

Chapter 4.

Freshwater Mussel Community Descriptions



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Introduction to Freshwater Mussel Communities and Mussel Conservation

Freshwater mussel populations are rapidly declining in North America. In the past 100 years, more than 10% of our continent's mussels have become extinct. For mussel species in the United States, nearly 25% have a status of federally endangered or threatened and 75% are listed as endangered, threatened or special concern by individual states (Nedeau et al. 2005).

Mussel communities are generally indicative of habitat types that are rare in Pennsylvania and becoming increasingly rarer. Mussel species are generally found in watersheds at least 75 km² in medium or large streams and rivers. Mussel richness generally increases with increasing watershed size (Strayer and Jirka 1997), so the largest rivers in Pennsylvania, like the Ohio, Allegheny, Susquehanna and Delaware Rivers generally have the most diverse mussel communities. Large streams and rivers of good quality without major habitat alterations are few.

Water quality threats to mussels include toxic and organic compounds released from industrial and municipal point sources. In recent decades, regulations of gross point source discharges have sufficiently improved water quality and allowed mussels to recolonize some streams and rivers (Strayer and Jirka 1997). Non-point source pollution contributed from large areas, like farms and cities, can also threaten water quality for mussels. Management of agricultural land can vary greatly, as can its influence on streams. In many instances, mussels can appear to be undisturbed by agricultural pollution, relative to other aquatic organisms. However, excessive sedimentation and habitat alteration from agricultural practices can be detrimental to mussel communities. Runoff from urban and suburban developments appears to be more damaging to mussels, most likely due to combined effects of altered hydrology, warmer water temperatures and excess sediment and nutrient levels (Strayer and Jirka 1997).

Dams generally negatively influence mussel communities via hydrologic alteration, disrupted connectivity, habitat modification, and changes in thermal properties of the water. Dams also restrict the movement of fish hosts that transport the larval, parasitic mussel glochidia; this

consequently restricts the dispersal ability and reproductive success of mussels. Alterations of the stream channel above and below dams usually alter available habitat for mussel communities. Water quality and temperature profiles are also largely distorted in a reservoir. Impoundment management plans that simulate natural riverine processes are vital for maintaining healthy mussel communities.

Invasive mussel species like the zebra mussel (*Dreissena polymorpha*) and the Asian clam (*Corbicula fluminea*) may be damaging to populations of native mollusks. Zebra mussels damage native mussels by attaching to individuals in large numbers and eventually killing them (Strayer and Jirka 1997). Other non-native mussels may alter food resources and habitat (Hakenkamp et al. 2001) and may also deteriorate endemic mussel populations.

Mussel habitat requirements are not well known. Protecting habitats where mussels are currently occurring is a first step to ensuring the long-term persistence of mussel populations. Protection from major channel alteration by bridges, dams and dredging is important for maintaining habitat. Preventing excessive amounts of sediments, nutrients, and toxins from entering streams and rivers will maintain good water quality to support healthy mussel communities. In urban watersheds, reducing the effects of runoff through zoning and stormwater detention ordinances will reduce the amount and toxicity of runoff introduced to streams. These actions will help to protect the sensitive habitats that support mussel populations.

Targeting biological communities is a proactive approach to biodiversity conservation because it protects whole assemblages of species before any single species declines into imperilment. In biological community protection, all species are protected: the common, the rare and those not yet known (Higgins et al. 1998). Pennsylvania is fortunate to harbor many inland freshwater mussel taxa that are globally rare. By conserving the processes that support these species, we are better able to conserve the species. We believe that it is important to protect each mussel community type and the habitats that contain rich mussel populations to effectively protect biodiversity.

Ohio – Great Lakes Basins Mussels: Fatmucket Mussel Community

Community Indicators: fatmucket (*Lampsilis siliquoidea*), giant floater (*Pyganodon grandis*), three-ridge (*Amblema plicata*), wabash pigtoe (*Fusconaia flava*)

Species of Conservation Concern: wabash pigtoe (S2/G5), three-ridge (S2S3/G5)

Habitat: Preferring quiet muddy waters in Pennsylvania, the Fatmucket Community inhabits various size streams, but usually occurs in rivers 4th order or greater. The community is common at moderate to high elevations (\bar{x} = 295 m) and low gradients (\bar{x} = 0.02%). The community occurs in waters with high specific conductivity (\bar{x} = 414 μ S/cm) and moderate alkalinity (\bar{x} = 55 mg/l).

Watersheds with the Fatmucket Community have moderate amounts of agriculture (\bar{x} = 24%) and relatively high levels of forest (\bar{x} = 60%). Water quality in Fatmucket Community habitats may be slightly degraded by non-point source pollution from agriculture sources. Sandstone and shale geology classes dominate the watersheds supporting this community.

This community occurs in rivers with sand and gravel substrate, but reaches greatest abundance in standing water, in clay, silt, or mud substrate (Parmalee and Bogan 1998). Fatmucket mussels prefer quiet or slow moving water with mud bottoms and avoid riffles (Parmalee and Bogan 1998). This species is widespread and occurs in a variety of habitats (Strayer and Jirka 1997).

The primary indicators are moderately strong indicators that this community is present, but these species are also found in other community types (especially the fatmucket mussel). A moderate number of rare and intolerant taxa are associated with this community. The Fatmucket Community is common throughout the Ohio River Basin.

Stream Quality Rating: Undetermined

Community Rarity: No

Threats: Since the Fatmucket Community habitat is often located in landscapes with potential non-point source pollution, water quality may be compromised. In some locations,

Strongest Indicators of Community Type



Fatmucket (*Lampsilis siliquoidea*)

Photo source: <http://www.inhs.uiuc.edu>



Giant floater (*Pyganodon grandis*)

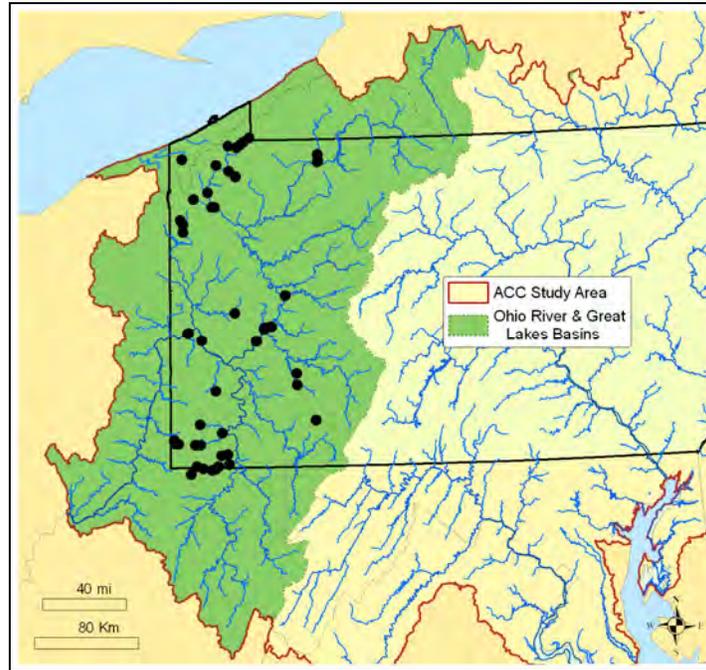
Photo source: <http://www.inhs.uiuc.edu>

siltation and removal of stream bank vegetation depress mussel communities. Silt may fill in the slow backwaters of large streams and rivers and degrade habitat conditions. Runoff may carry excessive nutrients, herbicides, and pesticides into the stream as well.

Conservation Recommendations: Conserving naturally low-gradient streams and the backwaters of rivers is a priority for the Fatmucket Community. Managing non-point sources in watersheds with potential runoff from agriculture and urban sources will maintain quality habitats. In addition, preventing severe in-stream and riparian habitat disturbance near community habitats will also ensure community survival over the long term. Maintaining and restoring wetlands and riparian buffers within these watersheds will ensure that runoff is filtered before entering the stream, reducing the amount of sediment and nutrient levels that reach the water and make the habitat unsuitable for these mussels. Other agricultural best management practices, such as utilizing grassed waterways and fencing cattle from streams, will further protect locations where this community is found.

Ohio – Great Lakes Basins Mussels: Fatmucket Mussel Community

Known Locations:



Example Habitat:



Slow backwaters of rivers and streams are the primary habitat for the Fatmucket Community.

Photo source: PNHP

Ohio – Great Lakes Basins Mussels: Spike Mussel Community

Community Indicators: spike mussel (*Elliptio dilatata*) and black sandshell (*Ligumia recta*)

Several other mussels including the mucket (*Actinonaias ligamentina*), fatmucket (*Lampsilis siliquoidea*), fluted shell (*Lasmigona costata*) and pocketbook (*Lampsilis cardium*), are also found in this community, but are common components of other communities as well.

Species of Conservation Concern: black sandshell (S3S4/G5), mucket (S4/G5), fatmucket (S4/G5), fluted shell (S4/G5)

Habitat: The habitat for the Spike Mussel Community is generally found in a large river system (average 6th order), such as the habitats found in the Allegheny River and its larger tributaries, as well as the Beaver River Basin. The community was not detected in the Monongahela watershed, which may be due to water quality issues rather than habitat availability.

Low gradient habitat ($\bar{X} = 0.04\%$), such as some locations in the main channel of the Allegheny River, is the typical environment for the Spike Mussel Community. These waters generally have high conductivity ($\bar{X} = 412 \mu\text{S}/\text{cm}$) and moderate alkalinity ($\bar{X} = 45 \text{ mg}/\text{l}$). Approximately 20% of the land in these watersheds is agricultural, while forested area makes up about 75% of these watersheds. Sandstone and shale geology dominate watersheds containing this community.

The species in this community are typically found in medium to large rivers in sand and gravel substrate and are often associated with riffles. The spike itself exists in a wide range of habitats of varied size and depth. It is one of the most abundant mussels in the Allegheny River Basin (Strayer and Jirka 1997). Although the strongest indicators of this community are very common, a number of rare and pollution-intolerant taxa are often associated with this group.

Stream Quality Rating: High

Community Rarity: No

Threats: Many tributaries to the Ohio River and lower Allegheny River are impaired. The rivers are heavily utilized in shipping and industry. These watersheds are heavily mined and urbanized in areas, especially in the southwestern corner of the state. Several stressors threaten water quality and habitat for this community type: non-point source

Strongest Indicators of Community Type



Spike mussel (*Elliptio dilatata*)

Photo source: <http://www.inhs.uiuc.edu>



Black sandshell (*Ligumia recta*)

Photo source: <http://www.inhs.uiuc.edu>

pollution, unnatural flow regimes (stormwater and dams), mine discharge, sewage effluent, and other urban pollutants. In some basins with improperly managed agriculture, siltation and excess nutrient loading threaten important habitats.

Conservation Recommendations: This community is characterized by high mussel diversity, many rare species, and very few species that can tolerate pollution; therefore it is a high conservation priority. This community occurs in sections of watersheds that currently experience relatively little watershed disturbance.

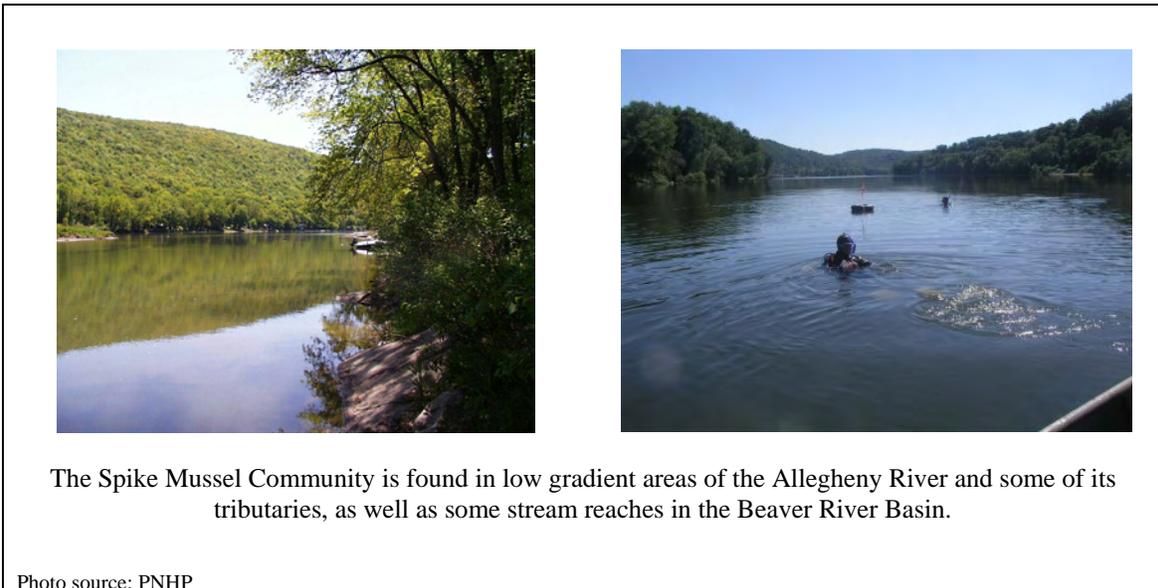
The upper Allegheny River watershed has special conservation value because of its diverse mussel and fish fauna. Public lands, like the Allegheny National Forest, protect some of the watershed. Protection of current high quality mussel habitat is important for the long-term viability of the Spike Mussel Community in the large river systems. Habitat disturbance from urbanization, bridge building and maintenance, dredging and other forms of landscape alterations should be minimized. Amelioration of non-point pollution sources is a difficult but worthy task. Proactive approaches to reducing sediment and nutrient loading in large rivers will improve habitat.

Ohio – Great Lakes Basins Mussels: Spike Mussel Community

Known Locations:



Example Habitats:



Ohio – Great Lakes Basins Mussels: Fluted Shell Mussel Community

Community Indicators: fluted shell (*Lasmigona costata*), kidneyshell (*Ptychobranhus fasciolaris*), mucket (*Actinonaias ligamentina*), elktoe (*Alasmidonta marginata*), squawfoot (*Strophitus undulatus*), pocketbook (*Lampsilis ovata*), plain pocketbook (*Lampsilis cardium*), wavy-rayed lampmussel (*Lampsilis fasciola*)

Species of Conservation Concern: fluted shell (S4/G5), kidneyshell (S4/G4G5), mucket (S4/G5), elktoe (S4 G4), squawfoot (S2S4/G5), pocketbook (S3S4/G5), plain pocketbook (S3S4/G5), wavy-rayed lampmussel (S4/G4)

Habitat: The Fluted Shell Community is characteristic of large streams and medium size rivers (average size 5th order). It is found throughout the French Creek watershed and in the upper Allegheny River as well. Community habitats have sand and gravel beds and occur at low to moderate gradients ($\bar{x} = 0.06\%$) with an average elevation of 332 m. Waters have moderate alkalinity ($\bar{x} = 54$ mg/l) and high conductivity ($\bar{x} = 278$ $\mu\text{S}/\text{cm}$) in the mucket community habitat. Land cover in these watersheds has been modified some by agriculture ($\bar{x} = 41\%$). Watersheds containing the Fluted Shell Community also contain more wetland area than those represented by other mussel communities. Sandstone is the most prominent geology type in these watersheds.

A number of rare and pollution-intolerant mussel species are associated with this community type. Consequently, the Fluted Shell Community may be found in ecosystems that are still able to support species that cannot survive in other areas.

Stream Quality Rating: High

Community Rarity: No

Threats: The watersheds associated with this community generally contain more agricultural land than watersheds associated with other Ohio Basin mussel communities. In parts of the Basin, poorly managed agricultural practices have resulted in excessive siltation and nutrient enrichment. Agriculture, mining, urbanization, and dams have affected water quality and habitat condition in various portions of the upper Allegheny River watershed.

Strongest Indicators of Community Type



Fluted Shell (*Lasmigona costata*)

Photo source: <http://www.inhs.uiuc.edu>



Plain Pocketbook (*Lampsilis cardium*)

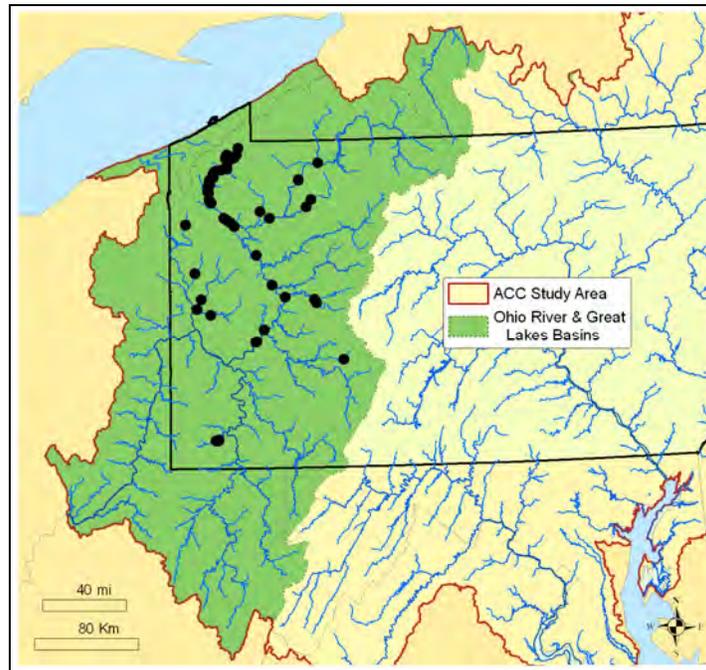
Photo source: <http://www.inhs.uiuc.edu>

Conservation Recommendations: This community is characterized by high mussel diversity, many rare species, and very few species that can tolerate pollution. It is a high conservation priority. The upper Allegheny River watershed has special conservation value because of its diverse mussel and fish fauna. Public lands, like the Allegheny National Forest, protect some of the watershed. The French Creek watershed is one area of notable mussel diversity and is also a habitat for the Spike Mussel Community. Protection of current high quality mussel habitat is important for the long-term viability of the Fluted Shell Community in the large river systems. Habitat disturbance from agriculture, urban sprawl, dredging, bridge maintenance and other forms of disturbance should be minimized.

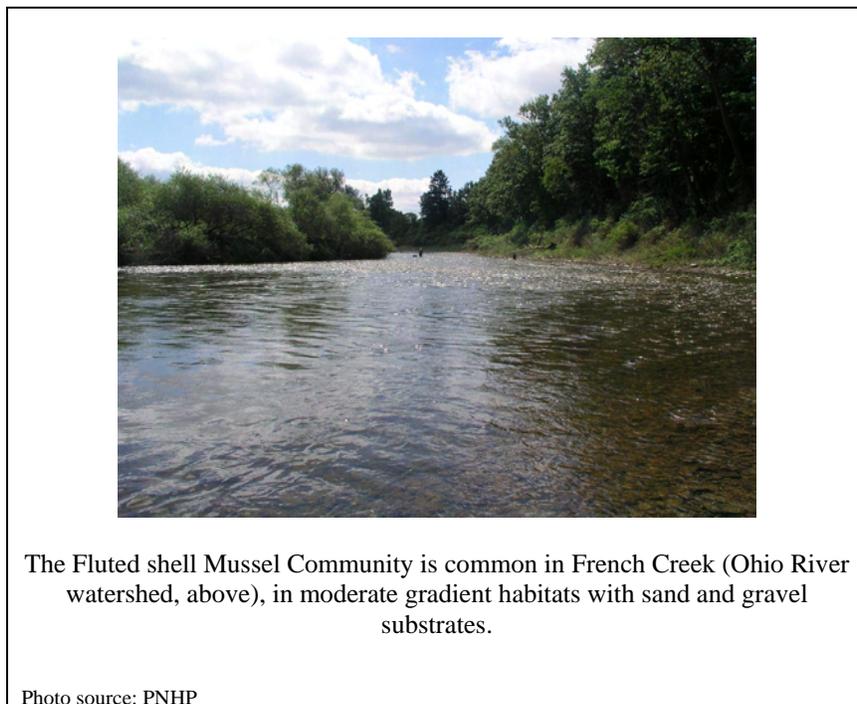
Similar to management recommendations for all large river communities, amelioration of upstream non-point sources is a difficult but worthy task. Proactive protection and restoration methods that reduce sediment and nutrient loading into large rivers will improve these unique habitats.

Ohio – Great Lakes Basins Mussels: Fluted Shell Mussel Community

Known Locations:



Example Habitat:



Ohio – Great Lakes Basins Mussels: Pink Heelsplitter Community

Community Indicators: pink heelsplitter (*Potamilus alatus*), mapleleaf (*Quadrula quadrula*), paper pondshell (*Utterbackia imbecillis*), fragile papershell (*Leptodea fragilis*)

Species of Conservation Concern: pink heelsplitter (S2/G5), mapleleaf (S1S2/G5), paper pondshell (S3S4/G5), fragile papershell (S2/G5)

Habitat: The Pink Heelsplitter Community occurrences documented by this study are concentrated in the mainstem Ohio River near the Pennsylvania-Ohio border. The 8th order Ohio River is wide and deep in this section with some sand and gravel bars. This community is found in habitat with an average elevation of 209 m and low gradient ($\bar{X} < 0.01\%$). Little water chemistry data is available at the community locations. Industry and urban development are common along the river in this region. This community is relatively tolerant of various types of pollution and is characterized by species that are globally common but somewhat rare in Pennsylvania.

Land cover in the watershed has been modified by urbanization ($\bar{X} = 3.0\%$ in watershed). Sandstone geology dominates watersheds containing this community, but shale is also prevalent.

The indicator taxa are associated with a variety of habitats, from slow quiet waters and riverbanks to riffle areas with high current. Typical substrates include mud, mixed mud, or sand and gravel (Parmalee and Bogan 1998). The pink heelsplitter is found in high abundance in this community type and is a very statistically strong indicator of this community.

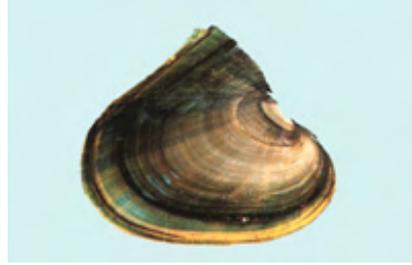
Stream Quality Rating: Undetermined

Community Rarity: No

Threats: This community is located in the mainstem Ohio River, which is heavily utilized for industry and commercial shipping. Consequently, the river is dredged and dammed, creating alterations in habitat and hydrology. Industrial point sources and commercial shipping traffic along the Ohio River likely contribute some chemical pollutants.

The Ohio River is affected by numerous upstream activities that may degrade water quality. Abandoned mine drainage and urban pollution (e.g., stormwater and road runoff, organic enrichment, and combined sewer overflows) are some pollution

Strongest Indicators of Community Type



Pink heelsplitter (*Potamilus alatus*)

Photo source: <http://www.inhs.uiuc.edu>



Fragile papershell (*Leptodea fragilis*)

Photo source: <http://www.inhs.uiuc.edu>

sources contributing to poor water quality in the Ohio River. Additionally, many of the direct tributaries to the Ohio River, and many sections of the Ohio River itself, do not meet Aquatic Life Use Standards according to the PA Department of Environmental Protection (PA DEP, 2006).

Conservation Recommendations: Large river habitat conservation is a daunting task since these watersheds are large and contain many potential pollution sources and habitat alterations. At the minimum, maintaining habitats where communities are currently residing and preventing further water pollution may help these communities persist. Ensuring adequate flow via regulated dam discharges, avoiding sand and gravel mining and other habitat disturbances will also help to protect these communities. Restoring habitats and water quality in tributaries may help currently declining mussel communities to recover.

Minimizing and remediating urban pollution and abandoned mine drainage to the Ohio River and its tributaries will improve aquatic habitats and water quality for mussel communities in the future.

Ohio – Great Lakes Basins Mussels: Pink Heelsplitter Community

Known Locations:



Example Habitats:



Ohio River habitats such as these typify the settings where the Pink Heelsplitter Community is found.

Photo source: PNHP

Susquehanna – Potomac River Basins Mussels: Eastern Elliptio Community

Community Indicator: eastern Elliptio (*Elliptio complanata*)

The rainbow mussel (*Villosa iris*), yellow lampmussel (*Lampsilis cariosa*) and eastern lampmussel (*Lampsilis radiata*) are not consistent community members, but are often associated with this community.

Species of Conservation Concern: rainbow mussel (S1/G5), yellow lampmussel (S3S4/G3G4) and eastern lampmussel (S1/G5).

Stream Quality Rating: Medium

Community Rarity: No

Habitat: The Eastern Elliptio Community is widely distributed across the study area and is found in a variety of environments. The most common community member, the eastern elliptio, tolerates variable habitats. This community is usually found in large streams (\bar{x} = 139 mi² watershed area) that are tributaries to the Susquehanna and Potomac Rivers. The habitats are generally in moderate elevations (\bar{x} = 224 m) and low gradients (\bar{x} = 0.06%). Stream bottom habitats can be variable, but this community requires some sand and silt mixed with larger cobble and gravel.

Water quality in the habitats of this community is typified by moderate alkalinity (\bar{x} = 63.6 mg/l) and low conductivity (\bar{x} = 199 μ S/cm). Water chemistry parameters may be influenced by non-point source pollution from agriculture and resource extraction. Relatively low amounts of forested area (\bar{x} = 55% of watersheds) and high amounts of agriculture in the watershed (\bar{x} = 23%) may contribute to elevated non-point source pollution in these habitats. Resource extraction, including sand and gravel mining, poorly managed forestry projects and road maintenance may also contribute non-point source pollution.

Shale (\bar{x} = 47%), sandstone (\bar{x} = 27%) and calcareous (\bar{x} = 18%) geology classes are all prevalent in watersheds containing this community. Modeling results also indicate a strong association between this community and the amounts of forest cover and calcareous geology in the watershed.

Strongest Indicator of Community Type



Eastern Elliptio (*Elliptio complanata*)

Photo source: PNHP

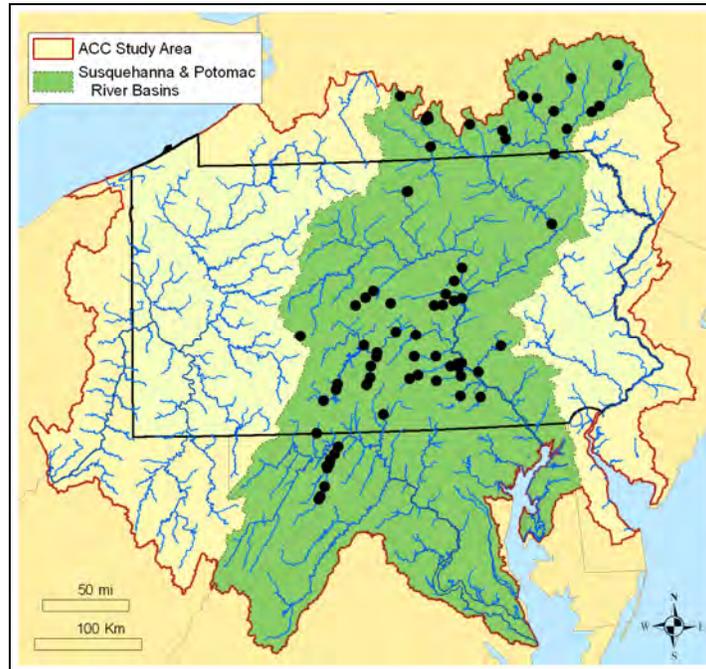
Threats: Large streams and rivers often face an assortment of landscape alterations that have degrading effects on water quality. Abandoned mine drainage, urban pollution (e.g., stormwater and road runoff, combined sewer overflows, etc.) and non-point source pollution from poorly maintained agricultural practices are some factors that lower water quality where the Eastern Elliptio Community is found. The invasion of non-native zebra mussels also poses a threat to the Eastern Elliptio Community.

Conservation Recommendations: Although the eastern Elliptio is not a rare species in Pennsylvania, some of the associated species that may occur with this community are species of conservation concern. Protection of current mussel habitats and maintenance of water quality standards will allow communities to endure and potentially recolonize areas where they have been lost. Additionally, monitoring of zebra mussel infestation will document the spread and effects of the non-native species on native mussel populations.

Additional study of the Eastern Elliptio Community is needed. The primary indicator species are statistically strong indicators of this community and thus when found, strongly indicate that this community is present. However, some are also found in several other community types in certain circumstances.

Susquehanna – Potomac River Basins Mussels: Eastern Elliptio Community

Known Locations:



Example Habitats:



The Eastern Elliptio Community can occupy diverse habitats from small, slow-moving rivers to large rivers like the Susquehanna.

Photo source: PNHP

Susquehanna – Potomac River Basins Mussels: Eastern Floater Community

Community Indicator: eastern floater
(*Pyganodon cataracta*)

The triangle floater (*Alasmidonta undulata*) is not a consistent community member, but is commonly associated with this community type.

Species of Conservation Concern: triangle floater (S3S4/G4)

Habitat: The community is found in medium to large river systems ($\bar{X} = 131 \text{ mi}^2$) at moderate elevations ($\bar{X} = 209 \text{ m}$). Species found in the community prefer quiet backwaters of rivers where gradient is low ($\bar{X} = 0.06\%$). Little information is currently available about water chemistry.

This community is associated with relatively high levels of watershed forest ($\bar{X} = 68\%$) and moderate agricultural cover ($\bar{X} = 23\%$). Sandstone ($\bar{X} = 48\%$), shale ($\bar{X} = 40\%$) and calcareous ($\bar{X} = 12\%$) are the predominant geology classes in watersheds containing this community.

Modeling results indicate strong associations between the occurrence of this community and the prevalence of open water, wetland areas, and calcareous geology.

Stream Quality Rating: Medium

Community Rarity: Yes

Threats: Community threats will be better understood once the habitat is better defined. Landscapes in the community watersheds may contain improperly managed agriculture and abandoned mine drainage. In many instances, excess nutrients and silt are likely contributed from the greater watershed, compromising habitat condition and reducing aquatic community health. Acidity and dissolved or precipitated metals from abandoned mine

Strongest Indicators of Community Type



Eastern floater (*Pyganodon cataracta*)

Photo source: PNHP

drainage are very toxic to mussel communities. The spread of non-native zebra mussels is also a concern.

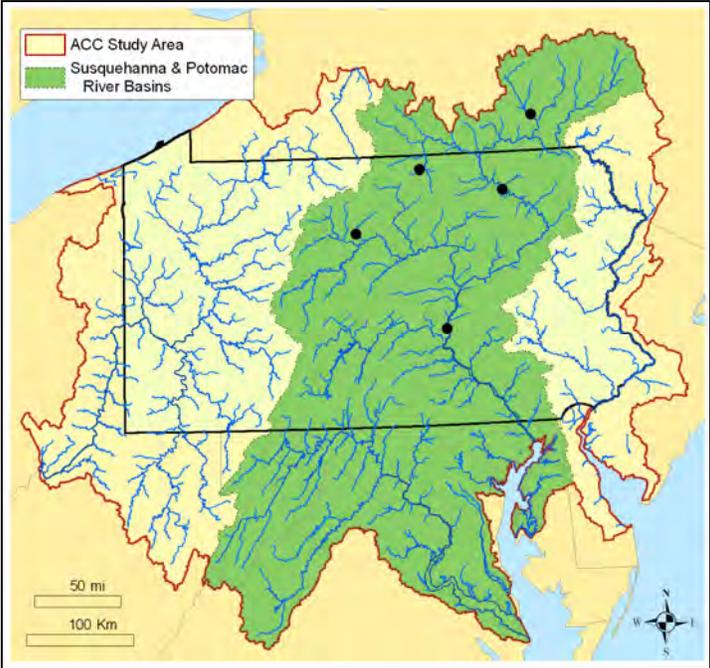
Conservation Recommendations: Since this community is usually found in slow moving backwaters or standing waters in fine sand, silt, or muddy substrates (Bogan 2002, Nedeau 2000, Strayer and Jirka 1997), protection of backwater habitats will ensure the overall conservation of this mussel community.

Additionally, monitoring of zebra mussel infestation will document the spread and effects of the non-native species on native mussel populations. Zebra mussels can have deleterious effect on native mussels by outcompeting the native fauna for food resources and habitat.

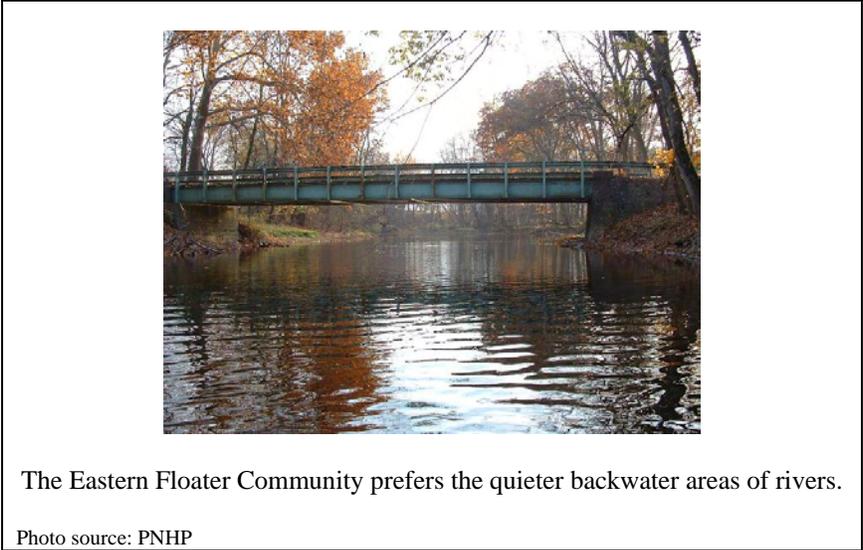
Further study of the Eastern Floater Community is needed. The primary species in this group are statistically strong indicators of this community and thus when found, strongly indicate that this community is present. However, they can also be found in several other community types in certain situations.

Susquehanna – Potomac River Basins Mussels: Eastern Floater Community

Known Locations:



Example Habitat:



Susquehanna – Potomac River Basins Mussels: Yellow Lampmussel Community

Community Indicator: yellow lampmussel (*Lampsilis cariosa*)

Additionally, the eastern floater (*Pyganodon cataracta*), eastern lampmussel (*Lampsilis radiata*) and triangle floater (*Alasmidonta undulata*) are all commonly associated with this community.

Species of Conservation Concern: yellow lampmussel (S3S4/G3G4), eastern lampmussel (S1/G5) and triangle floater (S3S4/G4)

Habitat: This community type is found in large river systems ($\bar{x} = 167 \text{ mi}^2$) in the Susquehanna and Potomac River drainages at low elevations ($\bar{x} = 198 \text{ m}$). Average stream gradient is 0.05%. Stream habitat scores may be lower than those for other communities.

Habitat information is currently limited for the Yellow Lampmussel Community. Little is known about water chemistry in the habitats where this community is found. The main indicator species, the yellow lampmussel, is a habitat generalist and occurs in a variety of substrate types including sand, silt, cobble and gravel (Connecticut DEP 2003; NatureServe 2005).

As is typical of larger river basins, watersheds with the Yellow Lampmussel Community have many road crossings and point sources of pollution. Watershed landcover typically shows moderate proportions of forest ($\bar{x} = 67\%$) and relatively high proportions of urban ($\bar{x} = 2.2\%$) and agricultural areas ($\bar{x} = 27\%$). Sandstone ($\bar{x} = 47\%$ average) and shale ($\bar{x} = 52\%$) geology classes dominate the watersheds containing this community.

Predictive modeling results indicate a strong association between this community and many variables, including many typically associated with large rivers as noted above.

Stream Quality Rating: Medium

Community Rarity: No

Strongest Indicator of Community Type



Yellow lampmussel (*Lampsilis cariosa*)

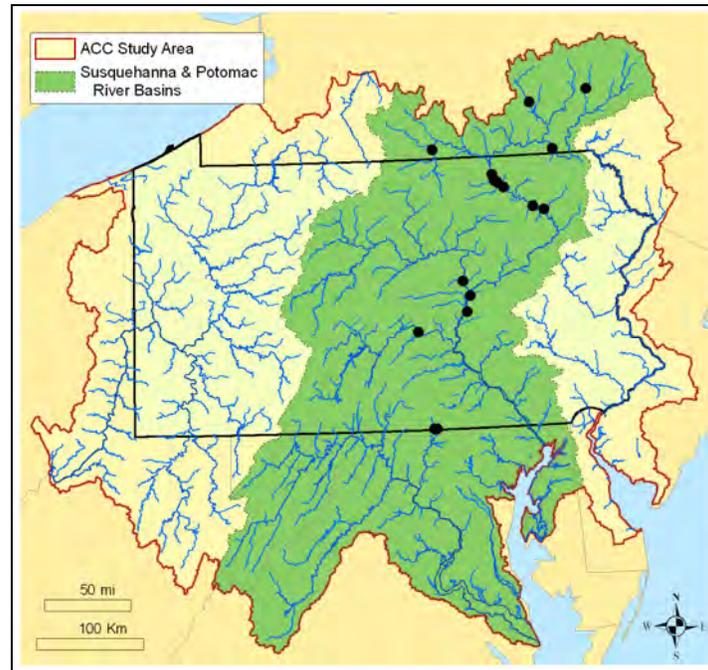
Photo source: PNHP

Threats: Watershed disturbances including coal mining and improperly managed agriculture may be detrimental to the Yellow Lampmussel Community. Upstream non-point source pollution from agriculture and stream bank vegetation removal may result in excess nutrients and silt contributed to streams. Nutrient enrichment and sedimentation are two of the biggest water quality impairments in Pennsylvania. Acidity and metals, commonly contributed to Pennsylvania streams from abandoned mine drainage, are extremely toxic to mussels. The spread of non-native zebra mussels is also a concern.

Conservation Recommendations: Large river habitat conservation is a daunting task since river watersheds are very expansive and contain many potential pollution sources and habitat alteration problems. At the minimum, maintaining habitats where communities are currently residing and preventing further water pollution will ensure that current communities will continue to exist. Restoring habitats and improving water quality where it has been degraded may allow for mussel species in decline to rebound. Remediating toxic water pollution problems, like abandoned mine drainage in tributaries to the Susquehanna River, will increase mussel community health and may allow communities to expand their range into pollutant-free habitats.

Susquehanna – Potomac River Basins Mussels: Yellow Lampmussel Community

Known Locations:



Example Habitats:



The Susquehanna River in Bradford Co., PA (above) is an example of habitat that is typical for the Yellow Lampmussel Community.

Photo source: PNHP

Susquehanna – Potomac River Basins Mussels: Squawfoot Mussel Community

Community Indicator: squawfoot (*Strophitus undulatus*)

This community type is also commonly associated with the triangle floater (*Alasmidonta undulata*), eastern lampmussel (*Lampsilis radiata*) and eastern Elliptio (*Elliptio complanata*).

Species of Conservation Concern: triangle floater (S3S4/G4) and eastern lampmussel (S2/G5)

Habitat: The Squawfoot Mussel Community was found to be common throughout the study area. It generally occurs at moderate elevations and gradients ($\bar{x} = 0.025\%$). Habitats include medium-sized streams and small rivers ($\bar{x} = 186 \text{ mi}^2$ watershed area).

The primary indicator of this community, the squawfoot, is commonly located in streams and small rivers but has occasionally been found in lakes and larger rivers. Preferred substrates of the squawfoot are sand and fine gravel (Bogan 2002, Nedea et al. 2000, Parmalee 1998, Strayer and Jirka 1997). It rarely inhabits water that is more than three or four feet deep (Parmalee 1998).

Water quality parameters indicate that the Squawfoot Mussel Community prefers low to moderate alkalinity ($\bar{x} = 44.8 \text{ mg/l}$) and moderate conductivity ($\bar{x} = 200 \text{ }\mu\text{S/cm}$). Similar to other mussel communities, the watershed landscape of the Squawfoot Mussel Community is largely forested ($\bar{x} = 85\%$) but typically contains less agricultural land ($\bar{x} = 8\%$) and less urban area ($\bar{x} = 0.5\%$) than some other groups. Shale ($\bar{x} = 45\%$), sandstone ($\bar{x} = 28\%$) and calcareous ($\bar{x} = 25\%$) geology classes are all common in watersheds containing this community. Calcareous geology is higher in these watersheds than in those associated with other mussel communities.

Modeling results show a strong association between this community and forest land, agricultural land, calcareous geology and high gradients.

Stream Quality Rating: High

Strongest Indicator of Community Type



Squawfoot (*Strophitus undulatus*)

Photo source: PNHP

Community Rarity: No

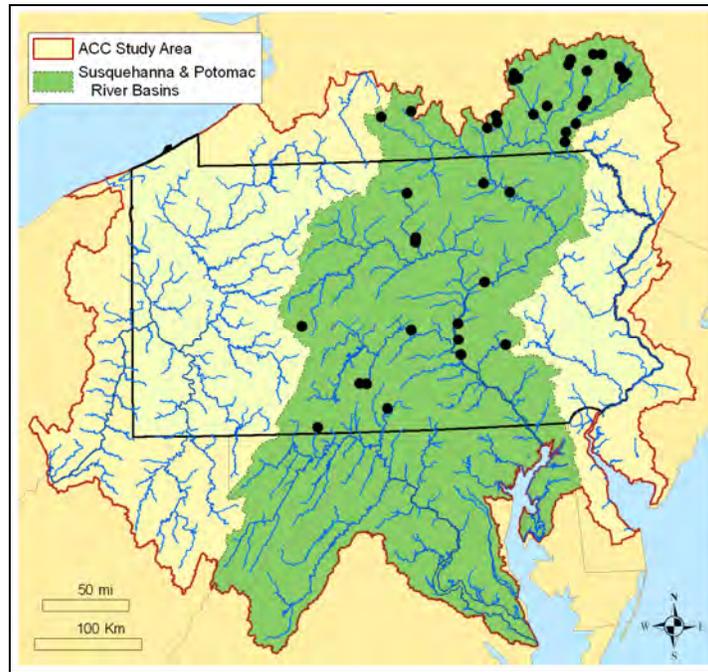
Threats: Since the Squawfoot Mussel Community exists mainly in streams and smaller rivers, it does not experience the same habitat and water quality impairments as other mussel groups living in large rivers. Abandoned mine drainage (AMD) and poorly maintained agricultural practices are likely the greatest threats to the habitats of this community group. AMD can contribute acidic and metal-laden discharges to streams at levels that are toxic to the resident organisms. Agricultural runoff brings excess sediment and elevated nutrient levels to streams. Large amounts of sediment can smother stream habitat and high concentrations of nutrients can create water chemistry situations that are unhealthy for mussels.

Conservation Recommendations: The squawfoot mussel, the primary indicator for this community, prefers clean, unpolluted waters. Populations could very easily become decimated if water quality declines. Management of non-point source pollution from agriculture and mitigation of AMD discharges will improve community habitats and water quality.

Additional study of the Squawfoot Mussel Community is needed. The primary species are statistically strong indicators of this community and thus when found, strongly indicate that this community is present. However, some of these species are also found in other community types under certain circumstances.

Susquehanna – Potomac River Basins Mussels: Squawfoot Mussel Community

Known Locations:



Example Habitat:



Mahatango Creek, (above) is an example of typical habitat for the Squawfoot Mussel Community.

Photo source: PNHP

Susquehanna – Potomac River Basins Mussels: Lanceolate Elliptio Complex Community

Community Indicators: Lanceolate Elliptio complex¹ (contains spike: *Elliptio producta* and/or northern lance: *Elliptio fisheriana*)

This community type is commonly associated with the plain pocketbook (*Lampsilis cardium*), eastern Elliptio (*Elliptio complanata*) and squawfoot (*Strophitus undulatus*)

Species of Conservation Concern: Atlantic spike (S2/G4Q), northern lance (SH/G4)

Habitat: Occurring only in the Potomac River watershed, this community type is found in large streams to medium-sized rivers (\bar{x} = 231 mi² watershed area) in valleys at low elevation (\bar{x} = 168 m). Stream gradient at community locations is low (\bar{x} = 0.08%).

The Lanceolate Elliptio Complex Community is associated with high alkalinity (\bar{x} = 164 mg/l) and moderate to high conductivity (\bar{x} = 221 μ S/cm). This community type occurred in watersheds dominated by sandstone geology, but habitat requirements for this community are not fully understood. Further studies of the environmental associations of this community are needed.

Preliminary studies indicate that this community is found in highly forested landscapes (\bar{x} = 77% of watershed), with lower amounts of agricultural area (\bar{x} = 13%) and little urbanized area (\bar{x} = 0.14%). Sandstone (\bar{x} = 56% of watershed), shale (\bar{x} = 38%) and calcareous (\bar{x} = 8%) geology classes dominate the watersheds containing this community. Sandstone geology is higher in these watersheds than in those associated with other communities.

Modeling results indicate strong associations between this community and forest cover in the watershed, sandstone geology and calcareous geology. High numbers of dams and point sources may also be associated with the occurrence of this community.

Stream Quality Rating: Medium

¹The taxonomic distinction between the northern lance (*Elliptio fisheriana*) and the Atlantic spike (*Elliptio producta*) is under current debate by experts. Species are grouped into the Lanceolate Elliptio complex for the purposes of this project.

Strongest Indicator of Community Type



Lanceolate Elliptio Complex
(*Elliptio producta*/*Elliptio fisheriana*)

Photo source: PNHP

Community Rarity: Yes

Threats: The Lanceolate Elliptio Complex Community has not been found in many locations in the study area. In the Pennsylvania portion of the Potomac River watershed, mussel communities appear to be receiving few threats. Non-point source pollution from agriculture, bringing excess sediment and nutrient levels to streams, could potentially degrade habitats and community health. However, current levels of non-point source pollution in the watersheds do not appear to be negatively influencing the Lanceolate Elliptio community.

Conservation Recommendations: Protection of freshwater habitats in the Potomac River Basin, where this community has a limited range, will be important for conserving habitat for this community type. Further sampling may uncover a wider distribution of the community type and more information about habitat requirements. Preliminary evidence indicates that this community type occurs with sandstone and shale geology with small amounts of calcareous geology; watersheds with this combination of geology types should be targeted for future mussel community surveys. For now, the apparent endemism of this community to a relatively small area in the Potomac River Basin makes this community a conservation priority.

Susquehanna – Potomac River Basins Mussels: Lanceolate Elliptio Complex Community

Known Locations:



Example Habitat:



Tonoloway Creek, a tributary to the Potomac River, is typical of the habitat that supports the Lanceolate Elliptio Complex Community.

Photo source: PNHP

Susquehanna – Potomac River Basins Mussels: Elktoe Community

Community Indicators: Elktoe (*Alasmidonta marginata*)

This community type is commonly associated with the triangle floater (*Alasmidonta undulata*) and the yellow lampmussel (*Lampsilis cariosa*).

Species of Conservation Concern: elktoe (S4/G4), triangle floater (G4/S3S4), and yellow lamp-mussel (S3S4/G3G4).

Habitat: The community was only found in the North Branch of the Susquehanna watershed in select locations. The species representing the community can tolerate a variety of habitat characteristics from small creeks to medium-sized and large-sized rivers (Strayer and Jirka 1997). Because the elktoe is distributed in the Susquehanna River and its tributaries through the river basin, the relative lack of communities dominated by this species is a puzzle.

The community is found in large river systems (\bar{x} = 1400 mi² watershed area) at moderate elevations (\bar{x} = 260 m). Species found in the community prefer quiet backwaters of rivers where gradient is low (\bar{x} < 0.001%). Little information is currently available about water chemistry where the Elktoe Community occurs. The upper Susquehanna River basin, where this community was found has high levels of watershed forest (\bar{x} = 70%) and moderate agricultural cover (\bar{x} = 26%). Sandstone (\bar{x} = 25% average) and shale (\bar{x} = 70%) geology classes dominate the watersheds containing this community.

The Elktoe Community indicates large river habitat, but further study is needed to determine habitat requirements. In the Susquehanna River Basin, the yellow lampmussel is very abundant in the large creeks and rivers (*personal observation*) and may dominate communities where the elktoe mussel occurs. This may be why the Yellow Lampmussel Community is more common in the Susquehanna River Basin.

Stream Quality Rating: Medium

Strongest indicator of community type



Elktoe (*Alasmidonta marginata*)

Photo source: <http://www.inhs.uiuc.edu>

Community Rarity: Yes

Threats: Watershed land use influences this community's habitat. Improperly managed agriculture may be detrimental to the Elktoe Community. Upstream non-point source pollution from agriculture and stream bank vegetation removal may result in excess nutrients and silt contributed to streams. Nutrient enrichment and sedimentation are two of the biggest water quality impairments in Pennsylvania. Runoff from roads, inputs from storm sewers, and sewage treatment plant discharges may also influence the water quality in the large rivers in the Susquehanna River Basin. The spread of non-native zebra mussels is also a concern.

Conservation Recommendations: Large river habitat conservation is a daunting task since river watersheds are very expansive and contain many potential pollution sources and habitat alteration problems. At the minimum, maintaining habitats where communities are currently residing and preventing further water pollution will ensure that current communities will continue to exist. Restoring habitats and improving water quality where it has been degraded may allow for mussel species in decline to rebound.

Susquehanna – Potomac River Basins Mussels: Elktoe Community

Known Locations:



Example Habitat:



The North Branch of the Susquehanna River is typical of the habitat that supports the Elktoe Community.

Photo source: PNHP

Delaware River Basin Mussels: Eastern Elliptio Community

Community Indicators: eastern Elliptio (*Elliptio complanata*)

The yellow lampmussel (*Lampsilis cariosa*), Alewife floater (*Anodonta implicata*), squawfoot (*Strophitus undulatus*) and triangle floater (*Alasmidonta undulata*) also occur occasionally with this community type on the mainstem Delaware River.

Species of Conservation Concern: yellow lamp-mussel (S3S4/G3G4), alewife floater (G5/SH), squawfoot (G5/S4S5) and triangle floater (G4/S3S4)

Habitat: The Eastern Elliptio Community is usually found in large streams and rivers (\bar{X} = 2705 mi² watershed area) in low to moderate elevation (\bar{X} = 157 m). Stream gradients are somewhat high for mussel habitat (\bar{X} = 0.10%). Substrate habitats can be variable, but this community requires some sand and silt mixed with larger cobble and gravel. This community is found in highly forested watersheds (\bar{X} = 77 %), with small amounts of agricultural land (\bar{X} = 12 %). Sandstone (\bar{X} = 49%) and shale (\bar{X} = 48%) are the prominent geology classes in watersheds containing this community.

The community has a wide range across the Delaware River Basin and is the dominant community described in the mainstem Delaware River. The adaptability of the main community indicator, the eastern elliptio, may explain community's wide distribution. The eastern elliptio is found in habitats ranging from brooks to the largest rivers and lakes in the Atlantic Basin in Pennsylvania. It is found in many types of substrates. Where it is found, this mussel is almost always the most abundant species in the community (Connecticut DEP 2003, Nedeau et al. 2000, Strayer and Jirka 1997). The eastern Elliptio has been located at some heavily disturbed and polluted sites, suggesting this species can tolerate some amounts of certain pollutants (Nedeau et al. 2000). Modeling results indicate strong associations between this community and large watershed area, low elevation, and high amounts of forested land.

Threats: This community is located in the mainstem Delaware River, which is subject to many threats in its lower portion because it is a large river system in an urbanized area. Abandoned mine drainage (AMD) and agricultural and urban pollution (including urban runoff, industrial point-source discharges, road runoff, organic enrichment, and combined sewer overflows) are some pollution sources contributing to poor water quality in the river. In the upper portion of the Delaware Basin, there is less urbanization and the watershed exists in more natural condition. In these areas, AMD and agricultural runoff may be the causes of small amounts of water quality impairment.

Strongest Indicator of Community Type



Eastern Elliptio (*Elliptio complanata*)

Photo source: PNHP

Conservation Recommendations: On the mainstem of the Delaware River, the Eastern Elliptio Community is common and abundant. Protecting this unique river from habitat and water quality detriments will ensure long-term community persistence. Characterized by the densest known populations of eastern Elliptio in the state, the mussel communities of the Delaware River filter the entire river water volume multiple times per day in the summer, greatly improving water quality (Lellis, *personal comm.*).

The alewife floater, a common inhabitant of this community, is restricted to free flowing rivers and may have its reproductive cycle linked to the migration of shad and herring in the Delaware River. Because the mainstem river is undammed, fish are able to freely migrate, carrying mussel larvae throughout the system. Maintaining the free flowing condition of the Delaware River is vital to the protection of this community.

Three large drinking water reservoirs for New York City exist on tributaries to the upper Delaware. Dam management on these tributaries should include maintaining adequate flow to support the Delaware River mussel communities.

Large river habitat conservation is a daunting task since river watersheds are expansive and contain many potential pollution sources and habitat alteration problems. Adequate remediation of urban runoff and AMD in the Delaware River and its tributaries and minimizing industrial point-source pollution on the river will improve aquatic habitats and water quality. Addressing these large-river issues will help ensure the continued existence of the mussel communities in the Delaware River.

Delaware River Basin Mussels: Eastern Elliptio Community

Known Locations:



Example Habitats:



The Eastern Elliptio Community can occupy diverse habitats from small, slow-moving rivers to larger rivers, like the Delaware River (Note: Eastern Elliptio Communities in the Susquehanna and Potomac River Basins occupy somewhat different habitat).

Photo source: PNHP

Delaware River Basin Mussels: Alewife Floater Community

Community Indicators: alewife floater (*Anodonta implicata*), eastern Elliptio (*Elliptio complanata*), squawfoot (*Strophitus undulatus*), eastern floater (*Pyganadon cataracta*) and triangle floater (*Alasmidonta undulata*)

Species of Conservation Concern: alewife floater (*Anodonta implicata*) (SH/G5), triangle floater (*Alasmidonta undulata*) (S3S4/G4)

Habitat: The Alewife Floater Community occurs in relatively few locations in large river habitats of the Delaware River ($\bar{X} = 3,808 \text{ mi}^2$ watershed area). This community prefers quiet backwaters and resides in side channels around some islands in the upper portions of the River. The main indicator taxon, the alewife floater, is found in coastal streams and lakes in sand and gravel substrates. It prefers slow currents as well as quiet standing waters.

This community occurs near Eastern Elliptio Community locations, but the Alewife Floater Community was found at sites with lower elevations ($\bar{X} = 95 \text{ m}$) and gradients ($\bar{X} = 0.05\%$). The side channel that holds this community is deeper and has slower flow and softer substrate than that of the Eastern Elliptio Community. In the upper Delaware River watershed, agricultural landcover represents 10 % of the watershed. Sandstone ($\bar{X} = 56\%$) and shale ($\bar{X} = 42\%$) geology classes are prevalent in watersheds containing this community.

The alewife floater, a species that in the northeast is restricted to free-flowing rivers, primarily characterizes this community. The reproductive cycle of the alewife floater is thought to be linked to the migration of shad and herring (Connecticut DEP 2003). The undammed condition of the mainstem Delaware allows this community to remain, while it has been lost from many of the other large, dammed coastal rivers in the northeast.

Stream Quality Rating: High

Community Rarity: Yes

Threats: This community is located in the mainstem Delaware River, which is subject to many threats in its lower portion because it is a large river system in an urbanized area. Abandoned mine drainage (AMD) and agricultural and urban pollution (including urban runoff, road runoff,

organic enrichment and combined sewer overflows) are some pollution sources contributing to poor water quality in the river. Industrial point sources likely contribute some chemical pollutants. In the upper portion of the Delaware River Basin, there is less urbanization and the watershed exists in a more natural condition. In these areas, AMD and agricultural runoff may be the causes of water quality impairment, although the upper portion of the river remains in very good condition. The alteration in riverine habitat that would occur with the construction of new dams on the mainstem Delaware River is the greatest threat to the Alewife Floater Community.

Conservation Recommendations: Maintaining the free-flowing status of the Delaware River will greatly help to protect this community. Because the river is undammed, fish are able to freely migrate, carrying mussel larvae throughout the system.

Maintaining pool habitats in the Delaware River is important to the long-term survival of this community. In addition, fish host species like American shad, alewife, and blueback herring are essential to the life cycle of the alewife floater mussel. Consequently, host fish habitats are also closely linked to the Alewife Floater Community.

Large river habitat conservation is a daunting task since river watersheds are expansive and contain many potential pollution sources and habitat alteration problems. At the minimum, maintaining habitats and preventing further water pollution may help the persistence of current communities. Ensuring adequate flow and avoiding dredging and other habitat disturbances in known areas of mussel habitat will help to protect this community. Restoring habitats and improving water quality in the tributaries may help mussel communities currently in decline to rebound.

The remediation of urban pollution and acid mine drainage in tributaries to the Delaware River will improve aquatic habitats and water quality. Minimizing industrial pollution on the river will also ensure the health of mussel communities. Additionally, prevention of upstream non-point source pollution from agriculture and urban developments is important for this mussel resource. Particularly where urban pollution is severe in the lower Delaware River Basin, efforts to remediate residential, road and municipal pollution sources are needed to improve water quality and habitats.

Delaware River Basin Mussels: Alewife Floater Community

Known Locations:



Example Habitats:



The free-flowing Delaware River supports the habitat of the Alewife Floater Community.

Photo source: George Gress

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