 26:1-113 + plates 1-27.
- Thames River Background Study Research Team. 1998. The Thames River Watershed: A Background Study for Nomination under the Canadian Heritage Rivers System. Upper Thames River Conservation Authority, London, ON.
- Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd Edition. *American Fisheries Society Special Publication* 26:ix-526.

- Tyrell, M., and D.J. Hornbach. 1998. Selective predation by muskrats on freshwater mussels in 2 Minnesota rivers. *Journal of the North American Benthological Society* 17(3):301-310.
- U.S. Fish and Wildlife Service. 2002. The Endangered Species Program, Species Information, Threatened and Endangered Animals and Plants. Web site: <http://endangered.fws.gov/wildlife.html>
- van der Schalie. 1938. The naiad fauna of the Huron River, in southeastern Michigan. Miscellaneous Publication No. 40, Museum of Zoology, University of Michigan. University of Michigan Press, Ann Arbor, Michigan. 83 pp + Plates I-XII.
- Vaughn, C.C., C.M. Taylor, and K.J. Eberhard. 1997. A comparison of the effectiveness of timed searches vs. quadrat sampling in mussel surveys. Pp. 157-162 in K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, (eds.) Conservation and Management of Freshwater Mussels II. Proceedings of the Upper Mississippi River Conservation Committee Symposium, St. Louis, Missouri, October 1995. Illinois Natural History Survey, Champaign, Illinois.
- Watters, G.T. 1993-94. Sampling freshwater mussel populations: the bias of muskrat middens. *Walkerana* 7(17/18):63-69.
- Watters, G.T. 1999. Morphology of the conglutinate of the kidneyshell freshwater mussel, *Ptychobranthus fasciolaris*. *Invertebrate Biology* 118(3):289-295.
- Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. *Fisheries* 18(9): 6-22.
- Zanatta, D.T., G.L. Mackie, J.L. Metcalfe-Smith, and D.A. Woolnough. 2002. A refuge for native freshwater mussels (Bivalvia: Unionidae) from impacts of the exotic zebra mussel (*Dreissena polymorpha*) in Lake St. Clair. *Journal of Great Lakes Research*: 28(3): 479-489.

BIOGRAPHICAL SUMMARY OF THE REPORT WRITERS

David T. Zanatta received a B.Sc. (Hons.) in Biology from Laurentian University (1998) and an M.Sc. (Zoology) from the University of Guelph (2000). His M.Sc. supervisor, Dr. Gerald L. Mackie, is currently chair of the Mollusc Species Subgroup Group of the Lepidoptera and Mollusca Subcommittee of COSEWIC. Mr. Zanatta's thesis was entitled "Biotic and abiotic factors relating to distribution of unionid mussel species in Lake St. Clair." Part of his thesis research, which documented the discovery of native mussel refuge sites in Lake St. Clair, has been published in the *Journal of Great Lakes Research*. He has also studied Lake Trout populations in Northwestern Ontario lakes and analyzed Walleye index netting data for the Ontario Ministry of Natural Resources. He is a member of the North American Benthological Society and the Freshwater Mollusk Conservation Society. David is currently a research technologist with the National Water Research Institute of Environment Canada in Burlington, Ontario. He has co-authored two previous status reports on mussel species at risk for COSEWIC.

Janice L. Metcalfe-Smith is an Aquatic Research Biologist with the National Water Research Institute of Environment Canada in Burlington, Ontario. She has a B.Sc. (Hons.) in Zoology from the University of Manitoba (1973), and 30 years of experience as a technologist (1973-1978) and biologist (1978-present) with the departments of Fisheries and Oceans (Winnipeg, Manitoba and St. Andrews, New Brunswick) and Environment (Burlington, Ontario). She has conducted research in several areas, including the effects of forestry practices and acid rain on Atlantic salmon, the use of benthic macroinvertebrate communities in water quality assessment, and the development of biological monitoring techniques for measuring contaminant trends in freshwater ecosystems. Since 1995, her research has focused on the assessment and conservation of freshwater mussels in Ontario. She has authored or co-authored over 70 scientific papers and reports, including 20 on biodiversity issues. She is a member of the North American Benthological Society, the Freshwater Mollusk Conservation Society, and the Mollusc working group of the Lepidoptera and Molluscs Specialist Subcommittee of COSEWIC. She co-authored seven previous status reports on mussel species at risk for COSEWIC.

AUTHORITIES CONTACTED

- Bogan A.. North Carolina State Museum of Natural Sciences, Research Laboratory, Raleigh, NC.
- Bruenderman, S. Fisheries Research Biologist/Malacologist, Missouri Department of Conservation, Conservation Research Center, Columbia, MO.
- Cicerello, R. Kentucky State Nature Preserves Commission, Frankfort, KY.
- Clayton, J. West Virginia Division of Natural Resources, WV.
- Davis, M. Minnesota Department of Natural Resources, Division of Ecological Services, Lake City, MN.
- Dextrase, A. Ontario Parks, Species at Risk Section, Ontario Ministry of Natural Resources, Peterborough, ON.
- Evans, R. Conservation Zoologist, The Western Pennsylvania Conservancy/ Pennsylvania Natural Diversity Inventory - Western Office, Pittsburgh, PA.
- Fowler, B.T. Co-chair, Lepidoptera and Molluscs Specialist Subcommittee, COSEWIC. Canadian Wildlife Service, Hull, Quebec.
- Garner, J. Malacologist, Alabama Division of Wildlife and Freshwater Fisheries, Florence, AL.
- Jacobs, C. Walpole Island Heritage Centre, Walpole Island First Nation, Wallaceburg, ON.
- Marangelo, P. Planning Ecologist, The Nature Conservancy, Michigan Chapter, East Lansing, MI.
- Mason, P. Grand River Conservation Authority, Cambridge, Ontario.
- Masteller, E. Emeritus Professor of Biology, Penn State Erie, The Behrend College, Erie, PA.
- Nicks, C. Water Quality Specialist - Species at Risk, Upper Thames River Conservation Authority, London, ON.

Schneider, K. Stuyvesant Environmental Consulting, LLC, Stuyvesant Falls, New York.
Smith, W. Natural Heritage Inventory Program, Wisconsin Department of Natural Resources, Madison, WI.
Strayer, D.L. Institute of Ecosystem Studies, Millbrook, NY.
Sutherland, D. Ontario Natural Heritage Information Centre, Ministry of Natural Resources, Peterborough, Ontario.
Woolnough, D. PhD Candidate, Ecology and Evolutionary Biology, Iowa State University, Ames, Iowa.

COLLECTIONS EXAMINED

In 1996, all available historical and recent data on the occurrences of freshwater mussel species throughout the lower Great Lakes drainage basin were compiled into a computerized, GIS-linked database referred to as the Lower Great Lakes Unionid Database. Data sources included the primary literature, natural history museums, federal, provincial, and municipal government agencies (and some American agencies), conservation authorities, Remedial Action Plans for the Great Lakes Areas of Concern, university theses, and environmental consulting firms. Mussel collections held by six natural history museums in the Great Lakes region (Canadian Museum of Nature, Ohio State University Museum of Zoology, Royal Ontario Museum, University of Michigan Museum of Zoology, Rochester Museum and Science Center, and Buffalo Museum of Science) were the primary sources of information, accounting for over two-thirds of the data acquired. The database continues to be updated and now has over 7000 records of unionids from the lower Great Lakes drainage. One of us (J.L. Metcalfe-Smith) personally examined the collections held by the Royal Ontario Museum, University of Michigan Museum of Zoology and Buffalo Museum of Science, as well as smaller collections held by the Ontario Ministry of Natural Resources.

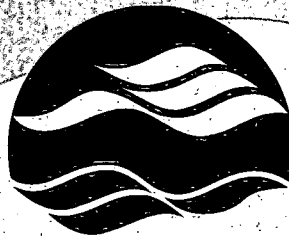
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L7R 4A6 Canada

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S7N 3H5 Canada

Centre national de recherche en hydrologie
11, boul. Innovation
Saskatoon, Saskatchewan
S7N 3H5 Canada

