RESTORING OUR PAST WITH MUSSEL POWER IN THE FRESHWATER PORTION OF THE DELAWARE ESTUARY WATERSHED

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ABSTRACT: Freshwater mussels are the most imperiled animal group in the Delaware Estuary's watershed, with all but a few of our native species in danger of being extirpated. In 2007 the Freshwater Mussel Recovery Program was launched to restore mussel population biomass, diversity, and resilience through a mix of conservation, reintroduction, and range expansion. In Southeastern Pennsylvania, the program is targeting streams found suitable for reintroduction by following the health of caged mussels (Gray, Poster). Reintroduction will be achieved by seeding streams with hatchery reared juvenile mussels and transplanting reproductively active adults. Broodstock of the eastern elliptio mussel (*Elliptio complanata*), along with prospective fish hosts for their larvae, were collected from two study sites and taken to Cheyney University. In the lab, approximately 165 of 508 pumpkinseed (*Lempomis gibbosus*), white suckers (*Catostomus commersonii*), and banded killfish (*Fundulus diaphanous* & *F. heteroclitus*) were successfully infested in 2008. While none of the glochidia metamorphosed, lessons learned in the hatchery tests, including a preference for American eels as hosts, should lead to successful production of >10,000 seed mussels in 2009. By reintroducing freshwater mussels into receptive streams where populations have been lost, we will fill open niches, boost population resilience, and enhance multiple ecosystem services.

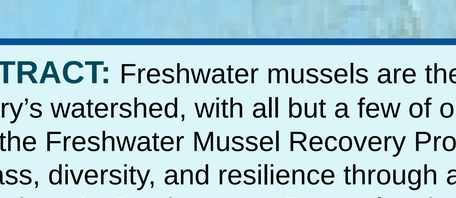

Figure A. *Elliptio complanata*.

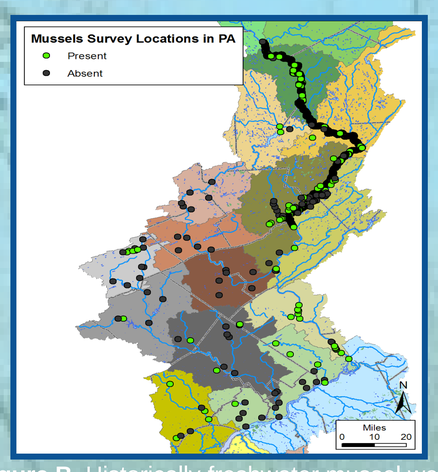

Figure B. Historically freshwater mussel were reported in most stream and river surveys, current data show the decline in occurrence.

Figure C. Two *Elliptio complanata* create a trail while moving to follow the receding waterline during a dam removal project.

		State Conservation Status		
Scientific Name	Common Name	DE	NJ	PA
ALASMIDONTA HETERODON	DWARF WEDGEMUSSEL	Endangered	Endangered	Critically Imperiled
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Extirpated ?	Threatened	Vulnerable
ALASMIDONTA VARICOSA	BROOK FLOATER	Endangered	Endangered	Imperiled
ANODONTA IMPLICATA	ALEWIFE FLOATER	Extremely Rare	no data	Extirpated ?
ELLIPTIO COMPLANATA	EASTERN ELLIPTIO	common	common	Secure
LAMPSILIS CARIOSA	YELLOW LAMPMUSSEL	Endangered	Threatened	Vulnerable
LAMPSILIS RADIATA	EASTERN LAMPMUSSEL	Endangered	Threatened	Imperiled
LASMIGONA SUBVIRIDIS	GREEN FLOATER	no data	Endangered	Imperiled
LEPTODEA OCHRACEA	TIDEWATER MUCKET	Endangered	Threatened	Extirpated ?
LIGUMIA NASUTA	EASTERN PONDMUSSEL	Endangered	Threatened	Critically Imperiled
MARGARITIFERA MARGARITIFERA	EASTERN PEARLSHELL	no data	no data	Imperiled
PYGANODON CATARACTA	EASTERN FLOATER	no data	no data	Vulnerable
STROPHITUS UNDULATUS	SQUAWFOOT	Extremely Rare	Species of Concern	Apparently Secure

Figure D. The status of most species of freshwater mussels is of conservation concern across the 3 states in the Delaware Estuary.

WHY RESOTRE MUSSELS? Bivalves have long been regarded worldwide as some of the best bio-indicators of environmental conditions, particularly of long-term status and trends. But we are only now beginning to appreciate the role that they play in maintaining ecosystem health. Where abundant, they are referred to as "ecosystem engineers" because they modify habitat and can dominate functional processes by large scale filter-feeding at the base of the food chain. Bivalves filter suspended solids, phytoplankton and perhaps even pathogens resulting in water quality improvement. Mass filtration leads to an increase in light penetration through the water column, improving growing conditions for bottom plants and algae. Their bio-deposits enrich sediments which benefit other fauna and flora. They also provide structural complexity and stabilize bottom sediments, providing habitat for other organisms.

Generally, the presence, diversity, and population health of bivalve shellfish throughout watersheds is directly indicative of the overall health of the system. Therefore, they represent an excellent "common denominator" target on which to base ecosystem restoration because to improve mussel populations, we will also need to improve water quality, riparian coverage and fish passage. And since mussels themselves boost water and habitat quality, mussel-based restoration will provide diverse positive feedbacks to ecosystem restoration, linking non-tidal and tidal areas.

Figure E: Revitalizing populations of freshwater mussels in rivers might improve water quality. Benefitting estuarine species downriver.

Figure F: Preferred habitat of *Elliptio complanatar* mussels in Pennsylvania

THE PROJECT: The Freshwater Mussel Restoration Program (FMRP) is a collaborative endeavor to rebuild the overall population vigor of native species throughout the Delaware Estuary and its Watershed. The project takes a holistic approach and includes biodiversity conservation, range expansion, and enhancing overall population abundance of a blend of species that fill different ecological niches combines. Current partners are PDE, The Academy of Natural Sciences, Cheyney University, and U.S. Fish and Wildlife Service. Initial efforts are aimed at expanding the population and range of common species to boost resilience and develop methods to be later used on threatened and endangered species of the area.

PROGRESS & NEXT STEPS: Studies were conducted in 2007 and 2008 to determine which streams in the Brandywine/Christina Creek watershed can support the reintroduction of mussels (see Gray, poster). Once candidate streams are selected for restoration, we will reintroduce reproductively active adults and/or hatchery raised juvenile mussels. Reproductively active adults will be taken from remaining populations within the watershed, and juveniles will be propagated at an aquaculture facility at Cheyney University of Pennsylvania. In 2008 experiments were conducted to determine suitable fish hosts for the most common mussel in the area *Elliptio complanata (EC). Fish hosts* tested included; pumpkinseed (*Lempomis gibbosus*), white suckers (*Catostomus commersonii*), and banded killifish (*Fundulus diaphanous* & *F. heteroclitus*). Pumpkinseed were more easily infested than white suckers and banded killifish. Of these approximately 165 out of 508 were successfully infested with mussel glochidia (larvae). Though these fish species were infested they did not successfully transform, therefore these are likely not good hosts for EC from the lower Delaware. Based on separate studies using hosts from the Susquehanna River, we anticipate the production of juvenile mussels by using American eels (*Anguilla rostrata)* as fish host during 2009. Our initial goal is to produce and plant 10,000 juvenile *EC* in several streams in the Christina watershed and adjacent streams such as Chester Creek. Seed will be monitored to gauge growth and project success. Each batch of 10,000 seed is projected to filter 0.8 million liters of water in their first year in-stream, totaling 1.92 billion liters of water over their first 30 years, not including water filtered by any progeny.

Status. Freshwater mussels are bivalve mollusks that live in lakes, rivers, streams and tidal freshwater areas. They once thrived across the Delaware Estuary watershed, but only one of the native 12+ species can be readily found in southeast Pennsylvania.Although this species (EC) can still be found, its distribution and reproduction appear greatly reduced. The severe local impairment is symptomatic of the rest of the United States – more than 75% of our native 300+ species are severely impaired. Freshwater mussels are regarded as the most imperiled of all plant and animal taxa in North America.

Ecology. These mussels can play a critical role in the function and structure of their ecosystem. By feeding at the base of the food chain on a rich mixture of suspended matter, they can grow to large sizes and reach tremendous population biomass much like marine species (oysters, clams and mussels). As filter-feeders, they improve water quality and clarity by removing particles and contaminants. They enrich sediments for fauna and flora. And like their marine counterparts, they are ecosystem engineers, providing greater stabilization and complexity of bottom habitats.

Life History. Freshwater mussels are much longer-lived than marine species, up to 80-100 years, and they don't reproduce until age 8+ or more. These mussels require fish as hosts for their larvae, a tactic that allows them to maintain themselves upstream and disperse across the watershed without the adults having to move themselves. Often a mussel species depend on specific fish species as hosts. When fish hosts become impaired or their movements are impeded by dams, mussels can not complete their life cycle.

Impairment. As filter feeders that have a complex life cycle, freshwater mussels are susceptible to shifts in water and habitat quality. After a population has been degraded, they are not capable of rapidly recovering, even after their habitat is restored, because of their slow growth. Because of this mussels are excellent bio-indicators of long term conditions.

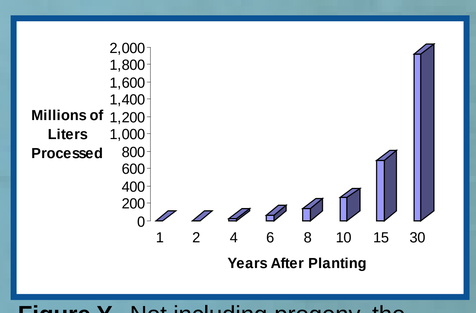

Figure Y. Not including progeny, the projected potential water processing over the first 30 years by 10,000 planted mussel seed.

We would like to thank the sponsors of this project for their generous support:

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