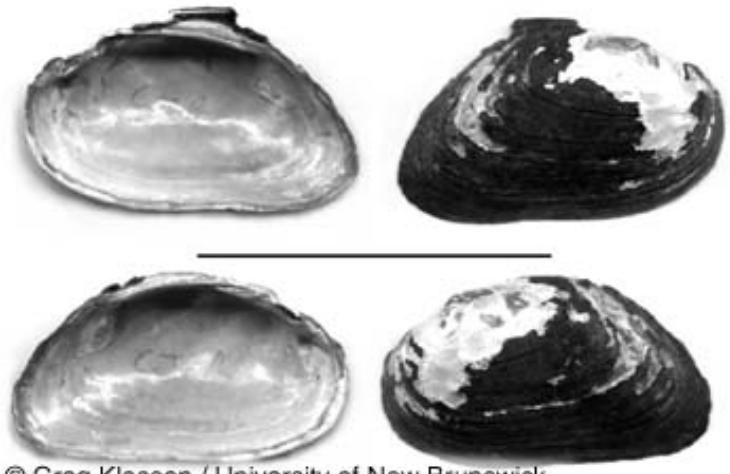
COSEWIC
Assessment and Update Status Report

on the

Dwarf Wedgemussel
Alasmidonta heterodon

in Canada



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EXTIRPATED
2000

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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Production note:
This species was designated extirpated by COSEWIC in 1999. The species was reassessed in 2000 and reconfirmed as extirpated. Please note the status recommended in the Section "Evaluation and Recommended Status" of the report may differ from the latest status assigned to the species by COSEWIC.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur l'alasmidonte naine (*Alasmidonta heterodon*) au Canada.

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COSEWIC
Assessment Summary

Assessment summary – May 2000

Common name
Dwarf Wedgemussel

Scientific name
Alasmidonta heterodon

Status
Extirpated

Reason for designation
This freshwater mussel was previously known in Canada from only one river drainage. It has disappeared subsequent to the building of a causeway across the river in 1967/68, and has not been found despite intensive systematic searches of its former habitat.

Occurrence
New Brunswick

Status history
Extirpated by 1968. Designated Extirpated in April 1999. Status re-examined and confirmed in May 2000.
Last assessment based on an existing status report.

COSEWIC
Executive Summary
from the 1999 Status Report

Dwarf Wedgemussel
Alasmidonta heterodon

Description

The Dwarf Wedgemussel is a small (up to 55 mm long) freshwater mussel that is roughly trapezoidal in shape. The periostracum is brown or yellowish brown with greenish rays in young or pale-coloured specimens. The nacre is bluish or silvery white and is iridescent in the posterior part of the shell. The hinge teeth are small but distinct. The pseudocardinal teeth are compressed, one or two in the right valve and two in the left. The lateral teeth are gently curved, and there are two teeth in the right valve and one in the left, which is the reverse of the pattern found in other species.

Distribution

The only recorded Canadian location for the Dwarf Wedgemussel is the Petitcodiac River drainage in New Brunswick. The species was last collected in this river in 1960, at which time it was described as common.

Habitat

This species inhabits small streams to medium-sized rivers with a slow to moderate current and a clean sand or gravel bottom. It tolerates very little silt, and seems to require some streamside vegetation.

Biology

The Dwarf Wedgemussel breeds in spring. The host fish species used in the wild by the parasitic (glochidial) stage is (are) unknown. In the laboratory, five fish species have served as hosts: Atlantic salmon (*Salmo salar*) parr, Johnny darter (*Etheostoma nigrum*), tessellated darters (*E. olmstedi*), mottled sculpin (*Cottus bairdi*), and pumpkinseed sunfish (*Lepomis gibbosus*). Of these, only Atlantic salmon occurred in the Petitcodiac watershed when the Dwarf Wedgemussel was extant there. The theoretical life span for the Dwarf Wedgemussel is 12 to 18 years.

Limiting factors

The Dwarf Wedgemussel is limited by the absence of host species for its parasitic larvae. It is intolerant of anoxic conditions and pesticide and metal contamination. It requires clean sediments (sand and gravel) with very little silt. Because dams block the movements of host fish species, the impoundment of rivers has been a major negative factor affecting the continued persistence of the Dwarf Wedgemussel. In 1967/68, a causeway was built between the city of Moncton and the town of Riverview in the tidal part of the Petitcodiac River, creating a freshwater headpond. This causeway has severely restricted passage of anadromous fishes into the freshwater stretches of the Petitcodiac River and its tributaries. Four fish species (American shad, Atlantic tomcod, striped bass, and Atlantic salmon) have disappeared completely from the river system. There have, however, been numerous attempts to re-establish Atlantic salmon through stocking since the completion of the causeway in 1968, but these have failed. With the loss of the host species, the recruitment of Dwarf Wedgemussels failed, and the mussel disappeared from the river by 1984.

Protection

The Dwarf Wedgemussel has no specific protection in Canadian waters. It has Endangered status under the U.S. *Endangered Species Act*.

Evaluation

The Dwarf Wedgemussel became extirpated from Canada following the completion of the Petitcodiac Causeway in 1968. Two surveys focused on detecting the species were conducted: one in 1984 and a second, more comprehensive, survey in 1997/98. The 1984 survey failed to recover living or dead specimens of the Dwarf Wedgemussel despite searches of sites where the species had been formerly collected and other sites where the habitat was considered suitable for the species. In the 1997/98 survey, all the sites covered in 1984 were revisited and many additional sites in the Petitcodiac River and its tributaries were also searched. No specimens of the Dwarf Wedgemussel were found in 1997/98, and some sites were severely degraded by excess nutrients and silt from agricultural sources. Nevertheless, extensive areas of suitable habitat currently exist in the Petitcodiac, Little, and Anagance rivers. Until the blockage caused by the Petitcodiac Causeway is removed and the fish host for the parasitic larvae (most likely the American shad) is re-established, the Dwarf Wedgemussel will not be re-established in Canada.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined 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 of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
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.

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.

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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

Dwarf Wedgemussel
Alasmidonta heterodon

in Canada

John Mark Hanson
Andrea Locke

1999

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INTRODUCTION

The only location where the Dwarf Wedgemussel (*Alasmidonta heterodon*) is known to have occurred in Canada is the freshwater reaches of the Petitcodiac River and the North River (a major tributary of the Petitcodiac), in New Brunswick. Based on collections by D. Athearn in 1953 and A.H. Clarke in 1960, the species was described as common in the Petitcodiac River system by Clarke (1981a,b). Range-wide surveys for this species in the United States have concluded it was in severe decline there. It has been extirpated from all but 20 of approximately 70 known localities, and only one of the extant populations is not in decline (U.S. Fish and Wildlife Service 1993; Strayer *et al*. 1996). The principal cause of population decline in this freshwater mussel in the U.S. are: damming and channelization of rivers; silt deposition from road construction, agriculture, and forestry; and industrial, agricultural and domestic pollution of the habitat (reviewed in U.S. Fish and Wildlife Service 1993; Michaelson and Neves 1995; Strayer *et al*. 1996).

The goal of this report is to evaluate the status of the Dwarf Wedgemussel in its only known location in Canada to determine what status it should be assigned by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

TAXONOMY

The Dwarf Wedgemussel was originally described as *Unio heterodon* by Lea (1829) and was later placed in the genus *Alasmidonta* by Simpson (1914). Ortmann (1914) considered the soft-tissue anatomy and shell characteristics sufficient to place it in the genus *Prolasmidonta*; however, Clarke (1981a,b) retained the genus name *Alasmidonta*. It is identified as *Alasmidonta heterodon* in all recent works (e.g., Williams *et al*. 1993; Strayer *et al*. 1996; Turgeon *et al*. 1998).

DESCRIPTION

Clarke (1981b) describes the Dwarf Wedgemussel as follows:

> "Shell up to about 45 mm long, 25 mm high, 16 mm wide, and with shell wall about 1 mm thick in the mid anterior region; more or less ovate or trapezoidal, roundly pointed posterio-basally, thin but not unduly fragile, with rounded posterior ridge, and of medium inflation. Females more inflated posteriorly than males. Sculpturing absent except for lines of growth and beak sculpture. Periostracum brown or yellowish-brown, and with greenish rays in young or pale-colored specimens. Nacre bluish or silvery white, and iridescent posteriorly. Beak sculpture composed of about 4 curved ridges, which are angular on the posterior slope. Hinge teeth small but distinct; pseudocardinal teeth compressed, 1 or 2 in the right valve and 2 in the left; lateral teeth gently curved and *reversed*, that is, in most specimens, 2 in the right valve and 1 in the left."

DISTRIBUTION

The distribution of the Dwarf Wedgemussel is well documented as a result of itS being declared “endangered” in the U.S. in 1990. The U.S. recovery plan lists 70 known (historical) locations (see Figure 1), but only 20 currently support populations of the species (U.S. Fish and Wildlife Service 1993; Strayer *et al*. 1996). This mollusc is recorded in coastal rivers from North Carolina north to the Connecticut River in Vermont. There is an interesting range discontinuity as there are no records of the Dwarf Wedgemussel in the state of Maine or in any of the rivers, other than the Petitcodiac, that flow into the Bay of Fundy (U.S. Fish and Wildlife Service 1993). The species range in Canada was restricted to the Petitcodiac River system of New Brunswick; however, in recent (since 1984) literature (e.g., Master 1986; U.S. Fish and Wildlife Service 1993; Strayer *et al*. 1996), the Canadian population is assumed to be extirpated. This status report confirms this presumed extirpation (see Population Size and Trend).

PROTECTION

This species is not protected in Canada. It is listed as endangered in the U.S., and a recovery plan has been developed (U.S. Fish and Wildlife Service1993).

POPULATION SIZE AND TREND

The Dwarf Wedgemussel has always been described as uncommon to rare across most of its range. All populations in the U.S. are “endangered” and all but one continue to decline (U.S. Fish and Wildlife Service 1993; Strayer *et al*. 1996). Densities in existing populations range between <0.01 and 0.05 animals/m^2 (Strayer *et al*. 1996). Unlike most populations in the USA, the Dwarf Wedgemussel was described as common in the Petitcodiac River system by Clarke (1981a,b) based on his survey in 1960. Clarke and D. McAlpine (New Brunswick Museum, St. John, NB) subsequently conducted a survey in 1984 with the specific goal of detecting this species. No specimens were found (see below). Hanson and Locke conducted a more comprehensive survey in 1997 and again in 1998 with the same negative result (see below). Therefore, the population trend is from common in 1960 to not detected in 1984 and not detected in 1997/98. The inescapable conclusion is that the Dwarf Wedgemussel has been extirpated from Canadian waters.

Figure 1. Range map (inset New Brunswick) for the Dwarf Wedgemussel (*Alasmidonta heterodon*). Solid circles represent extant populations. Open circles represent extirpated populations (from U.S. Fish and Wildlife Service 1993).

1984 survey

The 1984 survey used the timed-search method, which offers excellent detection of rare species (Strayer *et al*. 1997). Each of 12 sites (identified with a superscript in Table 1) in the Petitcodiac River and its tributaries was searched for 0.5 to 1.0 hours by A.H. Clarke and D. McAlpine between 27 and 29 August, 1984. No Dwarf Wedgemussels were found at any of the 12 sites.

Table 1. Qualitative index of abundance of *Alasmidonta heterodon* (A. h.), *A. undulata* (A. u.), *A. varicosa* (A. v.), *Margaritifera margaritifera* (M. m.), *Elliptio complanata* (E. c.) and *Pyganodon cataracta* (P. c.) collected at sample sites (stream length SL in m) in the Petitcodiac River searched during 1997/98. Mussel abundance was defined as: A = abundant (> 1/m^2); C = common (< 1/m^2, > 1/10m^2); S = scarce (10 to 100/site); R = rare (< 10/site); 0 = not found.

Site	Latitude	Longitude	SL	A. h.	A. u.	A. v.	M. m.	E. c.	P. c.
Petitcodiac R.									
Head of tide	46 01.95	65 00.75	1100	0	0	0	S	0	0
Railway bridge	46 01.76	65 01.21	300	0	0	R	S	0	0
Little R. mouth	46 01.64	65 01.62	750	0	0	S	S	R	0
Salisbury bridge[a]	46 01.35	65 02.08	900	0	R	R	S	S	R
French Brook[a]	46 00.93	65 03.85	1080	0	0	0	C	R	R
Pollett R. mouth	46 00.15	65 04.00	250	0	0	R	C	S	S
Covered bridge	45 59.84	65 05.56	310	0	R	R	R	A	R
Riverglade[ab]	45 58.84	65 06.67	950	0	R	R	R	S	R
Petitcodiac	45 56.41	65 10.77	650	0	0	0	R	0	S
Anagance River mouth[a]	45 55.76	65 11.19	1050	0	0	R	A	S	0
North River									
Glenvale	45 56.32	65 11.94	815	0	R	R	R	S	0
Intervale[a]	45 57.68	65 12.00	1040	0	0	R	0	R	R
Fawcett[a]	45 59.35	65 11.94	750	0	0	0	0	R	0
Scott Settlement	46 02.05	65 08.67	500	0	R	0	0	S	0
McLeod Brook[a]	46 03.04	65 06.88	270	0	R	0	0	S	0
2nd North R. Cemetery[a]	46 03.54	65 05.98	1300	0	R	0	R	R	0
Upstream Rte 112 bridge[ab]	46 03.92	65 05.54	350	0	R	0	R	S	R
Back road bridge	46 04.73	65 04.35	550	0	0	0	0	0	0
Upper North R.	46 04.78	65 01.65	310	0	0	0	0	0	0
Bennett Brook									
Upstream of mouth	45 57.54	65 12.13	155	0	0	0	0	0	0
Holmes Brook									
At Petitcodiac	45 55.49	65 11.19	200	0	0	0	R	0	0
Anagance River									
Upstream of mouth	45 55.65	65 11.29	500	0	R	0	C	C	0
1 km upstream	45 55.14	65 11.88	310	0	0	0	C	C	0
2 km upstream	45 54.89	65 11.96	300	0	0	0	C	C	0
Turtle Creek									
Rte 112 bridge[a]	46 02.68	64 52.54	300	0	R	0	0	R	A
Above head of tide	46 01.74	64 52.31	700	0	0	0	S	0	0
Below reservoir	46 00.41	64 52.05	350	0	0	0	S	0	0
Little River									
Upstream of mouth	46 01.57	65 01.63	250	0	R	S	S	0	0
Below 112 bridge	46 01.30	65 01.40	180	0	R	S	S	0	0
Above 112 bridge[a]	46 01.05	65 01.13	680	0	0	C	C	0	0
Route 895 bridge	46 00.34	64 59.02	662	0	R	S	A	0	0
Wilson Road	45 53.54	64 58.31	720	0	0	0	A	0	0
Nixon Settlement	45 57.37	64 57.50	1500	0	0	0	A	0	0
Parkingdale 1	45 54.00	64 59.23	470	0	0	0	A	0	0
Parkingdale 2	45 51.84	64 59.73	250	0	0	0	A	0	0
Intervale Road	45 50.62	64 59.81	535	0	0	0	A	0	0
Rafe Road	45 50.16	64 59.80	390	0	0	0	C	0	0
Nowlan Road	45 49.15	64 59.80	660	0	0	0	S	0	0
Hillside reservoir	45 45.92	65 02.08	150	0	0	0	0	0	A
Prosser Brook	45 51.74	64 58.94	150	0	0	0	1	0	0

Site	Latitude	Longitude	SL	A. h.	A. u.	A. v.	M. m.	E. c.	P. c.
Pollett River									
Mouth upstream[a]	45 59.74	65 05.42	850	0	0	0	A	0	0
Kay Settlement[a]	45 58.36	65 05.12	745	0	0	0	C	0	0
Rte 905 Glades Road	45 54.38	65 05.25	700	0	0	0	S	0	0
Harrison Settlement	45 53.30	65 05.69	590	0	0	0	R	0	0
Route 895 crossing	45 48.74	65 06.39	300	0	0	0	R	0	0
Gordon Falls	45 46.66	65 05.71	200	0	0	0	0	0	0
Church Corner	45 45.30	64 04.75	210	0	0	0	0	0	0
Petitcodiac Headpond									
A. near head of tide	46 01.86	65 00.74	11 sites	0	0	0	0	R	A
K. near causeway	46 04.33	64 48.88	N/A	0	0	0	0	R	A

[a]searched in 1984
[b]historical record for *A. heterodon*

1997/98 survey

We conducted a watershed-wide survey of freshwater mussel populations in the Petitcodiac River from 23 July to 21 October 1997 and from 2 June to 28 August 1998. We sampled 47 sites in the running water part of the watershed and 11 stations within the impoundment. At each running water site, we visually searched the full width of the river with a team of 2 to 3 searchers. The 1997 survey was considered to be preliminary because we conducted timed searches (1 to 2 hours). The 1998 survey was semi-quantitative because we measured the length of river or stream searched without any restriction on the amount of time spent at each location; however, we only made qualitative estimates of the numbers of freshwater mussels collected at most sites. All locations searched in 1984 and 1997 were also searched during the 1998 survey.

Each running water station in the 1997/98 survey was located by latitude and longitude at its point of entry to the water using a 1: 50,000 topographic map. The distance searched from the entry point (either a bridge or where the road closely approached the river) to an arbitrarily determined endpoint was measured using a 50-m tape measure or a metered thread-dispensing device. The stream length searched ranged from 150 to 1500 m (median 518 m; quartiles 300 and 750 m; Table 1), and stream width varied between 3 and about 50 m. Water depth seldom exceeded 50 cm at any location. All stream banks as well as sand and gravel bars were carefully searched for empty shells. Water clarity was excellent at all locations. All submersed habitat was carefully searched visually and by digging in sand and gravel around rocks and boulders. When locations with large deposits of sand and fine gravel were encountered, they were sampled with a 30-cm wide push net (each sample represented about 0.25 m^2, to a depth of 5-6 cm), the sediment samples were sieved through 6-mm mesh netting, and all mussels were identified to species before being replaced approximately where found. This method is even more sensitive than timed searches (described by Strayer *et al*. 1997) for detecting rare species because very small juveniles are collected. Sieving of sediments is almost a necessity when attempting to collect mussels less than 25 mm long (Hanson *et al*. 1988a; Amyot and Downing 1991; Richardson and Yokely 1996; Obermeyer *et al*. 1997). We recorded the species collected and a qualitative estimate of abundance at each site. We defined abundant

as more than 1 animal/m^2; common as between less than 1/m^2 but more than 1/10m^2; scarce as 10 to 100/site; rare as less than 10/site; and not found. In some instances, quantitative samples were collected from measured quadrats and taken to the laboratory as part of ongoing studies of freshwater mussel ecology.

The 11 stations in the headpond were sampled quantitatively during August 1997 using a 23 X 23 X 23 cm Ekman dredge, with 10 dredge hauls per sample and three samples at each of 1-, 2-, 3-, and greater than 4-m depths. Five of the stations were also sampled during August 1998. Sediments were washed on a 6-mm sieve, and all freshwater mussels retained were identified to species and taken to the laboratory for detailed biological sampling. The locations of the eleven stations in the headpond were chosen arbitrarily. The first station was 200 m upstream from the causeway structure and the last was just below the head of tide. The station positions were determined using a differential Global Positioning Satellite device.

Seven species of freshwater mussels have been recorded from the Petitcodiac watershed. Of these, four are listed as being of concern in the U.S. (Williams *et al*. 1993; Turgeon *et al*. 1996): the Dwarf Wedgemussel is endangered, the Brook Floater (*Alasmidonta varicosa*) is threatened, and the Triangle Floater (*A. undulata*) and Eastern Pearlshell (*Margaritifera margaritifera*) are of special concern in the U.S. The Eastern Pearlshell is the only freshwater mussel species that occurs naturally in both Europe and North America. It is endangered or extirpated throughout most of its range in Europe (Young and Williams 1983; Bauer 1988; Buddensiek 1995). The conservation status of Eastern Elliptio (*Elliptio complanata*), Eastern Floater (*Pyganodon cataracta*), and Newfoundland Floater (*P. fragilis*) is currently stable.

Five freshwater mussel species were detected in the 1997/98 surveys. The Dwarf Wedgemussel was not found, and we conclude that it had been extirpated. A second species, the Newfoundland Floater, was not detected either in this survey. The only prior record of this species is from the field notes of the 1984 survey where two specimens were listed from the Intervale site. We found a small number of *P. cataracta* at this site in the 1997 and 1998 surveys and suspect the 1984 identification might be erroneous because the two species are very similar in appearance.

Dwarf Wedgemussels were not detected at any sites in the watershed or the headpond. Suitable habitat (i.e., sand or fine gravel with very little silt and moderate current) was present in many areas of the Petitcodiac River, the Anagance River, and lower sections of the Little River. The substrate in the Pollett River is generally not suitable for the Dwarf Wedgemussel because it consists primarily of rock and large cobble with very few patches of sand or fine gravel. Elsewhere, the Dwarf Wedgemussel is usually found in association with the Eastern Elliptio, Eastern Pearlshell, Brook Floater, and Triangle Floater (Clarke 1981a; Master 1986; Strayer 1993; U.S. Fish and Wildlife Service 1993; Michaelson and Neves 1995). As described below, these four species still occur in the areas of the Petitcodiac watershed that represent suitable habitat for the Dwarf Wedgemussel.

One of the known locations where the Dwarf Wedgemussel occurred is no longer suitable habitat for any freshwater mussel species. During the 1984 survey, Clarke and McAlpine did not find Dwarf Wedgemussel in the North River sites from Fawcett to the route 112 bridge (including the site where it was considered common in 1960), but characterized this stretch of river as good habitat. In 1997 and 1998, however, this section of river had been severely degraded, principally by poor agricultural practices, and all species of mussels were rare to absent (Table 1). This habitat degradation included large areas of black anoxic sediments that give off methane and hydrogen sulphide gas when disturbed; sections fenced off across the stream to allow cattle full access to both sides of the river; silting resulting from both cattle collapsing the banks and fields cultivated to within 2-3 m of the bank; removal of almost all shoreline vegetation by cattle; and ditches and drainpipes emptying directly into the river. In some places, macrophyte growth was excessive, and both the plants and the substrate were thickly coated with algae, i.e., conditions under the plants were anoxic. Consequently, it is not surprising that no living mussels were found at these sites.

The Eastern Pearlshell (*Margaritifera margaritifera*) was the most abundant and widespread species in the running water part of the watershed. It does not occur in ponds and lakes, hence its absence from the headpond was expected. The only known fish hosts for North American populations of this long-lived species are juvenile Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*) (Smith 1976; Cunjak and McGladdery 1991; Nezlin *et al*. 1994). Although spawning populations of Atlantic salmon have been eliminated from the watershed by the Petitcodiac causeway, there have been numerous, unsuccessful attempts to re-establish the population through stocking of large numbers of parr. Consequently, the Eastern Pearlshell has been able to reproduce in some years as evidenced by our collection of small (< 40 mm long) specimens in sand and fine gravel habitats in the Little, Pollett, Anagance, and Petitcodiac rivers, but not in the North River.

The Brook Floater (*Alasmidonta varicosa*) was found in the lower reaches of the Little, Anagance and North Rivers and in sandy sections of the Petitcodiac River. Its distribution was patchy, and individuals less than 25 mm long were collected only in the Little and Petitcodiac Rivers (this is evidence of recent reproduction).

The Triangle Floater (*A. undulata*) was rare at all locations where it occurred. There was no evidence of recent reproduction; no individuals smaller than 35 mm long were collected.

The Eastern Floater (*Pyganodon cataracta*) was abundant in the Petitcodiac headpond and small reservoir on the Little River; elsewhere, it was rare or absent. It is not normally found in running water. This species has reproduced as recently as 1997 when numerous age-0 individuals were collected in the headpond (J.M. Hanson, unpublished data).

The Eastern Elliptio (*Elliptio complanata*) was rare in the headpond but common to abundant in quiet sections (with a sand and silt substrate) of the Petitcodiac and Anagance Rivers where individuals as small as 20 mm long were collected. The Eastern Elliptio was rarely found in the North River (Glenvale to the route 112 bridge) despite being recorded as abundant in this stretch of river during the 1984 survey.

HABITAT

The habitat requirements of the Dwarf Wedgemussel have been well documented in recent years (e.g., U.S. Fish and Wildlife Service 1993; Strayer and Ralley 1993; Michaelson and Neves 1995). The Dwarf Wedgemussel lives in running waters of all sizes, from streams less than 5 m wide to shallow rivers more than 100 m wide, usually where currents are moderate to slow. It occurs in areas of stones or cobble but always in patches of sand or fine gravel and shows very low tolerance for silt or low oxygen conditions (Master 1986; U.S. Fish and Wildlife Service 1993). It is often found near riverbanks under overhanging trees (Clarke 1981a). This type of habitat is common throughout the Petitcodiac watershed, with the exception of the Pollett River where the substrate is primarily large cobble and rock with very few areas with patches of sand or fine gravel.

GENERAL BIOLOGY

The biology of the Dwarf Wedgemussel has not been studied in Canada. There is limited information on its biology in U.S. waters (e.g., U.S. Fish and Wildlife Service 1993; Michaelson and Neves 1995). What is known of its biology does not differ from the general biology of freshwater mussels described by McMahon (1991). The Dwarf Wedgemussel is a long-term brooder. The eggs are fertilized in mid-summer or autumn, and the glochidia mature in the marsupia of females. The glochidia are released into the water in spring. The Dwarf Wedgemussel glochidium is roughly triangular (0.30 x 0.25 mm) and has hooks that allow it to attach to the fins and gills of fish. The glochidium then encysts, and after several weeks, it ruptures the cyst and falls to the bottom. The juvenile mussel then buries in soft sediments (sand and fine gravel) where it feeds by filtering algae and fine organic debris from the water. The size and age-at-first-maturity have not been determined for the Dwarf Wedgemussel.

The life span of the Dwarf Wedgemussel is not well known. Only one study attempted to determine ages in this species (Michaelson and Neves 1995). The authors reported that there was frequent substantial shell erosion at the umbo, and ages could not be reliably assigned for most animals showing more than 6 annuli, although some 10-year-olds were recorded, and the maximum theoretical age was 12 to 18 years. The first attempt to collect the Dwarf Wedgemussel after the completion of the causeway in 1968 was in 1984. It was unsuccessful, which suggests recruitment failure was almost immediate because individuals born as few as 6 or 7 years later should have been present in 1984.

The fish hosts for wild Dwarf Wedgemussels are unknown. Laboratory studies indicate mottled sculpin (*Cottus bairdi*), Johnny darter (*Etheostoma nigrum*), and tessellated darter (*E. olmstedi*) can serve as hosts (Michaelson and Neves 1995). Recent (1998) studies have added pumpkinseed (*Lepomis gibbosus*) and Atlantic salmon parr to the list of potential hosts (B. Wicklow, Biology Department, St. Anselm College, Manchester, New Hampshire 03102). With the exception of Atlantic salmon, none of these fish species ever existed in the Petitcodiac watershed. McAlpine and Master (1986) speculated that the loss of the Canadian population of the Dwarf Wedgemussel was due to the loss of the anadromous fish host, which was prevented from entering the river system when the Petitcodiac causeway was completed in 1968 and blocked access to the host's spawning grounds. Although they mentioned American eel (*Anguilla rostrata*) as a potential host, this species was not eliminated from the Petitcodiac watershed; indeed, it was frequently observed during our surveys.
We think the likeliest candidate for a fish host for Canadian populations of the Dwarf Wedgemussel was American shad (*Alosa sapidissima*). Of the four fish species eradicated by the closure of the Petitcodiac causeway, it was the only species that occurred at the known collection sites *and* was immediately eliminated from the system. The only other fish species eliminated from the Petitcodiac watershed that also occurred at known collection locations for the Dwarf Wedgemussel was Atlantic salmon. In the case of Atlantic salmon, however, a remnant spawning population, supplemented by heavy stocking of parr, persisted until the 1990s before disappearing. We would have expected some Dwarf Wedgemussels to have been present in 1984 if Atlantic salmon were the fish host for the glochidial stage.

LIMITING FACTORS

All freshwater mussels have two critical early-life stages: the parasitic (dispersal) stage that usually requires the presence of a specific fish host, and the early post-parasitic stage where specific microhabitat conditions are required for survival (Bauer 1988; Buddensiek 1995; Sparks and Strayer 1998). Although adult freshwater mussels release tens of thousands to millions of glochidia, only a very small fraction successfully attach to fish and survive to the benthic juvenile stage (Young and Williams 1983; Jansen and Hanson 1991; Buddensiek 1995). It is at the parasitic stage that the distribution of freshwater mussel species is determined because if the host fish cannot enter a stretch of water, the freshwater mussel species will not be found there (Watters 1992; Graf 1997; Haag and Warren 1998). Adult Dwarf Wedgemussels are largely sedentary—movement is measured in metres (Hanson *et al*. 1988b; McMahon 1991; Amyot and Downing 1997)—which results in their susceptibility to over-harvesting and habitat degradation. Under normal conditions, adult freshwater mussels generally have low natural mortality rates. The list of anthropogenic threats to the persistence of freshwater mussel populations is long and includes barriers to fish movement, habitat degradation, channelization, over-harvesting, anoxia, metal contamination, and introduction of encrusting competitors (i.e., the zebra mussel*, Driessena polymorpha*) (Nalepa *et al*. 1991; Bogan 1993; Blalock and Sickel 1996; Ricciardi *et al*. 1998; Sparks and Strayer 1998). Adult freshwater mussels have very few natural predators.

Blockage of streams and rivers is one of the most common threats to the persistence of freshwater mussel populations (Bogan 1993; Williams *et al*. 1993; Layzer *et al*. 1993; Strayer *et al*. 1996; Ricciardi *et al*. 1998) and appears to be the principal cause for the extirpation of the Dwarf Wedgemussel from Canada (Master 1986). A causeway was built in the tidal section of the Petitcodiac River in 1967 (completed in 1968) to provide a second crossing between the city of Moncton and the town of Riverview. This causeway has had a severe negative effect on populations of anadromous fishes. The populations of Atlantic salmon, striped bass (*Morone saxitilis*), American shad, and Atlantic tomcod (*Microgadus tomcod*) have been eliminated, while those of sea-run brook trout, rainbow smelt (*Osmerus mordax*), and gaspereau (*Alosa pseudoharengus* and *A. aestivalis*) have been greatly reduced. In correspondence with J.E. Stewart of the Department of Fisheries and Oceans, D. McAlpine speculated that the loss of the anadromous host fish (species unknown) for the glochidial stage of the Dwarf Wedgemussel was responsible for the apparent extirpation of the species from the Petitcodiac watershed because the habitat where the mussel formerly occurred was still suitable; indeed, many specimens of other freshwater mussels were collected at these sites, including two congener species (*A. varicosa* and *A. undulata*), as well as *Elliptio complanata* and *Margaritifera margaritifera*—species typically found in the same habitat as the Dwarf Wedgemussel (Clarke 1981a; U.S. Fish and Wildlife Service 1993; Strayer *et al*. 1996).

Other forms of habitat degradation are unlikely to have been factors in the extirpation of the Dwarf Wedgemussel from Canadian waters. As described above (see the 1997/98 survey), one section of the North River no longer represents suitable habitat for any species of freshwater mussel because of habitat degradation, but this habitat degradation has occurred since the 1984 survey, at which time the species could already not be found.

Muskrats (*Ondatra zibethicus*) are the only mammalian predators (other than humans) that kill large numbers of adult freshwater mussels (Hanson *et al*. 1989; Neves and Odom 1989; Jokela and Mutikainen 1995). Their predation tends to be localized and does not threaten the existence of populations of endangered freshwater mussels unless an area of high muskrat feeding coincides with a remnant concentration of an endangered species (Neves and Odom 1989; Bruenderman and Neves 1993; Hogarth *et al*. 1995). It is unlikely that muskrat predation was a factor in the extirpation of the Dwarf Wedgemussel from the Petitcodiac watershed because muskrat predation is not widespread in the watershed and tends to focus on molluscs of large body size (J.M. Hanson, unpublished data).

SPECIAL SIGNIFICANCE

North America has the highest diversity of freshwater mussels in the world. There are 281 recognized species, of which only 70 are considered to have stable populations, making freshwater mussels the most threatened taxon in North America (Williams *et al*. 1993; Stein and Chipley 1996; Primack 1998). In many cases,

freshwater mussels act as “miner’s canaries” for the health of aquatic habitats; their absence is considered a sign that a water body has been severely degraded.

Recently, a new threat has arisen. Already under severe threat of human alteration of their habitats, pollution, and over-exploitation, freshwater mussels are threatened by the recent invasion of the zebra mussel, which is expected to result in extensive extinctions of freshwater mussels across North America, including much of Canada (Ricciardi *et al*. 1998).

Clarke (1981b) lists 12 species of freshwater mussel in New Brunswick, one of which, the Dwarf Wedgemussel, is listed as endangered in the U.S. Although the species had a very restricted distribution in Canada, it was one of only two locations where the species was considered to be common (Clarke 1981a) despite being at the extreme northern edge of its range. Populations at the edge of a species’ range often contain unique genetic adaptations and, for this reason alone, are an important component of biological diversity and are worth protecting (Primack 1998). With the extirpation of the Dwarf Wedgemussel from Canadian waters, the unique adaptations that may have allowed this species to form a large population in the Petitcodiac River (Clarke 1981a) were lost.

RECOMMENDATIONS AND OPTIONS

The Dwarf Wedgemussel has been extirpated from Canadian waters. Its extirpation coincides with the closure of the river mouth by the Petitcodiac Causeway and subsequent local extermination of four species of anadromous fish species: Atlantic salmon, American shad, striped bass, and Atlantic tomcod. There is no chance of re-establishing the Dwarf Wedgemussel as long as the Petitcodiac Causeway inhibits fish passage. Should the locally exterminated anadromous fish species (in particular American shad) become re-established, it may be possible for the Dwarf Wedgemussel to re-colonize the river naturally, but it is more likely that re-establishment of the species in Canada will require seeding from U.S. populations (along with all of the complications this would entail). Although in the U.S. and Europe, relocation and stocking of mussels is a common management practice to recolonize areas where mussels have been eliminated or are threatened by human activities, such as pollution events, road and bridge construction, or to re-establish populations of endangered species (U.S. Fish and Wildlife Service 1993; Buddensiek 1995; Cope and Waller 1995; Waller *et al*. 1995), there has to be a source of animals to stock. Given the depressed population status of the remaining U.S. populations, it is unlikely that in the near future there will be excess animals available for out-of-country needs. In addition, Dwarf Wedgemussels from more southern locations may not be adapted to survive in Canadian conditions. Finally, the re-establishment of populations of any freshwater mussel species at some North River locations would require substantial rehabilitation of the habitat, i.e., destructive agricultural practices, especially that of cattle having free access to the river banks, would have to cease.

EVALUATION

The Dwarf Wedgemussel has been extirpated from Canadian waters. The direct cause was the closure of the mouth of the river by the Petitcodiac Causeway completed in 1968 and the subsequent local extirpation of the host fish species, most likely American shad. Since 1984, a portion of the former range of the Dwarf Wedgemussel has been degraded by agricultural runoff, bank destruction by cattle, pesticides, dumping of farm chemical, etc. There remain, however, large stretches of suitable habitat in the Little, Petitcodiac, North, and Anagance rivers. Re-introduction (from U.S. populations) is unlikely to be successful until anadromous fish (in particular American shad) populations are re-established in the river. This would require the removal of the blockage caused by the Petitcodiac Causeway. Part of the former range of this mussel would require substantial rehabilitation to reverse the effects of destructive agricultural practices.

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