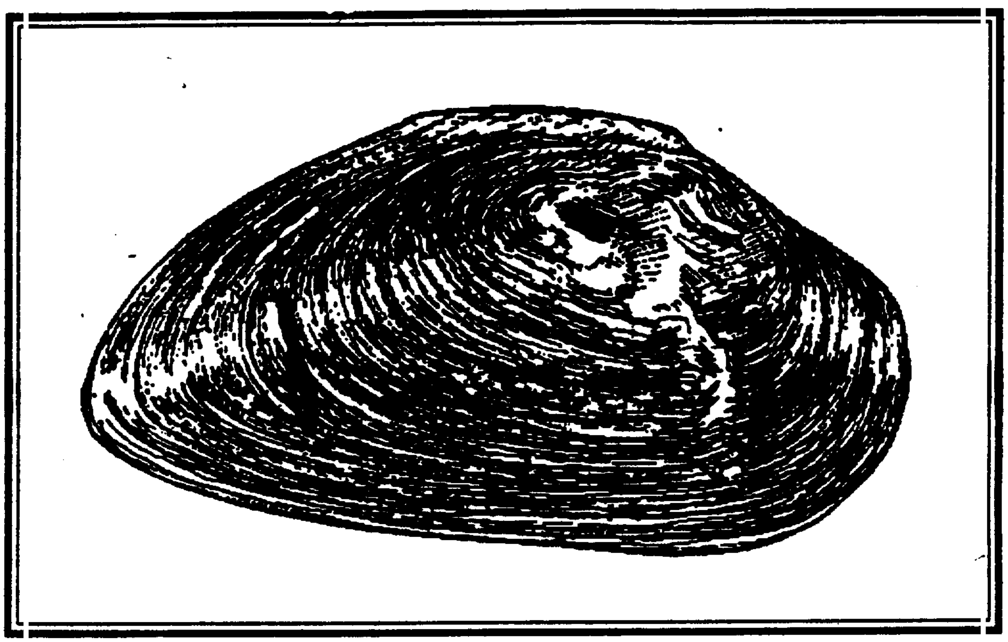
90-03-14-001

# DWARF WEDGE MUSSEL

*(Alasmidonta heterodon)*

# RECOVERY PLAN



U.S. Fish and Wildlife Service, Northeast Region

# DWARF WEDGE MUSSEL *(Alasmidonta heterodon)*

# RECOVERY PLAN

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Date: FEB 08 1993

# EXECUTIVE SUMMARY OF THE DWARF WEDGE MUSSEL RECOVERY PLAN

**CURRENT STATUS:** This freshwater mussel has declined precipitously over the last hundred years. Once known from at least 70 locations in 15 major Atlantic slope drainages from New Brunswick to North Carolina, it is now known from only 20 localities in eight drainages. These localities are in New Hampshire, Vermont, Connecticut, New York, Maryland, Virginia, and North Carolina. The dwarf wedge mussel (*Alasmidonta heterodon*) was listed as an endangered species in March of 1990.

**HABITAT REQUIREMENTS AND LIMITING FACTORS:** The dwarf wedge mussel lives on muddy sand, sand, and gravel bottoms in creeks and rivers of various sizes. It requires areas of slow to moderate current, good water quality, and little silt deposition. The species' recent dramatic decline, as well as the small size and extent of most of its remaining populations, indicate that individual populations remain highly vulnerable to extirpation.

**RECOVERY OBJECTIVES:** (1) Downlist to threatened status, and (2) delist.

**RECOVERY CRITERIA:** To downlist, populations of *A. heterodon* in the mainstem Connecticut River, Ashuelot River, Neversink River, upper Tar River, three sites in the Neuse River system, as well as in at least six other rivers, must be viable based on monitoring results over a 10-15 year period. To delist, populations must be dispersed widely enough within at least 10 of these rivers such that a single event is unlikely to eliminate a population from a given river reach. These populations must be distributed throughout the species' range, and must be permanently protected from foreseeable threats.

**ACTIONS NEEDED:**

1. Collect basic data needed for protection of *A. heterodon* populations.
2. Preserve *A. heterodon* populations and occupied habitats.
3. Develop an education program.
4. Conduct life history studies and identify ecological requirements of the species.
5. If feasible, re-establish populations within the species' historical range.
6. Implement a program to monitor population levels and habitat conditions.
7. Periodically evaluate the recovery program.

**ESTIMATED COSTS ($1000s):**

| Year | Need 1 | Need 2* | Need 3 | Need 4 | Need 5 | Need 6 | Total** |
|---|---|---|---|---|---|---|---|
| FY1 | 82 | 31 | | 35 | | | 148 |
| FY2 | 107 | 65 | 6 | | | 30 | 208 |
| FY3 | 107 | 75 | 11 | | | | 193 |
| FY4 | 55 | 45 | 1 | | | | 101 |
| FY5 | | 45 | 1 | | 15 | 30 | 91 |
| FY6 | | 45 | 1 | | 15 | | 61 |
| FY7 | | 15 | 1 | | 15 | | 31 |
| FY8 | | 15 | 1 | | 15 | 30 | 61 |
| FY9 | | 15 | 1 | | 15 | | 31 |
| FY10 | | 15 | 1 | | | 30 | 45 |
| Total | 351 | 366 | 24 | 35 | 75 | 120 | 971 |

* Total costs to provide long-term protection of essential habitats (Need 2) are not yet known.
** No costs are associated with Need 7.

**DATE OF RECOVERY:** Because a period of at least 10 years is required to document the stability of dwarf wedge mussel populations, downlisting will be considered sometime after the year 2002, when the recovery criterion has been met.

* * *

Recovery plans delineate reasonable actions needed to recover and/or protect listed species. Attainment of recovery objectives and availability of funds are subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

Recovery plans do not necessarily represent the views or official position of any individuals or agencies involved in plan formulation, other than the U.S. Fish and Wildlife Service. Approved recovery plans may be modified as dicatated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations for this plan should read as follows:

U.S. Fish and Wildlife Service. 1993. Dwarf Wedge Mussel (*Alasmidonta heterodon*) Recovery Plan. Hadley, Massachusetts. 52 pp.

Copies of this plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
301-492-6403
or
1-800-582-3421

Fees vary according to number of pages.

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## FIGURES AND TABLES

# PART I: INTRODUCTION

The dwarf wedge mussel (Alasmidonta heterodon) was listed as an endangered species on March 14, 1990 (55 FR 9447). This freshwater mussel has declined precipitously in the past hundred years (Master 1986). Always a rare species confined to Atlantic slope drainages from North Carolina to New Brunswick, the dwarf wedge mussel has been recorded in approximately 70 localities in 15 major drainages since the species' discovery in the early 1800s. It is now thought to have been extirpated from all but 20 localities. The 20 known remaining populations, with one exception, are thought to be relatively small and to be declining as a result of continued environmental assaults in the form of agricultural, industrial, commercial, and domestic pollution/runoff. Channelization, removal of shoreline vegetation, development, and road and dam construction also threaten some populations.

## DESCRIPTION

The dwarf wedge mussel was first described by Lea (1829) as Unio heterodon. It was subsequently placed in the genus Alasmidonta by Simpson (1914). Due to its unique soft-tissue anatomy and conchology, Ortmann (1914) placed it in a monotypic subgenus Prolasmidonta. Fuller (1977) believed the antiquity and unique shell characters of Prolasmidonta were sufficient for elevation to full generic rank and named the species Prolasmidonta heterodon. Clarke

(1981a) retained the genus name Alasmidonta and considered Prolasmidonta to be a subjective synonym of the subgenus Pressodonta Simpson 1900.

The species name, heterodon, refers to the chief distinguishing characteristic of this species, which is the only North American freshwater mussel that consistently has two lateral teeth on the right valve, but only one on the left (Fuller 1977). It is a small mussel whose shell rarely exceeds 1.5 inches (38 mm) in length. The largest specimen ever recorded was 56.5 mm long, taken from the Ashuelot river in New Hampshire (Clarke 1981a).

Clarke (1981a) describes the species as follows:

> "Shell up to about 45 mm long, 25 mm high, 16 mm wide, and with shell wall about 1 mm thick in 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 [outer layer of shell] brown or yellowish brown, and with greenish rays in young or pale-coloured 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; pseudo-cardinal 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."

Because atypical lateral dentition can occur in this species and others, the lateral tooth configuration should not be used alone to distinguish the species. The dwarf wedge mussel is likely to be confused only with young members of the genus Elliptio, from which it can be distinguished by its mottled but colorful mantle margin (Fuller 1977).

## LIFE HISTORY AND ECOLOGY

The dwarf wedge mussel lives on muddy sand, sand, and gravel bottoms in creeks and rivers of varying sizes, in areas of slow to moderate current and little silt deposition. In the southern portion of its range, it is often concentrated in areas along logs or in root mats. In the upper Connecticut River system in New Hampshire, it occurs in shallow water (generally less than one-meter depth during low water) with a firm substrate of sandy mud and gravel, scattered patches of wild celery (Valisneria americana), and little silt deposition (Master 1986). The most commonly associated freshwater mussels are Elliptio complanata and Alasmidonta undulata. Other mussels co-occurring throughout the species' range include Alasmidonta varicosa, Strophitus undulatus, Anodonta cataracta, Anodonta imbecilis, Anodonta implicata, Elliptio lanceolata, Elliptio fisheriana, Elliptio icterina, Villosa constricta, Villosa delumbus, Lampsilis radiata, Lampsilis cariosa, Lasmigona subviridis, and Leptodea ochracea.

Little is known about the reproductive biology of the dwarf wedge mussel; however, the reproductive biology of freshwater mussels appears to be similar among nearly all species (Figure 1). During the spawning period, males discharge sperm into the water column, and the sperm are taken in by females during siphoning (Figure 2). Eggs are fertilized in the suprabranchial cavity or gills, which also serve as marsupia for larval development to mature glochidia. A. heterodon glochidia (Figure 3) are roughly triangular, with hooks, and measure about 0.30 mm in length and 0.25 mm in height (Clarke 1981a). Clarke (1981b) indicates that the dwarf wedge mussel is a long-term brooder. In long-term brooders, fertilization typically occurs in mid-summer and fall, and glochidia are released the following spring and summer. Glochidial release for some long-term brooders also has been observed during fall and winter (Zale 1980). D. Michaelson (Virginia Polytechnic Institute and State University,

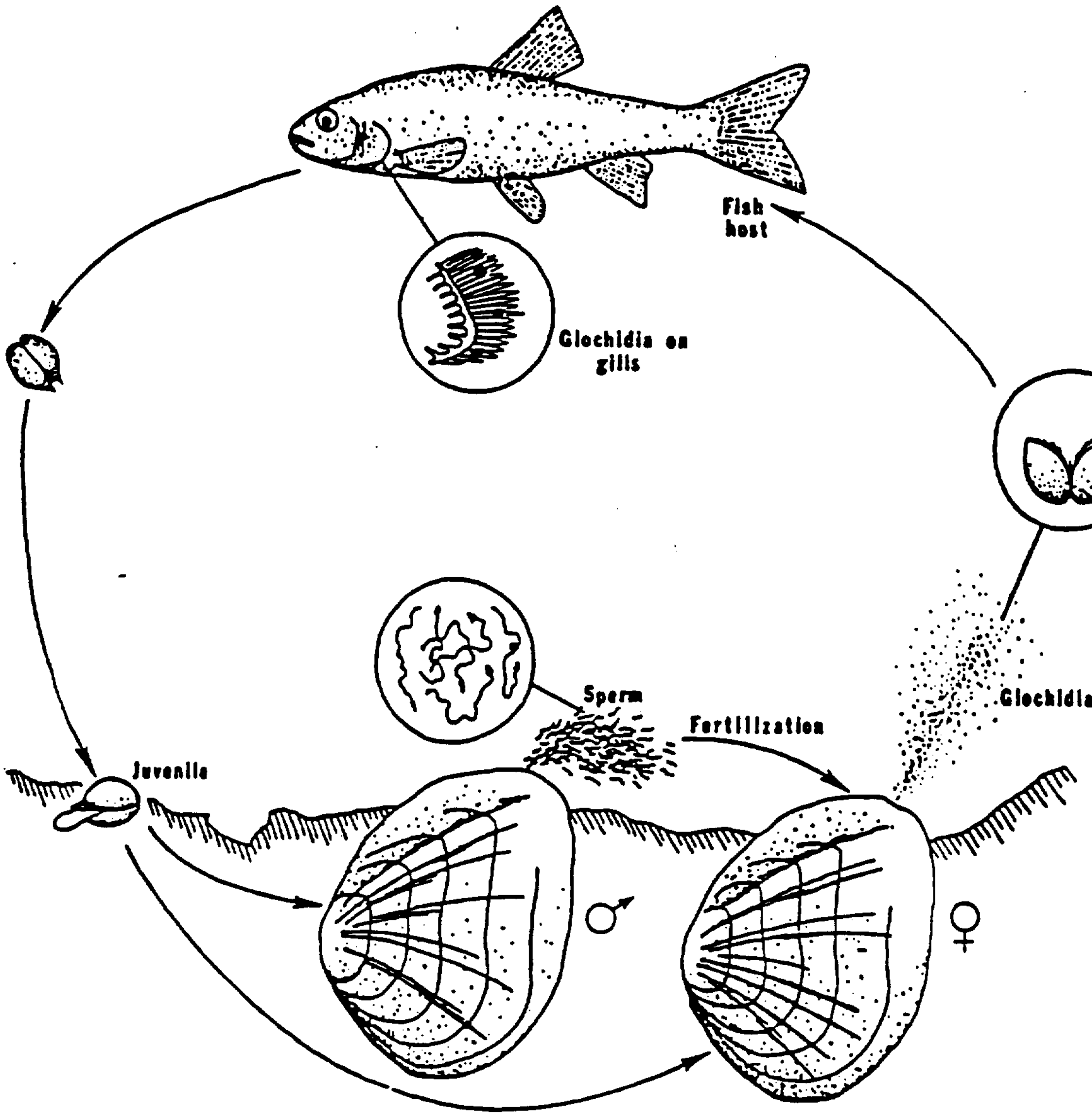



**Figure 1. Typical life cycle of a freshwater mussel**

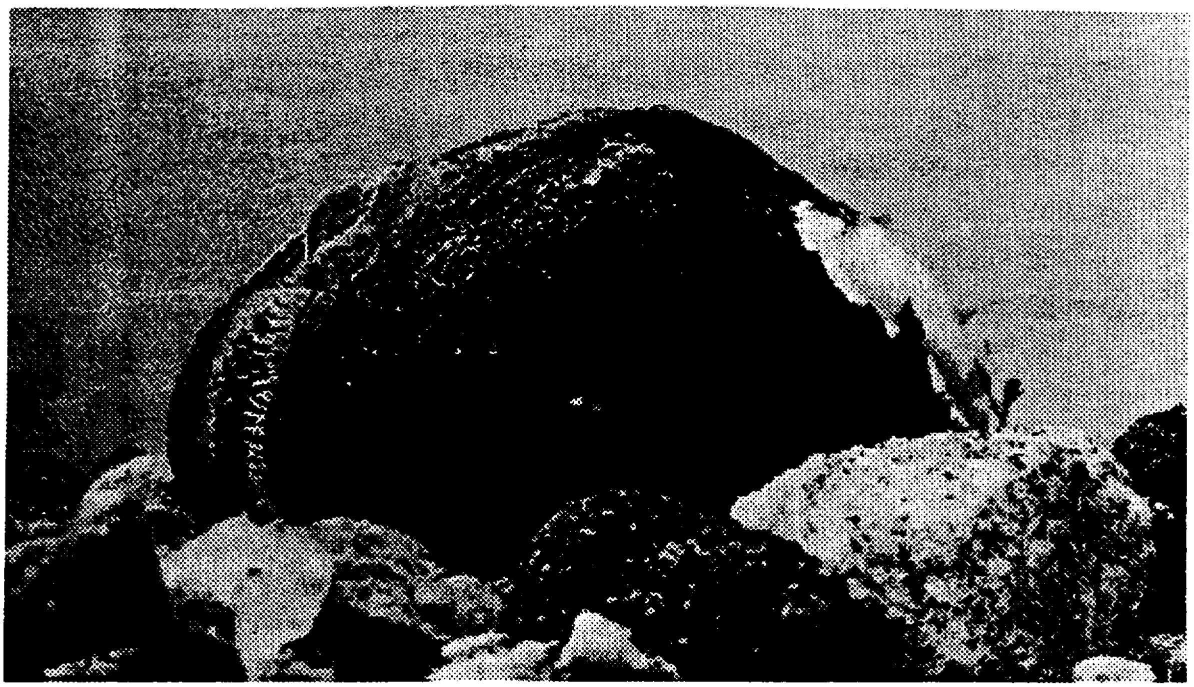


**Figure 2. Partially exposed Alasmidonta heterodon, siphoning**

*Photo courtesy of Doug Smith, University of Massachusetts, Amherst*

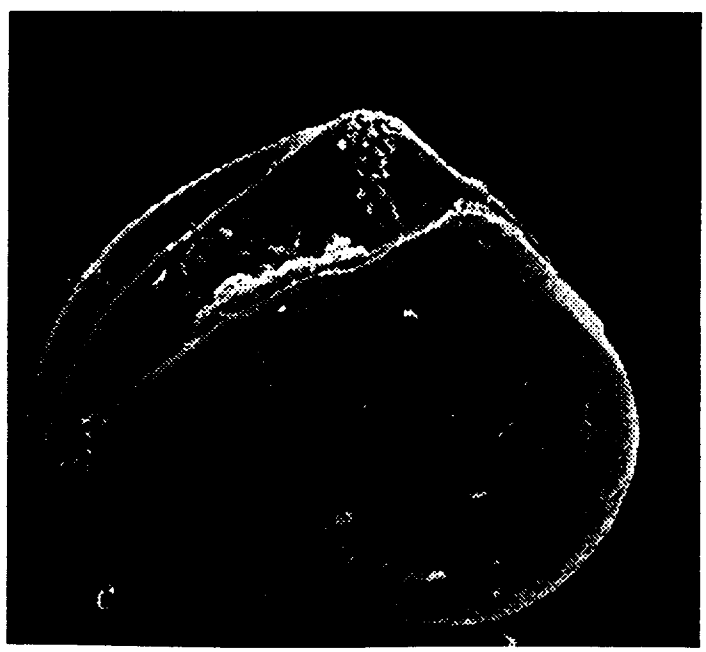


**Figure 3. Glochidia of Alasmidonta heterodon**

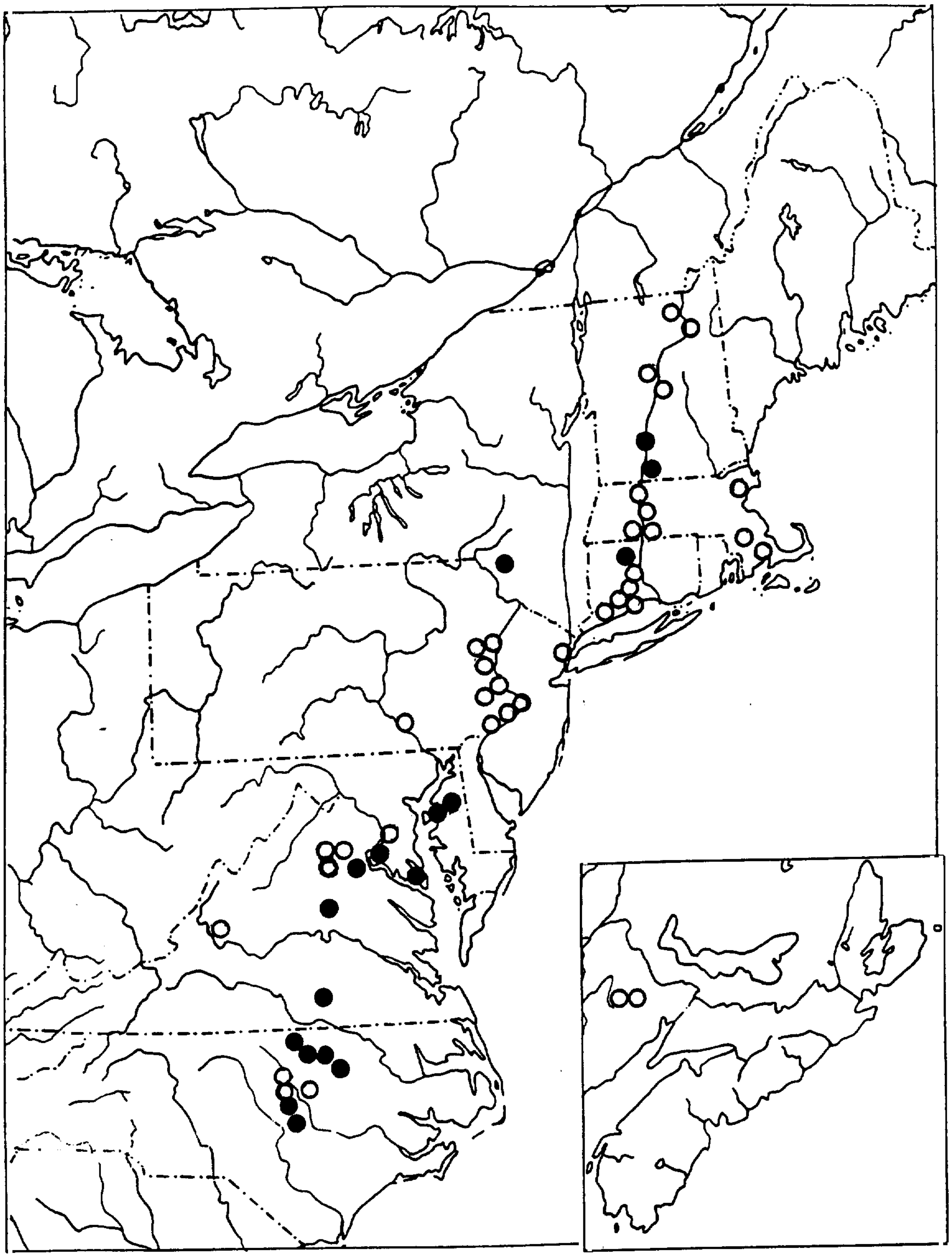
*Photo courtesy Smithsonian Institution Press, from Clarke (1988a)* pers. comm.) has indicated that the periods of gravidity and glochidial release are highly variable; much of this variation appears to be based on latitude. Upon release into the water column, mature glochidia of the genus Alasmidonta attach to the fins and soft tissue of the buccal cavity of appropriate host fishes to encyst and eventually metamorphose to the juvenile stage. When metamorphosis is complete, they drop to the streambed as juvenile mussels.

The host fish(es) for A. heterodon have not been determined. Studies are currently underway at the Cooperative Fishery and Wildlife Unit of the Virginia Polytechnic Institute and State University (VPI&SU) to determine this and other life history requirements.

## DISTRIBUTION

Historically, the dwarf wedge mussel was widely but discontinuously distributed in Atlantic drainages from the Petitcodiac River in New Brunswick, Canada, south to the Neuse River in North Carolina. The species was known from at least 70 locations in 11 states and one Canadian province.

Master (1986) reported that an extensive status survey of historical and potential sites turned up only eight extant populations. Since then, 12 additional extant populations have been found in Maryland, North Carolina, Virginia, and New York. Although a few additional populations may still be discovered, a clear pattern has emerged -- relatively small, scattered relict populations remain from a once extensive distribution. The Neversink River population in New York, estimated at 80,000 mussels, appears to be the sole exception to this pattern; it far outnumbers any other population, although it occupies a relatively short reach of the river. Figure 4 and Table 1 describe current and historical localities for the dwarf wedge mussel. The locations of the 20 extant populations are as follows:



● = Present occurrence
○ = Historical occurrence, presumed extirpated

**Figure 4. Distribution of** ***Alasmidonta heterodon***

(insert shows locations in New Brunswick)

Connecticut River Drainage

1. Connecticut River from the confluence with the Ottauquechee River to Weathersfield Bow in Sullivan County, New Hampshire and Windsor County, Vermont
2. Ashuelot River in Cheshire County, New Hampshire
3. Muddy Brook in Hartford County, Connecticut

Delaware River Drainage

4. Neversink River in Orange County, New York

Tuckahoe Creek (Choptank River) Drainage

5. Norwich Creek in Queen Anne's and Talbot Counties, Maryland
6. Long Marsh Ditch in Queen Anne's and Caroline Counties, Maryland

Potomac River Drainage

7. McIntosh Run in St. Mary's County, Maryland
8. Nanjemoy Creek in Charles County, Maryland
9. Aquia Creek in Stafford County, Virginia

York River Drainage

10. South Anna River in Louisa County, Virginia

Nottoway River Drainage

11. Nottoway River in Nottoway and Lunenberg Counties, Virginia

Tar River Drainage

12. Tar River in Granville County, North Carolina
13. Cedar Creek in Franklin County, North Carolina
14. Crooked Creek in Franklin County, North Carolina
15. Stony Creek in Nash County, North Carolina

Neuse River Drainage

16. Little River in Johnston and Wake Counties, North Carolina
17. Swift Creek in Johnston County, North Carolina
18. Middle Creek in Johnston County, North Carolina
19. Turkey Creek in Wilson and Nash Counties, North Carolina
20. Moccasin Creek in Nash, Wilson, and Johnston Counties, North Carolina

Of these populations, those located in the Connecticut River, the Neversink River, and the Upper Tar River appear to be the largest.

**Table 1. Historical (H) and present (P) occurrences of the dwarf wedge mussel**

| | | |
|---|---|---|
| | Petitcodiac River System, New Brunswick, Canada | |
| (H) 1953 | North River NW of Salisbury | Westmoreland County, NB |
| (H) 1960 | Petitcodiac River at River Glade | Westmoreland County, NB |
| | Merrimack River System | |
| (H) | Merrimack River at Andover | Essex County, MA |
| | Taunton River System | |
| (H) 1969 | Canoe river near Norton | Bristol County, MA |
| | Agawam River System | |
| (H) | Agawam River | Plymouth County, MA |
| | Connecticut River System | |
| (H) | Connecticut River at Bloomfield | Essex County, VT |
| (H) | Connecticut River at Northumberland | Coos County, NH |
| (H) | Connecticut River at Ryegate | Caledonia County, VT |
| (H) | Connecticut River N of Monroe | Grafton County, NH |
| (P) | Connecticut River from confluence with the Ottauquechee River to Weathersfield Bow | Sullivan County, NH and Windsor County, VT |
| (P) | Ashuelot River near Keene | Cheshire County, NH |
| (H) 1948 | Connecticut River at Northfield | Franklin County, MA |
| (H) 1979 | Connecticut River at Sunderland | Franklin County, MA |
| (H) | Connecticut River at Chicopee | Hampden County, MA |
| (H) 1940 | Canal at Westfield | Hampden County, MA |
| (H) | Connecticut River at Springfield | Hampden County, MA |
| (H) 1951 | Scantic River near Hampden | Hampden County, MA |
| (H) 1984 | Fort River in Amherst | Hampshire County, MA |
| (H) 1973 | Mill River at Northampton | Hampshire County, MA |
| (H) | Connecticut River at Hadley | Hampshire County, MA |
| (H) | Connecticut River at Granby | Hartford County, CT |
| (H) 1959 | Philo Brook at Suffield | Hartford County, CT |
| (P) | Muddy Brook | Hartford County, CT |
| | Quinnipiac River System | |
| (H) | Ten Mile River at Mixville | New Haven County, CT |
| (H) | Quinnipiac River at Meriden | New Haven County, CT |
| (H) | Wilmot Brook at New Haven | New Haven County, CT |
| | Hackensack River System | |
| (H) | Brook flowing W from Closter to Hackensack | Bergen County, NJ |
| | Delaware River System | |
| (P) | Neversink River | Orange County, NY |
| (H) 1919 | Delaware River at Shawnee | Monroe County, PA |
| (H) 1919 | Princess Creek at Kunkleton | Monroe County, PA |
| (H) | Pohopoco Creek near Leighton | Carbon County, PA |
| (H) | Delaware River | Bucks County, PA |

**Table 1 (continued). Historical (H) and present (P) occurrences of the dwarf wedge mussel**

| | | |
|---|---|---|
| | <u>Delaware River System (continued)</u> | |
| (H) | Big Neshaminy Creek near Edderson | Bucks County, PA |
| (H) | Schuylkill River at junction with Darby Creek | Delaware County, PA |
| (H) 1919 | Canal along Schuylkill at Manayunk | Philadelphia County, PA |
| (H) 1919 | Schuylkill River below Fairmount Dam | Philadelphia County, PA |
| | <u>Susquehanna River System</u> | |
| (H) | Susquehanna River at Columbia | Lancaster County, PA |
| | <u>Choptank River System</u> | |
| (P) | Norwich Creek | Queen Anne's and Talbot Cos., MD |
| (P) | Long Marsh Ditch | Queen Anne's and Caroline Cos., MD |
| | <u>Potomac River System</u> | |
| (H) | Potomac River near Washington, D.C. | Washington, D.C. |
| (P) | McIntosh Run | St. Mary's County, MD |
| (P) | Nanjemoy Creek | Charles County, MD |
| (P) | Aquia Creek | Stafford County, VA |
| | <u>Rappahannock River System</u> | |
| (H) | Mountain Run | Culpeper County, VA |
| (H) | Marsh Run near Remington | Fauquier County, VA |
| (H) | Blue River | Orange County, VA |
| | <u>York River System</u> | |
| (P) | South Anna River | Louisa County, VA |
| (H) | South Anna River | Hanover County, VA |
| | <u>James River System</u> | |
| (H) | Maury River (North River) at Lexington | Rockbridge County, VA |
| | <u>Nottoway River System</u> | |
| (P) | Nottoway River | Nottoway and Lunenberg Cos., VA |
| | <u>Tar River System</u> | |
| (P) | Tar River | Granville County, NC |
| (P) | Cedar Creek | Franklin County, NC |
| (P) | Crooked Creek | Franklin County, NC |
| (P) | Stony Creek | Nash County, NC |
| | <u>Neuse River System</u> | |
| (H) | Neuse River at Poolec Bridge | Wake County, NC |
| (H) | Neuse River E of Raleigh | Wake County, NC |
| (H) | Neuse River NE of Wendell | Wake County, NC |
| (P) | Little River | Johnston and Wake Cos., NC |
| (P) | Swift Creek | Johnston County, NC |
| (P) | Middle Creek | Johnston County, NC |
| (P) | Turkey Creek | Wilson and Nash Cos., NC |
| (P) | Moccasin Creek | Nash, Wilson, and Johnston Cos., NC |

## REASONS FOR DECLINE AND THREATS TO CONTINUED EXISTENCE

Although the dwarf wedge mussel still survives at a number of sites, its dramatic decline as well as the small size and extent of most of its remaining populations indicate that it is highly vulnerable to extirpation. Evidence is growing that the decline of Alasmidonta heterodon may be the forerunner of a general decline in the Unionid fauna of the Atlantic slope drainages. For example, recent status surveys indicate that other formerly widespread mussel species, including Alasmidonta varicosa and Lampsilis subviridis, are also declining. This section provides a general discussion of factors that may have contributed to the decline of the dwarf wedge mussel in the various Atlantic slope drainages within its range.

### Impoundment

The damming and channelization of rivers throughout the species' range has resulted in the elimination of much formerly occupied habitat. For example, dams have converted much of the Connecticut River mainstream into a series of impoundments (Master 1986). Immediately upstream from each dam, conditions (including heavy silt deposition and low oxygen levels) are inimical to mussel species such as the dwarf wedge mussel. Immediately downstream from these dams, daily water level and water temperature fluctuations resulting from intermittent power generation and hypolimnetic discharges are also stressful to mussels (Master 1986). Some extreme variations in flow have been observed below dams on the Ashuelot River in New Hampshire. Master (1992, in litt.) indicates that mollusks, including the dwarf wedge mussel, have been stranded by extreme low water on two recent occasions -- once when water discharge was lowered from over 100 CFS to 10 CFS in one day, and once in the summer of 1991 when a dam in Keene was under repair.

Hypolimnial discharges from reservoirs produce cold tailwater conditions that alter the typical fish and benthic assemblages (Fuller 1974). Fuller stressed that these changes associated with inundation adversely affect both juvenile and adult mussels and also alter the native fish fauna, eliminating possible fish hosts for glochidia.

Effects of dams on mussel habitat have not been entirely adverse. Some water supply reservoirs have protected watersheds and, therefore, high quality waters downstream. Populations of dwarf wedge mussels and other mussel species are often especially dense below mill dams and beaver dams (W. Adams, Army Corps of Engineers, pers. comm.)

## Siltation

Siltation, generated by road construction, agriculture, forestry activities, and removal of streambank vegetation is considered to be an important factor in the decline of many freshwater mussel species, including the dwarf wedge mussel.

Sediment loads in rivers and streams during periods of high discharge may be abrasive to mollusk shells. Erosion of the periostracum allows carbonic and other acids to reach and corrode underlying shell layers (Harman 1974). Feeding mollusks respond to heavy siltation by instinctive closure of their valves, since irritation and clogging of the gills and other feeding structures occurs when suspended sediments are siphoned from the water column (Loar et al. 1980). Although mussels possess the ability to secrete mucus to remove silt from body tissues, Ellis (1936) observed dying mussels with excessive quantities of silt in their gills and mantle cavities.

Freshwater mussels are long-lived and sedentary, with limited ability to move to more favorable habitats when silt is deposited over mussel beds. Ellis (1936) found that mussels could not survive in substrate on which silt (0.6-2.5 cm) was allowed to accumulate; death was attributed to interference with feeding and to suffocation. In this same study, Ellis determined that siltation from soil erosion reduced light penetration, altered heat exchange in the water, and allowed organic and toxic substances to be carried to the bottom where they were retained for long periods of time. This resulted in further oxygen depletion and possible absorption of these toxicants by mussels (Harman 1974).

Erosion and siltation resulting from land clearing and grading, and construction of bridges, roads, and other structures may be especially damaging to the dwarf wedge mussel's habitat. For instance, in Massachusetts, a dwarf wedge mussel population was decimated in one small stream when "... the construction of a small bridge resulted in accelerated sedimentation and erosion which buried and killed many of the bivalves" (Smith 1981).

Paradoxically, some bank erosion control measures such as riprapping may also adversely affect the species. A significant portion of one of the extant Connecticut River populations was eliminated in 1987 by burial under rock riprap placed along the shore of a Vermont State park.

## Pollution

The continuing decline and ultimate loss of the dwarf wedge mussel from most of its historical sites can best be explained by agricultural, domestic, and industrial pollution of its aquatic habitat. Mussels are known to be sensitive to potassium (a common pollutant associated with paper mills and irrigation return water), zinc, copper, cadmium, and other elements (Havlik and Marking 1987). Pesticides, chlorine, excessive nutrients, and silt carried by agricultural runoff also present a threat to this species.

No mussels survive in several large, undammed sections of the Connecticut and Delaware River drainages where water pollution has exacted a heavy toll on the benthic fauna. Even where water quality has improved, as in the lower Connecticut River, chemicals trapped in the sediments inhabited by mussels may impede the recovery of sensitive species (Master 1986).

One of the largest known remaining populations of the dwarf wedge mussel occurs where the Ashuelot River meanders through a golf course. This population has undergone a dramatic decline over the past 10-30 years. The continuing decline of the dwarf wedge mussel at this site, particularly downstream of the golf course, may well be attributed to fungicides, herbicides, insecticides, and fertilizers applied to the golf course and to agricultural runoff from abutting corn fields and pastures (Master 1986). It has been suggested that elevated cadmium levels, which have been found in the Ashuelot for short periods of time, may also be a contributing factor in this decline (S. von Oettingen, U.S. Fish and Wildlife Service, pers. comm.). In this case, the elevated cadmium levels appear to result from cleaning the gates on the Surry Mountain Dam, just upstream of the mussel population.

Pollutants may also affect the mussels indirectly; nitrogen and phosphorus input cause organic enrichment and, if extreme, oxygen depletion. Acid rain may mobilize toxic metals and lead to decreased alkalinity which is inimical to most mussels. Increased acidity may have contributed to the recent decline of the dwarf wedge mussel in the Fort River in Massachusetts (D. Smith, University of Massachusetts Museum of Zoology, pers. comm.).

Several studies have investigated the effects of specific chemicals and heavy metals on mussels. Fuller (1974) reviewed the effects of arsenic, cadmium, chlorine, copper, iron, mercury, nitrogen, phosphorus, potassium, and zinc on naiads. Of the heavy metals, zinc was noted as the most toxic, whereas copper, mercury, and silver were less harmful. Goudreau (1988) studied the effects on aquatic mollusks of chlorinated effluent from sewage treatment plants. She found that recovery of mollusk populations may not occur for up to two miles below the discharge point. Imlay (1973) studied the effects of different levels of potassium, an industrial pollutant associated with paper mills, irrigation return water, and petroleum brine. The maximum level of potassium which most mussel species could tolerate was 4 to 10 mg/l.

Salanki and Varanka (1978) found that insecticides have significant effects on mussels. Low concentrations of lindane (.006 g/l), phorate (.008 g/l), and trichlorfon (.02 g/l) caused a 50 percent reduction in siphoning activity, and 1 g/l phorate or 1 ml/l trichlorfon were lethal concentrations.

Recent studies on contaminants have focused primarily on heavy metal effects on mussels. Mathis and Cummings (1973) investigated concentrations of certain heavy metals (copper, nickel, lead, chromium, zinc, cobalt, cadmium) in the sediments, water, mussels, fishes, and tubificids in the Illinois River. Mussels analyzed (Fusconaia flava, Amblema plicata, Quadrula quadrula) contained higher concentrations of all metals than the water and lower concentrations than sediments. Mussels concentrated zinc to a greater degree than fishes or tubificids; all other metals were accumulated to intermediate concentrations. Salanki and Varanka (1976) found that the rhythmic activity (siphoning) of Anodonta cygnea was reduced by 10 percent when exposed to $10^{-5}$ mg/l of copper sulfate, the chemical was lethal at 10 mg/l. Havlik and Marking (1987) indicated that long-term exposure of mussels to concentrations of copper as low as 25 parts per billion (ppb) was lethal. Salanki (1979) investigated the behavior of Anodonta cygnea subjected to certain heavy metals (mercury and cadmium), herbicides, and pesticides (paraquat, lindane, phosphamidon, and phorate). The siphoning period of this species was reduced at some concentrations and the metabolic rate decreased. Manly and George (1977) collected Anodonta anatina from the River Thames and determined the distribution of zinc, nickel, lead, cadmium, copper, and mercury in body tissues. Zinc and copper were most highly concentrated in the mantle, ctenidia (gills), and kidneys; nickel levels were highest in the kidneys; lead in the digestive gland and kidneys; cadmium in the ctenidia, digestive gland, and gonads; and mercury in the kidneys.

Recent studies by Keller and Zam (1991), using juvenile Anodonta imbecilis, have shown that freshwater mussels are quite sensitive to metal pollution. Acute toxicity tests, using juvenile mussels reared in the laboratory, were performed for the following six metals: cadmium, chromium, copper, mercury, nickel, and zinc. Keller and Zam concluded that, overall, mussels were as sensitive to metals as Daphnia, but more sensitive than commonly tested fish and aquatic insects (Table 2).

## Other Factors

Land use changes throughout watersheds supporting the dwarf wedge mussel, especially along riparian corridors, may affect the species in a multitude of ways. The removal of streambank vegetation affects both the physical and biological processes of the waterways. Tree removal alters the amount of organic material and light reaching the stream, impacting both temperature and dissolved oxygen, which are critical factors for both fish and mussels. The floodplain biomass can also help buffer the stream from pollutants. Many of the "threats" identified above could be mitigated most efficiently by protecting the floodplain.

The invasion of the Asian clam (Corbicula fluminea) may be a significant threat to the dwarf wedge mussel. The Asian clam is one of 204 introduced mollusk species in North America (Dundee 1969). It was first discovered in the United States in the Columbia River, Oregon, in 1939. It appeared in California in the 1940's and 1950's, in the Ohio/Mississippi and Gulf of Mexico drainages in the 1960's and 1970's, and in the Atlantic drainage in the 1970's and 1980's (Clarke 1988). Once established in a river, Corbicula fluminea populations achieve high densities and expand rapidly. Densities of 1,000/m² in the James River, Virginia (Diaz 1974), the New River, Virginia (Rodgers et al. 1977), and the Tar River, North Carolina (Clarke 1983), and densities of 10,000/m² in the Altamaha River in Georgia (Gardner et al. 1976) have been reported. Clarke (1988) indicates that Corbicula was first introduced into the James River in 1971 near Hopewell, Virginia, about 15 miles below Richmond, and by 1984 had spread 195 miles upstream (an average of 15 miles per year). Malacologists are now concerned about the possibility of a competitive interaction between Asian clams and native bivalves. Quantitative studies by Cohen et al. (1984) support the hypothesis that an extensive C. fluminea bed in a reach of the Potomac River removed 40-60% of the phytoplankton in this reach. It is not unreasonable to conclude that C. fluminea has the potential to deplete the food supply of unionids. A similar threat may be posed by the recent invasion of the zebra mussel (Dreissena polymorpha). Although not yet known to be present in any of the rivers supporting the dwarf wedge mussel, the zebra mussel is expanding its range rapidly and can be expected to arrive in some of these rivers in the near future.

Mussel die-offs, the cause of which remains unknown, may be a threat to the dwarf wedge mussel. Since 1982 biologists and commercial musselmen have reported extensive mussel die-offs in rivers and lakes throughout the United States. Kills have been documented from the Clinch River (Virginia), Powell River (Virginia, Tennessee), Tennessee River (Tennessee), Grand River (Oklahoma), the Upper Mississippi River (Wisconsin to Iowa), and rivers in Illinois, Kentucky, and Arkansas (USFWS 1987). Lake St. Clair (Michigan), Chatauqua Lake (New York), and Court Oreilles Lac (Wisconsin) have also been affected. The cause is unknown, but numerous species of mussels are involved, including several commercially important and Federally listed species (USFWS 1987). A large mussel die-off has occurred in at least one river supporting the dwarf wedge mussel -- the Tar River in North Carolina. Personnel involved in a survey for the endangered Tar River spinymussel in April 1986 dicovered hundreds of freshly dead and recently dead juvenile and adult mussels of various species at two locations in the Tar River below Rocky Mount, North Carolina (USFWS 1987).

Most of the dwarf wedge mussel populations are small, and all are geographically isolated from each other. This isolation restricts the natural interchange of genetic material between populations. The small population size also reduces the reservoir of genetic variability within populations. It is likely that several of these populations are now below the level required to maintain long-term genetic viability. Furthermore, the small size of many of the dwarf wedge mussel's populations makes the species especially vulnerable to overcollecting.

Table 3 summarizes the status and extent of each extant dwarf wedge mussel population, and indicates the known threats -- current or potential -- to each population. These threats are keyed to the following list.

KEY TO MAJOR THREATS:

1. Point sources of pollution
2. Non-point chemical pollution
3. Sedimentation from forestry operations
4. Sedimentation from agriculture
5. Competition from exotic species
6. Food resource modification via forest overstory removal
7. Discharge rate modifications
8. Population density too low to allow successful reproduction
9. Population fragmentation
10. Significant point source non-compliance
11. Residential, highway, or industrial development
12. Reservoir construction
13. Possible landfill construction near waterbody
14. Toxic spill associated with highway or railroad
15. Headwater channelization and "stream improvement" projects

Table 3. Status of Dwarf Wedge Mussel Populations

| POPULATION | STATUS[1] | REPRODUCING[2] | MAJOR THREATS[3] | APPROXIMATE EXTENT |
|---|---|---|---|---|
| Connecticut River Drainage | | | | |
| Connecticut River (5 sites but one population) -- Sullivan County, NH and Windsor County, VT | fair to good | small numbers (since 1988 very few juveniles found) | 1, 2, 4, 7, 9, 11, 15 | 16-18 miles |
| Ashuelot River -- Cheshire County, NH | fair to poor, declining | unknown (no evidence of reproduction in 1991 and 1992) | 1, 2, 6, 7, 11, 16 | 1.5 miles |
| Muddy Brook -- Hartford County, CT | poor | no | 1, 2, 3, 6, 8, 9, 11 | 1 mile |
| Delaware River Drainage | | | | |
| Neversink River -- Orange County, NY | stable, very good (largest population) | yes | 1, 2, 4, 7, 13 | 5 miles |
| Tuckahoe Creek (Choptank River) Drainage | | | | |
| Norwich Creek -- Queen Anne's and Talbot Counties, MD | poor | no | 2, 4, 8, 11, 17 | 0.5 mile |
| Long Marsh Ditch -- Queen Anne's and Caroline Counties, MD | poor | no | 2, 3, 4, 8, 15 | 3 miles (scattered individuals) |
| Potomac River Drainage | | | | |
| McIntosh Run -- St. Mary's County, MD | fair (small population) | yes | 11 | 3 miles |
| Nanjemoy Creek -- Charles County, MD | fair (small population) | yes | | 1 mile |
| Aquia Creek -- Stafford County, VA | fair to good | unknown | 2, 3, 4, 11 | Approx. 0.5 mile |

1 Based on information provided by those individuals from each state or region most familiar with their respective populations.

2 Evidence of reproduction found, i.e., individuals less than 5 years of age or gravid.

3 See key on preceding page.

Table 3. Status of Dwarf Wedge Mussel Populations (continued)

| POPULATION | STATUS | REPRODUCING | MAJOR THREATS | APPROXIMATE EXTENT |
|---|---|---|---|---|
| **York River Drainage** | | | | |
| South Anna River -- Louisa County, VA | poor | unknown | 3, 4, 8, 11 | Approx. 0.5 mile |
| **Nottoway River Drainage** | | | | |
| Nottoway River -- Nottoway and Lunenberg Counties, VA | poor | unknown | 3, 4, 8, 11, 14 | Approx. 0.5 mile |
| **Tar River Drainage** | | | | |
| Tar River -- Granville County, NC | very good (largest in NC) | yes | 2, 9, 11, 14 | 10-15 miles |
| Cedar Creek -- Franklin County, NC | poor | no | 1, 2, 3, 4, 5, 8, 9, 11, 14 | < 1 mile |
| Crooked Creek -- Franklin County, NC | good | yes | 3, 4, 6, 9 | 1-2 miles |
| Stony Creek -- Nash County, NC | poor | no | 1, 2, 4, 8, 9, 11 | < 1 mile |
| **Neuse River Drainage** | | | | |
| Little River -- Johnston and Wake Counties, NC | fair to good | yes | 2, 3, 4, 5, 6, 9, 11, 12, 14 | 10-20 miles |
| Swift Creek -- Johnston County, NC | good | yes | 1, 2, 3, 4, 5, 6, 7, 9, 11, 14 | > 15 miles |
| Turkey Creek -- Nash and Wilson Counties, NC | good | yes | 1, 2, 3, 4, 5, 6, 9, 11, 12, 14 | 5-6 miles |
| Moccasin Creek -- Nash, Wilson, and Johnston Counties, NC | good | yes | 1, 2, 3, 4, 5, 6, 9, 11, 12, 14 | 6-7 miles |
| Middle Creek -- Johnston County, NC | poor/fair | no | 1, 2, 3, 4, 5, 8, 9, 11, 14 | 1-2 miles |

# PART II: RECOVERY

## RECOVERY GOAL

The goal of this recovery plan is to maintain and restore viable populations of Alasmidonta heterodon to a significant portion of its historical range in order to remove the species from the Federal list of endangered and threatened species. This can be accomplished by (1) protecting and enhancing habitat containing A. heterodon populations, and (2) establishing or expanding populations within rivers and river corridors that historically contained this species.

## RECOVERY OBJECTIVES

Objective 1. Reclassify Alasmidonta heterodon from endangered to threatened status when the likelihood of extinction in the foreseeable future has been eliminated according to the following criterion:

A. Populations of A. heterodon in the mainstem Connecticut River, Ashuelot River, Neversink River, upper Tar River, Little River, Swift Creek (Neuse system), and Turkey Creek, as well as populations in at least six other rivers (or creeks) representative of the species' range, must be shown to be viable[1]. This will require monitoring the occupied river reach over a 10-15 year period during which adequate population numbers, population stability, and evidence of recent recruitment (specimens age five or younger) are demonstrated.

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1 Viable population -- a population containing a sufficient number of reproducing adults to maintain genetic variability and in which annual recruitment is adequate to maintain a stable population.

Objective 2. Remove Alasmidonta heterodon from the Federal list of endangered and threatened species when the following additional criteria have been met:

B. At least ten of the rivers or creeks referred to in criterion A must support a viable population widely enough dispersed within its habitat such that a single adverse event in a given river would be unlikely to result in the total loss of that river's population. Meeting this criterion will require significant expansion of populations in most of the rivers. These rivers/populations should be distributed throughout the current range of the species, with at least two in New England, one in New York, and four to the south of Pennsylvania.

C. All populations referred to in criteria A and B must be protected from present and foreseeable anthropogenic and natural threats that could interfere with their survival.

## RECOVERY TASKS

1. Collect basic data needed for protection of Alasmidonta heterodon populations.

    1.1 Conduct additional population and habitat surveys.

        1.11 Conduct studies of species distribution and status. A considerable effort has been made over the past several years to locate extant dwarf wedge mussel populations. However, because of the wide distribution of this species on the Atlantic slope, some sites remain to be surveyed. These include the Connecticut River in the Thetford and Bloomfield/

Weathersfield areas in Vermont, and sections of the Connecticut River in Massachusetts. Other Connecticut River basin sites in need of surveys include Sugar River, Cold River, and Muscoma River in New Hampshire. In New York and New Jersey, the Upper Wallkill basin, Rondout Creek, the Ten Mile River, and the east and west branches of the Delaware River should be searched. To the south, a number of rivers and streams remain to be surveyed in Virginia, including sections of the Rappahannock, Pamunkey, Mattaponi, Shenandoah, Appomatox, Rivanna, and Pedlar Rivers, and several areas in the James and Chowan River basins. The total extent of each population must also be determined.

1.12 <u>Identify an initial list of potential reintroduction sites</u>. Observations of habitat conditions and species diversity while implementing task 1.11 should provide an initial indication of potential sites for future reintroduction efforts. Fish surveys may be needed later to determine whether host fish are present in sufficient numbers (following completion of Task 4.1).

1.2 <u>Identify essential habitat and key areas in need of protection</u>. Essential habitat can be delineated in the best known rivers/streams, including the Connecticut and Ashuelot, and other well-known sites, with little additional surveying. Delineation of essential habitat in most other rivers and creeks must await more definitive survey data developed during implementation of Task 1.11.

1.3 Identify and determine the significance of specific threats faced by the species such as pesticide contamination, siltation, acidification, and municipal and industrial effluents.

1.31 Review literature and compile existing information on point and non-point pollution sources; map pollution sources. Point sources of pollution and, where feasible, non-point sources should be mapped in each of the watersheds supporting populations of A. heterodon. Where large watersheds are involved, it may be necessary to focus pollution-source mapping in the stream section within 10 to 20 miles of known dwarf wedge mussel population sites.

1.32 Conduct water quality and contaminants sampling at extant population sites and potential reintroduction sites. This sampling program will determine the presence of contaminants at specific sites. Contaminants found at extant population sites could be the subject of further study, as called for in Task 1.33. Presence of significant levels of toxic contaminants at potential transplant sites would eliminate these sites from further consideration.

1.33 Conduct toxicity tests and bioassays of pesticides and other contaminants using surrogate mussel species. Because of the known intensive use of pesticides at the golf course adjacent to the Ashuelot River site, priority should be given to tests of turf/golf course chemicals. EPA has funded some work to develop pesticide toxicity test protocols for freshwater mussels (Johnson et al. 1988), and would be a logical agency to carry out further testing.

2. Preserve A. heterodon populations and occupied habitats.

2.1 Continue to utilize existing legislation and regulations (Federal and State Endangered Species Acts, water quality regulations, stream alteration regulations, etc.) to protect the species and its habitats. Known populations cannot be protected without full enforcement of existing laws and regulations. Land management and regulatory agencies that may have important roles to play in assisting the U.S. Fish and Wildlife Service with the recovery of this species include the U.S. Environmental Protection Agency, Soil Conservation Service, Army Corps of Engineers, Federal Energy Regulatory Commission, State natural resource agencies, and local planning and zoning departments. FERC may have an important role in reviewing low flow releases from hydro-electric facilities on the Connecticut River during relicensing. The assistance of EPA and State water quality control agencies may be particularly important since strict conditioning and enforcement of NPDES permits and non-point discharge permits will be essential for the recovery of this species. In addition, it will be the responsibility of EPA's pesticide labeling program to implement alternatives to avoid pesticide impacts on the dwarf wedge mussel, as required by Section 7 of the Endangered Species Act. Data developed by Task 1.33 should be helpful in this process.

2.2 Determine and implement protection strategies for essential habitat areas identified in Task 1.2.

2.21 Encourage additional legal protection through wild and scenic river designation, establishment of regulations to protect water quality, etc. The U.S. Fish and Wildlife Service will work with the National Park Service and State agencies to consider special status for river and stream reaches providing prime habitat for this mussel. For instance, in Virginia the Water Control Board is now considering designation of specific river/stream reaches for the protection of this endangered species. Additional legislation requiring or providing incentives for riparian buffer strips may be needed.

2.22 Work with landowners, local government officials, and regulatory agency representatives to solicit support for protection of the species and mitigation of impacts to the species and its essential habitats. Owners of riparian lands and local governments and regulatory agency officials will be informed of the species' presence and the importance of protecting its habitats. Zoning agencies will be encouraged to develop regulations or guidelines to protect aquatic habitats. Landowners will also be encouraged to work with the SCS and State agriculture agencies to develop measures to reduce sediment erosion, and runoff of pesticides toxic to mussels.

2.23 Provide long-term protection of essential habitats through acquisition, registry, management agreements, and the establishment of stream buffer zones. Where feasible, acquisition would provide the most effective protection for the species and its habitat, although a lesser degree of protection could be provided by registry and management agreements (including establishment of buffer zones) with private landowners. Management agreements or other mechanisms are needed to control erosion caused by agriculture, timber cutting, and other land-use activities adjacent to stream banks. Where riparian lands remain in private ownership, landowners should be encouraged to install fencing to limit access by farm animals, and to leave agricultural and silvicultural buffer strips along streambanks. A major role in this process could be played by SCS and related State programs through installation of agricultural best management practices and development of buffer zones under the conservation reserve program of the 1990 Food Security Act.

2.24 Develop an interim approach to deal with pesticide usage not currently covered by EPA/FWS endangered species consultations. Special attention must be given to pesticides used in agriculture, silviculture and turf management adjacent to dwarf wedge mussel habitats. Interim measures should be developed to protect freshwater mussels until EPA/FWS consultations and EPA labeling requirements have been completed. This is especially crucial for sites such as the Ashuelot River, where pesticides are thought to be a key factor in the species' decline.

3. Encourage protection of the species through development of an educational awareness program.

3.1 Develop and distribute informational and educational materials such as slide/tape shows and brochures to school children, civic groups, and the general public. Many schools are incorporating endangered species as subjects in their curricula, and they welcome new material. The development and distribution of material focusing on the protection of the dwarf wedge mussel's aquatic environment will enable a broad audience to become familiar with this species and its habitat.

3.2 Develop and distribute informational and educational materials aimed specifically at farmers and other pesticide users. This educational program should be developed under the leadership of EPA with input from State agriculture agencies. This program should include information on alternative methods of pest control or less hazardous pesticides to avoid negative impacts on the dwarf wedge mussel and other endangered species.

3.3 Continue to facilitate the initiation of River Watch Programs in dwarf wedge mussel rivers. River Watch Programs are volunteer programs established to provide information about existing and potential water quality problems. These programs promote a greater awareness of the importance of the aquatic systems being monitored and, in turn, involve citizens and students in the protection of these systems.

4. Conduct life history studies and identify ecological requirements of the species.

4.1 Conduct life history research on the species to include reproduction, food habits, age and growth, mortality factors, etc. Life history research, including population demographics, development of an age/length key, and the determination of host fishes, is currently underway at the VPI&SU. Supplementary studies may be needed to determine host species for dwarf wedge mussel populations in New England and New York.

4.2 Characterize the species' habitat requirements (relevant physical, biological, and chemical components) for all life history stages. Elements that should be considered include: current speed, water depth, substrate grain size, firmness and embeddedness of substrate, substrate stability, water temperature, and water quality factors such as nitrate and potassium levels, dissolved calcium, dissolved oxygen, and pH. The studies underway at VPI&SU will provide this information for southern populations. Additional studies may be needed to characterize features throughout the species' range.

5. Determine the feasibility of re-establishing populations within the species' historical range and, if feasible, introduce the species into such areas. The present range of the dwarf wedge mussel is much smaller than it was historically. There may be areas within the species' former range that could support re-established populations.

5.1 Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations. Several populations are likely below the number needed to maintain long-term viability. These populations may be able to expand naturally if environmental conditions are improved; however, some populations may need to be supplemented to reach a viable size. Populations for this task will be selected based on present population size, habitat quality, and the likelihood of long-term benefits from the effort. At any site selected for augmentation or re-establishment, the host fishes must be present in adequate numbers. Task 1.12 should provide the necessary information; the list of potential reintroduction sites generated in that task will be refined and feasibility will be determined on a site-specific basis.

5.2 Develop a successful technique for re-establishing and augmenting populations. This task is included in several other mussel recovery plans. Techniques developed for those species may work for the dwarf wedge mussel as well.

5.3 Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to select streams that may be suitable for augmentation and reintroduction and can be effectively protected from further threats. Results of Task 1.32 should provide preliminary information on potential sites. Special attention should be focused on sections of the Connecticut River to be included in the Silvio Conte National Wildlife Refuge.

5.4 Where appropriate, reintroduce the species within its historical range and evaluate success.

5.5 Implement the same protective measures for any introduced populations as outlined for established populations in Task 2.

6. Develop and implement a program to monitor population levels and habitat conditions at present and introduced population sites. In light of the dwarf wedge mussel's dramatic decline in the Ashuelot River, this task is critical.

6.1 Develop a monitoring protocol. A monitoring protocol will need to be established for all major A. heterodon sites. At a minimum, this will involve a semi-quantitative approach using mussels observed per unit effort. Quadrat sampling should be used, where appropriate, to provide a more quantitative indication of population trends and age-class distribution.

6.2 Implement monitoring. This task will begin with a baseline quantitative survey (including age-class distribution) and continue with systematic monitoring of all significant populations every two to three years.

7. <u>Periodically assess overall success of the recovery program and recommend appropriate actions (changes in recovery objectives, downlisting, implementing new measures, other studies, etc.)</u>. An informal recovery implementation group composed of representatives of the U.S. Fish and Wildlife Service, State agencies, conservation groups, etc., will be established to assist in implementing this task as well as other aspects of the recovery plan. The recovery plan will be evaluated to determine if it is on track and to recommend future actions. As more is learned about the species, the recovery objectives may need to be modified.

**Table 4. STEPDOWN RECOVERY OUTLINE**

1. Collect basic data needed for protection of *Alasmidonta heterodon* populations.

    1.1 Conduct additional population and habitat surveys for *A. heterodon*.

        1.11 Conduct studies of species' distribution and status.

        1.12 Identify an initial list of potential reintroduction sites.

    1.2 Identify essential habitat and key areas in need of protection.

    1.3 Identify and determine significance of specific threats faced by the species such as pesticide contamination, siltation, acidification, and municipal and industrial effluents.

        1.31 Review literature and compile existing information on point and non-point pollution sources; map pollution sources.

        1.32 Conduct water quality and contaminants sampling at extant population sites and potential reintroduction sites.

        1.33 Conduct toxicity tests and bioassays of pesticide and other contaminants using surrogate mussel species.

2. Preserve *A. heterodon* populations and occupied habitats.

    2.1 Continue to utilize existing legislation and regulations to protect the species and its habitats.

    2.2 Determine and implement protection strategies for areas identified in Task 1.2.

        2.21 Encourage additional legal protection through wild and scenic river designation, and establishment of regulations to protect water quality.

        2.22 Work with landowners, local government officials, and regulatory agency representatives to solicit support for protection of the species and mitigation of impacts to the species and its essential habitats.

        2.23 Provide long-term protection of essential habitats through acquisition, registry, management agreements, and the establishment of stream buffer zones.

        2.24 Develop an interim approach to deal with pesticide usage not currently covered by EPA/FWS endangered species consultations.

3. Encourage protection of the species through development of an educational awareness program.

    3.1 Develop and distribute informational and educational materials, such as slide/tape shows and brochures to school children, civic groups, and the general public.

3.2 Develop and distribute informational and educational materials aimed specifically at farmers and other pesticide users.

3.3 Continue to facilitate the initiation of River Watch Programs in dwarf wedge mussel rivers.

4. Conduct life history studies and identify ecological requirements of the species.

4.1 Conduct life history research on the species to include reproduction, food habits, age and growth, mortality factors, etc.

4.2 Characterize the species' habitat requirements (relevant physical, biological, and chemical components) for all life history stages.

5. Determine the feasibility of re-establishing populations within the species' historical range and, if feasible, introduce the species into such areas.

5.1 Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations.

5.2 Develop a successful technique for re-establishing and augmenting populations.

5.3 Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to determine which of the streams identified in Task 1.12 are suitable for augmentation and reintroductions and most easily protected from further threats.

5.4 Where appropriate, reintroduce the species within its historical range and evaluate success.

5.5 Implement the same protective measures for any introduced populations as outlined for established populations.

6. Develop and implement a program to monitor population levels and habitat conditions of presently established and introduced populations.

6.1 Develop a monitoring protocol.

6.2 Implement monitoring.

7. Periodically assess overall success of the recovery program and recommend appropriate actions (changes in recovery objectives, downlisting, implementing new measures, other studies, etc.).

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# PART III: IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and estimated costs of the recovery program. It is a guide for meeting the objectives discussed in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of the species and protect its habitat.

Key to Implementation Schedule Priorities (column 1)

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Key to Agency Abbreviations (column 6)

COE = Army Corps of Engineers
EPA = Environmental Protection Agency
FERC = Federal Energy Regulatory Commission
NPS = National Park Service
SAGD = State Agriculture Department
RIG = Recovery Implementation Group
SCS = Soil Conservation Service
SNGP = State Nongame and Endangered Species Programs
SNHP = State Natural Heritage Programs
SWCB = State Water Control Boards
TNC = The Nature Conservancy
VPI&SU = Virginia Polytechnic Institute and State University

## IMPLEMENTATION SCHEDULE
## DWARF WEDGE MUSSEL

February 1993

| Priority | Task Description | Task Number | Duration | Responsible Agency: USFWS | Responsible Agency: Other | Cost Estimates, $000: FY1 | FY2 | FY3 | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Conduct additional population and habitat surveys. | 1.1 | 3 years | Region 5 Region 4 | SNHP, SNGP | 30 | 30 | 30 | |
| 1 | Identify essential habitat and key areas in need of protection. | 1.2 | 3 years | Region 5 Region 4 | SNHP, SNGP | 2 | 2 | 2 | |
| 2 | Review literature and compile information on point and non-point pollution; map pollution sources. | 1.31 | 3 years | Region 5 Region 4 | SWCB, SNHP, SNGP, EPA | 20 | 20 | 20 | FWS Contaminants Program will have lead. |
| 2 | Conduct water quality and contaminants sampling. | 1.32 | 3 years | Region 5 Region 4 | | --- | 25 | 25 | + $25K in FY4. |
| 1 | Conduct toxicity tests of pesticides and other contaminants. | 1.33 | 4 years | Region 5 Region 4 | EPA | 30 | 30 | 30 | + $30K in FY4. |
| 1 | Continue to utilize existing legislation and regulations to protect the species. | 2.1 | Continuous | Region 5 Region 4 | SWCB, SNHP, SNGP, COE, EPA, FERC | 10 | 10 | 10 | + $10K/yr for 7 more years. |
| 2 | Encourage designation of wild and scenic rivers, and regulations to protect water quality. | 2.21 | ? | Region 5 Region 4 | SWCB, SNHP, SNGP, NPS | --- | 20 | 30 | + $30K/yr for 3 more years. |
| 1 | Work with landowners and others to solicit support for protection of the species. | 2.22 | Continuous | Region 5 Region 4 | TNC, SNHP, SNGP, SAGD, SCS | 5 | 5 | 5 | + $5K/yr for 7 more years. |
| 1 | Provide long-term protection of essential habitats. | 2.23 | 10 years | Region 5 Region 4 | TNC, SNHP, SNGP, SCS | 15 | 30 | 30 | Amount and cost of land acquisition not yet known. |

Dwarf Wedge Mussel Implementation Schedule (continued), February 1993

| Priority | Task Description | Task Number | Duration | Responsible Agency | | Cost Estimates, $000 | | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | | USFWS | Other | FY1 | FY2 | FY3 | |
| 1 | Develop an interim approach to deal with pesticide usage. | 2.24 | 1 year | Region 5 | EPA | 2 | --- | --- | |
| 3 | Develop an educational program for school children etc. | 3.1 | 1 year | Region 5 | Contract or TNC, SNGP, SNHP | --- | 5 | --- | |
| 3 | Develop an educational program aimed at pesticide users. | 3.2 | 1 year | Region 5<br>Region 4 | SAGD, EPA | --- | --- | 10 | |
| 3 | Facilitate river watch programs. | 3.3 | Continuous | Region 5<br>Region 4 | SNHP, SNGP | --- | 1 | 1 | + $1,000/yr for 7 more years. |
| 1 | Conduct life history studies and identify requirements of the species. | 4. | 2 years | Region 5 | Contract (VPI&SU) | --- | --- | --- | Already funded ($35K) and underway. |
| 3 | Determine feasibility of re-establishing populations within historic range. | 5. | 5 years | Region 5<br>Region 4 | SNHP, SNGP | --- | --- | --- | Implementation to be initiated after FY3 at approx. $15K/yr for 5 years. |
| 1 | Monitor populations levels and habitat conditions. | 6. | Continuous | Region 5<br>Region 4 | SNHP, SNGP | --- | 30 | --- | + $30K/yr in FY5, FY8, and FY10. |
| 3 | Assess overall success of the program and recommend appropriate actions. | 7. | Continuous | Region 5<br>Region 4 | RIG | --- | --- | --- | |

# APPENDIX: LIST OF REVIEWERS

An asterisk (*) indicates those reviewers who submitted comments on the Technical/Agency Draft recovery plan. All comments were reviewed and incorporated as appropriate into this final recovery plan. Comments and U.S. Fish and Wildlife Service responses are on file in the Service's Annapolis Field Office.

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