Freshwater Mussels
and the
Connecticut River Watershed

Chapter 4: Protect and Restore

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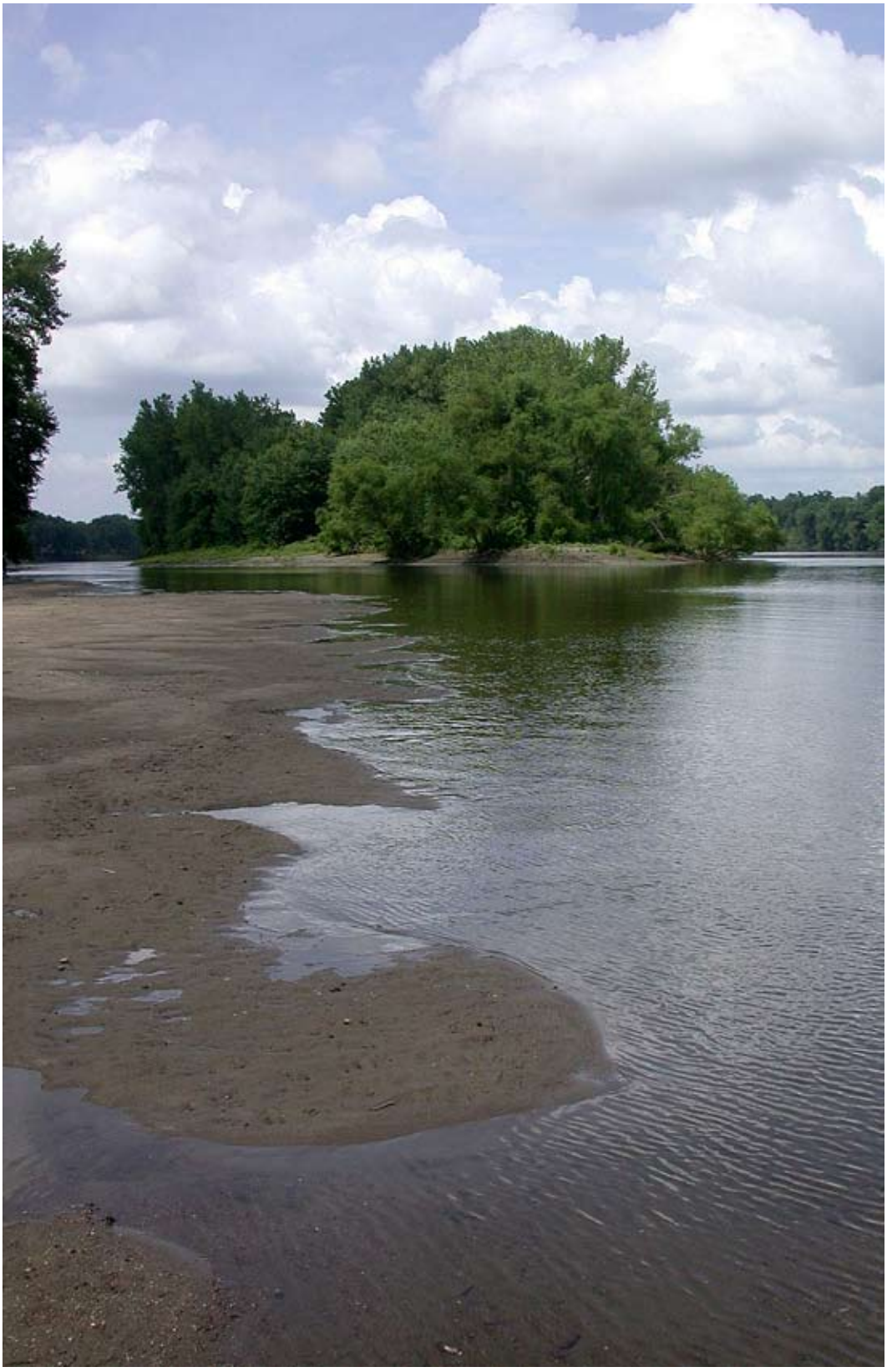

CHAPTER 4

Protect and Restore

Freshwater mussels need clean water, suitable habitat, and healthy fish assemblages. During the past four centuries, humans impaired or destroyed these three basic elements. Protection and restoration began long before the plight of mussels was realized due to public outcry over pollution, loss of fisheries, and acute degradation of rivers. Environmental conditions in the Connecticut River and its tributaries are considered to be better now than they were in recent decades, and there is growing optimism that the health of the river will continue to improve. It seems that the tides have turned. It is important to use this opportunity to protect and restore those species that endured the past four centuries and are poised—perhaps with some encouragement—to reclaim their native waters.

When considering restoration of freshwater mussels, it is essential to identify the factor(s) that caused a species to decline and continues to impede its recovery. This basic information is lacking for many of the most endangered species and populations in the watershed. Chapter 3 covered a broad spectrum of threats, but few of these are universal. It is possible to design protection or restoration strategies based on specific threats. This chapter introduces a variety of possibilities for protecting or restoring freshwater mussels and their habitats.

I. CONSERVATION TARGETS

What are we trying to protect or restore? The question is paramount because it will greatly influence the range of possibilities and the benchmarks used to measure progress and success. Some projects may focus specifically on mussels, whereas others may focus on ecosystem processes as a whole and assume that mussels—along with other groups of species such as aquatic insects, fish, amphibians, birds, and plants—will benefit.

In general, priority for research, protection, and restoration is given to state or federally listed species. These species are in greatest need of conservation. There are problems with relying solely on legal status to prioritize research and protection. The first is that legal status is based on best available information, and in many cases, too little information exists to confidently determine whether a non-listed species should be protected or if a protected species

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Photo: The Connecticut River downstream of the I-91 bridge in Windsor Locks, Connecticut. For a long time, this portion of the river was impaired by pollution from upstream cities and industries, but conditions have improved and this area is now critical habitat for tidewater muckets and yellow lampmussels. Ethan Nedeau

CONSERVATION TARGETS

The list below describes potential targets; "target species" generally refers to state or federally listed species but could also represent common species.

Individual animals: State and federal endangered species laws are written to protect individual animals. Laws state that it is illegal to "harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct" (quoted from the Massachusetts Endangered Species Act, which is similar to language from other states). State or federal agencies protect individual animals by not allowing harvest and by carefully regulating any activity that might directly or indirectly harm individuals. Common species are not legally protected, but should still be respected for their role in ecosystems and as indicators of ecosystem health.

Areas that harbor target species or assemblages: Portions of streams, rivers, and lakes that support target species or otherwise special mussel assemblages are often the focus of protection and restoration projects. Thorough surveys are needed to locate these important areas. Once located, they are protected through a variety of means such as outreach to landowners, conservation easements, land acquisition, or environmental permitting. If sites are degraded, identifying and addressing primary threats may help to restore these sites.

Areas with potential to harbor target species or assemblages: Protecting and restoring potential habitat is an important strategy for encouraging the long-term vitality of species. Humans have fragmented rivers and created conditions that eliminated species and continue to impede their recovery. If target species still exist in a watershed, but in low numbers and in a confined area, there is potential for these species to repopulate former habitat if conditions are favorable. In these situations, it is important to protect or restore areas where they occur and where they could occur.

Source populations of target species: Source populations are larger populations of a species that often have a high population density, even age structure, consistent recruitment, and high adult survival. It is prudent to locate and protect source populations because they are more critical to the persistence of a population than isolated and randomly distributed individuals. Thorough surveys are needed to locate source populations. In many rivers, source populations have not yet been discovered and may not exist. Identifying and protecting source populations is one of the most important challenges to freshwater mussel conservation in the watershed.

Connectivity: Connectivity refers to the connectedness of mussel habitat within a river corridor or watershed. Defining habitat is subjective and depends on the scale, attributes, and species of interest. When applied to freshwater mussel conservation, connectivity usually refers to the spatial arrangement of habitats that support a target species within a river or watershed. Ideally, patches of habitat should be close enough to each other to allow natural dispersal of mussels and their host fish, thereby maintaining genetic exchange between populations. High connectivity between populations decreases a species' vulnerability to random events that cause high mortality (e.g., floods, droughts, or oil spills). For many endangered species, patches of habitat are small and distances between them far exceed a species' dispersal ability. Locating these habitats, understanding connectivity, and protecting or restoring areas in between patches of habitat is an important long-term conservation strategy.

Environmental conditions and processes: Mussels are likely to benefit from any project that protects or restores healthy environmental conditions and natural ecosystem processes. A conservation strategy that focuses on ecological conditions and processes is often referred to as a "coarse filter approach" whereas a strategy that focuses on individual taxa is called a "fine filter approach." Coarse filter strategies protect habitat and conditions for most species but may not effectively target rare and endangered species. A combination of coarse filter and fine filter strategies should effectively conserve freshwater mussels.

should be de-listed. States rely on limited data and expert opinion to assess the status of each species. Most research focuses on the most endangered species, and species that might be imperiled remain poorly studied. For example, the creeper and triangle floater are widely distributed in the watershed but many of the known populations are small and exhibit few signs of recruitment. Massachusetts is the only state in the watershed that protects these two species. Research is needed to assess the status and trends of all species.

Another problem with using legal status to prioritize research and protection is that it may not recognize the rarity or importance of mussels at local or regional scales. Some species are more imperiled in the watershed or in specific tributaries than their legal status may suggest. Two examples are the tidewater mucket and eastern pondmussel that, despite being listed as special concern in Massachusetts, are more rare in the Massachusetts portion of the Connecticut River watershed than the yellow lampmussel (listed as endangered). This is because large populations of the tidewater mucket and eastern pondmussel exist in eastern Massachusetts, but these eastern Massachusetts populations should have no bearing on freshwater mussel conservation on a watershed-level. The dwarf wedgemussel may only be the fourth or fifth rarest species in the watershed, yet it is the only federally endangered mussel in the watershed. This is because the other species have a broader range and healthy populations elsewhere, whereas the dwarf wedgemussel is extremely rare or absent elsewhere in its native range.

Many rivers are nearly devoid of mussels due to natural environmental conditions or a legacy of habitat degradation, but we can still try to protect existing populations. Identifying and protecting exemplary mussel populations or habitats in these waters—regardless of the species—is important for maintaining biodiversity. Ensuring that common species remain common, and preserving the many important functions that freshwater mussels serve in ecosystems, is a worthwhile long-term conservation strategy.

II. CONSERVATION STRATEGIES

There are infinite possibilities for protecting and restoring freshwater mussels and their habitat. Benefits may be direct and measurable, and provide quick results. For example, moving mussels into deeper water while draining an impoundment produces instant and measurable results. Benefits may also be indirect and possibly not realized for decades or centuries. For example, restoring flow regimes or connectivity may improve conditions but it might take decades for mussel populations to show the intended response. Protecting and restoring freshwater mussels should be viewed as a long-term investment in rivers. Quick results are sometimes necessary, but long-term investments will have the most enduring positive influence on rivers and the vitality of mussel populations.

It is beyond the scope of this publication to cover all potential conservation strategies. However, enough strategies are listed to demonstrate the broad range of people who are (or could be) involved with river protection and restoration. Appendix 1 lists key agencies, organizations, web sites, and publications for these strategies. A slightly outdated but relevant overview can be found at NNMCC (1998).

CONSERVATION STRATEGIES

- Identify and address point source pollution
- Minimize threats from nonpoint source pollution and invasive species
- Protect land
- Protect or restore ecosystem processes and connectivity
- Minimize direct mortality and intervene with endangered populations
- Raise awareness and support for freshwater mussel conservation
- Conduct research and monitoring

STRATEGY 1
Identify and address point source pollution

Point sources that discharge pollutants into waterways are regulated by the Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) permit program, which was authorized by the Clean Water Act of 1972. Industrial, municipal, and other facilities that discharge materials into waterways must attain a permit, and the conditions of the permit are designed to protect the quality of the receiving waters. Permits must be renewed every five years. Four types of point sources are prevalent in the Connecticut River watershed: industries, municipal wastewater treatment plants, municipal combined sewer overflows, and thermal discharges from power plants. A fifth, concentrated runoff from animal feeding operations (especially large dairy farms) may also be present.

The NPDES permitting process is an opportunity to protect freshwater mussels. The process will benefit from the following information: (1) presence of state or federally listed mussels in the area of influence, (2) sensitivity of mussels or their host fish to specific water quality parameters, and (3) potential for a point source to harm a species or impede its recovery. Strict effluent standards may be applied in rivers that harbor rare species. The presence of rare species can provide pressure to target point sources that are not in compliance with NPDES permits. Because permits are reissued every five years (though sometimes with considerable delay), regulatory agencies should be informed when rare species are discovered in a waterbody.

Specific Actions

- States should review, modify, or develop (if necessary) effluent water quality standards that protect freshwater mussels; more stringent standards should be applied to waters that support state-listed or federally listed mussels.
- Ensure that wastewater treatment plants achieve high standards by reviewing NPDES permits and supporting funding and use of best available technology for facility upgrades.
- Identify and remediate existing combined sewer overflows (CSOs) to prevent the discharge of untreated domestic wastewater into waterways during storms.
- 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 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.
- Determine the overall effects of thermal discharges on the Connecticut River and tributaries and use this information in the NPDES permitting process.

COMBINED SEWER OVERFLOWS: AN URGENT PRIORITY

Tackling the problem of combined sewer overflows, or CSOs (described on page 39), is perhaps the most important conservation strategy for freshwater mussels in the mainstem Connecticut River downstream of South Hadley, Massachusetts. Combined sewer systems are being phased out but inadequate funding and lack of political will have impeded many municipalities from eliminating existing CSOs. State and federal agencies, municipalities, and a variety of stakeholders are working on the problem (Appendix 1) and some progress has been made in the last 15 years. But billions of gallons of untreated sanitary sewer flow is dumped into the river and its tributaries each year. This is an incomprehensible, intolerable condition in the 21st century. The Connecticut River and the citizens of the watershed deserve better.

Massachusetts

The cities of Holyoke, Chicopee, and Springfield, working with the Pioneer Valley Planning Commission, sampled water quality in the Connecticut River in 2001 and 2002. Data showed that bacteria levels spiked after rainstorms in the lower river, far exceeding state standards, and that CSOs were responsible for fully half of the bacteria found in waterways after those events. These cities have been issued Administrative Orders by the U.S. Environmental Protection Agency for their ongoing infractions. Some progress has been made, as described below. Fixing the remaining CSO discharges will be expensive, but with each passing year inflation and soaring constructions costs make financing even more of a challenge.

- Holyoke had been responsible for 517 MG/yr (million gallons per year) of untreated sewage entering streams and rivers. As of 2007, 61 MG/yr was eliminated and 260 MG/yr was being treated before reaching rivers.
- Chicopee had been responsible for 466 MG/yr of untreated sewage entering streams and rivers. As of 2007, 136 MG/yr was eliminated and 43 MG/yr was being treated before reaching rivers.
- Springfield had been responsible for 632 MG/yr of untreated sewage entering streams and rivers. As of 2007, 83 MG/yr was eliminated.
- According to their plans, the three cities will cut their annual CSO discharges from 1.6 billion gallons to 788 million gallons by 2010. It's a vast improvement, but a figure that's still alarmingly high. It will contribute to unsafe neighborhood environments and impaired water quality in the Connecticut River for years to come.

Connecticut

In the Greater Hartford area, CSOs convey more than one billion gallons per year of untreated sewage to the Connecticut River, causing spikes in bacteria and other pollution as far as 30 miles downstream from their sources. The Metropolitan District Commission (MDC) is making progress toward controlling CSOs. The Clean Water Project was launched in 2006 to implement MDC's Long Term Control Plan mandated by federal and state law (for more information about the Clean Water Project, go to http://thecleanwaterproject.com/). In 2006, citizens voted in favor of an $800 million bond referendum to upgrade sewer systems. That victory was the result of a massive public education campaign by CRWC River Steward Megan Hearne in tandem with the Clean Water Project, its consultants, and the Citizen's Advisory Committee. Bundled into the 2006 legislation was a major new responsibility for the MDC: they'll be adding de-nitrification capacity to wastewater treatment plants which will benefit the Connecticut River and Long Island Sound.

CRWC has also been an important advocate for increasing Connecticut's Clean Water Fund that provides grants and loans to municipalities upgrading their wastewater treatment infrastructure. The Clean Water Fund had a negative balance in 2003 and 2004, but after a lot of hard work and strong advocacy by a large and diverse coalition, the legislature and Governor Rell approved $90 million to be put into the fund for the next two years. It was the largest annual allocation to the Clean Water Fund since its inception in 1986. This funding needs to continue as a standard minimum allocation to make necessary progress on clean water infrastructure in the state.

CRWC River Steward Megan Hearne received an award from the Connecticut Fund for the Environment and Save the Sound honoring her work to improve water quality through public education and advocacy to stop sewage overflows. To learn more about how sewage impacts the health of local rivers and what you can do to protect the rivers and people you love, go to www.ctriver.org.

STRATEGY 2

Minimize threats from nonpoint source pollution and invasive species

Nonpoint source (NPS) pollution can be addressed by a broad range of land treatment and operational procedures known as best management practices, or BMPs. BMPs work in three ways: (1) reduce the source of pollution, (2) reduce the transport of pollution, or (3) remediate or intercept pollutants before they reach and degrade waterbodies. BMPs have been developed for nearly every type of land use or activity that might impact water quality, such as timber harvesting, agriculture, site excavation, building construction, urban development, management of domestic septic systems, marinas, road construction and maintenance, sand and gravel mining, dumps, turf management (e.g., golf courses), and landfills (New Hampshire Department of Environmental Services 2004). Invasive species have been called "biological pollution" and many of the same practices used to curtail NPS pollution can also minimize the effects and spread of invasive species.

Developing, adopting, and enforcing BMPs could fix many severe and pervasive water quality problems in North America. While it may be tempting to seek complex solutions to the complex problem of degraded aquatic ecosystems, the collective effects of many simple solutions, such as those prescribed in BMPs, can protect and restore aquatic ecosystems. Federal agencies, states, municipalities, and landowners have an enormous potential to reduce NPS pollution, restore the quality of water and habitat, and encourage the long-term vitality of freshwater mussels.

Specific Actions

- Identify sources of sediment to rivers and seek ways to reduce sedimentation.
- Identify sources of nutrients and reduce nutrient loading to streams, rivers, and lakes.
- 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.
- 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 sensitive areas and reduce excessive use of road salt and sand; annually remove sand deposits from areas that could contribute to stream sedimentation.
- Identify unnaturally unstable banks that threaten critical mussel habitat and consider options for increasing bank stability and reducing sloughing/sedimentation.
- Coordinate with existing local, state and federal agencies to prevent or reduce the spread of damaging invasive species.

STRATEGY 3
Protect land

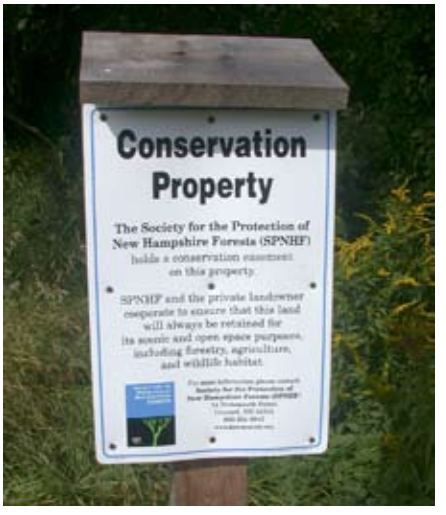
Land protection is a strong tool for protecting and restoring freshwater mussels and their habitat. NPS pollution stems from activities on the landscape, and the hydrologic connections between a river and its landscape strongly contribute to the health of a river. Many of the best mussel assemblages in the Connecticut River watershed occur in areas where much of the upland landscape is protected from development, such as along the Eightmile River, Farmington River, and Salmon River. Many of the disparities between the mussels that should occur in a river (or a location within a river) versus what actually occurs are often related to an unprotected and degraded upland landscape. Strategic land protection is essential to the long-term vitality of freshwater mussels in the watershed.

Freshwater mussels—particularly endangered species—can provide incentive and leverage for land protection along river corridors and even parcels far upland of rivers. Surveys are needed to determine the distribution and demographics of species within a watershed, and this information can then be used to assess threats and identify priorities for land protection or restoration. A project that benefits endangered species might attract partners and funding sources not otherwise available and will certainly present a strong case for protection. Endangered species and the waters and uplands that support them should be explicit priorities in municipal, regional, and statewide land use planning.

Landowners are critical to protecting land for wildlife. Most land along rivers is privately owned and, in many cases, landowners have a strong tradition of using the land and water for their livelihoods. Agencies such as the Natural Resource Conservation Service work with landowners to protect and restore wildlife habitat and these programs contribute enormously to freshwater conservation in the Connecticut River watershed. Increasingly, landowners that own large parcels are confronted with skyrocketing land value and the financial incentive to sell their land for development. One cannot understate the importance of identifying critical privately owned parcels along rivers and working with landowners to conserve these lands (Clay *et al*. 2006).

Specific Actions

- Protect land along river corridors, including uplands, wetlands, groundwater recharge areas, and other areas that influence the quality and quantity of water and habitat in the river.
- Encourage land trusts, watershed associations, conservation organizations, and other nonprofit groups to use mussels and other endangered species in support of land conservation.
- Incorporate endangered species considerations into town, regional, and state land use planning.
- Encourage additional legal protection through Wild and Scenic River designation.



The Society for the Protection of New Hampshire Forests is one of the many groups trying to conserve land through cooperative agreements with landowners. Ethan Nedeau

WORKING WITH LANDOWNERS

The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) offers several voluntary programs aimed at landowners to improve environmental quality on their lands and to increase the stability and sustainability of agricultural operations and the rural communities that depend on them. These programs have enormous potential to protect and restore lands and waters of the Connecticut River watershed for the benefit of humans and wildlife.

Wildlife Habitat Incentives Program (WHIP): WHIP is a voluntary program that encourages creation of high quality habitats that support wildlife of national, state, tribal, and local significance. Through WHIP, the NRCS provides technical and financial assistance to landowners and others to restore and manage upland, wetland, riparian, and aquatic habitats on their lands. There is an increasing emphasis on riparian and aquatic areas.

Wetlands Reserve Program (WRP): WRP is a voluntary program that provides technical and financial assistance to eligible landowners to address wetland, wildlife habitat, soil, water, and related natural resource concerns on private lands. WRP participants benefit by (1) receiving financial and technical assistance in return for restoring, protecting and enhancing wetlands, (2) reducing problems associated with farming potentially difficult areas.

Environmental Quality Incentives Program (EQIP): EQIP assists farmers to promote agricultural production and environmental quality as compatible goals, optimize environmental benefits, and help farmers and ranchers meet federal, state, tribal, and local environmental requirements. EQIP has focused on improving water quality, conserving ground and surface water, reducing soil erosion, improving rangeland, improving riparian and aquatic habitats, improving air quality, and addressing wildlife issues.

Agricultural Management Assistance (AMA): AMA provides cost-share and incentive payments to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation practices into their farming operations. Some of these practices are intended to mitigate the risk of drought. Producers may construct or improve water management structures or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices.

Farm and Ranch Lands Protection Program (FRPP): FRPP is a voluntary program that helps farmers and ranchers keep their land in agriculture. The program provides matching funds to state, tribal, or local governments and non-government organizations with existing farm and ranch land protection programs to purchase conservation easements. Participating landowners agree not to convert their land to non-agricultural uses and to develop and implement a conservation plan for any highly erodible land.

Conservation Security Program (CSP): CSP is a voluntary conservation program that supports stewardship of private agricultural lands by providing payments for maintaining and enhancing natural resources. CSP identifies and rewards those farmers who are meeting the highest standards of conservation and environmental management, while creating powerful incentives for other producers to meet those same standards. CSP helps these farms become even more environmentally sustainable.

Conservation Technical Assistance (CTA): CTA focuses on the sound use and management of soil, water, air, and plant and animal resources. NRCS provides technical assistance that helps clients manage their resources to prevent resource degradation, ensure sustainability, and improve productivity. The planning process is based on the premise that clients will make and implement sound decisions if they understand their resources, potential problems and opportunities, and the effects of their decisions.

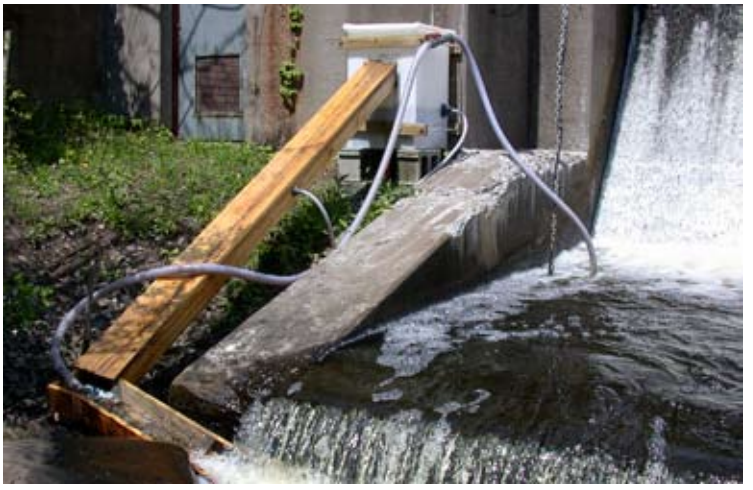
STRATEGY 4
Protect or restore ecosystem processes and connectivity

With new technology, a better understanding of aquatic ecosystems, and a growing commitment to aquatic ecosystem health, there is a tremendous opportunity to protect and restore critical aspects of ecosystems that were altered in the last 400 years. An increasing number of agencies and organizations are involved with projects that seek to restore natural flow regimes, remove stream barriers, restore natural geomorphic processes, and restore connectivity with riparian areas and floodplains (Appendix 1). Such projects often look beyond individual species and focus on the long-term benefits of restored and balanced ecosystems.

Some species—including some species of mussels—can inhabit and even thrive in altered environments. Restoring those environments may come at a cost to the animals living in the altered environment; a good example is the effects of dam removal on mussels that live in the impoundment (Nedeau 2006f). Endangered species deserve special consideration in the design of ecosystem restoration projects that might have negative consequences for those species. Any project that seeks to change processes or conditions from their current state, even if done to restore natural processes or conditions, must weigh benefits and costs.

Specific Actions

- Identify aspects of the natural flow regime most critical to mussels, and where possible, restore those aspects of the natural flow regime.
- Consider removing small dams and other unnatural migration barriers to restore longitudinal connectivity within rivers and their tributaries.
- Provide or enhance fish passage facilities at dams that cannot be removed and that block migratory species from reaching historic habitat.
- Restore the form and function of river channels by giving rivers enough space (i.e., protect a wide enough corridor) and time to restore habitat diversity and achieve equilibrium.
- Protect and restore connectivity with riparian areas and floodplains.
- Incorporate mussel ecology into the dam relicensing process, especially when considering operational changes that might affect mussels or their habitat.



Enthusiasm for river restoration in the Connecticut River watershed is benefitting many migratory fish and the mussels that rely on them. This fish passage structure on the Mount Holyoke College campus in South Hadley, Massachusetts is designed for American eels. It enables juveniles to reach upper portions of watersheds where they will remain for 10-30 years until they are ready to return to the Atlantic Ocean to spawn. Ethan Nedeau

FRESHWATER MUSSELS AND DAM REMOVAL

Freshwater mussels do not like change. They are like the elderly couple down the street that has lived in the same 19th century farmhouse for decades, endured the Great Depression, and clung ever more tightly to their traditions as they watched the world change around them. This quality is incompatible with the rate at which humans alter streams and rivers, making freshwater mussels one of the most endangered groups of species on Earth. River restoration is gaining momentum in our region and resource managers are seizing the opportunity to undo many of the large-scale changes that were wrought decades or centuries ago. But change is change, and mussels deserve special consideration as we return rivers to their natural state and destroy habitat that they have come to rely on.

Dam removal is emerging as one of the greatest tools for restoring rivers. By 2020, 85 percent of all government-owned dams in the United States will have reached the end of their design lifespan and will need to be repaired, rebuilt or removed. Many dams are simply left to the erosive forces of water since there is little funding to actively remove them. Whether dam removal is active, with heavy equipment and expectant onlookers, or passive, by ignoring decrepit dams until they finally collapse, it is important to consider the ecological costs of dam removal and loss of the impoundment.

Studies on the biological response to dam removal have usually focused on fish or macroinvertebrates that are highly mobile or have short life cycles and can rapidly disperse into new habitats. Dams obviously impede fish, and within days of removing a dam, fish can be documented swimming upstream. Mussels are not so adaptable; mussels are much more glacial in their response to habitat modification. Freshwater mussels will be no more happy about dam removal than they were about dam construction, at least not in the short term, because it represents a dramatic change in their habitat that they are ill-equipped to tolerate.

When a dam is breached and the water levels drop in the impoundment, mussels will move slowly toward deeper water, as long as they are in fine substrates (silt, sand and gravel) that they can move through and if there are no obstructions. Mussels will often amass behind boulders or logs that block them from moving farther into the river. Some mussels move into pools that are then cut off from the river and become too hot or evaporate, causing all mussels to perish. Many mussels respond by burrowing into the sediment, a behavior that enables them to survive short-duration dewatering events. But when dewatering is permanent, such as when a dam is removed and an impoundment is drained, these mussels are digging their own graves. In addition, studies have shown that 25 to 50 percent of the mussel population at any given time (a higher percentage during colder months) are buried, particularly juveniles. These mussels cannot respond to dewatering. When an impoundment is drained, perhaps more than 90 percent of all mussels in the dewatered area will die from thermal stress, desiccation and opportunistic predators.

Pizzini Dam in East Haddam, CT, moments before it was removed to allow better connectivity in the Eightmile River. Eastern pearlshell were moved to a safe haven before work began (see page 60).

Megan Hearne/Connecticut River Watershed Council

Some mussel species flourish in lake-like conditions upstream of large dams, or upstream of small run-of-river dams whose impoundments retain flowing water and stream-like conditions but with the added benefit of hydrologic stability. Some species also thrive downstream of dams that provide stable flow and temperature. Water exiting impoundments is often rich in nutrients

(continued)

due to algal production in the impoundment, creating abundant food for filter-feeding animals such as mussels. Mussels are more likely to flourish downstream of small dams and flood control dams. Some dams may also have unintended positive effects on mussel communities by impeding non-native fish that might otherwise overrun a watershed and outcompete native stream fish.

Dam removal has a number of downstream effects, but of greatest consequence for mussels is the release of large amounts of sediment. The volume and movement of sediment depends on the nature of the dam, flow regime of the river, sediment stabilization efforts during the removal process, and precipitation. Sediment can smother mussels, clog their gills, and cause mortality if sedimentation is high and persistent. One of the few published studies on the effect of dam removals on mussels was conducted in Wisconsin, where a small dam on a 5th order stream (average width=10 meters or 33 feet) was removed (Sethi *et al.* 2004). The study documented 95 percent mortality of mussels in the former impoundment due to desiccation and exposure. In the three years after the dam was removed, downstream migration of silt and sand from the former impoundment smothered mussel beds, as silt increased from 16.8 percent to 30.4 percent of the total area sampled, and sand increased from 1.1 percent to 15.9 percent. Mussel densities declined downstream of the dam, and one rare species was altogether eliminated. This study was eye opening for dam removal advocates because it sent an unequivocal message that there are serious consequences of dam removal that need to be addressed before projects begin. The authors of the paper espouse dam removal as a restoration option, but they remind us that we should proceed cautiously to minimize adverse effects.

Should impoundments be viewed as mussel habitat that should be protected, or as artificial habitats that can be taken away because humans created them in the first place? Once created, should artificial habitats earn the same protections as natural habitats? The issue becomes contentious when state or federally endangered species are involved. For these species, there is a strong legal mandate to not "harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct" (Massachusetts Endangered Species Act). What level of mortality is acceptable, especially for endangered or threatened species, as an unfortunate and inevitable consequence of restoring rivers and improving conditions for other species, such as migratory fish? If we are to proceed with dam removal despite the presence and habitat requirements of freshwater mussels, citing long-term ecosystem benefits rather than short-term losses, then what steps can we take to ensure that dam removal does not cause irreparable harm to mussel populations?

A growing number of dam removal projects enlist volunteers to walk the shoreline and move mussels to deeper water, but there is little empirical data on the percent of the population that is moved, habitat suitability in areas where mussels are moved to, survival of relocated mussels, or the recovery of populations within affected areas. Protocols and guidelines are lacking or are difficult to implement for large projects where mussel populations may number in the tens to hundreds of thousands and where environmental conditions make surveying difficult. Due to a lack of funding or expertise, long-term monitoring is rarely conducted.

Aside from relocating mussels, two other options to minimize mortality are to conduct the drawdown very slowly (months to years) to allow mussels to adjust to changing water levels, and to stabilize sediments within the impoundment. Neither of these options were implemented in the Wisconsin study described above, and the result can be considered a worst-case scenario for the effect of dam removal on mussels. More case studies and success stories are needed to gain confidence that dam removals can be done without catastrophic effects on mussels.

It is important to be aware of potential positive and negative effects of dams and dam removals on freshwater mussels and all other native species. General statements about potential effects often impede critical review and creative solutions. Each dam is different, and the ecological context of each dam should be carefully considered and communicated to all stakeholders. Standardized monitoring will improve the ability to assess the long-term benefits of restoration, develop more effective restoration techniques, and communicate results to stakeholders and the public. Freshwater mussels are just one of several groups of animals that could be measured when dams are removed (Collins *et al.* 2007). However, mussels will challenge our resolve to restore rivers in the most environmentally friendly way because they are likely to suffer in the short-term, and the long-term effects may never be documented unless we plan carefully and commit to long-term monitoring.

Text adapted from Nedeau (2006f)

STRATEGY 5
Minimize direct mortality and intervene with endangered populations

State and federally listed species are legally protected from any harm that results from a human activity, whether intentional (e.g., harvest) or unintentional (e.g., habitat alteration, mortality associated with construction projects, etc.). Harvest or possession of state or federally listed species is a punishable crime. Effects of construction projects or any project that alters habitat are regulated through an environmental review process; permit conditions usually specify protective measures such as BMPs, limits on the amount of habitat that can be altered, and the relocation of protected species out of an area before a project commences. Bridge and road repairs, bank stabilization, dam removal or repair, and dredging are projects that usually involve relocating state or federally listed species to a safe area of the river. Relocation follows standard protocols and often includes follow-up monitoring to ensure that mussels can survive being moved and adapt to new surroundings.

Direct intervention is sometimes considered with the most endangered populations. If, through careful evaluation and expert opinion, a population has declined to the point where natural reproduction is unlikely to occur, then state agencies or the USFWS may consider direct intervention. Options include moving animals closer together to increase breeding success, caging host fish within high-density populations to increase spawning success, taking animals into captivity to propagate them in a controlled environment, and reintroducing animals into historic habitat. These efforts can help maintain populations while the underlying causes for their rarity or inability to reproduce are investigated. Direct intervention is a last resort; resource managers should first focus on restoring habitat conditions and encouraging mussel populations to recover on their own.

Specific Actions

- State agencies and the USFWS should continue to authorize relocation of mussels prior to projects that may result in direct mortality, such as bridge repair and construction, bank stabilization, dam repair and removal, and dredging.
- State agencies and the USFWS should consider captive propagation plans for state and federally listed species.
- State agencies and the USFWS may evaluate the feasibility of reintroducing mussels into former habitat using animals collected from nearby source populations or animals raised in captivity.

PROTECTING MUSSELS DURING DAM REMOVALS

Connecticut River Watershed Council (CRWC) is a leader in restoring migratory fish habitat and has been completing dam removals and fishways for more than ten years. In two recent dam removals, special care was given to freshwater mussel populations. Prior to the Pizzini dam removal (East Haddam, CT) in 2005, the Connecticut Department of Environmental Protection and CRWC collected, marked, and moved 66 eastern pearlshell to an upstream preserve to avoid potential impact from sediment release. Prior to the Raymond Brook dam removal (Hebron, CT) in 2007, the author (with support of CRWC and The Nature Conservancy) moved 1,869 mussels from the impoundment to a safe haven in the nearby Jeremy River. CRWC will continue to accommodate freshwater mussel needs in all future river restoration work.

STRATEGY 6
Raise awareness and support for mussel conservation

The primary goal of this publication is to raise awareness and support for mussel conservation. There is already strong public and legislative support for conservation in the Connecticut River watershed; mussels are yet another compelling reason why the Connecticut River is special. Mussel conservation closely aligns with widely held goals for the Connecticut River watershed, such as fishable and swimmable waters, scenic beauty, regional identity, and economic vitality.

Specific Actions

- Seek public and legislative support for freshwater mussel conservation.
- Identify funding sources for protection, restoration, and research.
- Develop and distribute educational materials to the public about freshwater mussels and other aquatic biodiversity in the watershed.
- Educate the public about the consequences of land-based activities for aquatic ecosystems and endangered species.
- Develop a coordinated freshwater mussel conservation strategy for the entire Connecticut River watershed and distribute it to target audiences.

Bank of the Connecticut River in Charlestown, New Hampshire, along the grounds of the historic Fort at No. 4. In 2003, a badly eroding riverbank was stabilized with rock and native plantings to protect archaeological remains and to stem further erosion. With the support of the Connecticut River Joint Commissions, biologists surveyed and moved the federally endangered dwarf wedgemussel out of the area before construction began to minimize mortality. The event attracted public interest and provided a unique opportunity for public education. Ethan Nedeau

STRATEGY 7
Conduct research and monitoring

The "toolbox" for protecting and restoring mussels is not full. Resource managers lack critical information on topics such as basic biology of endangered species, distribution, population trends, sensitivity to environmental stressors, and effects of various activities on mussels. There is a dire need for research that focuses on endangered species, especially the dwarf wedgemussel, brook floater, and yellow lampmussel. Although many surveys have been completed in the last 30 years, more than 90 percent of river miles in the watershed remain unsurveyed and many endangered populations await discovery and protection. Each year, projects are permitted despite an incomplete understanding of their ecological effects. Even well intended restoration projects, such as dam removals, can have severe effects on endangered mussel populations.

State and federal agencies, colleges and universities, non-government organizations, and environmental consultants should prioritize research needs and seek funding. Citizens can contribute by learning to identify species and submitting observations to the appropriate state agency (Appendix 2). Citizens can also monitor populations of common species, monitor water quality, document habitat, identify threats, and contribute to watershed assessments.

Specific Actions

- Conduct basic mussel surveys to document the distribution and health of populations.
- Locate source populations within rivers.
- Conduct life history, demographic, and habitat studies of at-risk species and populations.
- Identify potential reintroduction sites for the most endangered species based on presence of host fish, habitat suitability, historic records, and prevalence of threats.
- When appropriate, reintroduce species into former habitat and assess each project's success.
- Develop protocols for monitoring mussel populations.
- Establish long-term population monitoring sites throughout the watershed.
- Research the effect of dam removals on mussels and their host fish that occur within impoundments and in downstream areas.
- Research the effect of lake and reservoir drawdowns on mussel communities.
- Review and research the sensitivity of mussels to various water quality parameters.
- 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.
- Analyze the status, threats, and possible conservation strategies for each species at various spatial scales (e.g., sub-river, river, region, watershed, town, or state). Incorporate this information into a watershed-wide conservation strategy.
- Assess how current water withdrawals (surface water and groundwater) and water resource management policies affect rivers and their fauna. Revise policies and laws based on anticipated future demand for water.
- Assess the effects of altered flow regimes on mussel populations downstream of hydroelectric dams and flood control dams.
- Assess the effects of altered thermal regimes on mussels or their host fish downstream of industries that discharge heated effluent.

III. SUMMARY

- Many options exist for contributing to freshwater mussel conservation, but before starting it is important to define a conservation target (or targets) and relevant threats, and to consider benchmarks for measuring progress and success.
- Examples of conservation targets include individual animals, actual habitat for target species, potential habitat for target species, source populations of target species, connectivity between habitats or source populations, and environmental conditions and processes.
- While there is a great need to protect and restore endangered species, freshwater mussel conservation should be considered even in rivers without endangered species. Ensuring that common species remain common, and preserving the many important functions that mussels serve in ecosystems, is a worthwhile conservation strategy.
- It is important to become familiar with the agencies, organizations, and other entities who are typically involved with freshwater mussels and river conservation and who may provide permission, oversight, technical guidance, and support for projects. Many of these are listed in Appendix 1.
- The general conservation strategies and specific actions outlined in this chapter are examples of things that are currently being done in the watershed or could be done if a broader range of people were involved in river conservation. There are infinite possibilities for people to protect rivers and native biodiversity, and it is important to highlight some of these and to demonstrate how individual efforts fit into the collective efforts to make the Connecticut River watershed more fishable, swimmable, livable, and a national model for environmental stewardship.