

## Dwarf Wedgemussel

*Alasmidonta heterodon*

Federal Listing	E
State Listing	E
Global Rank	G4
State Rank	S1
Regional Status	Very High



Photo by Ethan Nedeau

### Justification (Reason for Concern in NH)

Freshwater mussels have declined dramatically in diversity, abundance, and distribution within the last 200 years and are considered the most imperiled fauna in North America (Richter et al. 1997, Lydeard et al. 2004). In the genus *Alasmidonta* 9 of 13 species are threatened, endangered, or extinct (Williams et al. 1992). Historically, the dwarf wedgemussel was found from the Petitcodiac River in New Brunswick, Canada to the Neuse River in North Carolina, and was found in 15 major Atlantic slope river systems (United States Fish and Wildlife Service 1993). It is now extinct in Canada, extirpated in the Neuse River, and present in low densities throughout much of its former range (USFWS 2002). Only 54 populations remain globally; 41 of these are estimated to contain fewer than 50 individuals and of these, 32 have fewer than 10 individuals or are possibly extirpated; 8 or 9 are estimated at between 50 and 1,000 individuals; 4 are estimated at between 10,000 and 100,000 individuals (NH WAP Profile 2005). Recent surveys in the Ashuelot and Connecticut Rivers indicate an apparent decline in dwarf wedgemussels and therefore further reason for concern in New Hampshire (Nedeau 2013). Human impacts including riparian disturbance, pollution, sedimentation, impoundments, artificial flow regimes, and stream fragmentation disrupt mussel life cycles, prevent host fish migration, block gene flow, and prohibit re-colonization, resulting in reduced recruitment rates, decreased population densities and increased probability of local extinctions (Neves et al. 1997, Watters 1999, Strayer et al. 2004).

### Distribution

Historically, the dwarf wedgemussel was found from the Petitcodiac River in New Brunswick, Canada to the Neuse River in North Carolina, and was found in 15 major Atlantic slope river systems (United States Fish and Wildlife Service 1993). It is now extinct in Canada, extirpated in the Neuse River, and present in low densities throughout much of its former range (USFWS 2002).

The Connecticut River drainage in New Hampshire has held the largest remaining dwarf wedgemussel populations and represents the northern limit of the distribution (USFWS 2002). Nevertheless, these populations are extremely patchy, clustered in scattered mussel beds.

### Habitat

Dwarf wedgemussels, *Alasmidonta heterodon*, are Atlantic slope species inhabiting small streams to large rivers with moderate flow. They are found in hydrologically stable areas within a variety of substrates including gravel and coarse sands, fine sands, and clays in depths from a few centimeters to several meters. Mussels are suspension and deposit feeders, subsisting on phytoplankton, bacteria, fine particulate organic matter, and dissolved organic matter (Strayer et al. 2004).

## *Appendix A: Freshwater Mussels*

The dwarf wedgemussel's life cycle is complex. Gametogenesis occurs from May through July (Michaelson and Neves 1995). Spawning occurs in summer when sperm are released into the water column and drawn into the inhalant aperture of the female. Eggs are fertilized, undergo development, and mature in the outermost demibranchs of each gill, which function as marsupia. Well-developed glochidia are present in the Connecticut River mussels as early as late August. Dwarf wedgemussels are long-term brooders, holding glochidia through the winter until release begins in early March and continues through mid-June (Wicklow unpublished data). Glochidia must attach to a host fish in order to complete development and to facilitate dispersal. Host fish include the tessellated darter (*Etheostoma olmstedii*), johnny darter (*Etheostoma nigrum*), mottled sculpin (*Cottus cognatus*), (Michaelson and Neves 1995), slimy sculpin (*Cottus cognatus*), and juveniles and parr of the Atlantic salmon (*Salmo salar*) (B. Wicklow, Saint Anselm College, unpublished data). Atlantic salmon restoration efforts ended during 2012 and therefore are not available as a fish host in NH (Matthew Carpenter, NHFG, personal communication). Due to fish range limitations, the tessellated darter and slimy sculpin are the only host fish available for dwarf wedgemussel glochidia in New Hampshire. The dwarf wedgemussel is the only species of *Alasmidonta* that uses a behavioral display to attract host fish (B. Wicklow, Saint Anselm College, unpublished data).

Dwarf wedgemussels require unpolluted streams or rivers with high dissolved oxygen, moderate current, and stable substrata within refugia (Strayer 1993b, Strayer and Ralley 1993). Stream fragmentation from dams, causeways, impoundments, channelization, and inhospitable stream segments results in spatially and genetically disjunct populations. Perhaps 50% or more of populations have densities that put them in jeopardy of extinction from catastrophes or stochastic demographic, genetic, or environmental events. Though populations range from 100 to 10,000 individuals, densities are low enough (mean = 0.01 to 0.05 per square meter, Strayer et al. 1996) to cause concern. Because mussels are broadcast spawners, populations with low densities may suffer reduced fertilization success (Downing et al. 1993, McLain and Ross 2005), which may strongly limit recruitment. Dwarf wedgemussels occupy small, linear ranges, putting populations at higher risk from impacts of pollution, habitat degradation, and disease (Strayer et al. 1996).

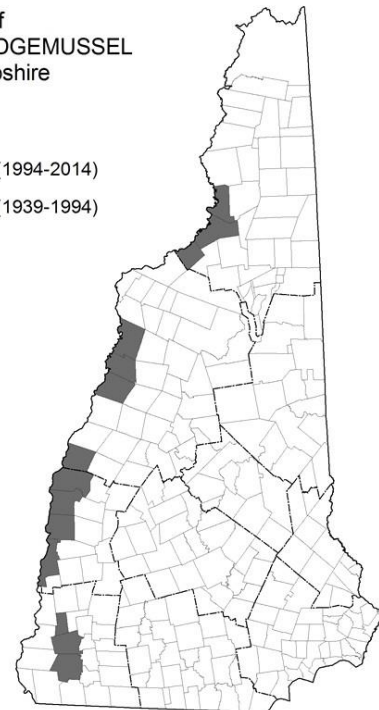
## Appendix A: Freshwater Mussels

### NH Wildlife Action Plan Habitats

- Large Warmwater Rivers
- Warmwater Rivers and Streams

Distribution of  
DWARF WEDGEMUSSEL  
in New Hampshire

■ Current (1994-2014)  
■ Historic (1939-1994)



Distribution Map

### Current Species and Habitat Condition in New Hampshire

During the 2005 NH Wildlife Action Plan assessment for dwarf wedgemussels, it was determined that the north and south populations on the Connecticut River main stem and the Ashuelot population appear viable and that the north Connecticut River population appears to be most robust. Dwarf wedgemussels (*Alasmidonta heterodon*) were rediscovered in the middle portion of the upper Connecticut River in 2005 and a follow-up survey was initiated to determine the range and habitat of this population (Nedeau 2006a). Dwarf wedgemussels were encountered at 12 of 20 locations (14 of 29 for 2005 and 2006 combined) and occupied an 18-mile reach of the river, indicating the presence of a potentially regionally significant population (Nedeau 2006a). During 2006, dwarf wedgemussels were discovered in the Johns River in Dalton NH (Nedeau 2006b, Nedeau 2006c).

Recent surveys in the Ashuelot and Connecticut Rivers indicate an apparent decline in dwarf wedgemussels (Nedeau 2013). In recent surveys conducted as part of the relicensing of three TransCanada hydropower projects, dwarf wedgemussels were undetected at a number of formerly-occupied sites or were found in much lower numbers than in previous surveys (Melissa Grader, personal communication; Biodrawiversity and Louis Berger 2012).

### Population Management Status

A USFWS recovery plan for dwarf wedgemussels exists (USFWS 1993) and a 5-year review was published in 2007 (USFWS 2007). An assessment of the distribution, threats, and conservation actions needed for the dwarf wedgemussel (*Alasmidonta heterodon*) in the middle and northern macrosites

## *Appendix A: Freshwater Mussels*

of the Upper Connecticut River was completed during 2008 (Nedeau 2008b).

Dwarf wedgemussel assessments have been done for a variety of proposed construction projects (e.g., shoreline hardening, dam removal or repair, bridge replacement) in or along the Connecticut River (Nedeau 2003b, Nedeau 2004c, Nedeau 2008) and Ashuelot River (Oakhill Environmental Services. 2009, Nedeau 2012, Nedeau 2014). In some cases, these assessments have resulted in the relocation of dwarf wedgemussels away from construction impacts (United States Fish and Wildlife Service 2003, Nedeau 2003b, Nedeau 2004a, Nedeau 2012).

### **Regulatory Protection (for explanations, see Appendix I)**

- Federal Endangered Species Act
- Endangered Species Conservation Act (RSA 212-A)
- Fill and Dredge in Wetlands - NHDES
- Rivers Management and Protection Program - NHDES
- Comprehensive Shoreland Protection Act - NHDES
- Clean Water Act-Section 404
- Federal Energy Regulatory Commission (FERC)

### **Quality of Habitat**

The north, middle, and south populations in the Connecticut River main stem have been estimated at between 10,000 and 100,000 individuals (Nedeau 2006). These populations have been surveyed qualitatively and are in need of quantitative, statistically valid monitoring. Nevertheless, the Lancaster, New Hampshire, and Lunenburg, Vermont sites have patches of high mussel density, with all age classes present, and a high density of tessellated darter host fish (Gloria and Wicklow 2000, Nedeau 2004). This section of river is free flowing from the Murphy Dam at Lake Francis in Pittsburg to the Moore Dam Reservoir in Littleton and hosts the most vigorous, viable population known. The Ashuelot River Population, also considered among the largest populations, extends from the Surry Mountain Dam to Swanzey and is estimated at 10,000 individuals. Two sites downstream of Surry Mountain Dam were monitored quantitatively. The site closest to the dam showed an age distribution skewed toward older individuals, with little evidence of recruitment, whereas the downstream site showed a wider age distribution, with evidence of recruitment (Nedeau 2004). Recent surveys at long-term monitoring sites below the Surry Dam indicated an apparent decline in dwarf wedgemussels between 2006 and 2013 and bank erosion was detected in these areas (Nedeau 2013).

Many NH tributaries were small, shallow, and rocky, thereby providing little or no habitat for freshwater mussels (Nedeau 2006). Some of the larger rivers (e.g., Mascoma River and Sugar River) were highly altered and degraded, and even if dwarf wedgemussels once inhabited these rivers, current conditions and/or long distances to source populations may prohibit them from becoming reestablished (Nedeau 2006).

### **Habitat Protection Status**

Conservation lands are scattered along the Connecticut and Ashuelot Rivers. The Army Corps of Engineers operates the Surry Mountain Flood control dam and holds land downstream to the East Surry Road Bridge.

## Appendix A: Freshwater Mussels

### Habitat Management Status

Currently there are no management or restoration efforts targeting dwarf wedgemussel habitat in the state. However, the Nature Conservancy, the Monadnock Conservancy, the Society for the Protection of New Hampshire Forests, and the Southwestern Regional Planning Commission have developed a conservation plan for the Ashuelot River Watershed (Zankel 2004). The Connecticut River Joint Commission published a Connecticut River Management Plan for the main stem during 2008. An assessment of the distribution, threats, and conservation actions needed for the Dwarf Wedgemussel (*Alasmidonta heterodon*) in the middle and northern macrosites of the Upper Connecticut River was completed during 2008 (Nedeau 2008b).

### Threats to this Species or Habitat in NH

*Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.*

### Habitat degradation and mortality from dams that alter hydrology upstream and downstream (Threat Rank: High)

The conversion of free-flowing rivers to highly regulated rivers has seriously affected freshwater mussels. Dams, causeways, reservoirs, gravel mining, dredging, channelization, poor land use, and municipal and industrial pollution have resulted in scattered populations. Barriers cause direct mortality, prevent dispersal, block gene flow, prohibit re-colonization of unoccupied but rehabilitated habitat, and prevent host fish migration (Layzer et al. 1993, Parmalee and Hughes 1993, Vaughn and Taylor 1999, Watters 1996).

On the Connecticut River main stem the Moore, Comerford, and Wilder Dams have divided dwarf wedgemussels into 3 populations. Dams on the Ashuelot River are also barriers to dispersal; in a survey in the Ashuelot River dwarf wedgemussels were absent below the Swanzey Dam (Nedeau and Werle 2003), and historic water and habitat degradation was apparent (Nedeau and Werle 2003). Notably, the 1968 construction of a causeway across the Petitcodiac River in New Brunswick Canada transformed a macro-tidal estuary into a shallow freshwater impoundment thereby eliminating diadromous fish including the Atlantic salmon (Locke et al. 2003), a host fish of the dwarf wedgemussel (Wicklow, unpublished data). By the 1980s, the dwarf wedgemussel had disappeared from the Petitcodiac River and in 1999 the Committee on the Status of Endangered Wildlife in Canada declared the dwarf wedgemussel officially extinct (Hanson and Locke 2000). On the Ashuelot River, recent surveys at long-term monitoring sites below the Surry Dam indicated an apparent decline in dwarf wedgemussels between 2006 and 2013 and bank erosion was detected in these areas (Nedeau 2013).

### Habitat impacts (fragmentation) from dams that cause inhospitable stream conditions (Threat Rank: High)

See 'Habitat degradation and mortality from dams that alter hydrology upstream and downstream' and 'Habitat degradation and mortality from increased flooding that destroys mussel beds' threat summaries.

## *Appendix A: Freshwater Mussels*

### **Habitat degradation and mortality from increased flooding that destroys mussel beds (Threat Rank: High)**

Cycles of extreme episodic flooding and dewatering causes direct mortality to mussels. Extreme fluctuations in flow disrupt mussel life cycles by exposing glochidia and juveniles to flood-induced damage, mortality, or displacement to potentially unfavorable habitat downstream (Layzer et al. 1993, Richter et al. 1997). Dewatering exposes mussels to heat, desiccation, and opportunistic predators. Predator foraging efficiency increases with decreasing depth.

In 1999, Wicklow showed a correlation between presence of glochidia in stream drift samples and high flow releases from the Surry Mountain Dam on the Ashuelot River (Wicklow, Saint Anselm College, unpublished data). In addition, over 100 dwarf wedgemussel valves were collected from muskrat middens in a 15 m segment of the Ashuelot River during a period of extremely low water (von Oettingen, USFWS and Wicklow, Saint Anselm College, unpublished).

### **Species impacts from reduction or loss of host fish from degraded habitat and species composition changes (Threat Rank: High)**

Freshwater mussels require specific fish species as hosts for glochidia development. As such, reductions in fish densities or species available to host glochidia for mussels will adversely impact reproduction of dwarf wedgemussel populations.

Tessellated darters are often common in streams occupied by dwarf wedgemussels so the likelihood of this threat needs further evaluation. However, tessellated darters may have limited movement during dwarf wedgemussel glochidia release periods, which may limit the ability of dwarf wedgemussels to expand and recolonize new areas (McLain and Ross 2005).

### **Habitat degradation and mortality from impervious surface run-off that contains excess nutrients, sediment and toxins (Threat Rank: High)**

As development increases and riparian vegetation buffers decrease, the effects of pollution on the biota in the Connecticut River and tributaries will increase. Runoff from municipalities, industrial waste, sewage outfalls, golf courses, poor agricultural and silviculture land contributes to sedimentation, organic pollution, and general water quality degradation (Poole and Downing 2004). Mussels are sensitive to toxins, such as chlorine and ammonia, and to heavy metals introduced through runoff and atmospheric deposition (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are the most sensitive to pollutants, juveniles because they burrow into and feed within the sediments. Thus sediment, particularly when low in pore-water oxygen and high in toxins, may be a major contamination pathway for infaunal juveniles, as well as for adults, who may also deposit feed (Newton et al. 2003, Poole and Downing 2004).

The effect of acute pollution on freshwater mussels is well documented (Neves et al. 1997). Chemical and agricultural waste spills cause direct mussel mortality. The most widely reported sources of pollution are poor agriculture practices (Neves et al. 1997, Poole and Downing 2004); 20 dwarf wedgemussels and hundreds of other mussel species were killed by waste runoff from a small farm in the Connecticut River Watershed (USFWS 2002). The effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are much more sensitive to toxins than are glochidia (Cherry et al. 2005).

## *Appendix A: Freshwater Mussels*

### **Habitat impacts and disturbance from development of riparian habitats that increases stream temperature (Threat Rank: Medium)**

Increased water temperatures and associated reduced oxygen availability were predicted to adversely impact mussel populations.

In the Delaware River, it was determined that in population centers of dwarf wedgemussels, maximum daily water temperature of 26.5°C lasting for more than 7 days is a rare event and consequently this condition should be avoided (Castelli et al. 2012). Thresholds for these stressors need further evaluation.

### **Mortality from recreational activities within a stream that can crush mussels (Threat Rank: Medium)**

Mussels can be crushed when stepped on. Human recreation (swimming, fishing, boat access, vehicle crossing streams) in streams can result in killed mussels and reduced population densities.

There are reports of mussels crushed at high use recreation sites. A sizable number of tidewater mucket mussels, a thin-shelled mussel species, were found dead along lakefront properties in a Massachusetts pond and densities of tidewater muckets were greater in an undisturbed private beach compared to a busy public beach, suggesting trampling of mussels may be impacting those populations (Nedeau 2009).

### **List of Lower Ranking Threats:**

Habitat degradation and mortality from streambank stabilization

Mortality from the introduction and spread of problematic diseases and parasites

Species impacts from introduced or invasive animals that result in competition, predation, and reduced habitat quality

Habitat impacts from introduced or invasive plants

### **Actions to benefit this Species or Habitat in NH**

#### **Restoration and management of streams and rivers, with an emphasis on reducing stream fragmentation and restoring natural flow regimes, reducing pollution and riparian disturbance**

**Primary Threat Addressed:** Habitat degradation and mortality from dams that alter hydrology upstream and downstream

**Specific Threat (IUCN Threat Levels):** Natural system modifications

#### **Objective:**

Restoration of fragmented rivers will allow increased dispersal, increasing the overall potential for persistence of mussels. As mussels are established in new habitat, linear range, re-colonization, and population size increase.

#### **General Strategy:**

Stream fragmentation, and attendant gene flow restrictions, will be reduced by removing barriers

## *Appendix A: Freshwater Mussels*

such as nonfunctional dams, where feasible, by operating dams at “run of the river” flow regimes, and by rehabilitating degraded river reaches. These measures will increase dispersal and recolonization of mussels into rehabilitated river reaches. Mussel populations and habitats must be assessed prior to implementation. Mussels found below a dam removal site or rehabilitated river reach may appear within 3 to 5 years, but 10 to 20 years or more may be necessary to establish a viable population. Riparian protection and restoration will be a long-term effort. As additional water quality and habitat assessment information is collected, efforts can be redirected or expanded. Pollution may render stream reaches uninhabitable. Destruction and transformation of riparian corridors accelerates erosion, bank sloughing, and runoff leading to increased levels of stream toxins, sediment, and higher stream temperatures. Education should be provided to adjacent landowners about practices that contribute pollutants into nearby rivers, streams, and ponds. Protection of riparian corridors through fee simple land acquisition, conservation easements, and private landowner cooperation will reduce pollution runoff and sedimentation. Properly sized culverts will reduce sedimentation and mass mortality of mussel beds. Surveys are needed to choose long-term, quantitative monitoring sites in occupied rivers and streams to assess patterns of disturbance and pollution. Following riparian disturbance mitigation or efforts to decrease pollution, the initial response of mussel populations should be monitored with qualitative surveying. As mussel populations increase in size, quantitative methods will be used (Strayer and Smith 2003). As additional water quality and habitat assessment information is collected, efforts can be redirected or expanded. The number of reproducing subpopulations of mussels will indicate the success of the program.

### **Political Location:**

Carroll County, Cheshire County, Coos County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

## **Minimize threats from invasive species**

**Primary Threat Addressed:** Mortality from the introduction and spread of problematic diseases and parasites

**Specific Threat (IUCN Threat Levels):** Invasive & other problematic species, genes & diseases

### **Objective:**

Minimize threats from invasive species

### **General Strategy:**

From Nedeau (2008b): Coordinate with existing local, state and federal agencies and conservation groups to prevent or reduce the spread of damaging invasive species. Public education and prevention is the only effective means of dealing with aquatic invasive species.

### **Political Location:**

Cheshire County, Coos County, Grafton County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

## **Minimize threats from nonpoint source pollution**

**Primary Threat Addressed:** Habitat degradation and mortality from impervious surface run-off that



## *Appendix A: Freshwater Mussels*

contains excess nutrients, sediment and toxins

**Specific Threat (IUCN Threat Levels):** Pollution

**Objective:**

Minimize threats from nonpoint source pollution

**General Strategy:**

From Nedeau (2008b): Identify major sources of sediment to the upper Connecticut River and its tributaries (especially sources caused or exacerbated by humans) and seek ways to reduce sedimentation.

Identify sources of nutrients and reduce nutrient loading to the upper Connecticut River and its principal tributaries.

Expand water quality monitoring, including increasing the number of sampling stations, the frequency of sampling dates, and the number of parameters that are measured.

Reduce the quantity and improve the quality of storm water entering streams and rivers.

Develop, revise, or enforce BMPs for a variety of activities that affect rivers and their fauna (agriculture, livestock grazing, forestry, construction, golf courses, etc.).

Identify areas where riparian buffers provide inadequate shade, habitat, storm water retention, and nutrient retention. Encourage creative partnerships to address these problems.

Examine proposed development within river corridors in terms of their potential effect on streamside vegetation, bank stability, or storm water runoff. Minimize effects via alternative siting or BMPs.

Develop and enforce shoreline protection laws and regulations.

Use environmentally sound designs and BMPs for transportation projects (roads, railways, bridges, and culverts).

Identify unnaturally unstable banks that threaten critical mussel habitat and consider options for increasing bank stability and reducing sedimentation.

**Political Location:**

Cheshire County, Coos County, Grafton County, Sullivan County

**Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

### **Identify and minimize point source pollution**

**Primary Threat Addressed:** Habitat degradation and mortality from impervious surface run-off that contains excess nutrients, sediment and toxins

**Specific Threat (IUCN Threat Levels):** Pollution

**Objective:**

Identify and minimize point source pollution to river stretches within the current or historic range of dwarf wedgemussels.

**General Strategy:**

From Nedeau (2008b):

- New Hampshire and Vermont should review, modify, or develop (if necessary) effluent water quality standards that protect dwarf wedgemussels. More stringent standards should be applied for entities that discharge directly into actual dwarf wedgemussel habitat or a reasonable distance

## *Appendix A: Freshwater Mussels*

upstream (given the amount and type of discharge, dilution factor, etc.)

- Ensure that wastewater treatment plants achieve high standards by reviewing NPDES permits and supporting funding and use of best available technology for facility upgrades.
- Expand water quality monitoring along the Connecticut River mainstem and its tributaries, including increasing the number of sampling stations, the frequency of sampling dates, and the number of parameters that are measured.
- Identify and characterize risk from concentrated animal feeding operations along the upper Connecticut River and its tributaries.
- Identify and remove or mitigate sources of groundwater and sediment contamination.
- When total maximum daily loads (TMDLs) are developed for impaired water bodies, review plans for potential effects on mussels.

### **Political Location:**

Cheshire County, Coos County, Grafton County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

## **Evaluate conservation actions for stream reaches.**

**Primary Threat Addressed:** Habitat degradation and mortality from increased flooding that destroys mussel beds

**Specific Threat (IUCN Threat Levels):** Climate change & severe weather

### **Objective:**

Evaluate whether species augmentation, translocation, or reintroduction feasible.

### **General Strategy:**

Determine whether species active management techniques are warranted for certain stream reaches. Coordinate with USFWS and regional biologists on priority stream reaches for management and/or restoration. Evaluate husbandry, augmentation, and translocation techniques.

### **Political Location:**

Northeast, Cheshire County, Coos County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

## **Regional Coordination**

### **Objective:**

Participate in regional efforts to conserve the species.

### **General Strategy:**

NHFG will continue to participate in regional discussions and meetings to further the conservation purposes of dwarf wedgemussels.

## *Appendix A: Freshwater Mussels*

### **Political Location:**

Northeast, Cheshire County, Coos County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

### **Direct swimming and fishing access points away from mussel beds**

**Primary Threat Addressed:** Mortality from recreational activities within a stream that can crush mussels

**Specific Threat (IUCN Threat Levels):** Human intrusions & disturbance

### **Objective:**

Reduce mortality of mussels from recreational activities within a stream, river or pond.

### **General Strategy:**

As additional information on mussel occurrences is collected and mapped, managers should consider ways to direct recreational activities away from sensitive mussel beds. This can include strategically placing docks, boat launches, parking areas, beaches, and trails away from documented mussel beds. This will help reduce disturbance to mussels, reduce the potential for direct mortality, and help reduce pollution and sedimentation into mussel habitat. Targeted outreach to fishermen may occur coinciding with this effort, advising that mussels not be cracked open and used for bait. This has been commonly observed during mussel surveys.

### **Political Location:**

Carroll County, Cheshire County, Coos County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed, Lower CT Watershed

### **Review projects that have potential to harm dwarf wedgemussel populations.**

**Primary Threat Addressed:** Habitat degradation and mortality from streambank stabilization

**Specific Threat (IUCN Threat Levels):** Natural system modifications

### **Objective:**

Review projects that have potential to harm dwarf wedgemussel and develop guidance for minimizing impacts.

### **General Strategy:**

Dwarf wedgemussels are listed as endangered in New Hampshire. As such, NHFG will review any proposed activities (residential, commercial, road construction and maintenance, recreation, dam licensing) that has the potential to harm dwarf wedgemussel. NHFG will work with applicants and permitting staff from other state and federal agencies, primarily Department of Environmental Services (Wetlands Bureau) and U.S. Fish and Wildlife Services and U.S. Army Corps of Engineers, to identify avoidance and minimization conditions for permit applicants. NHFG will develop guidelines for consistent and effective review of projects potentially impacting dwarf wedgemussels. Guidelines will consider scenarios where impacts should be avoided and scenarios where impact minimization of mitigation may be appropriate. Pre- and post- construction monitoring of dwarf wedgemussel and

## *Appendix A: Freshwater Mussels*

associated habitat should be considered as a component of project review.

### **Political Location:**

Carroll County, Coos County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed,  
Lower CT Watershed

## **Monitor mussel populations**

### **Objective:**

Conduct surveys to detect mussel populations and collect additional land use data in mussel-occupied habitats to better inform management decisions and create conservation plans for the species.

### **General Strategy:**

General distribution surveys should be focused on historic sites and areas where data is lacking. Data on population structure, age class distribution, sex ratio, recruitment, growth rates, and migration is needed, as well as distribution and abundance data on host fish. Studies may also examine the effects of predation and competition. Research is needed to determine the biological response of mussels to artificial flow regimes. Response variables include displacement of juveniles, interference of spawning success, larval release patterns, and host fish attachment success. Villella et al. (2004) used mark-recapture techniques to estimate survival, recruitment, and population growth of freshwater mussels, and this technique could provide valuable demographic information. Currently, much of the information on the condition of mussel populations and habitat is qualitative. Needed are quantitative studies to assess the physical habitat, including sediment type and hydrology, particularly shear, and water quality. As actions are initiated and populations potentially enlarge, mussel sites should be monitored using quantitative, statistically valid methods. Water quality monitoring stations upstream of mussel populations must be established.

From Nedeau 2008b:

Conduct mussel surveys to document the distribution, health, and habitat of dwarf wedgemussel populations in the Middle Macrosite, Northern Macrosite, and Johns River.

Integrate biological and physical data into fine-scale range maps across multiple spatial scales to fully understand the size and extent of dwarf wedgemussel populations.

Consider establishing aquatic reserves in areas that harbor the “best” dwarf wedgemussel populations. Within these reserves, increase scrutiny of threats, tighten environmental permitting, and encourage creative partnerships to protect and restore habitat.

Investigate potential habitat within tributaries, assess continuity with the mainstem, and seeks ways to improve continuity to encourage dwarf wedgemussels to become established in tributaries. Identify potential reintroduction sites for dwarf wedgemussels based on presence of host fish, habitat suitability, historic records, and threats.

Develop and implement a repeatable, robust, and long-term monitoring program for dwarf wedgemussels in the upper Connecticut River.

In areas where at-risk species occur, monitor water quality more frequently and expand the parameters that are measured, considering the sensitivity of mussels to such parameters.

Review the effects of toxic chemicals and heavy metals on freshwater mussels and assess the risk that such materials pose to mussel populations throughout the watershed.

Conduct a comprehensive geomorphic study of the reach between Wilder Dam and Moore Dam, similar to the work sponsored by the Connecticut River Joint Commissions for the reach upstream of the Moore Reservoir.

## *Appendix A: Freshwater Mussels*

Assess how current water withdrawals (surface water and groundwater) and water resource management policies affect rivers and their fauna.

Assess the effects of altered flow regimes on mussel populations downstream of hydroelectric dams and flood control dams in order to recommend operational changes that might encourage the reestablishment of mussel populations in reaches currently affected by altered hydrology.

### **Political Location:**

Cheshire County, Coos County, Sullivan County

### **Watershed Location:**

Upper CT Watershed, Middle CT Watershed,  
Lower CT Watershed

## **References, Data Sources and Authors**

### **Data Sources**

Information on the life history, habitat requirements, and distribution of dwarf wedgemussels was obtained from the scientific literature, unpublished reports, databases, expert consultation, unpublished research results, and mussel recovery meetings. Threat assessments were completed by Michael Marchand (NHFG), Barry Wicklow (St. Anselms), and Susi von Oettingen (USFWS). Distribution data were obtained from the New Hampshire Natural Heritage Bureau Element Occurrence Database, unpublished reports, scientific literature, and consultation with experts.

### **Data Quality**

Dwarf wedgemussels in the Connecticut River main stem have been surveyed and intermittently monitored since 1988. Early surveys were conducted by canoe and snorkeling in shallow water, usually within 15 meters of the bank. Later SCUBA surveys found a significant number of dwarf wedgemussels in depths greater than 1.5 meters. Most of the early monitoring efforts employed Catch Per Unit Effort (CPUE) methods. While helpful in determining presence or absence, CPUE methods are not statistically valid and therefore cannot be reliably used to determine population changes or trends.

Dwarf wedgemussels in the Connecticut River main stem have been surveyed and intermittently monitored since 1988. Dams and reservoirs divide mussels into 3 spatially and genetically disjunct populations.

Much of the information on the condition of dwarf wedgemussel populations and habitat is qualitative. Needed are quantitative studies to assess the physical habitat, including sediment type and hydrology, particularly shear, and water quality. Also needed are data on dwarf wedgemussel population structure, age class distribution, sex ratio, recruitment, growth rates, and migration, as well as distribution and abundance data on host fish. Studies that examine the effects of predation and competition would be helpful.

### **2015 Authors:**

Michael Marchand, NHFG

### **2005 Authors:**

Barry J. Wicklow, Saint Anselm College

## Appendix A: Freshwater Mussels

### Literature

- Hanson, J.M., A. Locke. 2000. The status of the Dwarf Wedgemussel, *Alasmidonta heterodon*, in Canada. *Canadian Field-Naturalist*. 114:271-278.
- Nedeau, E. 2013. Quantitative survey of Dwarf Wedgemussels (*Alasmidonta heterodon*) in the Ashuelot River downstream from the Surry Mountain Dam. Report prepared for the United States Fish and Wildlife Service, Concord NH and the United States Army Corps of Engineers, Surry Mountain Lake/Otter Brook Lake, Keene, New Hampshire.
- Nedeau, E. 2008b. Distribution, Threats, and Conservation of the Dwarf Wedgemussel (*Alasmidonta heterodon*) in the Middle and Northern Macrosites of the Upper Connecticut River. Report submitted to the New Hampshire Fish and Game Department and Vermont Fish and Wildlife Department.
- Castelli, E., P. Parasiewicz; and J. N. Rogers. 2012. Use of Frequency and Duration Analysis for the Determination of Thermal Habitat Thresholds: Application for the Conservation of *Alasmidonta heterodon* in the Delaware River. *Journal of Environmental Engineering*. August: 886-892.
- Nedeau, E. 2006a. Characterizing the Range and Habitat of Dwarf Wedgemussels in the 'Middle Macrosite' of the Upper Connecticut River. Report submitted to the United States Fish and Wildlife Service, Concord, New Hampshire and the NH Fish and Game Department, Concord NH.
- Biodrawversity and Louis Berger Group, Inc., 2012. Freshwater Mussel Survey in the Connecticut River for the Vernon, Bellows Falls, and Wilder Hydroelectric Facilities. Prepared for TransCanada Hydro Northeast, Inc.
- Cherry, D. S., T. W. Valenti, R. J. Currie, R. J. Never, J. W. Jones, R. A. Mair, and C. M. Kane. 2005. Chlorine toxicity to early life stages of freshwater mussels. Report submitted to U. S. Fish and Wildlife Service, Virginia Field Office, Gloucester, Virginia.
- Downing, J.A. Y. Rochon, M. Perusse, H. Harvey. 1993. Spatial aggregation, body size, and reproductive success in the fresh-water mussel *Elliptio complanta*. *Journal of the North American Benthological Society*. 12:148-156.
- Gabriel, M. 1996. 1996 Monitoring of the dwarf wedgemussel (*Alasmidonta heterodon*) in the Ashuelot and Connecticut Rivers, New Hampshire. Report submitted to The Nature Conservancy, Eastern Regional Office, Boston, Massachusetts. 27 pp.
- Gloria, T. and B. Wicklow. 2001. Unpublished report. A third investigation of the survival of dwarf wedgemussels for the relocation project on the Connecticut River, Route 2 stabilization project, Lunenburg, Vermont. Report to the Vermont Agency of Transportation. Montpelier, Vermont. 24 pp.
- Hardison, B.S., J.B. Layzer. 2000. Relations between complex hydraulics and the localized distribution of mussels in three regulated hydraulics and the localized distribution of mussels in three regulated rivers. *Regulated Rivers: Research and Management*.
- Hastie, L.C., P.J. Boon, M.R. Young, S. Way. 2001. The effects of a major food on an endangered freshwater mussel population. *Biological Conservation*. 98:107-115.
- King, T.L., M.S. Eackles, B. Gjetvaj, W.R. Hoeh. 1999. Intraspecific phylogeography of *Lasmigona subviridis* (Bivalvia: *Unionidae*): Conservation implications of range discontinuity. *Molecular Ecology*. 8 (suppl.1): S65-S78.
- Layzer, J.B., L.M. Madison. 1995. Microhabitat use by freshwater mussels and recommendations for determining their instream flow needs. *Regulated Rivers: Research and Management*. 10:329-345.

## *Appendix A: Freshwater Mussels*

- Layzer, J.B., M.E. Gordon, and R.M. Anderson. 1993. Mussels: The forgotten fauna of regulated rivers. A case study of the Caney Fork River. *Regulated Rivers: Research and Management*. 8:63-71.
- Locke A., J.M. Hanson, G.J. Klassen, S.M. Richardson, C.I. Aube. 2003. The damming of the Petitcodiac River: Species, populations, and habitats lost. *Northeastern Naturalist*. 10:39-54.
- Lydeard C., R.H. Cowie, W.F. Ponder, A.E. Bogan, P. Boucet, S.A. Clark, K.S. Cummings, T.J. Frest, O. Gargominy, C.G. Herbert, R. Hershler, K. E. Perez., B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. The global decline of nonmarine mollusks. 2004. *Bioscience*. 54:321-330.
- McLain D.C., M.R. Ross. 2005. Reproduction based on local patch size of *Alasmidonta heterodon* and dispersal by its darter host in the Mill River, Massachusetts. *Journal of North American Benthological Society*. 24(1):139-147.
- Michaelson, D.L., R.J. Neves. 1995. Life history and habitat of the endangered dwarf wedgemussel *Alasmidonta heterodon* (Bivalvia:Unionidae). *Journal of the North American Benthological Society*. 14:324-340.
- Nedeau, E. 2002. Unpublished report. Dwarf wedgemussel (*Alasmidonta heterodon*) survey near the Fort at no. 4 on the Connecticut River Charlestown, New Hampshire. Unpublished report prepared for the Connecticut River Joint Commission. 12pp.
- Nedeau, E. 2003b. Relocation of Dwarf Wedgemussels Prior to Bank Stabilization at the Fort at No. 4, Charlestown, New Hampshire. Unpublished report prepared for the Connecticut River Joint Commission.
- Nedeau, E. 2004c. Freshwater Mussel Survey in the Connecticut River near Northumberland, New Hampshire. Report submitted to the Town of Northumberland.
- Nedeau, E. 2006c. Dwarf wedgemussel surveys in the Johns River (New Hampshire) and several Vermont Rivers. Report submitted to the United States Fish and Wildlife Service, Concord New Hampshire.
- Nedeau, E. 2008a. Dwarf wedgemussel survey and habitat assessment in the Connecticut River near the Centennial Mill Dam (Dalton, New Hampshire). Report prepared for the Dalton Hydro Company, Dalton, NH
- Nedeau, E. 2009. Effects of docks, beaches, and shoreline development on a regionally important freshwater mussel assemblage in Johns Pond (Mashpee, Massachusetts). Report to Massachusetts Division of Fisheries and Wildlife.
- Nedeau, E. 2014. Fish and mussel communities in the Ashuelot River upstream and downstream from the West Street Dam (Keene, New Hampshire). Report prepared for West Street Hydro, Inc.
- Nedeau, E., 2004a. A fourth investigation of the survival of dwarf wedgemussels (*Alasmidonta heterodon*) for the relocation project on the Connecticut River, Route 2 stabilization project, Lunenburg, Vermont.
- Nedeau, E., 2004b. Quantitative survey of dwarf wedgemussel (*Alasmidonta heterodon*) populations downstream of the Surry Mountain Flood Control Dam on the Ashuelot River. Report submitted to United States Fish and Wildlife Service, Concord, New Hampshire.
- Nedeau, E., and S. Werle. 2003a. Freshwater Mussels of the Ashuelot River. Report submitted to United States Fish and Wildlife Service, Concord, New Hampshire.
- Nedeau, E.J. 2006b. Freshwater mussel survey in New Hampshire's Connecticut River tributaries. Report prepared for New Hampshire Fish and Game, Concord, NH.

## *Appendix A: Freshwater Mussels*

Nedeau, E. 2012. Dwarf Wedgemussel (*Alasmidonta heterodon*) Monitoring in the Ashuelot River

Following Removal of the Homestead Dam. Report prepared for Homestead Woolen Mills, Inc., West Swanzey, New Hampshire.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: A downward spiral of diversity Pages 43-85 in Bens G.W., D.E. Collins, eds. Aquatic Fauna in Peril: The Southeastern Perspective. Decatur (GA): Lenz Design and Communications.

Newton, T.J., J.W. Allran, J.A. O'Donnell, M.R. Bartsch, and W.B. Richardson. 2003. Effects of ammonia on juvenile unionid mussels (*Lampsilis cardium*) in laboratory sediment toxicity tests. Environmental Toxicology and Chemistry. 22:2554-2560.

O'Brien, C. 2001. Unpublished report. Inventory and monitoring of the dwarf wedgemussel (*Alasmidonta heterodon*) in the Connecticut River in New Hampshire and Vermont. Report submitted to the Nongame & Natural Heritage Program, Vermont Fish and Wildlife Department, 103 South Main St., Waterbury, VT. 16 pp.

Oakhill Environmental Services. 2009. Unpublished report. A freshwater mussel survey of the Ashuelot River at the Court Street (Route 12A) Bridge project, Keene NH. Report submitted to the United States Fish and Wildlife Service.

Parmalee, P.W., M.H. Hughes. 1993. Freshwater mussels (Mollusca; Pelecypoda: Unionidae) of Tellico Lake: twelve years after impoundment of the Little Tennessee River. Annals of the Carnegie Museum. 62:81-93.

Poole, K.E., J.A. Downing. 2004. Relationship of declining mussel biodiversity to stream-reach and watershed characteristics in an agricultural landscape. Journal of the North American Benthological Society. 23:114-125.

Richter, B.D., D.P. Braun, J.A. Mendelson, L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology. 11:1081-1093.

Strayer, D. L., D. R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society. Monograph 8, Bethesda, Maryland.

Strayer, D.L. 1999a. Effects of alien species on freshwater mollusks in North America. Journal of the North American Benthological Society. 18:74-98.

Strayer, D.L. 1999b. Use of flow refuges by unionid mussels in rivers. Journal of the North American Benthological Society. 18:468-476.

Strayer, D.L., J. Ralley. 1993. Microhabitat use by an assemblage of stream-dwelling unionaceans (Bivalvia), including two rare species of *Alasmidonta*. Journal of the North American Benthological Society. 12:247-258

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, S.J. Nichols. 2004. Changing Perspectives on Pearly Mussels, North America's Most Imperiled Animals. BioScience. 54: 429-439.

Strayer, D.L., S.J. Sprague, S. Claypool. 1996. A range-wide assessment of populations of *Alasmidonta heterodon*, an endangered freshwater mussel (Bivalvia: *Unionidae*). Journal of the North American Benthological Society. 15:308-317.

United States Fish and Wildlife Service (USFWS). 2007. Dwarf Wedgemussel (*Alasmidonta heterodon*) 5-Year Review: Summary and Evaluation. New England Field Office, Concord, NH.

United States Fish and Wildlife Service. 1993. Dwarf Wedgemussel *Alasmidonta heterodon* Recovery



## *Appendix A: Freshwater Mussels*

Plan. Hadley, Massachusetts.

United States Fish and Wildlife Service. 2003. Biological opinion on the bank stabilization project at the Fort at Number 4 site, Charlestown, NH. Report. Concord Field Office.

Vaughn, C., C.M. Taylor. 1999. Impoundments and the decline of freshwater mussels: a case study of an extinction gradient. *Conservation Biology*. 13:912-920.

Villella, R.F., D.R. Smith, D.P. Lemaire. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. *American Midland Naturalist*. 151:114-133.

Watters G.T. 1996. Small dams as barriers to freshwater mussels (*Bivalvia*, *Unionoida*) and their hosts. *Biological Conservation*. 75:79-85.

Watters, T. 1999. Freshwater mussels and water quality: A review of the effects of hydrologic and in-stream habitat alterations. Proceedings of the First Freshwater Mollusk Conservation Society Symposium, 1999. Ohio Biological Survey, Columbus Ohio. Page 261-274.

Wicklow, B.J. 2000. The correlation of physical factors on larval release patterns of the endangered dwarf wedgemussel, *Alasmidonta heterodon* (Unionidae, Bivalvia) in the Ashuelot River, New Hampshire. Report submitted the Silvio O. Conte National Fish and Wildlife Refuge, Turners Falls, MA., 16pp.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.H. Harris, R.J. Neves. 1992. Conservation Status of Freshwater Mussels of the United States and Canada. *American Fisheries Society*. 18:6-22.