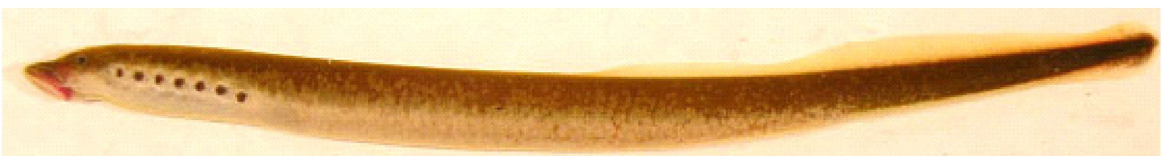
COSEWIC
Assessment and Update Status Report

on the

northern brook lamprey
Ichthyomyzon fossor

Great Lakes – Upper St. Lawrence populations
Saskatchewan – Nelson population

in Canada



Great Lakes – Upper St. Lawrence populations - SPECIAL CONCERN
Saskatchewan – Nelson population – DATA DEFICIENT
2007

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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COSEWIC
Assessment Summary

Assessment Summary – April 2007

Common name
Northern brook lamprey – Great Lakes - Upper St. Lawrence populations

Scientific name
Ichthyomyzon fossor

Status
Special Concern

Reason for designation
This nonparasitic lamprey is distributed in streams throughout the Great Lakes basin (except Lake Ontario) and in southwestern Quebec. In the Great Lakes basin, which comprises most of its range, about 50% of the streams it is known to inhabit are subjected to ongoing chemical treatment for sea lamprey control which causes mortality to its larval stage. However, in untreated streams, the species is still abundant.

Occurrence
Ontario, Quebec

Status history
The species was considered a single unit and designated Special Concern in April 1991. When the species was split into separate units in April 2007, the "Great Lakes - Upper St Lawrence populations" unit was designated Special Concern. Last assessment based on an update status report.

Assessment Summary – April 2007

Common name
Northern brook lamprey – Saskatchewan - Nelson population

Scientific name
Ichthyomyzon fossor

Status
Data Deficient

Reason for designation
This nonparasitic lamprey has not been the subject of any targeted and comprehensive survey since it was first reported from Manitoba in the late 1970s, and accordingly, the distribution and status of its populations are not well known.

Occurrence
Manitoba

Status history
The species was considered a single unit and designated Special Concern in April 1991. When the species was split into separate units in April 2007, the "Saskatchewan-Nelson population" unit was designated Data Deficient. Last assessment based on an update status report.

COSEWIC
Executive Summary

northern brook lamprey
Ichthyomyzon fossor

Great Lakes – Upper St. Lawrence populations
Saskatchewan – Nelson population

Species information

The northern brook lamprey is one of six species of the genus *Ichthyomyzon*. It is eel-like in appearance, reaches approximately 160 mm in length as an adult, and is non-parasitic. Adults can be distinguished from other lampreys by a single dorsal fin and characteristic teeth patterns. Ammocoetes (larval lampreys) within the genus are generally indistinguishable from one another. Some recent genetic analyses have questioned whether this species is truly distinct from the silver lamprey. Although its taxonomic status has been the subject of some debate, this question has not yet been resolved and pending resolution it is herein recognized as a distinct species.

Distribution

Adults have been found in streams throughout Ontario, southwestern Quebec, and southeastern Manitoba. Increased sampling efforts have revealed more locations over the past several years in Ontario. The widespread occurrence of *Ichthyomyzon* larvae may indicate a much wider distribution, but collection of adults is required to confirm identification.

Distribution in the United States is patchy, but includes Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Vermont, West Virginia, and Wisconsin.

Habitat

This lamprey is generally found in clear water streams of a wide range of sizes. Larval northern brook lamprey reside in burrows in silt and sand substrate. After metamorphosing into juveniles, the larvae emerge from their burrows and attach themselves to the stream bottom. For spawning, they require a substrate composed of coarse gravel with a relatively swift, unidirectional current.

Biology

A freshwater fish that inhabits stream sediment in their filter-feeding larval stage, it lives for 3 to 7 years burrowed in soft areas of the stream bottom. After transformation, the northern brook lamprey lives from four to six months before spawning and dying, and does not feed at all during its adult stage.

Population sizes and trends

No population estimates have been made for this species. Northern brook lamprey are no longer found in a number of streams around the Great Lakes that historically supported populations. However, large numbers of ammocoetes of this genus, many of which are thought to be northern brook lamprey, are encountered incidentally through assessment of larval sea lamprey.

Limiting factors and threats

Applications of lampricides to habitats where the sea lamprey and northern brook lamprey coexist have caused reductions in populations around the Great Lakes. These applications are conducted periodically to control the invasive sea lamprey, but have inadvertently resulted in native lamprey declines as well. Water level manipulation, water temperature changes, and pollution have been identified as additional threats.

Special significance of the species

This species, as with all lamprey species, is valuable in that they allow investigation of evolutionary history due to their ancient origins. Northern brook lamprey have been used successfully as biomonitors of contaminants. They also may play a role in nutrient cycling.

Existing protection or other status designations

The northern brook lamprey is currently considered a species of Special Concern in Canada. Their habitat is protected under the *Canadian Fisheries Act* as well as Regulations respecting wildlife habitats in Quebec.

In the United States, they are currently ranked as critically imperiled in Illinois, New York, Pennsylvania, Vermont and West Virginia, imperiled in Kentucky and Ohio, and vulnerable in Minnesota.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS

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

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

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

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

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

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

Update
COSEWIC Status Report

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northern brook lamprey
Ichthyomyzon fossor

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SPECIES INFORMATION

Name and classification

Class:	Cephalaspidomorphi
Order:	Petromyzontiformes
Family:	Petromyzontidae
Scientific name:	*Ichthyomyzon fossor* Reighard and Cummins 1916
English common name:	northern brook lamprey
French common name:	lamproie du nord

The northern brook lamprey is one of six species in the genus *Ichthyomyzon*. The six species are composed of pairs of a closely related parasitic (stem) and a non-parasitic (satellite) species (Hubbs and Potter 1971). The northern brook lamprey is considered a dwarfed relative of the larger, parasitic silver lamprey (*I. unicuspis*) (Potter 1980a). Two species in this genus, the parasitic chestnut lamprey (*I. castaneus*) and the silver lamprey have overlapping ranges with northern brook lamprey (Vladykov and Kott 1979).

There have been several studies investigating the genetics of silver lamprey (Mandrak *et al.* 2004; Docker *et al.*, 2005; Filcek *et al.*, 2005) and its relationship to the northern brook lamprey (see Genetic Description). Nelson *et al*. (2004) recognized the northern brook lamprey as a valid species.

A history of nomenclature, according to Scott and Crossman (1973) includes:

Ichthyomyzon fossor	Reighard and Cummins 1916
Ammocoetes unicolor	DeKay 1842
Ammocoetes borealis	Agassiz 1850
Ichthyomyzon (Reighardina) unicolor DeKay	Creaser and Hubbs 1922
Reighardina unicolor (DeKay)	Jordan *et al*. 1930

The confusing history of the nomenclature of this species is likely due to the difficulty in identifying larvae, which are very similar among species (Scott and Crossman 1973).

Morphological description

The adult northern brook lamprey has small eyes and seven pairs of gill openings (Figure 1). They can be distinguished from other lamprey species due to their small size, dentition, and single, continuous dorsal fin. Adult length ranges have been documented as 86 – 166 mm (Morman 1979) and 105 – 162 mm (Becker 1983). Average length of 67 adult northern brook lamprey collected from Great Lakes tributaries by the Department of Fisheries and Oceans (DFO), Sea Lamprey Control Centre (SLCC) between 1996 and 1999 was 127 mm (range 104 – 154 mm). The teeth of the adult northern brook lamprey are small, dull, and knob-like in contrast to the sharp, longer teeth of the parasitic species. All endolateral teeth are unicuspid.

Figure 1. Adult northern brook lamprey, *Ichthyomyzon fossor* (total length of this specimen is 148 mm).

Their skin is smooth and scale-less. The adult is dark grayish brown on its back and sides, and pale gray or silvery white on its belly (Vladykov 1949). The sense organs of the lateral line system are of the same colour as its trunk, which separates it from its parasitic stem species, the silver lamprey. In contrast, the silver lamprey appears slightly spotted as an adult due to the dark colouration of the lateral line organs (Becker 1983). After spawning, northern brook lamprey become slate-blue to black on their back and sides, and white or white-gray on their ventral surface (Becker 1983). Prior to spawning, the female can have an orange-tinted ventral surface, where the eggs show though the body wall (Vladykov 1949).

The Canadian distribution of northern brook lamprey overlaps the distributions of four other lamprey species (Page and Burr 1991). Adult northern brook lamprey can be distinguished from the American brook lamprey (*Lampetra appendix*) and sea lamprey (*Petromyzon marinus*) by the two dorsal fins present in these species (Scott and Crossman 1998). It can be distinguished from the chestnut lamprey and silver lamprey by the sharp, long teeth present in these species (Scott and Crossman 1998).

The larvae, known as ammocoetes, vary little within the *Ichthyomyzon* genus. They lack eyes and teeth, and possess an oral hood in contrast to the sucker mouth of the adult (Scott and Crossman 1973). Larval silver and northern brook lampreys have been differentiated using differences in pigmentation patterns in the branchial region (Lanteigne 1981, Lanteigne 1988, Stewart and Watkinson 2004) and tail (Vladykov and Kott 1980, Fuiman 1982). Other authors have found no reliable differences between ammocoetes of these two species (Purvis 1970, Morman 1979, Becker 1983, Neave 2004). Large ammocoetes (>105 mm) of the chestnut lamprey develop pigmented lateral line organs that appear as spots; however, before reaching this size this pigmentation character is not reliable (Neave 2004). All other features of larval chestnut lamprey are very similar to northern brook lamprey ammocoetes (Neave 2004).

Genetic description

No consistent differences between the paired northern brook lamprey and silver lamprey were detected in a study by Mandrak *et al.* (2004).They analyzed seven adult northern brook lamprey and five adult silver lamprey from different regions around the Great Lakes. Although they found intraspecific differences likely due to geographic variation, they found no species-specific differences between the two species in the

10,255 base pairs of the mitochondrial genome and the 523 base pairs from the nuclear genome that have been sequenced. This raises questions regarding the separate species status of the silver and northern brook lamprey. Subsequent genetic analysis showed that individuals from the two species could be distinguished using microsatellite analysis (Filcek *et al*., 2005). Using one microsatellite locus, Filcek *et al.* (2005) had high success rates in differentiating between silver and northern brook lampreys from tributaries to Lake Michigan and Lake Superior, respectively. However, a follow-up study using the same microsatellite markers and individuals from a greater geographic range and from areas where they occur sympatrically found substantially different results: Docker *et al*. (2005) suggested that northern brook and silver lampreys are different feeding types of the same species. This was supported by low F_{ST} values, which indicates contemporary gene flow between northern brook and silver lampreys. Interspecific variation was found to be less than intraspecific variation, which indicated the two species may not be distinct (Docker *et al*. 2005). The debate over whether the northern brook lamprey represents a distinct species will not be resolved in the near future. In the meantime, the northern brook lamprey is considered to be a distinct species through the invoking of the precautionary principle.

Several studies have examined the genetic relationship between other paired lamprey species, such as the river lamprey (*Lampetra ayresii*) and the western brook lamprey (*L. richardsoni*) (Docker *et al.* 1999, Meeuwig *et al*. 2002); and the European brook lamprey (*L. planeri*) and the European river lamprey (*L. fluviatilis*) (P. Raposo de Almeida, pers. comm. 2004) and found no clear genetic differences. Schreiber and Engelhorn (1998) concluded that there must be some degree of gene flow between the European brook lamprey and the European river lamprey due to a lack of allozyme differentiation between the two species. These studies showed the genetic similarity of many of these paired species, and indicated that some paired species have either separated very recently, or are capable of hybridizing.

Successful hybridization experiments have been performed between both northern brook and silver lampreys, and northern brook and chestnut lampreys (Piavis *et al.* 1970); however, the offspring were not raised beyond several weeks, and the reproductive capacity of the offspring of these crosses is unknown.

Being largely non-migratory, northern brook lamprey populations are likely to have limited gene flow between streams, but gene flow may be mitigated by potential crosses with migratory silver lamprey. Barriers interfering with movement in streams may impede within-stream gene flow (Schreiber and Engelhorn 1998).

Designatable units

There were two distinct dispersal routes for this species following the Wisconsian glacial period (Mandrak and Crossman 1992). The source of both routes was the Mississippian Refugium, with subsequent colonization via the Warren or Brule-Portage routes (Mandrak and Crossman (1992). This has resulted in Canadian populations in two national freshwater biogeographic areas used by COSEWIC: Great Lakes-Upper

St. Lawrence; and Saskatchewan-Nelson. Therefore, the populations in these two biogeographic areas are separate designatable units.

DISTRIBUTION

Global range

The distribution of the northern brook lamprey includes Illinois, Indiana, Kentucky, Manitoba, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania, Quebec, Vermont, West Virginia and Wisconsin (Figures 2 and 3).

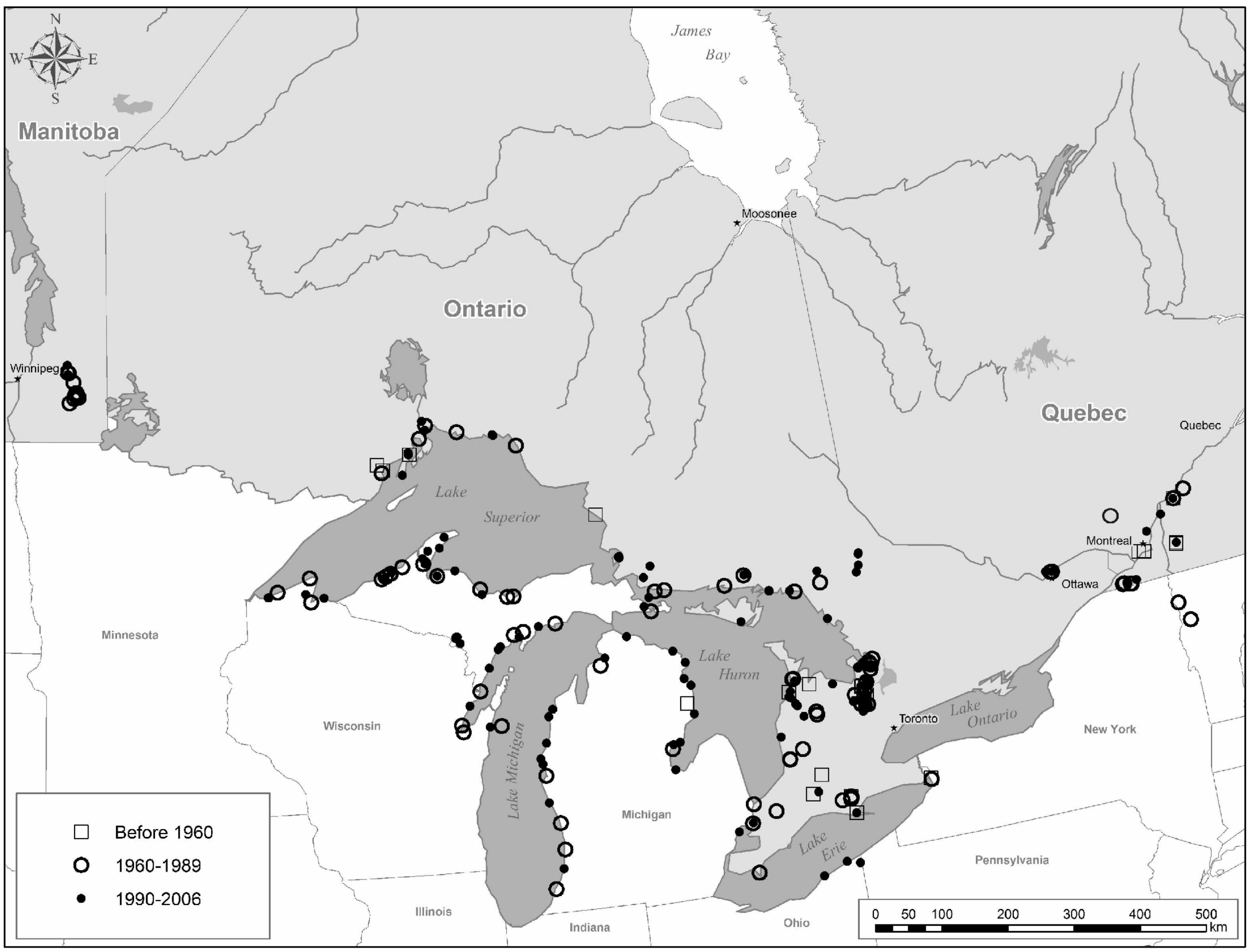

Figure 2. Distribution of the northern brook lamprey in Canada and the American portion of the Great Lakes basin. Dates indicate time of most recent collections.

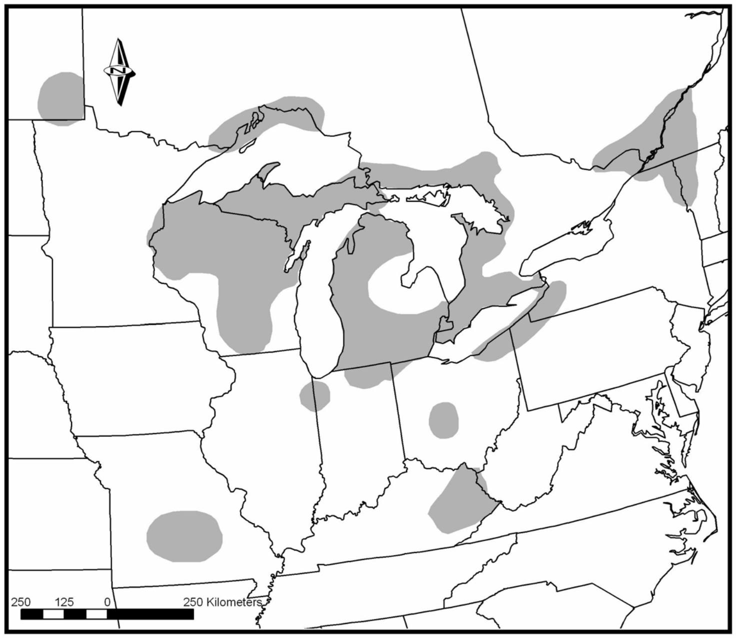

Figure 3. Distribution of the northern brook lamprey in North America (adapted from Page and Burr 1991).

In general, the distribution is likely more widespread than indicated by existing records because of the difficulty in identifying ammocoetes and collecting ammocoetes and adults (Becker 1983). The specialized equipment and techniques required to collect lampreys have not often been used in many regions outside of the Great Lakes basin. The widely used electrofishing surveys that target multiple species of fishes rarely collect larval lampreys, as the ammocoetes tend to become 'narcotized' within their burrows. Because, special efforts usually must be made to obtain representative samples, the number of ammocoete populations is probably largely under-represented (Fortin *et al*. 2005). To obtain a true understanding of their distribution, surveys that specifically target lamprey species are required on a much broader scale than they are currently performed. Streams within the Great Lakes basin have been sampled more intensively due to regular and specialized assessment for sea lamprey ammocoetes. However, even within the Great Lakes basin, assessment activities are normally restricted to sections of streams accessible to lake-dwelling migratory species of lampreys, and headwater areas are often overlooked.

Canadian range

In Canada, the distribution of this species is limited to the Great Lakes, St. Lawrence, and the Winnipeg River watersheds (Figure 2). Since 1990, adults or transforming individuals of this species have been found in 36 stream systems, including tributaries to Lake Nipissing, Lake Superior, Lake Huron, Lake Erie, Winnipeg River, Ottawa River, and St. Lawrence River (Table 1).

Table 1. Tributaries in Canada with adult or transformed northern brook lamprey detected since 1990. Distances occupied and mean stream width used to calculate area of occupancy are included. Widths marked with an asterisk were not available, and the mean width of known streams was used as a surrogate.

Stream Name	Length (km)	Width (m)	Basin
Grand R.	65.64	60.00	Lake Erie
Thames R.	3.24	*31.92	Lake St. Clair
Bar R.	16.45	10.50	Lake Huron
Beaver R.	10.02	*31.92	Lake Huron
Browns Cr.	3.78	4.55	Lake Huron
Chikanishing R.	2.90	12.11	Lake Huron
Hog Cr.	10.44	5.00	Lake Huron
Manitou R.	5.38	18.06	Lake Huron
Nine Mile R.	6.15	*31.92	Lake Huron
Nottawasaga R.	132.10	23.45	Lake Huron
Sauble R.	15.67	50.17	Lake Huron
Saugeen R.	82.49	105.61	Lake Huron
Shebeshekong R.	5.65	15.43	Lake Huron
Wye R.	14.40	*31.92	Lake Huron
Coldwater R.	19.08	15.00	Lake Huron
Echo R.	35.04	13.89	Lake Huron
French R.	5.10	*31.92	Lake Huron
Spanish R.	92.19	20.28	Lake Huron
St. Clair R.	Not available		Lake St. Clair
Chippewa Cr.	3.23	3.00	Lake Nipissing
Wolsely R.	8.93	20.00	Lake Nipissing
South Cr.	7.60	*31.92	Lake Nipissing
Bear Cr.	6.56	6.00	Lake Nipissing
Nipigon R.	17.02	257.50	Lake Superior
Pearl R.	4.95	16.42	Lake Superior
Prairie R.	2.21	*31.92	Lake Superior
Stokely Cr.	0.48	8.42	Lake Superior
Unnamed	0.34	2.00	Lake Superior
Sibley Cr.	1.08	3.00	Lake Superior
Birch. R.	35.77	*31.92	Winnipeg River
Whitemouth R.	114.01	*31.92	Winnipeg River
Rivière Châteauguay	4.12	*31.92	St. Lawrence River
Rivière Gatineau (Comtois *et al*., 2004)	0.8	250.00	St. Lawrence River
			St. Lawrence River
Rivière aux Outardes-Est Rivière Richelieu	Not available		St. Lawrence River
Rivière des Prairies	Not available		St. Lawrence River
Rivière Saint-François	Not available		St. Lawrence River

The SLCC has documented streams throughout the Great Lakes drainage (n= 66) with *Ichthyomyzon* ammocoetes over the previous 15 years (Table 2); however, these individuals could not be identified to species as a result of a lack of distinguishing characters for ammocoetes. It is strongly suspected that, due to their location within the stream system (Schuldt and Goold 1980), over half of these populations are northern brook lamprey. As silver lamprey are migratory in nature and usually swim downstream to a large lake for the parasitic phase of their life cycle (Scott and Crossman 1973), it is unlikely that larvae found above barriers are silver lamprey. The absence of adult silver lamprey in sea lamprey traps (which are ineffective in catching smaller brook lampreys) in many of these streams also suggests that the larvae are northern brook lamprey. Sampling efforts targeting adult lampreys are required to unequivocally determine the identity of these larval populations.

The extent of occurrence encompasses a large range, at 441,922 km^2. Once broken down in terms of DUs, this corresponds to an extent of occurrence of 280,000 km^2 and 5,000 km^2 for the Great Lakes – Upper St. Lawrence DU and Saskatchewan-Nelson DU, respectively. In Canada, total length of known occupied stream (i.e. having had adult or transformed northern brook lamprey documented since 1990) is estimated at 733 km. The area of occupancy, based on approximate area of stream inhabited is 31 km^2 (see Table 1); about 26 km^2 for the Great Lakes – Upper St. Lawrence DU and 5 km^2 for the Saskatchewan – Nelson DU. This total stream length and the area of occupancy are conservative, given that they exclude several streams for which data were unavailable (see Table 1) as well as streams where ammocoetes have been identified to genus only but that presumably harbour some northern brook lamprey (see Table 2).

HABITAT

Habitat requirements

Rocky or gravel substrate with swift-flowing water is the preferred spawning area for northern brook lamprey. They require a small amount of silt-free sand or some other fine material to which the eggs can adhere, uni-directional current, and suitable water temperatures (Manion and Hanson 1980). Nests have been found in interstices beneath large stones (18 to 36 cm in diameter) (Lanteigne 1991), usually in gravel shallows just above riffles (Hankinson 1932). Larval northern brook lamprey are usually found in depositional areas with soft silt and sand substrate.

Table 2. Tributaries in Canada with *Ichthyomyzon* ammocoetes found since 1990, but not identified to species (northern brook lamprey or silver lamprey).

Lake	Stream Name	Lake	Stream Name
Lake St. Clair	St. Clair R.	Lake Nipissing	Bear Cr.
	Thames R.		South Cr.
Lake Erie	Silver Cr.		Wolsely R.
	Big Otter Cr.		Chippewa Cr.
	Big Cr.	Lake Superior	West Davignon Cr.
	Grand R.		Little Carp R.
Lake Huron	St. Mary's R.		Cranberry Cr.
	Root R.		Goulais R.
	Garden R.		Stokely Cr.
	Echo R.		Jones Landing Cr.
	Bar R.		Chippewa R.
	Thessalon R.		Pic R.
	Mississagi R.		L. Munro Cr.
	Blind R.		Little Pic R.
	Serpent R.		Prairie R.
	Spanish R.		Pays Plat R.
	Kagawong R.		Gravel R.
	Manitou R.		Jackfish R.
	Blue Jay Cr.		Nipigon R.
	Chikanishing R.		Black Sturgeon R.
	French R. System		Pearl R.
	Key R.		Sibley Cr.
	Still R.		Mackenzie R.
	Magnetawan R.		Neebing-McIntyre Floodway
	Naiscoot R.		
	Shawanaga Landing Cr.		
	Shebeshekong R.		
	Blackstone Cr.		
	Musquash R.		
	Coldwater R.		
	Sturgeon R.		
	Hog Cr.		
	Wye R.		
	Nottawasaga R.		
	Silver Cr.		
	Beaver R.		
	Bighead R.		
	Sydenham R.		
	Sauble R.		
	Saugeen R.		
	Nine Mile R.		
	Bayfield R.		

Northern brook lamprey are reported to occur in a large range of stream sizes, as authors have claimed they are found in small rivers (Vladykov 1949); small to moderate streams (Scott and Crossman 1973); and moderate-sized to large streams (Morman 1979). According to Becker (1983), it generally occurs in larger stream than the American brook lamprey and in smaller streams than the parasitic silver lamprey. The average width and depth of streams inhabited by northern brook lamprey was documented by Becker (1983) to be 19 m wide and 0.7 m deep. Schuldt and Goold (1980) found northern brook lamprey most common in streams with summer flows of 0.3 to 28.3 cubic metres per second (cms). More recent Canadian stream data show a wide range in mean summer discharges of the stream systems within which northern brook lamprey reside, ranging from 0.17 to 70.99 cms, with an average value of 12.2 cms (SLCC, unpublished data). The average alkalinity of the streams was 91.55 mg/l $CaCO_3$, with a range of 5.86 to 221.00 mg/l $CaCO_3$ (SLCC, unpublished data).

No literature has dealt with northern brook lamprey preferences with respect to pH, salinity or hardness. In studies of other lamprey species, Potter *et al.* (1986) found that organic matter, chlorophyll *a*, macrophyte roots, and low-angle shading are important habitat characteristics for Australian lamprey (*Geotria australis*) larvae. Beamish and Jebbink (1994) found that small larvae of the southern brook lamprey (*Ichthyomyzon gagei*) preferred a higher percentage of fine sand in their habitat than did larger larvae. Beamish and Lowartz (1996) found that larval American brook lamprey densities were correlated to the amount of sand and organic matter in the stream substrate.

Habitat trends

In Canada, the northern brook lamprey occurs in many areas that have undergone extensive deforestation due to logging and agriculture. However, no studies exist that specifically examine changes in lamprey habitat over time.

Habitat protection/ownership

In Canada, all publicly owned waters and associated fish habitat within these waters is protected by the federal *Fisheries Act*. Provincial laws also protect the habitat of this species (e.g. Regulation respecting wildlife habitats in Quebec). Northern brook lamprey may also be found in the following native reservations within its range: Garden River 14, Pays Platt 51, Lake Helen 53A, Fort William 52, Chippewas of Georgina Island, Nawash Burial Ground 1&2, Rankin Location 15D, Red Rock 53, Saugeen 29 and Walpole Island 46. A literature search was performed for Aboriginal traditional knowledge with respect to this species, but provided no new information on the northern brook lamprey.

BIOLOGY

Several authors have studied the biology of the northern brook lamprey. Leach (1940) examined the northern brook lamprey and its habitat in Indiana, while Vladykov (1949, 1952) studied the species in Quebec, and Purvis (1970) conducted work on the south shore of Lake Superior. Scott and Crossman (1998) also provide a review of the biology of this species.

Life cycle and reproduction

The northern brook lamprey has two stages in their development: blind, filter-feeding larvae, and non-feeding adults. About 14 days after fertilization, larvae hatch, drift downstream, and begin to burrow, forming U-shaped holes in stream substrate (Becker 1983). Burrows are made generally in soft substrate, composed of silt and sand. A small tube allows the lamprey to draw water into its burrow, from which it extracts oxygen (Sutton and Bowen 1994). Churchill (1945) found burrows occurring at depths of 0.2 – 0.6 m.

Larval densities can be very high, such as in an area in the Brule River where 153 northern brook lamprey were found in 15.6 m^2 (Churchill 1945). The larval stage of the northern brook lamprey ranges from 3 to 7 years (Purvis 1970, Scott and Crossman 1973). Larval duration is dependent on location and food availability (Scott and Crossman 1973). Their diet is made up of a 'sestonic biofilm', composed of diatoms, desmids, protozoans, green algae, detritus and pollen (Scott and Crossman 1973, Yap and Bowen 2003). Sutton and Bowen (1994) found almost 98% of the diet of larval sea and northern brook lampreys to be organic detritus, the remainder being algae (2%) and bacteria (0.1%). Purvis (1970) documented annual growth increments as 37 mm, 28 mm, and 15 mm for the first three years of growth, respectively, in a Lake Superior tributary.

Downward drift of the ammocoetes occurs throughout the life of the ammocoete to varying degrees, and is influenced by stream gradient, stream discharge levels, and water temperature (Potter 1980b).

After what has been termed a 'resting period' (Leach 1940), where feeding does not occur and a reduction in total length often takes place, the ammocoetes metamorphose into juveniles. Transformation takes place in individuals ranging in length from 12.0 to 15.0 cm. Transformation commences in August or September, and is a two to three month process (Leach 1940). During transformation, the oral hood changes to a buccal funnel with teeth, and is described in detail by Leach (1940). The onset of this process is variable, as not all lamprey of the same cohort transform in the same year (Potter 1980b). In January and February the lamprey begin to emerge fully transformed from their burrows and swim periodically (Becker 1983).

Full sexual maturity is reached in May, just before spawning. Average maturation age is 6 years (Fortin *et al.* 2005). The duration of the adult stage is from 4 to 6 months (Potter 1980b). As an adult, no feeding takes place. The alimentary canal is not functional. They over-winter in or near the substrate before congregating in riffle areas to spawn in the spring.

Like all lampreys, northern brook lamprey spawn only once, and adults die shortly after spawning (Leach 1940), hence the average age at maturity corresponds to generation time. Water temperature determines the timing of the spawning event (Scott and Crossman 1973). However, spawning temperatures may vary by region. In Quebec, spawning occurs in May, when water temperature is between 13 and 16°C (Vladykov 1949). In Michigan, adults were observed spawning in June, when water temperatures ranged between 16.5 and 20.5°C (Morman 1979). Reighard and Cummins (1916) published the optimal spawning temperature at between 20 and 22°C.

Males initiate the nesting, moving small stones and gravel with their mouths, creating a small depression. They also use body movements to move sand (Hardisty and Potter 1971b). The nest has a diameter from 7.6 to 10.2 cm (Scott and Crossman 1973). During nest building, the body tends to be oriented vertically rather than horizontally, as in other lamprey species.

Spawners are usually concentrated in a small area, in water 20.3 to 45.7 cm deep (Scott and Crossman 1973). Spawning usually takes place in a shallow, pool-riffle, high-gradient stretch of the stream. Nests are inconspicuously located in spaces between large stones (Morman 1979). Although typically thought to spawn in open, gravel-bottomed habitat, documentation of spawning under different types of cover has been made (Cooper 1983; Cochran and Gripentrog 1992). Usually communal spawners, northern brook lamprey exhibit behaviour very similar to that of the American brook lamprey, where groups of three to seven individuals coil their bodies around one another (Becker 1983). Cochran and Pettinelli (1987) reported four males and one female spawning together, and Morman (1979) documented an average of seven lamprey per nest. Chestnut lamprey nests have been used by northern brook lamprey spawners (Pflieger 1975).

While in the nest, the male attaches to the female, but does not wrap around the female, as occurs in most lamprey species. Vigorous vibration accompanies spawning (Scott and Crossman 1973), and after fertilization the eggs are sometimes covered with the substrate surrounding the nest (Hardisty and Potter 1971b).

Purvis (1970) analyzed sex ratios for northern brook lamprey at different life stages. He found that 49% of the larvae examined were males (n=627), 97% of the transformers from an early fall collection were males (n=33), and 75% of spawners were males (n=24). A higher proportion of males in spawning populations of lampreys is common (Applegate 1950, Hardisty 1961).

Mean fecundity of the northern brook lamprey has been estimated at 1,200 (Leach 1940), with ranges from 1,115 to 1,979 (Vladykov 1951). Schuldt *et al.* (1987) found the number of eggs laid is roughly proportional to the size of the female. The average egg size ranges from 1.0 to 1.2 mm (Scott and Crossman 1973).

Eggs hatch in two to four weeks (Leach 1940). The survival of northern brook lamprey eggs has not been documented. According to Hardisty (1979) hatch rates of sea lamprey eggs likely do not exceed 5.3-7.8%; however, Manion and Hanson (1980) estimated hatch success at 90%. Mortality can be high, particularly during the early stages of ammocoete life (Potter 1980b). Larvae are sensitive to temperature fluctuations and predation when very small, but mortality declines quickly with age (Potter 1980b).

The total life span of the northern brook lamprey is up to 7 or 8 years, but this is difficult to confirm because of difficulties in aging these animals. Many studies have used length-frequency analysis to determine ages of larvae (e.g. Leach 1940, Scott and Crossman 1973, Quintella *et al.* 2003). Length-frequency age determination is not often applied to adults and large larvae, due to their lack of growth prior to and following metamorphosis.

Predation

As eggs and freshly hatched larvae, lamprey species are fed on by larger fish (Potter 1980b). Predation on ammocoetes is minimal due to the largely sedentary existence in burrows for extended periods. However, given the opportunity, piscivorous fishes likely consume ammocoetes, considering the historic use of ammocoetes as bait by anglers (Vladykov 1973). Predation on adult lamprey likely occurs most often during the spawning event, as egg laying usually takes place in shallow water (Manion and Hanson 1980) where the fish are vulnerable. Documented predators on adult northern brook lamprey include rainbow trout (*Oncorhynchus mykiss*) (Churchill 1945), rock bass (*Ambloplites rupestris*) (Scott and Crossman 1973), and brown trout (*Salmo trutta*) (Cochran *et al.* 1992).

Physiology

Strictly a freshwater resident, the northern brook lamprey lives in a wide range of stream sizes and alkalinity levels, as discussed in the habitat requirements section. Although little is known about the physiology of the northern brook lamprey, knowledge of other lamprey species is likely comparable. Sea lamprey eggs are very sensitive to temperature, as eggs hatch only between 15.5 and 21.1°C (Piavis 1961). It has been found that 18.4°C is the optimal rearing temperature for sea lamprey eggs (Piavis 1961), a temperature that has also been found to be conducive to rearing northern brook lamprey eggs (Smith *et al.* 1968). Sea lamprey larvae mortality increases markedly at 22°C (Piavis 1961).

Water depth and velocity were important factors in determining location of larval European brook lamprey (Malmqvist 1980). Sutton and Bowen (1994) reported that northern brook lamprey and sea lamprey larvae consumed from 4.2 to 5.5 $mg \cdot g^{-1} \cdot day^{-1}$ of detritus.

Dispersal/migration

Northern brook lamprey make a short, non-synchronous movement toward spawning grounds in the spring (Leach 1940). Dispersal is limited to downstream drift by ammocoetes, where larvae passively travel short distances. This drift is seasonal and usually occurs at night, and is correlated with water temperature. Streams with higher gradients tend to have larvae distributed further from spawning grounds than do streams with lower gradients, where larvae are more closely associated with the location of the nests (Potter 1980b).

Interspecific interactions

Vladykov (1951) suggested that the high fecundity of sea lamprey may lead to competition with lampreys native to the Great Lakes. Northern brook lamprey co-exist in the same stream system with silver lamprey and sea lamprey, and occasionally American brook lamprey. Where ranges overlap, generally only one species is common (Becker 1983).

Growth of lamprey ammocoetes is affected by ammocoete density (Hardisty and Potter 1971a). The application of a lampricide called TFM (3-trifluoromethyl-4-nitrophenol) to streams to kill larval sea lamprey, and subsequent lamprey population decrease have been shown to result in increased growth rates in re-establishing year classes of larval lamprey (Purvis 1970). This is likely due to greater availability of food and space. Scott and Crossman (1973) suggested there may be competition among ammocoetes for food and habitat.

Huggins and Thompson (1970) observed another closely related pair of lampreys, the European brook lamprey and the European river lamprey, spawning on the same nest. Given that the spawning of silver and northern brook lampreys can coincide (Manion and Hanson 1980), similar interactions may occur between these two species.

In the Brule River in Wisconsin, Churchill (1945) found that northern brook lamprey burrows are often close to burrowing mayfly nymphs and small mussels. All three of these organism types feed directly on microscopic aquatic organisms and may compete with one another for food. However, Churchill dismissed the importance of this, as these three species co-exist in substantial numbers.

Adaptability

The restricted mobility and relatively low fecundity of northern brook lamprey suggest that they are not highly adaptable. However, given that another ecologically similar lamprey, the American brook lamprey, has accidentally been introduced into other streams and achieved high survival rates (D. Cuddy, pers. observ.), it is likely that there is some degree of adaptability to new areas, and that this species could be a good candidate for translocation.

POPULATION SIZES AND TRENDS

Search effort

Given the difficulty in collecting and identifying ammocoetes, sampling is usually limited to post-transformation individuals in the fall, or sampling in early spring before post-spawning mortality. Most of the distribution information in this report is based on incidental catch data obtained through assessment of sea lamprey by Department of Fisheries and Oceans and United States Fish and Wildlife Service (USFWS) staff. Sea lamprey control surveys target larval sea lamprey, and are biased toward streams with known sea lamprey populations. Backpack electrofishing surveys constitute the majority of this effort. A smaller proportion of the data are derived from surveys conducted by boat in deeper water using the granular formulation of the lampricide “Bayluscide”. Other collections were made during TFM stream treatments.

Stewart and Watkinson (2004) imply that the search effort in Manitoba has not been thorough, as they suggest that this species may have a larger distribution than available data indicate.

In the spring of 2000 and 2001, assessment staff at the SLCC conducted electrofishing surveys explicitly to identify undocumented locations of adult and transformed northern brook lamprey. These efforts identified two previously unknown locations in the Lake Nipissing drainage (Wolsely R. and Bear Cr.), and confirmed other existing populations in the Great Lakes region (SLCC, unpublished data).

Abundance

Scott and Crossman (1973) stated that this species is not known to be abundant anywhere in its range. However, over 5700 *Ichthyomyzon* lamprey ammocoetes were incidentally caught through larval sea lamprey assessment in Canadian tributaries to the Great Lakes between 2000 and 2004. In the previous five year period (1995-1999), over 8000 *Ichthyomyzon* ammocoetes were collected in a similar collecting effort (SLCC, unpublished data). This identification is only to genus, but due to the rarity of collection of adult silver lamprey in assessment traps, one can assume that a high percentage of these ammocoetes are likely northern brook lamprey, suggesting that this species is much more abundant than previously thought.

In a survey of streams in the Lower Peninsula of Michigan, northern brook lamprey were the most common species of lamprey, occurring in 31 streams in the drainage areas east of Lake Michigan and west of Lake Huron and Lake Erie (Morman 1979).

Abundance data are not available for the Manitoba and Quebec populations.

Fluctuations and trends

It is difficult to examine trends in the distribution and abundance of northern brook lamprey because of the difficulty in identifying ammocoetes and collecting ammocoetes and adults, and limited targeted sampling of native lampreys. However, some trends can be derived from the literature, and from the limited data available.

In the Great Lakes basin, Schuldt and Goold (1980) compared the occurrence of *Ichthyomyzon* ammocoete (likely both northern brook lamprey and silver lamprey) data for Lake Superior between two time periods (1953-1972, 1973-1977). They found that their presence in Canadian streams had dropped from 41 to 17 streams. This reduction is likely due to the effects of lampricide treatments. Recent data (1990-2004) indicate that 20 Canadian tributaries to Lake Superior currently have *Ichthyomyzon* ammocoetes, indicating a stabilization of these populations (Table 2). This is likely the result of most of these populations not being exposed to lampricide treatments.

In the Lake Superior basin, adult northern brook lamprey have not been recently (i.e. in the last 15 years, or approximately three generations) recorded in three of the nine streams where they were historically (1960-1989) present, including Chippewa River, Neebing-McIntyre River, and Black Sturgeon River (Figure 2). In the Lake Huron basin, they have been recently documented in most streams where they were historically present (except Bannockburn River, Bayfield River, St. Mary's River, Thessalon River, Koshkawong River and North River) and in several streams where they were not found before (Figure 2). One other stream where northern brook lamprey have historically been found, but have not been documented between 1990 and 2004, is Big Otter Creek (Lake Erie).

Currently, 13 of 28 streams where adult northern brook lamprey have been collected in the Canadian Great Lakes basin are not inhabited by sea lamprey and have not been exposed to lampricide. Densities are much higher in these streams than in the treated streams (SLCC, unpublished data). Populations in untreated sections of treated streams (e.g. those above barriers) and in untreated streams tend to be stable (SLCC, unpublished data). As mentioned previously, several new streams have been found to harbour northern brook lamprey in recent years (including Wabuno Cr., tributary to the Thames River, and Bear Cr. and Wolsely River, tributary to Lake Nipissing). These new records are likely a result of a lack of earlier directed survey efforts, rather than novel populations. Similarly, streams that have not received intensive survey efforts which are indicated on the map as not recently having northern brook lampreys present may be due to this lack of effort.

In other areas of Ontario, they have been recently found where they were historically present in the St. Clair and Ottawa rivers, and recently found in parts of the Lake Nipissing basin (Figure 2).

In Quebec, there are too few records to examine trends in northern brook lamprey. Vladykov (1952) reported a high abundance of ammocoetes in the Yamaska River; however, Renaud *et al*. (1995) reported that the northern brook lamprey was no longer found in similar areas of the stream. This stream was not treated with lampricide, and the decline is attributed to pollution. Renaud *et al.* (1995) indicated that one other Quebec river, the Saint-François River, documented by Vladykov (1952) as having northern brook lamprey still had them as of 1990. In addition to the Yamaska River, the northern brook lamprey was only collected prior to 1960 in Lac Saint Louis (1941), Rivière Nicolet Sud-Ouest (1951), and the St. Lawrence River at Lachine (1950) (Figure 2). It was collected only in Rivière Hinchinbrooke and Rivière Trout in 1976 (D. Banville, pers. comm.). Finally, it has been collected only since 1990 at Rivière

Châteauguay (1990, 1992), Rivière Richelieu (1990), Rivière des Prairies (1998), Rivière Gatineau (1999) and Rivière aux Outardes-Est (2002) (Figure 2). The current distribution of northern brook lamprey, in the St. Lawrence basin is likely accurate as a result of recent extensive fishing effort within the Réseau de suivi ichtyologique du Saint-Laurent (La Violette and Richard, 1996; La Violette *et al.* 2003; Société de la faune et des parcs du Québec, unpublished data).

In Manitoba, the northern brook lamprey was first reported in a small portion of the Winnipeg River system in 1979 (Jyrkkanen and Wright 1979). Too few specimens have been caught to infer trends, but the most recent record caught in 2003 indicates that this population is still extant (Stewart and Watkinson 2004). Stewart and Watkinson (2004) feel that this species may be more widespread in Manitoba.

Rescue effect

The non-migratory nature of northern brook lamprey suggests that potential rescue effects between streams are minimal. Within streams, dispersal of larval lampreys occurs through downstream drift (Purvis 1970, Potter 1980b). Schuldt and Goold (1980) documented streams which, after lampricide treatments of the lower section, have re-populated with brook lampreys from upper reaches of the stream.

LIMITING FACTORS AND THREATS

This species is affected by ongoing lampricide applications conducted by Canadian and American agents of the sea lamprey management program in the Great Lakes basin. These applications reduce populations of sea lamprey; however, other lamprey species are similarly vulnerable to the chemical (King and Gabel 1985). Some streams with northern brook lamprey that have been infested by sea lamprey and subsequently treated with lampricide have undergone significant reductions, or extirpations, of populations of native lampreys. Larval northern brook lamprey are 25% less susceptible to the lampricide than sea lamprey larvae, but this difference is insufficient to allow for control of sea lamprey without impacting native lampreys (King and Gabel 1985). Barriers to sea lamprey migration offer some refuge in the upper reaches of streams that often support northern brook lamprey, as these portions of the stream are not exposed to the chemical applications. Barriers can also serve as a threat to these lamprey, potentially limiting gene flow (Schreiber and Engelhorn 1998). However, this threat is likely minor due to the limited migration of northern brook lamprey.

Fluctuating water levels are suspected to cause ammocoete mortality, due to low water levels exposing larval burrows (Bailey 1959), and flooding conditions causing excessive movement (Potter 1980b). Renaud *et al*. (1995) has also listed pollution (specifically, an herbicide called atrazine) as a possible contributor to ammocoete mortality. The Yamaska River in Quebec, which once had a high density of northern brook lamprey (Vladykov 1952), was found, 40 years later, to not have ammocoetes of any species (Renaud *et al*. 1995). Renaud *et al*. (1995) speculated that phytoplankton levels were reduced by this chemical; thereby limiting food availability for the ammocoetes.

The removal of riparian vegetation is also thought to contribute to lamprey decline (Fortin *et al.* 2005). This trend, which often accompanies agricultural and suburban development, increases sediment load in a stream and decreases shade and natural filtering of fertilizers and pesticides. The extent of all of the above listed threats has not been quantified.

The introduction of the American brook lamprey to streams along the north shore of Lake Superior (D. Cuddy, pers. observ) may pose an additional threat to northern brook lamprey in this region. American brook lamprey and northern brook lamprey rarely co-exist (Becker 1983), and this introduction and subsequent range increase may result in competition to the detriment of the less common northern brook lamprey. However, there is no documentation of northern brook lamprey extirpation caused by the introduction of other lamprey species.

SPECIAL SIGNIFICANCE OF THE SPECIES

Lampreys are the most ancestral living vertebrates and provide insight into the origins and evolution of vertebrates. Lampreys have been used extensively in laboratory studies on numerous subjects such as developmental biology and neurobiology (Moyle and Cech 2004).

Further study of the northern brook lamprey and its parasitic sister species, the silver lamprey, may provide insight into the evolution of alternate feeding strategies, and could lead to new ways of controlling introduced sea lamprey. Due to their sedentary nature, larval lampreys have been used as biomonitors of organochlorine contaminants in fresh water (Renaud *et al*. 1995, Renaud *et al*. 1999).

The filter-feeding northern brook lamprey larvae undoubtedly play a role in nutrient cycling in the streams that they inhabit.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The northern brook lamprey is currently listed on Schedule 3 of the *Species at Risk Act* as Special Concern in Canada based on a previous COSEWIC report (Lanteigne 1991). It is listed as a species of special concern in the Species at Risk in Ontario List. (http://www.mnr.gov.on.ca/mnr/speciesatrisk). Wildspecies 2005 (http://www.wildspecies.ca/wildspecies2005) lists the northern brook lamprey as sensitive in Canada. Provincially, Wildspecies lists populations as sensitive in Ontario and Quebec, and ‘May be at risk’ in Manitoba. In Quebec, the advisory committee on threatened or vulnerable wildlife species recommended in June 2005 that the northern brook lamprey be listed as vulnerable.

It is currently classified as G4 (apparently secure) on a worldwide scale, N4 (apparently secure) in the United States, and N3 (vulnerable) in Canada. Provincially it is ranked as S2 (imperiled) in Manitoba, and S3 (vulnerable) in Ontario and Quebec. Within the United States, the northern brook lamprey is also currently classified as critically imperiled (S1) in Illinois, New York, Pennsylvania, Vermont and West Virginia, imperiled (S2) in Kentucky and Ohio, vulnerable (S3) in Minnesota, and apparently secure (S4) in Indiana, Michigan, Missouri, and Wisconsin (NatureServe 2006).

The habitat of the northern brook lamprey is protected in principle under the federal *Fisheries Act*. In Quebec it is protected by the *Loi sur la conservation et la mise en valeur de la faune* (Act respecting the conservation and development of wildlife).

TECHNICAL SUMMARY

Ichthyomyzon fossor

Northern brook lamprey — lamproie du nord

Range of Occurrence in Canada: Ontario, Quebec (Great Lakes - Upper St. Lawrence Biogeographic Area)

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* – based on Figure 2	280,000km²
• *Specify trend in EO*	Stable
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* – based on Table 1 (sum of stream widths x occupied lengths)	>26 <31 km²
• *Specify trend in AO*	Declining
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	36 streams
• *Specify trend in #*	Declining (11 streams no longer occupied since 1960-1989 time period, seven new streams documented since 1990; three in Ontario and four in Quebec)
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Now stable
Population Information	
• *Generation time (average age of parents in the population)*	6 years
• *Number of mature individuals*	Unknown
• *Total population trend:*	Declining
• *% decline over the last/next 10 years or 3 generations.*	Unknown
• *Are there extreme fluctuations in number of mature individuals?*	No
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	3 of 9 streams not documented in Lake Superior basin in the last 15 years (roughly three generations)
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each:	
Threats (actual or imminent threats to populations or habitats)	
Lampricide treatments of populations co-existing with sea lamprey larvae, stream barriers impeding gene flow, sedimentation.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** Stable [other jurisdictions or agencies]	
• *Is immigration known or possible?*	Possible, but unlikely due to non-migratory behaviour
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No
OtherStatus: COSEWIC: Special Concern(1991) Classified as S2 (imperiled) in Manitoba, S3 (vulnerable) in Ontario and Quebec.	

Northern Brook Lamprey- Great Lakes - Upper St. Lawrence populations

<table>
<tr><td>Status: Special Concern</td><td>Alpha numeric Code: not applicable</td></tr>
<tr><td colspan="2">Reason for Designation:
This nonparasitic lamprey is distributed in streams throughout the Great Lakes basin (except Lake Ontario) and in southwestern Quebec. In the Great Lakes basin, which comprises most of its range, about 50% of the streams it is known to inhabit are subjected to ongoing chemical treatment for sea lamprey control which causes mortality to its larval stage. However, in untreated streams, the species is still abundant.</td></tr>
<tr><td colspan="2">Applicability of Criteria
Criterion A: Not met.
Criterion B: Not met.
Criterion C: Not met.
Criterion D: Not met.
Criterion E: Not met.</td></tr>
</table>

TECHNICAL SUMMARY

Ichthyomyzon fossor
Northern brook lamprey — lamproie du nord
Range of Occurrence in Canada: Manitoba (Saskatchewan-Nelson Biogeographic Area)

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* – based on Figure 2	5,000 km^2
• *Specify trend in EO*	Unknown
• *Are there extreme fluctuations in EO?*	Unknown
• *Area of occupancy (AO) (km²)* – based on Table 1 (sum of stream widths x occupied lengths)	5 km^2
• *Specify trend in AO*	Unknown
• *Are there extreme fluctuations in AO?*	Unknown
• *Number of known or inferred current locations*	2 streams
• *Specify trend in #*	Unknown
• *Are there extreme fluctuations in number of locations?*	Unknown
• *Specify trend in area, extent or quality of habitat*	Unknown
Population Information	
• *Generation time (average age of parents in the population)*	6 years
• *Number of mature individuals*	Unknown
• *Total population trend:*	Unknown
• *% decline over the last/next 10 years or 3 generations.*	Unknown
• *Are there extreme fluctuations in number of mature individuals?*	Unknown
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Stable
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each	Unknown
Threats (actual or imminent threats to populations or habitats)	
Stream barriers impeding gene flow, sedimentation.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** Stable [other jurisdictions or agencies]	
• *Is immigration known or possible?*	Possible, but unlikely due to non-migratory behaviour
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No
Other Status: COSEWIC: Special Concern (1991) Classified as S2 (imperiled) in Manitoba, S3 (vulnerable) in Ontario and Quebec.	

Northern Brook Lamprey- Saskatchewan - Nelson population

<table>
<tr><td>Status: Data Deficient</td><td>Alpha numeric code: not applicable</td></tr>
<tr><td colspan="2">Reason for Designation:
This nonparasitic lamprey has not been the subject of any targeted and comprehensive survey since it was first reported from Manitoba in the late 1970s, and accordingly, the distribution and status of its populations are not well known.</td></tr>
<tr><td colspan="2">Applicability of criteria:
Criterion A: Not met.
Criterion B: Not met.
Criterion C: Not met.
Criterion D: Not met.
Criterion E: Not met.</td></tr>
</table>

ACKNOWLEDGEMENTS AND AUTHORITIES CONSULTED

Authorities consulted include Parks Canada, Canadian Wildlife Service, OMNR, Manitoba provincial agencies, Canadian Museum of Nature, Royal Ontario Museum, and Department of Fisheries and Oceans Canada. See appendix for details.

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Recovery team (if one exists)	Not applicable