User's Manual And Data Guide To The Pennsylvania Aquatic Community Classification

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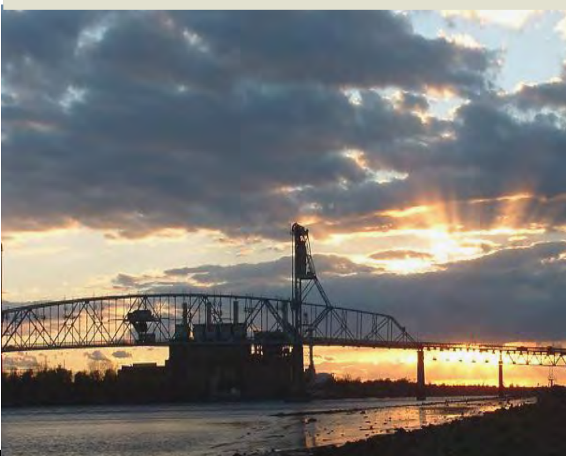

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ACC User's Manual Table of Contents

List of Tables

List of Figures

1. Project Summary

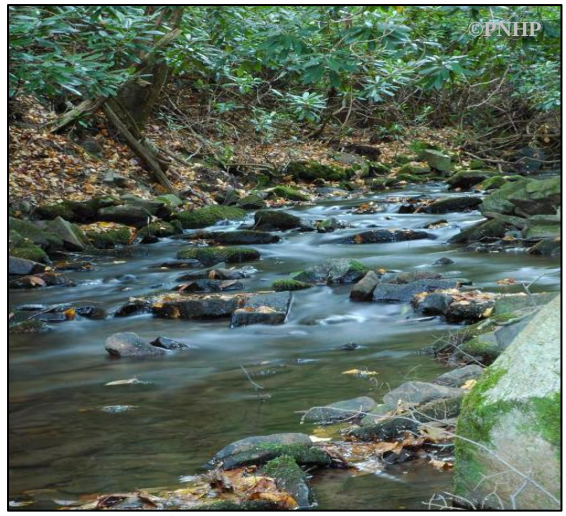
Threats to our region's aquatic habitats are numerous. About 39% of the nation's waters are classified as polluted according to assessments required by the Clean Water Act (Environmental Protection Agency 2002). Causes of aquatic habitat degradation include direct and indirect human influences on the streams and rivers and their natural processes. Common threats to streams and rivers in Pennsylvania include atmospheric acid and mercury deposition, channel alteration, dredging, runoff from urban centers and roads, siltation and nutrient loading from poorly managed agricultural and siliviculture practices, municipal and industrial wastewater effluent, and pollution from mine drainage. Many pollution sources present challenging remediation problems.

As a result of poor water quality and habitat loss, many freshwater species are facing serious imperilment. Globally, 69% of mussels, 51% of crayfish and 37% of fish species in freshwater habitats are extinct, critically imperiled, imperiled, or vulnerable in freshwater habitats (Master 2000). Habitat ranges are greatly declining in extent for many species. For example, healthy populations of brook trout currently exist in only 5% of sub-watersheds compared to their historical range (Trout Unlimited 2006).

Goals of the ACC

The goal of the Pennsylvania Aquatic Community Classification (ACC) project was to describe patterns in aquatic biodiversity for the purpose of prioritizing conservation activities and informing aquatic resource management. Although assessments and aquatic inventories are numerous and ongoing in Pennsylvania's waters, little public information for Pennsylvania and the surrounding region is available to natural resource managers, watershed groups, local government officials, conservation planners, and others about biodiversity and watershed quality.

In order to address immediate threats faced by our region's flowing waters, the Pennsylvania Aquatic Community Classification was designed to systematically identify stream community and habitat types for the freshwater mussels, macroinvertebrates, and fish that reside in



Roaring Run, Centre County, PA.

Pennsylvania's streams. Descriptions of biological communities and stream habitat types provide a baseline for monitoring and conserving flowing water systems. Stream community typing can be used to help assess the status of streams and rivers, restore waters in poor condition and preserve high quality aquatic habitats. The results of the ACC project provide information on biological community types, the condition of Pennsylvania's streams and rivers, and the physical habitats of these aquatic systems.

Contents of the *User's Manual* Document*:*

The project methods and results are described in this document and the *Classifying Lotic Systems for Conservation: Methods and Results of the PA Aquatic Community Classification* document. In this *User's Manual and Data Guide* document and the accompanying data files, we include:

- Suggested applications of the Pennsylvania Aquatic Community Classification (ACC) for conservation planning and natural resource management;
- Community descriptions that note the species and habitats associated with each community type;
- Information about physical stream types categorized by geology, gradient, and watershed area;

- Description of the accompanying data, including community locations, physical stream types, streams with the least amount of watershed disturbance (called "Least-Disturbed Streams"), Conservation Priority Watersheds, Restoration Priority Watersheds, and Enhancement Area Watersheds;

- Maps of Least-Disturbed Streams, Conservation Priority Watersheds, Restoration Priority Watersheds, and Enhancement Area Watersheds. Methods for determining stream and watershed categories are documented;

- The Pennsylvania Aquatics Database, which contains information on biological, physical habitat, and water chemistry survey data from numerous sources on the region's streams.

In the *Classifying Lotic Systems for Conservation: Methods and Results of the PA Aquatic Community Classification* document, detailed information on the project approach, data analysis, methods, statistical outcomes, and other project results are presented.

History of the Pennsylvania Aquatic Community Classification Project

The project began in 2000 when biologists in the Pennsylvania Natural Heritage Program recognized the need for a system to identify flowing water community types, akin to plant community types used by vegetation ecologists. The ACC was developed to stratify types of flowing waters based on biological gradients so that streams could be inventoried and surveyed in an ecologically meaningful way. A pilot study, *The Pennsylvania Aquatic Community Classification Project: Phase I Final Report*, was completed in 2004. This report documented the evaluation of our project approach and methods (Nightingale et al. 2004).

Agencies with jurisdictional authority relating to water quality and aquatic organisms also realized that an aquatic classification system was imperative for comparing ecologically similar waters. In the last decade, ideas for classifying the ecology of aquatic systems converged on concepts of biological and physical habitat schemas. Academic researchers, USGS GAP programs, NatureServe, The Nature Conservancy, and others have conceptualized broad-scale habitat types and ecological classifications of stream systems.

Methods for the classification analysis and applications for the ACC were discussed at roundtable meetings with aquatic experts. Collaboration and consultation with professionals at governmental agencies, conservation organizations, river basin commissions, conservation planning agencies, and universities was imperative during the project development to integrate scientifically accepted methods and maximize the project applications.

Major Accomplishments of the ACC:

- A database of biological, chemical, and habitat information for study area streams;

- A community classification system to identify types and categories of flowing waters based on stream-dwelling animals;

- Models of community habitats;

- A system of physical stream classes, describing major stream environments;

- A ranking of high quality streams (Least-Disturbed Streams) in the region having the least amount of disturbance in their watersheds;

- Categorization of watersheds by quality into Conservation Priority Watersheds, Restoration Priority Watersheds, and Enhancement Area Watersheds.

A filter feeding mucket mussel (Actinonaias ligamentina)

Other Project Highlights & Findings

Patterns in biodiversity applicable to freshwater conservation are detailed in other sections of this document. In brief, the project highlights are:

- We discovered that 13 mussel communities, 11 fish communities, and 12 genus-level macroinvertebrate communities (8 family-level) are found in Pennsylvania.

- Biodiversity in Pennsylvania streams follows a gradient of habitat from the headwaters to the larger lower river reaches.

- Some communities indicated specialized or relatively rare habitat; at least 13 communities have special conservation value. Communities indicative of high quality systems, particularly rare species, or occur in unique habitats are categorized as having high conservation value.

- Four community types were indicative of degraded water quality conditions. The primary associates of poor quality communities were abandoned mine drainage (AMD), acid deposition, poorly maintained agriculture, and urbanization.

- Large streams and rivers are often threatened by habitat or water quality degradation. For example, the lower portion of the Delaware River has more than 920 point sources of pollution and 260 dams in its upstream basin.

- Least-Disturbed Streams (LDS) were common in areas that are largely forested and have less human influence than other regions. Concentrations of LDS streams were found in the north-central region of Pennsylvania, the West Branch of the Susquehanna River Basin, the forested watersheds of Laurel Highlands, the upper Allegheny watershed, and the headwaters of the Delaware River watershed.

- Additional selection of LDS was applied to identify the best examples of quality habitats in areas facing much watershed disturbance; separate LDS streams were chosen from areas of calcareous geology, Waynesburg Hills Physiographic Section, and Piedmont Physiographic Province, French Creek (Ohio River Basin), and large river habitats.

- Watershed Conservation Priorities included watersheds with LDS, high quality communities, and community metrics indicative of high water quality. Watersheds nominated as Conservation Priorities were found mainly in north-central Pennsylvania and were associated with ridges in the Ridge and Valley province.

- Watersheds prioritized for restoration were concentrated around densely populated areas in southeast and southwest Pennsylvania, agricultural valleys of southeastern Pennsylvania, and the lower reaches of the Allegheny, Monongahela and Delaware Rivers. These results highlight the challenges in conservation of large rivers and watersheds that contain areas of intensive agriculture and urbanization.

The scenic upper Delaware River has relatively few human disturbances. Photo: George Gress

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Nightingale, B., M. Walsh, D. Homans, R. Evans, E. Bond, and J. Deeds. 2004. Pennsylvania Aquatic Community Classification Project: Phase I Final Report. PA Natural Heritage Program.

Trout Unlimited 2006. Eastern brook trout: Status and threats. 36 pp., Arlington, VA.

2. Introduction to the Pennsylvania Aquatic Community Classification (ACC) Products

Aquatic Communities

A community represents a group of organisms that occur together in a defined habitat. These organisms require similar habitat features, may be dependent on each other for food or other resources, and may be dependent on similar processes in their environment. The aquatic communities in this report refer to three types of organisms found in streams in our study area (Figure 2-1): freshwater mussels, macro-invertebrates, and fish. Aquatic communities for each type of organism can be used to describe the habitats and water quality of the streams in which they are found. The community types from each taxa group are described in detail in Chapters 4-7.

Figure 2-1. The ACC study area includes the entire Delaware, Susquehanna, Allegheny and Monongahela River Basins and parts of the Erie, Genessee, Potomac and Ohio River Basins.

Information about communities at large scales can reveal general patterns in biodiversity and habitat types. For instance, the most dominant communities can be examined across large basins, like the Schuylkill River watershed. In the Schuylkill basin, the most commonly occurring fish communities per 12-digit HUC (Hydrologic Unit Code) small watershed included the Coldwater Community, the Coolwater 2 Community, the Warmwater 2 Community and the River & Impoundment Community (Figure 2-2, see Chapter 7 for descriptions of fish communities). Some sub-watersheds of the Schuylkill like Perkiomen and French Creek watersheds mainly had habitats for warm-water communities; however the Coolwater 2 Community was also commonly found in the Little Schuylkill River basin. The lower main channel of the Schuylkill River and associated sub-basins primarily had fish found in the River & Impoundment Communities. Details in the community descriptions offer information about associated community species, habitats, community rarity, and conservation recommendations.

Further examination of communities at smaller scales could yield more specific information about stream habitat, condition and biological patterns. At the stream reach scale, community types determined by stream survey samples disclose the biological associations that are specific to a waterway. In French Creek State Park (also in the Schuylkill River watershed), a mix of habitats that support the Coldwater Community, Coolwater Community 2, Warmwater Community 1 and the River and Impoundment Community are found (Figure 2-3). The Coldwater Communities were found at the headwaters of French Creek and Six Penny Creek, where appropriate water quality and habitats are found. In contrast, sections of the lower parts of the French Creek watershed mainly have Coolwater Community 2 assemblages. The habitats in these reaches may be characterized by warmer waters and altered water chemistry.

Community types predicted for stream reaches where communities have not yet been sampled supply information about potential community types and habitats in a watershed. The prediction probability can be considered an index of likelihood for community occurrence; high prediction probabilities of > 60% are considered likely habitat reaches for the predicted assemblage. For example, the Coolwater Community predicted to occur in French Creek had a low prediction probability (30%), while the Warmwater 2 Community was predicted in the Schuylkill River with relatively high probability of occurrence (68%) (Figure 2-3).

The use of different taxonomic levels of macroinvertebrates in both community classification and biological monitoring are the subject of much debate in the aquatic science community (Reynoldson et al. 2001, Waite et al. 2004). An exploratory part of this project was to investigate differences between macroinvertebrate community classifications at two taxonomic levels: family and genus. These taxonomic levels are both commonly used in stream analyses for developing macroinvertebrate community groups and general aquatic research. Upon final analysis of the results from the communities at each taxonomic level, we determined that the genus macroinvertebrate classes were the most meaningful statistically and biologically. Therefore, we are endorsing our genus-level macroinvertebrate classification for use in applications related to ACC products and tools. In order to show the results of our community analyses and present users with the differences between classifications, both family and genus macroinvertebrate community classifications are described in the community descriptions (Chapters 5 & 6).

Physical Stream Types

We classified streams by physical, or "abiotic", characteristics to describe the physical diversity of flowing waters. Physical stream classes characterizing geology, stream slope (gradient), and watershed size were related to community habitats and represent environments supporting a variety of biological diversity. Stream classes can be used by conservationists, aquatic resource managers, and watershed planners to identify the range of aquatic environments in their area of interest. Stream types that are degraded in the majority of their range, like limestone streams in agricultural environments, may be considered for distinctive conservation actions. The physical stream type classification and its conservation and restoration applications are discussed further in Chapter 8.

Least-Disturbed Streams (LDS) Analysis

Information about the relative condition of community habitats and physical stream types can be used to prioritize management and protection actions for aquatic resource managers. We identified high-quality stream reaches (called Least-Disturbed Streams (LDS)) as those having little watershed disturbance in a landscape analysis. LDS reaches met criteria for having little non-point source pollution, point source pollution, and hydrologic alteration. In areas where streams face nearly ubiquitous disturbance (e.g., Piedmont streams), sliding scale LDS criteria were developed. The LDS criteria in these areas were relaxed to select the best examples of stream types.

High quality stream reaches have applications in biomonitoring, conservation, and restoration. Communities found in LDS reaches can be used as benchmarks for community restoration. Relatively undisturbed streams, such as those selected as LDS reaches, are used in biomonitoring; streams such as these are used as the standard against which polluted streams and biological assemblages evaluated. The LDS analysis is described in Chapter 9.

Watershed Conservation Prioritization

By combining data from many parts of the Aquatic Community Classification project, we are able to highlight unique riverine conditions that designate certain watersheds to be of greater conservation concern than others. Some watersheds may be of importance due to a single occurrence of a natural feature, such as the presence of a rare fish species or a high quality mussel community, but watersheds that hold multiple traits of conservation value should be set apart as a higher protection priority.

Information was combined from the biological community classification, the Least-Disturbed Stream (LDS) reach analysis, and biological metric scores calculated with fish and macroinvertebrate data from the ACC database. The metric calculations allowed us to assign metric scores to streams and watersheds and then rank them based on water quality and habitat condition (See Chapter 10 for more information on these metric calculations). The quantitative metric scores complement the community information, which provides qualitative information about the presence of certain community types and stream habitats. The watershed conservation prioritization is discussed in Chapter 10.

Watershed Restoration Prioritization

The goal of this portion of the study was to use all of the data compiled in the ACC project to determine which watersheds are in the worst shape and therefore a priority for habitat restoration. To do so, we combined information from our LDS reach analysis (see Chapter 9), biological metric scoring (see Chapter 10) and the locations of biological communities indicative of poor-quality stream habitat (Table 12-1). A multi-faceted approach such as this is more useful than simply examining developed land use or the occurrence of pollution-tolerant taxa; with the combination of both biotic and abiotic factors we are able to paint a picture of watersheds that are physically altered and the resident stream assemblages are experiencing the direct effects. The watershed restoration prioritization is detailed in Chapter 11.

Watershed Enhancement Areas

A third category of watersheds was developed for those areas that do not fall within either the Conservation or Restoration Prioritization categories. These intermediate quality "Watershed Enhancement Areas" represent watersheds that would likely benefit the most from restoration action, since they continue to hold some ecological value despite having some water quality issues. The same abiological and biological datasets were used in defining and describing these areas. This analysis is detailed in Chapter 12.

Combining ACC Tools

By combining the elements discussed above, we present unique ways to investigate stream resources and implement aquatic conservation practices. Utilizing these tools and methods should make conservation and restoration work in Pennsylvania more efficient, more measurable and more effective.

Stream conservation efforts can be easily streamlined with the use of the LDS and abiotic stream habitat tools. For example, after a project area (e.g., a watershed) has been identified, the habitat types within that project area may be determined. Determining which biological communities should be found in the various habitat types should help the monitoring and follow-up evaluation of these high quality watersheds.

ACC tools will make stream restoration efforts more efficient and measurable as well. Target conditions for degraded streams in need of restoration activity may be established by finding an LDS stream of the same abiotic habitat type and determining the biological community that exists there. The LDS stream will serve as a benchmark stream which will represent the goal condition of the stream in need of restoration. This will be a way to evaluate and measure the success of restoration work.

The utilities of all ACC tools are discussed further in the following chapters.

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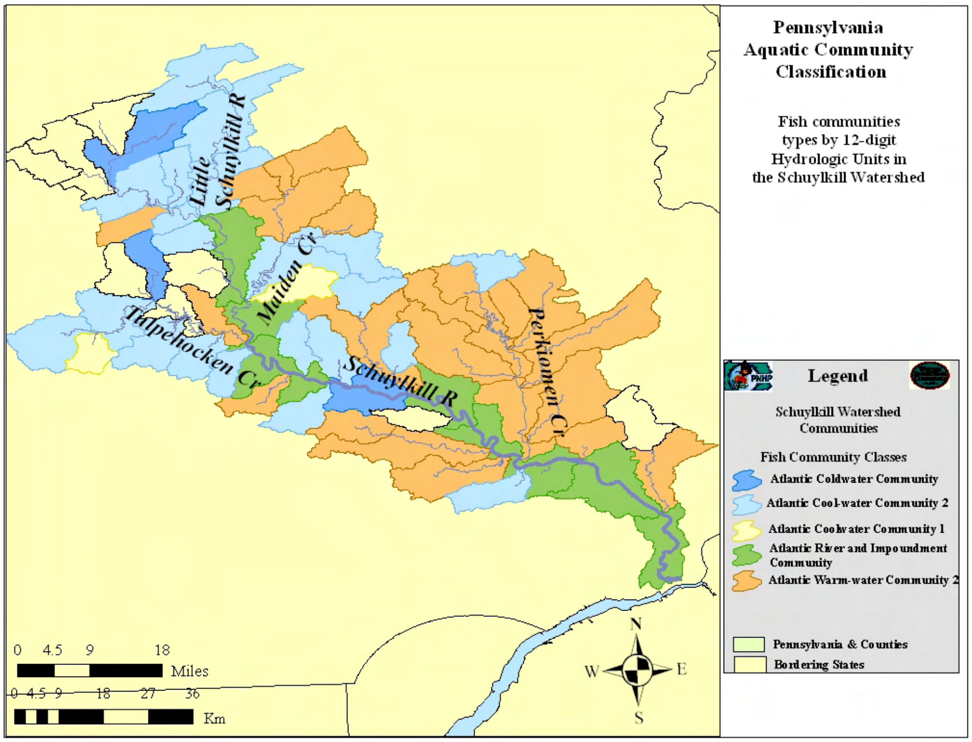

Figure 2-2. Watersheds in the Schuylkill Watershed, represented by their most commonly occurring fish communities.

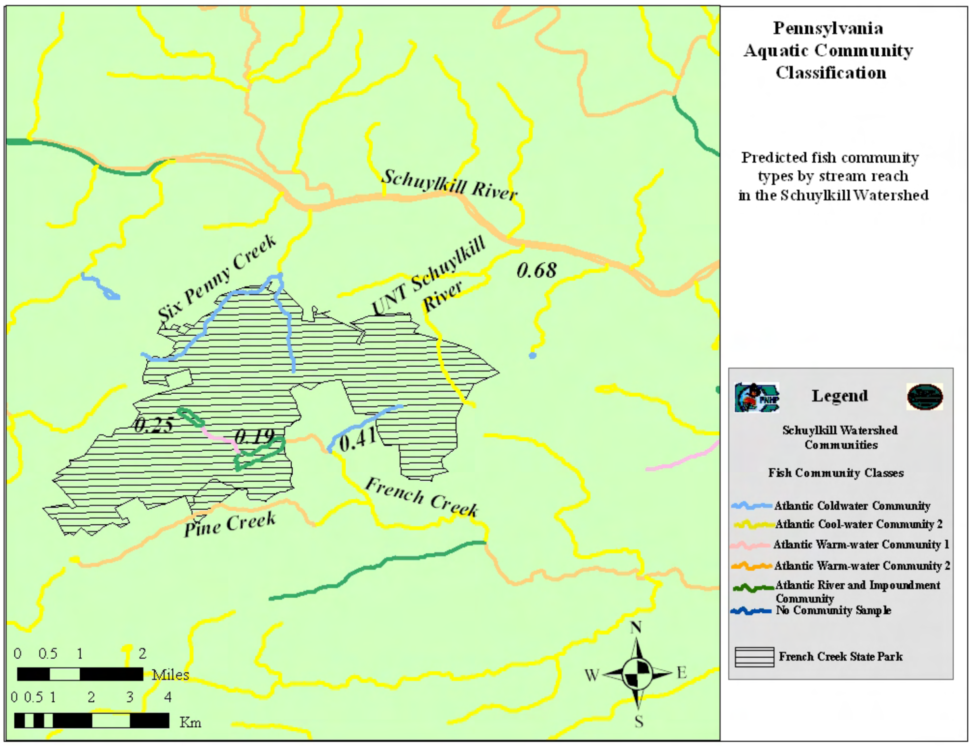

Figure 2-3. Actual and predicted fish communities classify stream reaches in and adjacent to the French Creek State Park in the Schuylkill River Watershed. The prediction probabilities for selected community reaches indicate that some communities are predicted with relatively high likelihood (>0.60), but others with lower prediction probabilities are less likely to occur.

3. Introduction to the Aquatic Communities of Pennsylvania

In the community description chapters (4-7), fish, mussel, and macroinvertebrate communities are described by the taxa that indicate each community type and the stream habitats the communities are commonly found in. Information about community rarity, threats and conservation recommendations is also included.

Due to zoogeographic differences associated with the multiple drainage basins in Pennsylvania, fish and mussel community classifications were segregated by major watersheds. Fish communities are described for two separate watersheds: Atlantic Basin (Delaware, Susquehanna and Potomac River watersheds) and the Ohio – Great Lakes Basins (Ohio River, Genesee River and Lake Erie watersheds). Mussel communities are described from three areas: 1) Delaware River Basin, 2) Susquehanna and Potomac River Basins and 3) the Ohio River and Lake Erie Basins (Figure 2-1).

Aquatic communities and watersheds

What is an aquatic community?

A biological community represents a group of organisms that occur together in a particular habitat. These organisms require similar habitats, may be dependent on each other for food or other resources, and likely depend on similar processes in their environment.

The aquatic communities in this report refer to three types of organisms found in streams: mussels, macroinvertebrates, and fish. All three groups were classified separately. Aquatic communities can be used to describe the habitats and water quality of the streams that they are found in.

Where do these aquatic communities occur?

The community types described here are restricted to flowing water habitats, such as rivers and streams. Communities are identified within watersheds, which are commonly defined as an area of land where all water drains to the same point (www.epa.gov). In watersheds, the water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways converge into streams and rivers, which become progressively larger as the water moves on downstream, eventually reaching an estuary and ultimately the ocean. All land is part of a watershed and every stream, tributary, or river has an associated watershed. Small watersheds join to become larger watersheds, just as small streams join to become larger streams.

In order to discuss watersheds in terms of community types and watershed conservation, we are using relatively small units of land known as Hydrologic Unit Code 12, or "HUC12", watersheds (generally around 20,000 acres in size). The United States Geological Survey is responsible for delineating HUC watersheds of different sizes. For more information on HUC watersheds: http://water.usgs.gov/GIS/huc.html.

How were aquatic communities determined?

As a statewide project of the Pennsylvania Natural Heritage Program, researchers working on the Pennsylvania Aquatic Community Classification (ACC) project collected aquatic datasets from state and federal agencies, interstate basin commissions, universities and museums. The biological, habitat and water chemistry data were first centralized into a large database. The information was then analyzed with standard statistical methods in order to identify biological community types and stream habitat associations.

In some places, the most common community type in each small watershed was chosen to represent typical watershed organisms and habitats. Although other community types may exist in a particular watershed, the major community type is described.

What do mussels, macroinvertebrates and fish tell me about streams and watersheds?

All three of these types of organisms hold unique niches in Pennsylvania's streams and rivers. Macroinvertebrates include aquatic insects, worms and crustaceans (e.g., crayfish and scuds), which generally occupy the lower levels of food webs in aquatic systems. The presence of certain macroinvertebrates reflects differences among stream locations in food availability, water quality and habitat type. Perhaps most importantly, macroinvertebrate communities provide an overall picture of stream health; macroinvertebrate taxa generally respond to environmental stress in predicable ways, based on their levels of tolerance to different stressors.

Macroinvertebrates are an important prey source for many fish. Food resources and spawning habitats can be specific for different species of fish as different species will have different habitat requirements and habitat needs. Just like macroinvertebrates, fish are influenced by stream quality and the condition of the watershed. For example, sediment from erosion at a mismanaged construction site near a stream may cover substrates that are necessary for fish such as brook trout to lay their eggs. Layers of fine particles from sedimentation such as this can also smother the habitats that developing fish require, preventing them from reaching adult life stages.

As filter feeders, which siphon water to extract particles of food, mussels also require relatively clean water to survive. They are particularly sensitive to industrial discharge, abandoned mine drainage and urban runoff pollution. Mussels generally require gravelly, sandy or muddy habitats where they can burrow into the stream bottom. They typically occur in larger streams and in rivers that contain sufficient nutrient levels to supply them with food.

Many factors influence the occurrence of aquatic communities, including natural variations in stream environments. Fast-flowing, cold streams flowing from ridge tops provide different habitat types than slow, warmer rivers meandering through valleys. Aquatic communities reflect these differences in stream type and environment. Geology varies widely across Pennsylvania, and flowing water may have unique chemical compositions based on the types of rocks that it contacts.

Human alterations to aquatic environments can exert much stronger effects than any type of natural variation discussed above. Many changes in a watershed can be detected within its streams and rivers. If implemented improperly, timber harvest, agriculture, urban development and road management are among some watershed alterations that may cause changes in water quality and stream habitats from non-point source pollution. Additionally, a number of pollutants can enter aquatic systems from point sources, such as discharges from sewage treatment plants, abandoned mines and other industrial sources.

Why are there two macroinvertebrate community classifications?

The use of different taxonomic levels of macroinvertebrates in both community classification and biological monitoring are subject of debate in the aquatic science community (Reynoldson et al. 2001, Waite et al. 2004). An exploratory part of this project was to investigate differences between macroinvertebrate community classifications at two taxonomic levels: family and genus. These taxonomic levels are both commonly used in stream analyses for developing macroinvertebrate community groups and general aquatic research. Upon final analysis of the results from the communities at each taxonomic level, we determined that the genus macroinvertebrate classes were the most statistically and biologically meaningful. Therefore, we are endorsing our genus-level macroinvertebrate classification for use in applications related to ACC products and tools. In order to show the results of our community analyses and present users with the differences between classifications, both family and genus macroinvertebrate community classifications are described in the community descriptions (Chapters 6 & 7).

A plain pocketbook mussel (**Lampsilis cardium*****) in Conewango Creek, Warren Co., PA displaying its fish-mimicing egg lure in order to attract fish. Mussels release their larvae, or glochidia, onto the gills of fish in order to disperse their offspring.***

How is an organism's rarity determined?

Species of conservation concern (considered state or globally rare) that may occur with each community type are listed (Table 3-1). State rankings refer to an animal's rarity status in Pennsylvania, and the global rankings refer to an organism's rarity on the world-wide scale.

NatureServe, the parent organization of Natural Heritage programs, works with Heritage biologists to assign these rankings to each species individually and use these rankings as a way to quantify the rarity, and therefore conservation priority, of all organisms. An organism can have any combination of state and global ranks; if an organism is rare in Pennsylvania, but its populations are secure worldwide, it may have a ranking of S3/G5. If an organism is rare worldwide and extremely rare in Pennsylvania, it may be assigned a ranking of S1/G3. More information on the state- and global-ranking system is available at: www.natureserve.org.

Table 3-1. State and Global ranks and definitions used by Natural Heritage programs to rank the rarity of organisms at the state and global levels.

State/Global Rank	Rank Description
SX/GX	**Extirpated** - Element is believed to be extirpated/extinct from the state/ its entire global range
SH/GH	**Historical** – Only known from historical records
S1/G1	**Critically Imperiled** - Critically imperiled because of extreme rarity or because vulnerability to extirpation.
S2/G2	**Imperiled** - Imperiled because of extreme rarity or because vulnerability to extirpation.
S3/G3	**Vulnerable** - Vulnerable because rare and uncommon, or found only in a restricted range
S4/G4	**Apparently Secure** - Uncommon but not rare, and usually widespread.
S5/G5	**Secure** - Demonstrably widespread, abundant, and secure

How does this classification compare to other classifications of Pennsylvania's streams?

The state of Pennsylvania protects aquatic life using a "designated use" classification system of waters in the Commonwealth under the federal Clean Water Act. Four types of aquatic life should be propagated and maintained based on their designation in Pennsylvania (PA Code 93.3; http://www.pacode.com/secure/data/025/chapter93/s93.3.html):

- **Cold Water Fishes (CWF)**: Fishes and associated aquatic flora and fauna preferring colder waters (trout species are included in the cold water fishes).
- **Warm Water Fishes (WWF)**: Fishes and associated aquatic flora and fauna preferring warmer waters.
- **Trout Stocked Fishes (TSF)**: Stocked trout species (maintained from Feb 15 to July 31) and warm-water flora and fauna.
- **Migratory Fishes (MF)**: Fishes (those having anadromous, catadromous or similar life histories) which must migrate through flowing waters to their breeding habitats.

Additionally, some waterbodies receive additional special protections as "Exception Value" or "High Quality" waters because they are especially valued for aquatic life, water quality, and/or recreation. Meeting relatively high water quality and other standards qualify the water bodies for additional protections from degradation beyond the aquatic life uses (PA Code 93.4b, www.pacode.com/secure/data/025/chapter93/s93.4b.html).

The purpose and meanings differ between the classes defined in Pennsylvania aquatic life use/special protection designations and aquatic fish assemblages from the Pennsylvania Aquatic Community Classification. The similar nomenclature of both classifications may be confusing, but in both cases it is meant to relatively define the organisms and aquatic habitats along a gradient of water temperatures (and associated stream size). The PA stream designations broadly encompass habitats occupied by several ACC fish assemblages (Table 3-2) and are used in water quality regulation. The ACC biological community descriptions generally offer more information about associated species, stream type and habitat condition than the classification systems currently used by Pennsylvania's state agencies. See Appendix C for more information.

What information is used to describe the communities and their habitats?

<u>Community Indicators</u> - The animals that are most commonly associated with each community type are listed. While not every organism described in a given community will occur in each location where this community is found, organisms listed in this section give a general account of which organisms to expect in that community's habitat.

Table 3-2. Pennsylvania aquatic life uses and special protection water designations and their occurrence with ACC fish assemblages. (EV = Exceptional Value Waters, HQ = High Quality waters, CWF= Cold Water fishes, WWF= Warm Water Fishes, TSF= Trout Stocked Fishes, MF= Migratory Fishes)

Increasing watershed area ↓	Atlantic Basin	Ohio – Great Lakes Basins	EV	HQ	CWF	WWF	TSF	MF
	Coldwater	Coldwater	x	x	x			
	Coolwater 1, Coolwater 2	Coolwater		x	x	x	x	x
	Warmwater 1, Warmwater 2	Warmwater			x	x	x	x
	River & Impoundment	Large River				x		x
	Lower Delaware River					x		x

<u>*Species of Conservation Concern*</u> - For taxa groups that have rare species tracked (fish and mussels, in this study), any taxa that are associated with a community and are also tracked for their rarity (Table 3-1) are noted.

<u>*Habitat*</u> - Average values of the community characteristics across their entire range from a large dataset are presented. Size of the stream's watershed, gradient (slope) and elevation are a few habitat characteristics that may be important to the community type. Local conditions are also mentioned.

Some specific criteria about community types and their watersheds are included in the *Habitat* section of the community descriptions:

- *Land Use Composition* - Trends in land use patterns were also calculated for each stream reach as percentages of the entire contributing watershed. Different amounts of urban, agricultural or forested area in watersheds can directly influence stream habitat and resident organisms. For example, some organisms are only found in heavily forested (undisturbed) watersheds, while others can tolerate the altered habitat types that are found in heavily agricultural or urbanized settings.

In the Macroinvertebrate sections, some metrics are discussed in the *Habitat* sections that provide information about the health and ecological function of the streams:

- *EPT Richness* - Proportion of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) that make up a sample of aquatic macroinvertebrates. These three kinds of insects are generally the most sensitive to habitat alteration. The higher the EPT richness, the higher the quality of the water and habitat.

- *Taxa Richness* - The number of taxa present in a sample. Generally, the more species an assemblage has, the healthier and more naturally-functioning a stream is.

- *Pollution Tolerance* - Macroinvertebrate taxa have rankings on a scale of 0-10 that refer to their tolerance level to organic pollution. A score of zero indicates that a certain taxon is intolerant of any pollution, while a score of 10 signifies that the organism is capable of living in high levels of pollution. Since tolerance values can vary regionally, we used the Pennsylvania Department of Environmental Protection's rankings whenever possible.

Some water chemistry variables are also valuable in understanding the habitat conditions of a community:

- *pH* - The degree of acidity of the water, measured by the concentration of hydrogen ions in a solution. Stream water is generally near neutral, with a pH of around seven. The concentration of hydrogen ions determines the alkalinity ($pH > 7$) or acidity ($pH < 7$) of stream water.

- *Water Temperature* - This is important to stream organisms because it influences their metabolism and growth. Each aquatic animal species has a tolerance for specific temperature ranges and cannot survive temperatures outside of their range. Cool water temperatures are also related to high dissolved oxygen levels in streams.

- *Conductivity* - Defined as the capacity of the water to conduct an electrical current. It is expressed in microsiemens per centimeter (µS/cm) at 25 °C. Conductivity is determined by the types and quantity of dissolved substances (ions) in water. In streams, conductivity can be elevated because of pollution (generally from urbanization) or natural causes.

- *Alkalinity* - A measure of how well a waterbody resists or does not resist changes in acidity. If a stream has high alkalinity and can neutralize acids sufficiently, then it is subject to little change in pH. A stream with low alkalinity is less resistant to changes in acidity. In addition, a stream with low alkalinity is more susceptible to becoming acidic from acid precipitation or other causes.

Stream Quality Rating - Community types are generally ranked as low, medium, or high quality based on habitat, water chemistry and sensitivity of the community's organisms to pollution.

Community Rarity - Rarity was determined by examining the number and distribution of known community locations in Pennsylvania.

Threats - Where known, potential pollution sources or other threats that may alter the natural state of the community are described.

Conservation Recommendations - Issues for natural resource managers and land planners to consider in the protection, restoration, and management of watersheds and communities are described.

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United States Geological Survey, Water Resources; http://water.usgs.gov/GIS/huc.html.

Waite I.R., A.T. Herlihy, D.P. Larsen, N.S. Urquhart and D.J. Klemm. 2004. The effects of macroinvertebrate taxonomic resolution in large landscape bioassessments: an example from the Mid-Atlantic Highlands, USA. *Freshwater Biology*. 49 (4): 474-48.

Quick Reference: Definitions & Abbreviations Used in Community Descriptions

EPT Richness - Proportion of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) that make up a sample of aquatic macroinvertebrates.

Gradient (%) - Used to describe how steep the slope is for a stream segment, and therefore how fast the water moves. Measured as a percent change in elevation from the top of the reach to the bottom.

m - Abbreviation for 'meter'. One meter = 3.28 feet.

mg/l - Milligrams per liter. Here, it is the unit of measure used to quantify alkalinity.

mi^2 - Square miles; used here to describe the size of watersheds.

MI - Macroinvertebrate

µS/cm - Microsiemens per centimeter. Here, this is the unit of measure used to quantify the specific conductivity of stream water.

$\bar{x}$ - Symbol for "average of".

Chapter 4.

Freshwater Mussel Community Descriptions

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 km^2 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.

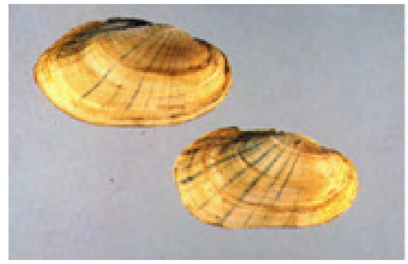
Invasive mussel species like the zebra mussel (*Dreissena polymorpha*) and the Asian clam (*Corbicula fluminea*) may be damaging to populations of native mollusks. Zebra mussels damage native mussels by attaching to individuals in large numbers and eventually killing them (Strayer and Jirka 1997). Other 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

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

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 µS/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 maybe compromised. In some locations, 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 back-waters 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 water-sheds 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*)

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

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 µS/cm) and moderate alkalinity ($\bar{x}$ = 45 mg/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

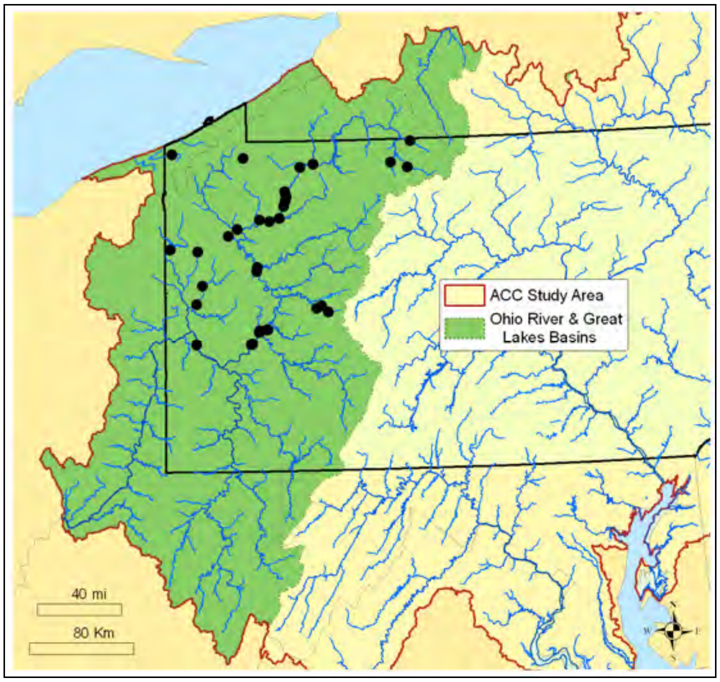
Threats: Many tributaries to the Ohio River and lower Allegheny River are impaired. The rivers are heavily utilized in shipping and industry. These watersheds are heavily mined and urbanized in areas, especially in the southwestern corner of the state. Several stressors threaten water quality and habitat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

The Spike Mussel Community is found in low gradient areas of the Allegheny River and some of its tributaries, as well as some stream reaches in the Beaver River Basin.

Photo source: PNHP

Ohio – Great Lakes Basins Mussels: Fluted Shell Mussel Community

Community Indicators: fluted shell (*Lasmigona costata*), kidneyshell (*Ptychobranchus 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 5^{th} 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 µS/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

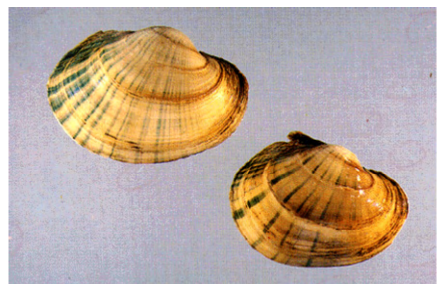
Community Rarity: No

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:

The Fluted shell Mussel Community is common in French Creek (Ohio River watershed, above), in moderate gradient habitats with sand and gravel substrates.

Photo source: PNHP

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 ($\overline{X}$ < 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 ($\overline{X}$ = 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.

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

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 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 mi^2 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 µS/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

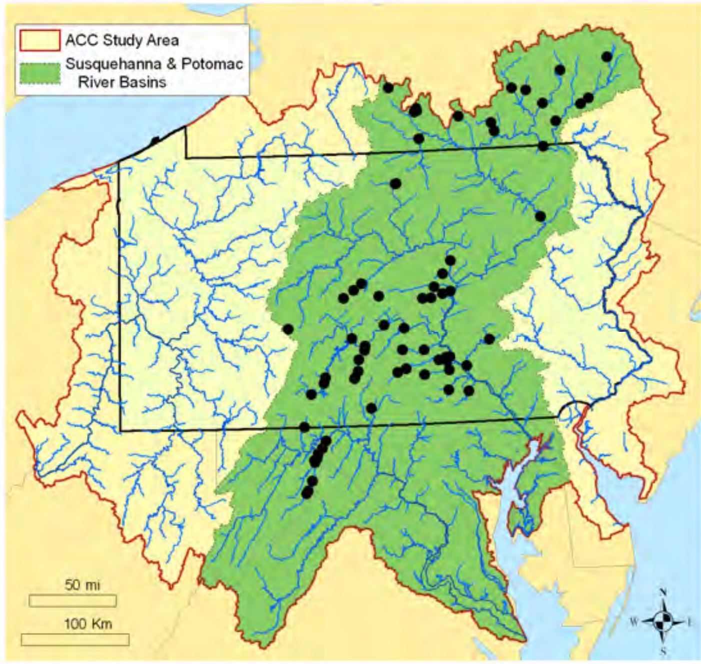
Threats: Large streams and rivers often face an assortment of landscape alterations that have degrading effects on water quality. Abandoned mine drainage, urban pollution (e.g., stormwater and road runoff, combined sewer overflows, etc.) and non-point source pollution from poorly maintained agricultural 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

Strongest Indicators of Community Type

Eastern floater (*Pyganodon cataracta*)

Photo source: PNHP

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 mi^2) at moderate elevations ($\bar{x}$ = 209 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 drainage are very toxic to mussel communities. The spread of non-native zebra mussels is also a concern.

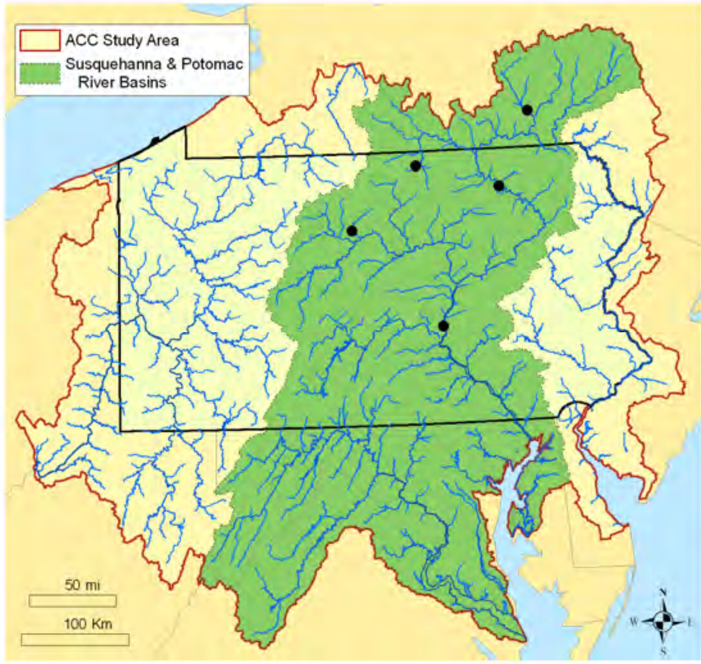
Conservation Recommendations: Since this community is usually found in slow moving backwaters or standing waters in fine sand, silt, or muddy substrates (Bogan 2002, Nedeau 2000, Strayer and Jirka 1997), protection of backwater habitats will ensure the overall conservation of this mussel community.

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:

The Eastern Floater Community prefers the quieter backwater areas of rivers.

Photo source: PNHP

Susquehanna – Potomac River Basins Mussels: Yellow Lampmussel Community

Community Indicator: yellow lampmussel (*Lampsilis cariosa*)

Additionally, the eastern floater (*Pyganadon 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 mi^2) in the Susquehanna and Potomac River drainages at low elevations ($\bar{x}$ = 198 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*)

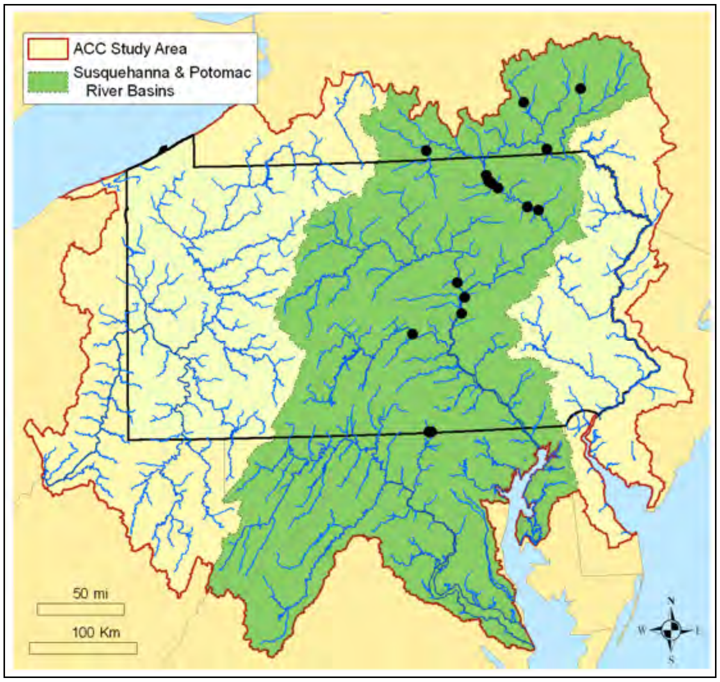
Photo source: PNHP

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 udulatus*)

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 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, Nedeau 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 mg/l) and moderate conductivity ($\bar{x}$ = 200 µS/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

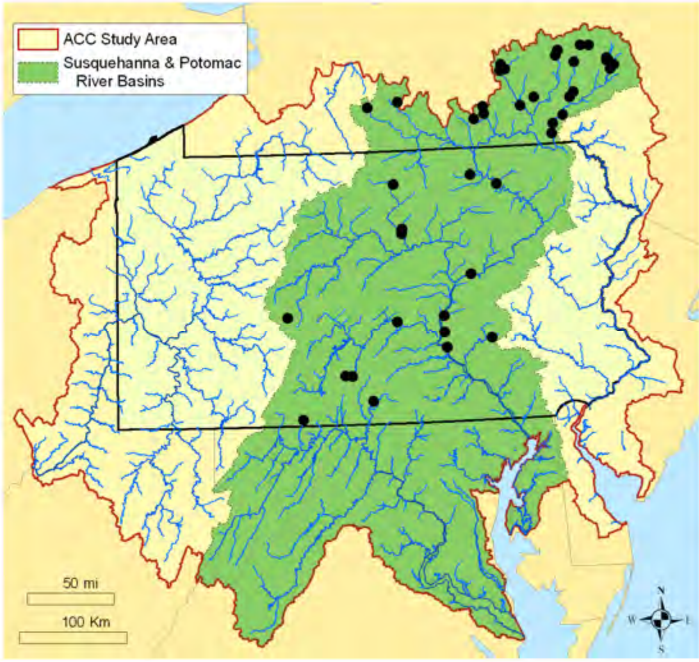
Threats: Since the Squawfoot Mussel Community exists mainly in streams and smaller rivers, it does not experience the same habitat and water quality impairments as other mussel groups living in large rivers. Abandoned mine drainage (AMD) and poorly maintained agricultural practices are likely the greatest 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 complex[1] (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 mi^2 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 µS/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

[1]The 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).

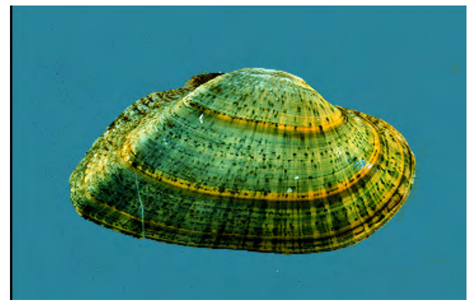
Habitat: The community was only found in the North Branch of the Susquehanna watershed in select locations. The species representing the community can tolerate a variety of habitat characteristics from small creeks to medium-sized and large-sized rivers (Strayer and Jirka 1997). Because the elktoe is 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 mi^2 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 ($\overline{X}$ = 2705 mi^2 watershed area) in low to moderate elevation ($\overline{X}$ = 157 m). Stream gradients are somewhat high for mussel habitat ($\overline{X}$ = 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 ($\overline{X}$ = 77 %), with small amounts of agricultural land ($\overline{X}$ = 12 %). Sandstone ($\overline{X}$ = 49%) and shale ($\overline{X}$ = 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 (*Pyaganadon 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 ($\overline{X}$ = 3,808 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 ($\overline{X}$ = 95 m) and gradients ($\overline{X}$ = 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 ($\overline{X}$ = 56%) and shale ($\overline{X}$ = 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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Chapter 5.

Family-Level Macroinvertebrate Community Descriptions

Family MI High Quality Headwater Stream Community

Strongest Indicators of Community Type

Rolledwinged stonefly (Leuctridae)

Photo source: www.dfg.ca.gov

Small minnow mayfly (Baetidae)

Photo source: www.dec.state.ny.us

Community Indicators: rolledwinged stonefly (Leuctridae), small minnow mayfly (Baetidae), crayfish (Cambaridae), trumpetnet caddisfly (Polycentropodidae), darner dragonflies (Aeshnidae)

Habitat: Typically found in small ($\bar{x}$ = 33.2 mi^2 watershed area), high gradient ($\bar{x}$ = 2.3%), high elevation ($\bar{x}$ = 397 m) streams, this community is indicative of high quality headwater stream habitats. Water chemistry is characterized by moderate values of alkalinity ($\bar{x}$ = 51 mg/l) and conductivity ($\bar{x}$ = 223 uS/cm).

This community is typified by a diverse group of macroinvertebrates that are generally sensitive to organic pollution. These organisms may tolerate other types of pollution, namely those types that can be found in suburban streams. The amount of urban area in the watershed is fairly low ($\bar{x}$ = 1.3%), but agricultural land makes up a relatively large proportion of the watershed ($\bar{x}$ = 29.6%) and may negatively influence some habitats that support this community.

Despite some potential pollution sources, the imprint from human development seems to be small where this community is found. This community has the second highest taxa richness ($\bar{x}$ = 16.3) and EPT richness ($\bar{x}$ = 8.3) values of all the family-level macroinvertebrate spring communities. It also has a low proportion of organisms that are tolerant of organic pollution ($\bar{x}$ = 3.9%).

Stream Quality Rating: High

Community Rarity: No

Threats: This community usually occurs in watersheds with moderate urban and agricultural development. In some locations, siltation and excess nutrients from agriculture may be impairing stream systems. Urban streams generally receive more storm water runoff from roads and municipal point source discharges, such as sewage treatment plant effluent.

Conservation Recommendations: This community is representative of high-quality stream habitat. Reducing runoff from poorly buffered agricultural land would be most beneficial for improving stream quality for the High Quality Headwater Stream Community. In areas such as these, runoff and stream bank erosion can be controlled by installing riparian buffers of an adequate width along pastures and crop fields and excluding livestock from streams and riparian zones. Stream habitats will improve over time with the addition of riparian buffers.

Retention and treatment of storm water from roads and urban developments would ameliorate water quality problems in streams receiving these urban effluents. In addition, adequate remediation of sewage treatment discharges would improve stream water quality and habitat condition for all aquatic communities. Mitigation of all direct stream discharges is recommended.

Family MI High Quality Headwater Stream Community

Known Locations:

Example Habitat:

Small, high-gradient streams with rocky habitats are typical habitats of the Family MI High Quality Headwater Stream Community.

Photo source: PHNP

Family MI Common Headwater Stream Community

Community Indicators: little plain brown sedge (Lepidostomatidae), slender winter stonefly (Capniidae), spiketail dragonflies (Cordulegastridae)

Habitat: The Common Headwater Stream Community is generally found in high gradient ($\bar{X}$ = 3.0%) streams at high elevations ($\bar{X}$ = 397 m). Streams where this community exists appear to have a diversity of in-stream habitat types with little channelization or riparian disturbance.

Streams that support this community type generally have low amounts of dissolved ions, low alkalinity ($\bar{X}$ = 22 mg/l) and moderate conductivity ($\bar{X}$ = 269 µS/cm) values are typical. However, this community type may occur in streams that are degraded by abandoned mine drainage (AMD) (Figure 5-1), which can dramatically alter the water chemistry profiles for affected streams.

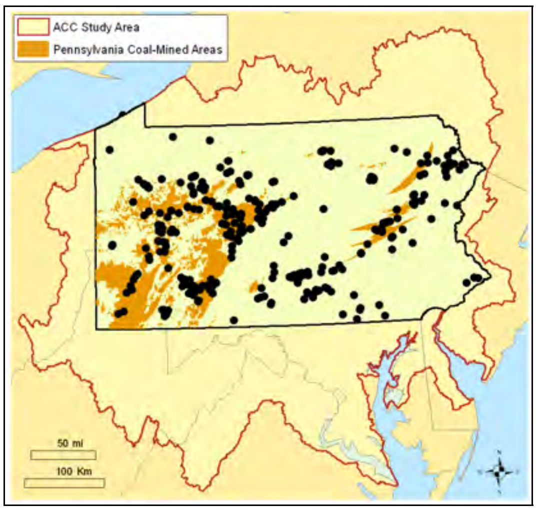


Figure 5-1. The locations of the Common Headwater Stream Community (black dots) show considerable overlap with the coal-mined areas of Pennsylvania.

The watersheds are primarily forested where this community occurs. Typically, only small amounts of agriculture ($\bar{X}$ = 12.2% of the watershed) and urbanization ($\bar{X}$ = 2.0%) are associated with these watersheds.

The taxa richness of this community is relatively moderate ($\bar{X}$ = 10.4), but the EPT richness is comparatively high ($\bar{X}$ = 7.9) and the proportion of pollution tolerant organisms is second lowest of all spring family-level macroinvertebrate communities ($\bar{X}$ = 2.5%).

Stream Quality Rating: Low

Community Rarity: No

Strongest Indicators of Community Type

Little plain brown sedge (Lepidostomatidae)

Photo source: www.dec.state.ny.us

Slender winter stonefly (Capniidae)

Photo source: www.dec.state.ny.us

Threats: AMD and acid deposition from air pollution occur often with this stream community, and appear to be the driving force behind its biological composition. Acidic streams can be inhabited by some stoneflies that are tolerant of low pH, but few other organisms can survive in streams with toxic AMD.

Conservation Recommendations: Addressing water pollution from AMD is critical for the Common Headwater Stream Community. Adequate remediation of the water that discharges from abandoned mines can reduce its acidity and levels of dissolved metals, greatly improving water quality and habitat condition. Liming, or the application of alkaline materials, watersheds and/or streams raises the pH of the water to normal levels and decreases the solubility of the dissolved metals associated with AMD. This method can be expensive due to the costs of the materials and maintenance that is required post-liming; the alkaline materials produce a metal-laden sludge that must be removed from the streams.

Passive treatment of AMD can offer a lower cost alternative to active chemical application. For example, constructed wetlands allow naturally occurring chemical and biological processes that facilitate AMD treatment to take place in a controlled treatment system, rather than in the receiving water body. For more information on AMD and its remediation, see the Pennsylvania DEP's Bureau of Abandoned Mine Reclamation webpage:

http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm

Family MI Common Headwater Stream Community

Known Locations:

Example Habitat:

High quality habitats in small streams are the typical habitat of the Common Headwater Stream Community (A). However, sources of abandoned mine drainage (B) may impair streams such as these.

Photo source: PNHP

Family MI AMD Stream Community

Strongest Indicators of Community Type

Alderfly (Sialidae)

Photo source: www.benthos.org

Dance Fly (Empididae)

Photo source: http://ceratium.ietc.wwu.edu/IWS

Community Indicators: alderfly (Sialidae), dance fly (Empididae). This community is also associated with the watersnipe fly (Athericidae), saddlecase maker (Glossosomatidae), and common burrower mayfly (Ephemeridae).

Habitat: The AMD (abandoned mine drainage) Stream Community is found in small to medium sized streams ($\bar{X}$ = 33.5 mi^2 watershed area) with intermediate gradient ($\bar{X}$ = 1.6%). The high conductivity ($\bar{X}$ = 417 µS/cm) and low pH that often accompany AMD are found in watersheds containing the AMD Stream Community. Alkalinity is typically moderate in the streams with this community type ($\bar{X}$ = 47 mg/l).

Watershed land use suggests that agricultural land ($\bar{X}$ = 19.0% of the watershed) and urbanization ($\bar{X}$ = 15.6%) likely lead to water quality impairment where this community is found. However, coal mining is probably the main source of degradation in these streams (Figure 5-2). Poor habitat quality scores also accompany this community type.

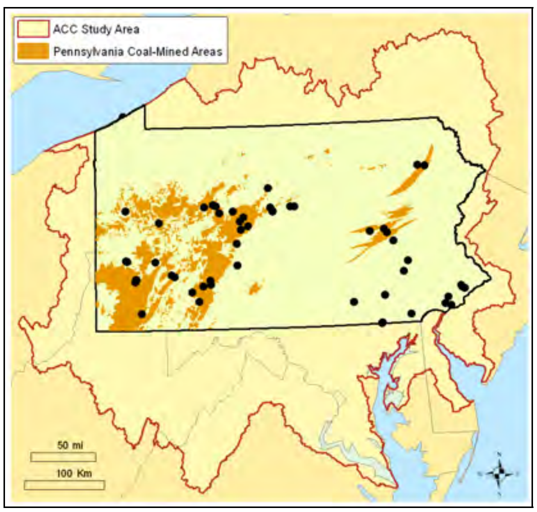


Figure 5-2. Locations of the AMD community (black dots) show considerable overlap with the coal-mined areas of PA.

This community shows the poorest taxa metrics of all family-level macroinvertebrate groups, with a mean taxa richness of 5.2 and mean EPT richness of 6.3. The proportion of pollution-tolerant organisms is also relatively high ($\bar{X}$ = 12.4%).

Stream Quality Rating: Low

Community Rarity: No

Threats: AMD is the most common pollution source in watersheds that contain the AMD Stream Community. In some areas, siltation and lack of riparian vegetation may also degrade these habitats.

Conservation Recommendations: Addressing water pollution from AMD and acid deposition are critical for the AMD Stream Community. Treating AMD can reduce acidity and levels of dissolved metals in the water and greatly improve stream habitat quality. Liming, or the application of alkaline materials, watersheds and/or streams raises the pH of the water to normal levels and decreases the solubility of dissolved metals associated with AMD. This method can be expensive due to material cost and the required maintenance post-liming; alkaline materials produce a metal-laden sludge that must be removed from the stream.

Passive treatment of AMD, such as the use of mitigated AMD wetlands, can offer a lower cost alternative to active chemical application. For more information on AMD and its remediation, see the PA DEP's Bureau of Abandoned Mine Reclamation webpage:

http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm

Family MI AMD Stream Community

Known Locations:

Example Habitat:

The presence of the AMD Stream Community generally indicates the presence of urbanization and/or abandoned mine drainage (AMD) in the watershed.

Photo source: PNHP

Family MI High Quality Small Stream Community

Community Indicators: brushlegged mayfly (Isonychiidae), fingernet caddisfly (Philopotamidae), dobsonfly (Corydalidae), saddlecase maker (Glossosomatidae), watersnipe fly (Athericidae), common burrower (Ephemeridae), snail-case maker caddisfly (Helicopsychidae)

Strongest Indicators of Community Type

Brushlegged mayfly (Isonychiidae)

Photo source: www.dec.state.ny.us

Fingernet caddisfly (Philopotamidae)

Photo source: www.dec.state.ny.us

Habitat: This community is found in small to medium-size streams ($\bar{x}$ = 67 mi^2 watershed area) of moderate elevation ($\bar{x}$ = 251 m) and intermediate gradient ($\bar{x}$ = 1.4%). Urban land cover in the watershed is relatively low ($\bar{x}$ = 1.9%), but moderate amounts of agricultural land ($\bar{x}$ = 33.0%) may have an adverse influence on water quality and stream habitat where this community occurs.

The High Quality Small Stream Community is typically found in streams with mixed substrates. This community type is indicative of high quality streams, and the associated organisms are generally intolerant of pollution.

Water chemistry values of the streams that support this community type are usually typified by moderate alkalinity ($\bar{x}$ = 53 mg/l), moderate conductivity ($\bar{x}$ = 203 µS/cm) and a neutral pH.

This community has high values for taxa richness ($\bar{x}$ = 16.0) and EPT richness ($\bar{x}$ = 8.2). These values are among the highest of all family-level macroinvertebrate communities. Only a small portion of the organisms that make up this community are tolerant to pollution ($\bar{x}$ = 5.8%), which also indicates streams of high quality.

Stream Quality Rating: High

Community Rarity: No

Threats: Organisms in the High Quality Small Stream Community are sensitive to organic pollution and habitat degradation. The group occurs in watersheds with moderate amounts of agricultural land, which can alter in-stream habitat if improperly managed. Poorly buffered agricultural land can lead to the input of excess nutrients and sediments into streams.

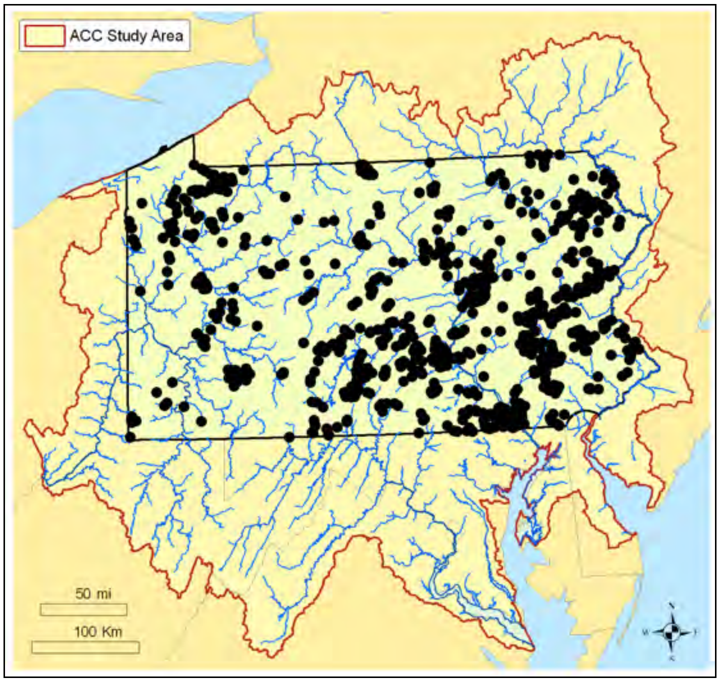
In urban locations, municipal point sources (e.g., sewage treatment plants and impervious surface runoff) may affect water quality. Urban streams receive elevated levels of inorganic pollutants and are prone to dramatic rises in water levels during storm events.

Conservation Recommendations: This community is representative of high-quality stream habitat. While some non-point source pollution occurs in watersheds supporting the High Quality Small Stream Community, the pollution problems here are less severe than in other stream types. In areas where non-point source agricultural pollution is occurring, runoff and stream bank erosion can be controlled by installing riparian buffers of an adequate width along pastures and crop fields and excluding livestock from streams and riparian zones. Stream habitats will improve over time with the addition of riparian buffers.

Mitigation of any direct stream discharges, including urban stormwater runoff and point-source sewage effluent, is recommended. Retention and treatment of storm water would ideally ameliorate water quality issues in streams receiving urban effluents. Upgrades in sewage treatment systems would also improve stream water quality and habitat condition.

Family MI High Quality Small Stream Community

Known Locations:



Example Habitat:

Typical habitats of the High Quality Small Stream Community are small to medium-sized streams with diverse stream-bottom habitats and high water quality.

Photo source: PNHP

Family MI Low Gradient Valley Stream Community

Community Indicators: riffle beetle (Elmidae), waterpenny beetle (Psephenidae) netspinning caddisfly (Hydropsychidae), Asian clam (*Corbicula fluminea*), narrow-winged damselfly (Coenagrionidae), rusty dun mayfly (Caenidae), fingernail clam (Sphaeriidae), freshwater limpet (Ancylidae), broad-winged damselfly (Calopterygidae)

Habitat: This community generally occurs in medium-sized streams ($\bar{x}$ = 75.3 mi^2 watershed area). The intermediate gradients ($\bar{x}$ = 1.0%) of valley streams at moderately low elevations ($\bar{x}$ = 201 m) characterize the habitat for this community.

Water chemistry values associated with the Low Gradient Valley Stream Community are high for alkalinity ($\bar{x}$ =76 mg/l) and conductivity ($\bar{x}$ = 318 µS/cm), but pH generally remains neutral. Moderately high amounts of urban and agricultural land cover in the watershed ($\bar{x}$ = 7.2 % and 44.5%, respectively) contribute to water quality issues in watersheds where this community occurs. Additionally, forest cover is relatively low in these watersheds ($\bar{x}$ = 46.1% of the watershed).

This community has moderate values for taxa richness ($\bar{x}$ = 13.5) and EPT richness ($\bar{x}$ = 7.0). However, over 14% of the organisms in these communities are tolerant to organic pollution, which is the second highest proportion for all family-level macroinvertebrate communities. This means that this community represents a biologically diverse assemblage of macroinvertebrates that are not necessarily sensitive to disturbances in the watershed.

Stream Quality Rating: Medium

Community Rarity: No

Threats: The exotic Asian clam, *Corbicula fluminea*, commonly occurs with this community type. The Asian clam may be a threat to other bivalves due to competition for food resources and habitat.

The habitats for this community type may receive pollution from a variety of sources. In these streams, water quality may be moderately degraded from excess nutrients, habitat modification or siltation due to poorly maintained agricultural practices. In heavily populated areas, municipal point sources such as sewage treatment plants and urban stormwater effluents may contaminate these streams. Abandoned mine drainage (AMD) may negatively influence water quality and community habitats in some locations.

Strongest Indicators of Community Type

Riffle beetle (Elmidae)

Photo source: www.epa.gov

Waterpenny beetle (Psephenidae)

Photo source: www.dec.state.ny.us

Conservation Recommendations: Where this community is found, non-point source pollution from the surrounding watershed may be contributing to degraded water quality and habitat conditions. Although this community type does not suggest extremely poor stream quality, some stresses to stream condition are indicated.

Watersheds with large amounts of agriculture have the potential to contribute non-point source pollution to streams in the form of excess nutrients and sediments. In these environments, runoff and stream bank erosion can be controlled by installing riparian buffers of an adequate width along pastures and crop fields and excluding live-stock from streams and riparian zones. Stream habitats will improve with the addition of riparian buffers.

Mitigation of any direct stream discharges, including urban stormwater runoff and point-source sewage effluent, is recommended. Retention and treatment of storm water would ideally ameliorate water quality problems in streams receiving urban effluents. Upgrades in sewage treatment systems would also improve stream water quality and habitat condition.

Family MI Low Gradient Valley Stream Community

Known Locations:

Example Habitat:

The Low Gradient Valley Stream Community is typically found in slow-flowing valley streams with some influence from agricultural practices in the watershed.

Photo source: PNHP

Family MI High Quality Mid-Sized Stream Community

Strongest Indicators of Community Type

Green stonefly (Chloroperlidae)

Photo source: www.dec.state.ny.us

Giant black stonefly (Pteronarcyidae)

Photo source: www.dec.state.ny.us

Community Indicators: green stonefly (Chloroperlidae), giant black stonefly (Pteronarcyidae), spiny crawler (Ephemerellidae), flat-headed mayfly (Heptageniidae), free-living caddisfly (Rhyacophilidae), light brown stonefly (Perlodidae), prong-gill mayfly (Leptophlebiidae), common stoneflies (Perlidae), crane fly (Tipulidae), roachlike stoneflies (Peltoperlidae), clubtail dragonfly (Gomphidae), northern case maker (Limnephilidae), uenoid caddisfly (Uenoidae), odontocerid caddisflies (Odontoceridae)

Habitat: The High Quality Mid-Sized Stream Community is found in medium-sized streams ($\bar{x}$ = 94.6 mi^2 watershed area) in high elevations ($\bar{x}$ = 371 m). Streams are generally high gradient systems ($\bar{x}$ = 2.8%) with good habitat quality.

Streams where this community is found generally have low values of alkalinity ($\bar{x}$ = 27 mg/l) and conductivity ($\bar{x}$ = 178 µS/cm). Watersheds are typically undisturbed by humans and are often in heavily forested basins ($\bar{x}$ = 80.5%). Landscape disturbance is relatively uncommon in these watersheds, as there is very little urban or agricultural area ($\bar{x}$ = 0.9% and 15.9%, respectively). The most common community members are a combination of stoneflies, mayflies, caddisflies and other organisms that are generally pollution sensitive.

The biota of this community shows the highest values for taxa richness ($\bar{x}$ = 18.4) and EPT richness ($\bar{x}$ = 8.9) of all family-level macro-invertebrate spring community groups. This community also has the lowest proportion of pollution-tolerant organisms of all communities ($\bar{x}$ = 2.1%).

Stream Quality Rating: High

Community Rarity: No

Threats: Streams with the High Quality Mid-Sized Stream Community generally have few threats compared to other communities. Since high elevation streams tend to be on steep slopes, which are not generally conducive to human development, the typical urban and agricultural pollution problems are not as common in this community type as they are in streams indicated by other communities. Acidification from abandoned mine drainage (AMD) and air pollution is likely the most prominent pollution threat. In some locations, siltation from agriculture or industrial point source pollution may degrade the habitat of the High Quality Mid-Sized Stream Community.

Conservation Recommendations: As streams get larger, they generally experience more habitat disturbance and water quality alteration. This community represents relatively undisturbed mid-sized stream habitat, indicating a unique resource that should be preserved.

Addressing water pollution from AMD and acid deposition are critical for the High Quality Mid-Sized Stream Community. Treating AMD can reduce acidity and metals and greatly improve water quality. Liming watersheds and/or streams is one option for minimizing the effects of AMD and acid deposition. The creation of AMD-mitigation wetlands offers a lower-cost alternative for AMD remediation. For more information on AMD and its treatment, see the Pennsylvania DEP's Bureau of Abandoned Mine Reclamation webpage:

http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm

Family MI High Quality Mid-Sized Stream Community

Known Locations:

Habitat:

Mid-sized, high gradient streams with high quality habitats and water quality are the typical habitat of the High Quality Mid-Sized Stream community.

Photo source: PNHP

Family MI Common Large Stream Community

Community Indicators: nemourid broadback stonefly (Nemouridae), ameletid mayfly (Ameletidae), taeniopterygid broadback stonefly (Taeniopterygidae)

Habitat: The streams that support the Common Large Stream Community occur at relatively high elevations ($\bar{x}$ = 333 m) and high gradients ($\bar{x}$ = 2.3%), with a diverse assemblage of organisms. These moderately large ($\bar{x}$ = 155.8 mi^2 watershed area) streams also have high quality in-stream habitats.

Water chemistry profiles usually show moderate to high values of alkalinity ($\bar{x}$ = 58 mg/l) and conductivity ($\bar{x}$ = 320 µS/cm). Macroinvertebrates in this community are slightly more tolerant of organic pollution than the High Quality Mid-Sized Stream community (pg. 5-11). Agriculture is the predominant land alteration in these watersheds ($\bar{x}$ = 28.9% of the watershed), and may be negatively influencing water quality in some locations. Urban influences are less prominent where this community is found ($\bar{x}$ = 2.0 %).

The biota found with this community type show relatively high values for taxa richness ($\bar{x}$ = 13.4) and EPT richness ($\bar{x}$ = 8.0). The proportion of pollution-tolerant organisms in this community ($\bar{x}$ = 6.25%) is moderate relative to the other community types, but represents quality large-stream or river conditions.

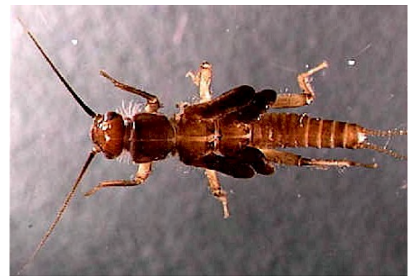
This community type is indicative of larger streams of good quality, despite being affected by watershed disturbances that alter the habitats of most streams of this size.

Stream Quality Rating: Medium (higher in larger streams and rivers)

Community Rarity: No

Threats: Excess siltation from agricultural runoff and animal feed lots is likely impairing the habitats where this community is found. In addition, acid mine drainage may also occur in some watersheds where this community occurs, but it is not usually associated with this community type. As with other streams of larger size, development pressure in the watershed is an issue for this community.

Strongest Indicators of Community Type



Nemourid broadback stonefly (Nemouridae)

Photo source: www.dec.state.ny.us

Ameletid mayfly (Ameletidae)

Photo source: www.dec.state.ny.us

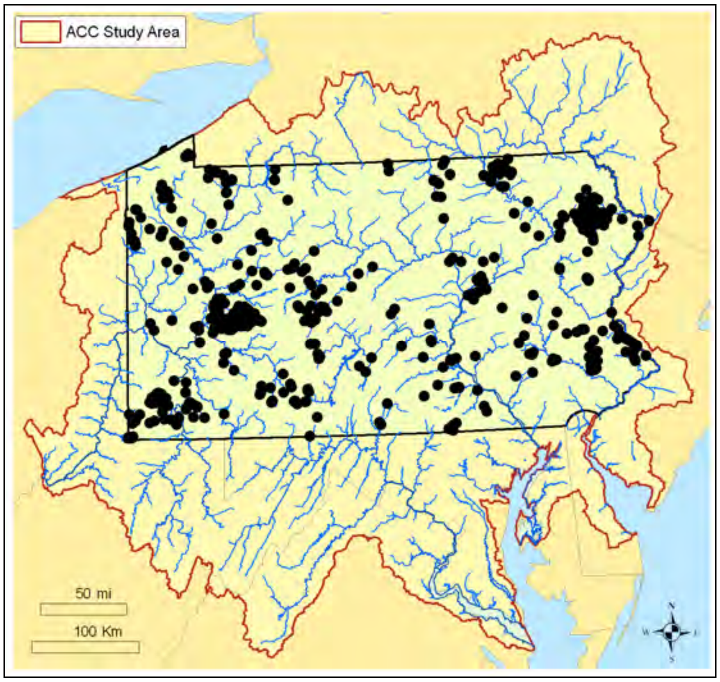
In heavily populated areas, municipal point sources such as sewage treatment plants and urban stormwater effluents may contaminate these streams.

Conservation Recommendations: While some non-point source pollution problems occur in watersheds with the Common Large Stream Community, pollution is less severe than in other streams of similar size. In areas where non-point source agricultural pollution occurs, runoff and stream bank erosion can be controlled by installing vegetative buffers of an adequate width along streams in pastures and crop fields. Excluding livestock from streams and riparian zones will also help improve stream habitats.

Large streams and rivers typically flow through populated areas, and therefore experience the water quality issues that are associated with urban settings. To combat these effects, mitigation of stream discharges, including stormwater runoff and point-source sewage effluent, is recommended. Retention and treatment of stormwater and keeping sewer treatment systems upgraded ameliorates water quality problems and habitat condition in streams receiving urban effluents.

Family MI Common Large Stream Community

Known Locations:



Example Habitat:

Large to medium-sized high gradient streams are typical habitats of the Common Large Stream Community. Non-point source pollution can cause excess stream sediment or other poor water quality conditions.

Photo source: PNHP

Family MI Limestone / Agricultural Stream Community

Community Indicators: scud (Amphipoda), black fly (Simuliidae), aquatic sowbug (Isopoda), Planaria (Turbellaria), segmented worms (Annelida), midge (Chironomidae), common pond snail (Physidae), predacious diving beetle (Dytiscidae), ram's horn snail (Planorbidae)

Habitat: This community is found in large streams ($\bar{x}$ = 368 mi^2 watershed area) with low gradients ($\bar{x}$ = 1.1%). It occurs at moderate to low elevation ($\bar{x}$ = 200 m), mainly in valleys with calcareous geology (Figure 5-3). Relatively large amounts of agriculture ($\bar{x}$ = 46.3%) and urban areas ($\bar{x}$ = 11.6%) in the watershed likely contribute to degradation of stream habitat.

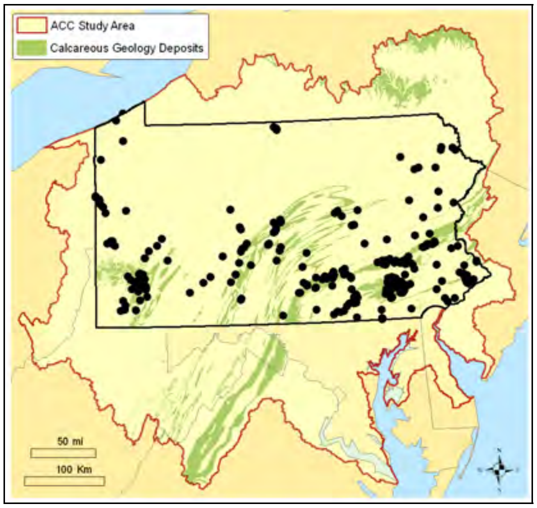


Figure 5-3. The locations of the Limestone / Agricultural Stream Community Locations are concentrated in areas of calcareous geology.

With calcareous geology influences, high alkalinity ($\bar{x}$ = 95 mg/l) and conductivity ($\bar{x}$ = 364 mg/l) values are typical water chemistry profiles of streams that support this community. The values for taxa richness ($\bar{x}$ = 8.8) and EPT richness ($\bar{x}$ = 6.8) are among the lowest of all family-level macroinvertebrate groups, and the percentage of pollution-tolerant organisms is the highest of all family groups ($\bar{x}$ = 23.3%).

Stream Quality Rating: Low

Community Rarity: No

Threats: This community is generally found in streams influenced by calcareous geology, in the valleys of central and eastern Pennsylvania. Minimally degraded limestone streams are very rare in the commonwealth, as these areas are usually heavily populated and/or in agricultural production. Both of these landscape alterations can have negative effects on stream habitat. Poorly buffered agricultural areas can lead to excess nutrient loading and siltation of streams, altering habitat and adversely affecting resident communities.

Strongest Indicators of Community Type

Scud (Amphipoda)

Photo source: www.dec.state.ny.us

Black fly (Simuliidae)

Photo source: www.epa.gov

Conservation Recommendations: The agricultural non-point source pollution issues associated with this community may be more severe than in streams indicated by other community types, based on watershed characteristics and the characteristic taxa. In areas where agricultural pollution is occurring, installing riparian buffers along pastures and crop fields and excluding livestock from streams and riparian zones can control bank erosion and improve stream habitats over time.

In urban settings, mitigation of direct stream discharges is recommended. Adequate retention and treatment of storm water ameliorate water quality and habitat condition issues in streams receiving urban effluents.

Family MI Limestone / Agricultural Stream Community

Known Locations:

Example Habitat:

Calcareous geology provides habitat for the Limestone / Agricultural Stream Community. Agricultural or developed valleys may contribute non-point source pollution to the watershed.

Photo source: PNHP

Family MI Photo Credits – *all photos used with permission*

http://ceratium.ietc.wwu.edu/IWS: Western Washington University, Institute for Watershed Studies

Pennsylvania Natural Heritage Program (PNHP), all rights reserved.

www.benthos.org: North American Benthological Society.

www.dec.ny.gov: New York State Department of Environmental Conservation.

www.dfg.ca.gov: State of California Department of Fish and Game.

www.epa.gov: United States Environmental Protection Agency.

Chapter 6.

Genus-Level Macroinvertebrate Community Descriptions

Genus MI Forested Headwater Stream Community

Community Indicators: little yellow stonefly (*Alloperla*), Tipulan crane fly (*Tipula*), dark brown spinner mayfly (*Ameletus*)

Habitat: This community is found in very small streams ($\bar{x}$ = 2.7 mi^2 watershed area) in sparse distribution across the study area. It occurs at very high elevations ($\bar{x}$ = 410 m) and gradients ($\bar{x}$ = 3.7%). There is slightly over 4% urban land cover and nearly 15% agricultural land cover in the basins where this community occurs, which is high considering the small size of these watersheds. However, the catchments remain almost 80% forested, which may account for the persistence of the environmentally sensitive taxa that represent this community group.

Water chemistry values show a slight impairment in stream condition, likely from the agriculture and urbanization existing in the watersheds. These streams are slightly alkaline ($\bar{x}$ = 54.2 mg/l), but have relatively low specific conductivity ($\bar{x}$ = 173 µS/cm) and cool temperatures ($\bar{x}$ = 15.5°C).

The taxa richness ($\bar{x}$ = 9.3) for this community suggests moderate to good water quality despite the fact that high elevation, heavily forested headwater streams such as these generally do not support highly diverse assemblages of organisms. The taxa that make up the assemblages in this community are the most sensitive to organic pollution of all genus-level macroinvertebrate communities. EPT richness ($\bar{x}$ = 5.9) is high relative to the overall taxa richness, which means that the taxa that comprise the majority of the organisms in this community are generally sensitive to alterations in habitat and stream function.

Stream Quality Rating: High

Community Rarity: Yes

Threats: Found in the smallest streams, the Forested Headwater Stream Community faces fewer threats than communities in larger streams and rivers. In these high elevation watersheds, agriculture and urban developments are not substantial threats. Maintenance of forest cover in the watershed, especially within the riparian corridor, will help preserve this community type.

Strongest Indicators of Community Type

Little yellow stonefly (*Alloperla*)

Photo source: http://bio-ditrl.sunsite.ualberta.ca

Tipulan crane fly (*Tipula*)

Photo source: www.lrca.org

Poor acid buffering capacity in small, ridgetop watersheds makes these headwater streams more susceptible to the effects of acid precipitation. Abandoned mine drainage (AMD) can be a common pollution source in the small watersheds where the Forested Headwater Stream community is found.

Conservation Recommendations: This community should be of utmost conservation importance not only because of its quality and environmental sensitivity, but also because of its rarity. It only occurs in only 19 of over 850 stream locations used to define these macroinvertebrate communities. Watersheds where this community is known to occur should be preserved. Additionally, steps should be taken to preserve these habitats from damage due to AMD and/or acid deposition.

Genus MI Forested Headwater Stream Community

Known Locations:

Example Habitats:

Deadman Run, Fayette County, PA

UNT Cowanshannock Creek, Armstrong County, PA

Photo source: PNHP

Genus MI Sluggish Headwater Stream Community

Community Indicators: common pond snail (Physidae), leech (Hirudinea), ram's horn snail (Planorbidae), midge (Chironomidae), agabian predaceous diving beetle (*Agabus*), dextral pond snail (Lymnaeidae).

Habitat: The Sluggish Headwater Stream Community is found in headwater streams of moderate gradient ($\bar{x}$ = 1.3%) in areas impaired by human influence. Communities are usually found in small ($\bar{x}$ = 5.7 mi^2 watershed size), moderate to low elevation streams ($\bar{x}$ = 206 m).

High amounts of watershed urbanization ($\bar{x}$ = 22.7%) and agricultural land ($\bar{x}$ = 36.6%) occur with this community type, and natural vegetation land cover is low ($\bar{x}$ = 39.3% forested area in watershed). Warm water temperatures ($\bar{x}$ = 17.4°C) and poor water quality are likely contributing to the poor habitat conditions where this assemblage is found. High alkalinity ($\bar{x}$ = 107 mg/l), pH ($\bar{x}$ = 7.16) and conductivity ($\bar{x}$ = 431.8 µS/cm) suggest ion concentrations may be artificially high because of pollution.

The taxa richness and EPT richness are both very low ($\bar{x}$ = 8.2 and 2.0, respectively), which also suggest degraded habitat. Most taxa occurring in this community group are tolerant to organic pollution.

Since the indicator taxa of this community are also representative of wetland environments – still or slow moving water with abundant aquatic vegetation – the presence of this community may indicate a transitional stream-wetland habitat. However, the mean values for the environmental data suggest that most of these locations are severely impaired, regardless of habitat type.

Stream Quality Rating: Low

Community Rarity: No

Threats: The Sluggish Headwater Stream Community is concentrated near the urban centers of Philadelphia and Pittsburgh and in some agricultural valleys throughout the state. Point and non-point source pollution from both agriculture and urban areas appear to impair streams with this community. The presence of this community type is an indicator for severe pollution problems of various types.

Strongest Indicators of Community Type

Common pond snail (Physidae)

Photo source: www.usask.ca

Leech (Hirudinea)

Photo source: www.troutnut.com

Excess nutrient runoff and siltation usually lead to stream impairment in watersheds with a large amount of agricultural land. In urban areas, runoff from impervious surfaces and storm sewers threatens water quality. In both environments, habitats are modified when they are channelized and stream riparian buffers are removed. Other point sources from municipalities, such as industrial discharges and water treatment plants, can also lead to stream impairment.

Conservation Recommendations: In watersheds with poorly maintained agricultural areas, installing riparian buffers along pastures and crop fields can control excess nutrient runoff and stream bank erosion. Excluding livestock from streams and riparian zones will also restore water quality and stream habitats.

Retention and treatment of stormwater from roads and urban developments would ameliorate water quality problems in streams receiving these urban effluents. In addition, adequate remediation of sewage treatment discharges would improve stream water quality and habitat condition for all aquatic communities. Mitigation of all direct stream discharges is recommended.

Genus MI Sluggish Headwater Stream Community

Known Locations:

Example Habitats:

Un-named tributary to
Brush Creek, Butler County, PA

Updike Run, Jefferson County, PA

Photo source: PNHP

Genus MI High Quality Headwater Stream Community

Community Indicators: forestfly (*Amphinemura*), tube-case caddisfly (*Lepidostoma*), rolled winged stonefly (*Leuctra*), blackfly (*Prosimulium*)

Habitat: This community occurs in high quality headwater streams ($\bar{x}$ = 6.3 mi^2 watershed area) that exist in high elevation ($\bar{x}$ = 439 m). These catchments are well forested ($\bar{x}$ = 78% of watershed) and have high stream gradients ($\bar{x}$ = 2.9%). There is very little urbanization ($\bar{x}$ = 1.4% of watershed area) in these watersheds, but there is some agricultural land ($\bar{x}$ = 18.1%) where this community is found. Alkalinity ($\bar{x}$ = 25.3 mg/l) and pH ($\bar{x}$ = 6.62) values are comparatively low and conductivity is moderate ($\bar{x}$ = 172.0 µS/cm). Water temperatures are typically cool ($\bar{x}$ = 15.5°C).

The High Quality Headwater Stream Community has slightly lower values of taxa richness, EPT richness, and number of intolerant taxa than the other high quality communities ($\bar{x}$ = 16.2, 9.0, and 6.5, respectively). However, these metrics still suggest a high level of water quality, since biotic assemblages in headwater streams are generally not as diverse as those found in larger stream reaches that exist lower in the watershed.

Stream Quality Rating: High

Community Rarity: Potentially

Threats: The acidification of water from abandoned mine drainage (AMD) and acidic precipitation is likely the most prominent pollution threat in these headwater streams. Small, high-elevation streams such as these generally have poor acid buffering capacity, which can exacerbate the effects of acidic inputs and lead to stream acidity outside the tolerable range for most organisms. Additionally, the effects of poorly maintained agricultural land in the watershed may affect water quality and stream habitat in some locations.

Conservation Recommendations: This community type represents the highest quality headwater stream macroinvertebrate assemblage in the study area. Headwater streams of similar size that are in need of restoration may use the community type as a restoration target.

Strongest Indicators of Community Type

Forestfly (*Amphinemura*)

Photo source: http://www.lrca.org/

Tube-case caddisfly (*Lepidostoma*)

Photo source: http://www.dfg.ca.gov

Installing riparian buffers along streams in areas of poorly maintained agricultural land can reduce nutrient runoff and stream bank erosion. Excluding livestock from streams and riparian zones will also restore stream quality and habitat.

Addressing water pollution from AMD and acid deposition are critical for the community. Treating AMD can reduce acidity and metals and greatly improve water quality. Liming watersheds and/or streams is one option for minimizing the effects of acid deposition. Other AMD remediation options include passive treatments, such as AMD mitigation wetlands. For more information on AMD, see the PA DEP's Bureau of Abandoned Mine Reclamation webpage:

http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm

Genus MI High Quality Headwater Stream Community

Known Locations:

Example Habitats:

Un-named tributary to
Limestone Run, Fayette County, PA

Cherry Creek, Clarion County, PA

Photo source: PNHP

Genus MI Mixed Land Use Stream Community

Strongest Indicators of Community Type

Cinnamon caddis (*Hydropsyche*)

Photo source: http://www.usask.ca/biology/skabugs

Fishfly (*Nigronia*)

Photo source: www.troutnut.com

Community Indicators: Cinnamon caddisfly (*Hydropsyche*), fishfly (*Nigronia*), prong-gill mayfly (*Leptophlebia*), watersnipe fly (*Atherix*).

Habitat: This group is generally found in headwater streams ($\bar{x}$ = 6.8 mi^2 watershed size) with moderately high gradients ($\bar{x}$ = 2.1%) and elevations ($\bar{x}$ = 345 m). There are some occurrences of this community in headwater streams of the Delaware River, Lake Erie, and the Youghiogheny River basins. Streams are normally alkaline ($\bar{x}$ = 68.6 mg/l), with high conductivity ($\bar{x}$ = 242.3 µS/cm).

The water quality where this community is found may be impaired by runoff from relatively large amounts of agricultural activity ($\bar{x}$ = 25% watershed landcover) and moderate levels of urbanization pressure ($\bar{x}$ = 3.0% watershed landcover). There is some remaining natural vegetation cover in the watershed ($\bar{x}$ = 63% forested area), which likely aids in buffering pollutants from runoff that originates from agricultural and urban land areas. Additionally, low pH values may be reflective of presence of abandoned mine drainage (AMD) in some areas.

Modest scores for taxa richness and EPT richness ($\bar{x}$ = 8.8 and 6.0, respectively), suggest that this community is found in streams of moderate quality.

Stream Quality Rating: Medium

Community Rarity: Yes

Threats: Similar to large streams, small headwater streams may also suffer from the influence of urbanization and agriculture. This community type reflects locations that are influenced by moderate amounts of agriculture and urbanization, but do not have the necessary forest area in the watershed to counteract the effects of the disturbances. For example, the High Quality Headwater Stream Community (pg. 6-5) is found in similarly sized watersheds ($\bar{x}$ = 6.3 mi^2) with nearly 20% agriculture land cover, but the effects from the this appear to be mitigated by nearly 80% forest cover in the watershed.

Conservation Recommendations: A lack of natural vegetation near headwater streams can negatively influence water quality in lower stream reaches. Streamside vegetation helps keep headwater streams cool and contributes leaf litter that supports important components of the stream food chain. Stream restoration in headwater habitats should involve the establishment or maintenance of a riparian area and forest maintenance in the greater watershed. Restoration of streams lower in the watershed will be more effective if water quality issues at the headwaters are resolved first.

In areas with a large amount of agriculture, the installation of riparian buffers along pastures and crop fields can control excess nutrient runoff and stream bank erosion. Excluding livestock from streams and riparian zones will also restore stream quality. In urban settings, the retention and treatment of municipal discharges and stormwater helps improve stream water quality and habitat condition.

Genus MI Mixed Land Use Stream Community

Known locations:

Example Habitats:

Sixteen Mile Creek, Erie County, PA

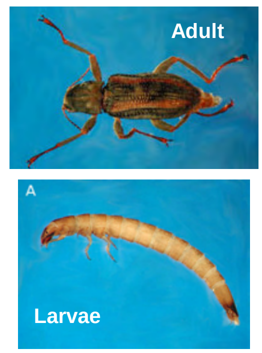
Photo source: PNHP

Genus MI Small Urban Stream Community

Strongest Indicators of Community Type:

Netspinning caddisfly (*Cheumatopsyche*)

Photo source: www.epa.gov



Riffle beetle (*Stenelmis*)

Photo source: www.waterbugkey.vcsu.edu

Community Indicators: Netspinning caddisfly (*Cheumatopsyche*), Stenelmian riffle beetle (*Stenelmis*), blackfly (*Simulium*), dancefly (*Hemerodromia*)

Habitat: This community type is typical of small streams ($\bar{x}$ = 13.1 mi^2 watershed area) flowing through highly urbanized watersheds ($\bar{x}$ = 25.4% urban area). It is mainly found in urban Philadelphia and surrounding counties (Chester, Delaware, Philadelphia and Montgomery). There are a small number of occurrences spread across the remainder of the study area.

This community type occurs in streams of low elevation ($\bar{x}$ = 141 m) and low to moderate gradient ($\bar{x}$ = 1.1%), mainly in the Piedmont region (Figure 9-2). These streams are generally alkaline ($\bar{x}$ = 73.6 mg/l), have a neutral pH ($\bar{x}$ = 7.0) and very high conductivity ($\bar{x}$ = 492.4 µS/cm). High conductivity values such as this are usually indicative of pollution resulting from large amounts of urbanization in a watershed. This community is commonly found in areas of crystalline silicic geology.

On average, 25.4% of the watershed is urbanized and 30.0% is agricultural. Only a small portion of the watershed has natural vegetation ($\bar{x}$ = 43% forested area), which amplifies the effects of developed and farmed land because there is little absorption of pollutants before they reach streams. This occurrence is reflected by the poor biological integrity of the community; this group displays low means for EPT richness ($\bar{x}$ = 4.3), number of pollution intolerant taxa ($\bar{x}$ = 1.4) and taxa richness ($\bar{x}$ = 12.2).

Stream Quality Rating: Low

Community Rarity: Yes

Threats: This community has many threats from the surrounding landscape. Urbanization can be severely damaging to streams, generally because of road or stormwater runoff and industrial discharges. Runoff from roads and parking lots may be laden with metals, sediments, hydrocarbons and other pollutants. Channelization and other permanent habitat modifications are also common in urban streams. Industrial discharges are frequently found in developed areas and carry a number of pollutants to stream channels. Runoff containing excess nutrients and toxins from residential areas (lawns, parks, etc.) can lead to a variety of stream impairments.

Conservation Recommendations: This community type is common in the Piedmont region of southeastern Pennsylvania, where geology types are unique to the study region. Crystalline silicic geology may represent specialized habitats for this community type.

In urban settings, the retention and treatment of municipal discharges and stormwater helps improve stream water quality and habitat condition. This may be accomplished through mitigated wetlands or stormwater retention ponds. Additionally, both in-stream and riparian habitats can be restored through stream bank riparian zone plantings and restoration of natural stream channels. Restoration of larger streams will be more effective if water quality issues at the contributing headwaters are resolved first.

Genus MI Small Urban Stream Community

Known locations:

Example Habitats:

Salt Lick Creek, Susquehanna County, PA

Martin Creek, Susquehanna County, PA

Photo source: PNHP

Genus MI High Quality Small Stream Community

Community Indicators: iron dun (*Epeorus*), oulimnian riffle beetle (*Oulimnius*) stripetail stonefly (*Isoperla*), salmonfly (*Pteronarcys*), free-living caddisfly (*Rhyacophila*)

Habitat: This community type is found in smaller streams ($\bar{x}$ = 16 mi^2 watershed area) in heavily forested headwater catchments ($\bar{x}$ = 88.4% forested area in watershed) with very low urbanization ($\bar{x}$ = 0.7%) and agricultural ($\bar{x}$ = 9.1%) development.

This community occurs in streams of high elevation ($\bar{x}$ = 406 m) and gradient ($\bar{x}$ =1.6%). Water quality is typical of undisturbed headwater streams, with low alkalinity ($\bar{x}$ = 22 mg/l), pH ($\bar{x}$ = 6.68) and conductivity ($\bar{x}$ = 99.5 µS/cm). Water temperatures are cool ($\bar{x}$ = 14.1°C). This community is widespread across the region, but is generally absent from the lower Susquehanna River watershed.

The High Quality Small Stream Community has a rich assemblage of organisms, including a large number of EPT taxa ($\bar{x}$ = 15.2) and number of taxa that are intolerant to organic pollution ($\bar{x}$ = 11.7). The most common community members indicate the presence of quality riffle habitat.

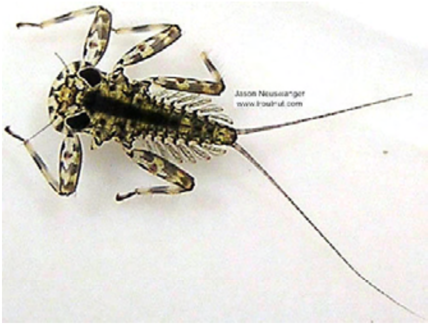
Stream Quality Rating: High

Community Rarity: No

Threats: Found in high-elevation headwater streams, this community faces fewer threats than valley stream communities. However, in a few locations the High Quality Small Stream Community may be in watersheds potentially degraded by poorly maintained agricultural land or abandoned mine drainage (AMD). In small watersheds, such as those that contain this community type, unpaved roads can cause increased sedimentation rates in streams. Poorly buffered agricultural land can contribute unhealthy levels of sediment and nutrients to these streams.

Conservation Recommendations: This community group is a strong indicator of a high quality, naturally functioning small stream system. This community can serve as a target community type for the restoration of similar streams in poor condition.

Strongest Indicators of Community Type



Iron dun (*Epeorus*)

Photo source: www.troutnut.com

Riffle beetle (*Oulimnius*)

Photo source: Brady Richards

Addressing water acidification from AMD and acidic deposition is critical for the High Quality Small Stream Community. Treatment of AMD can reduce acidity and levels of metallic compounds in the discharge effluent, greatly improving water quality.

Adequate maintenance of unpaved road surfaces and management of stormwater from paved roads will reduce the amount of sediments and contaminants introduced to streams.

In agricultural areas, runoff and stream bank erosion can degrade stream quality by enriching nutrient concentrations beyond safe levels and smothering important stream habitat with sediment. Nutrient enrichment and sedimentation can be controlled by installing vegetated riparian buffers of adequate widths along pastures and crop fields.

Genus MI High Quality Small Stream Community

Known Locations:

Example Habitats:

Silver Creek, Butler County, PA

Sides Run, Indiana County, PA

Photo source: PNHP

Genus MI Common Small Stream Community

Community Indicators: Cahill mayfly (*Stenonema),* waterpenny beetle (*Psephenus*), yellow caddisfly (C*himarra*), saddlecasemaker (*Glossossoma*), brushlegged mayflies (*Isonychia*)

Habitat: The Common Small Stream Community occurs in small watersheds ($\bar{x}$ = 22.5 mi^2 watershed area). Streams typically have low gradients ($\bar{x}$ =1.2%) and occur at low elevations ($\bar{x}$ = 183 m). These streams are generally alkaline ($\bar{x}$ = 61 mg/l), with a basic pH ($\bar{x}$ = 7.6) and moderate specific conductivity ($\bar{x}$ = 172 µS/cm).

This community is commonly found in valley streams with large amounts of agriculture ($\bar{x}$ = 34.4%) and some urbanization ($\bar{x}$ = 5.2%) in their watersheds. It occurs in relatively dense concentrations in southeastern PA in agricultural and suburban watersheds, and has a small number of locations in the Ohio River Basin.

Although agricultural land areas may have some negative influences on water quality or in-stream habitat, the biological metrics suggest that the Common Small Stream Community is relatively unimpaired. The assemblages of taxa in this community remain remarkably diverse ($\bar{x}$ = 20.2 taxa richness), and the mean tolerance values are comparatively low ($\bar{x}$ = 3.6). The EPT richness for this community type ($\bar{x}$ = 11.8) indicates that the organisms in this community do not generally tolerate high levels of pollution.

Stream Quality Rating: Medium

Community Rarity: No

Threats: The small watersheds where this community occurs may be subject to water quality and habitat degradation due to poorly maintained agricultural land. In the absence of vegetated riparian buffers, agricultural streams can experience flow modifications, increased sedimentation, and excessive nutrient inputs. Municipal point source pollution, like sewage treatment plants and stormwater outfalls, likely pollute these streams in some locations.

Conservation Recommendations: The macroinvertebrates that comprise this community type suggest streams of high quality, but the environmental settings where it is found appear to be at least somewhat degraded. This condition may indicate that the habitats where the Common Small Stream Community exists in are especially threatened by watershed development. This community type occurs frequently in the Piedmont region of southeastern Pennsylvania. The area is subject to continued pressure from agricultural and urban development, which will likely have negative effects on the persistence of this community in these areas.

Restoring channelized streams to natural meanders will help to ameliorate factors that inhibit natural stream function. Establishing or maintaining riparian buffers will help to reduce sediment runoff and nutrient enrichment in agricultural areas.

In urban settings, the retention and treatment of municipal discharges and stormwater helps improve stream water quality and habitat condition. Restoration of larger streams will be more effective if water quality issues at the contributing headwaters are resolved first.

Strongest Indicators of Community Type:

Cahill mayfly (*Stenonema*)

Photo source: www.troutnut.com

Waterpenny beetle (*Psephenus*)

Photo source: www.epa.gov

Genus MI Common Small Stream Community

Known Locations:

Example Habitats:

Little Salmon Creek, Forest County, PA

Salmon Creek, Forest County, PA

Photo source: PNHP

Genus MI High Quality Large Stream Community

Community Indicators: blue-winged olive dun (*Drunella),* acentrellan mayfly (*Acentrella*), dark leadwinged olive (*Serratella*), ephemerellid mayfly (*Ephemerella*), pale evening dun (*Leucrocuta*), fingernet caddisfly (*Dolophilodes*), netspinner caddisfly (*Ceratopsyche*), small minnow mayfly (*Baetis*).

Habitat: This community represents high-quality mid-reach streams ($\bar{x}$ = 39 mi^2 watershed area) found at high to moderate elevations ($\bar{x}$ = 328 m) with moderate gradients ($\bar{x}$ = 1.2%). Alkalinity ($\bar{x}$ = 38.9 mg/l) and conductivity ($\bar{x}$ = 156.9 µS/cm) values are higher than that of headwater streams, but do not indicate elevated levels of pollution in larger streams. Streams are cool ($\bar{x}$ = 15.4 °C), have high quality habitats and are in highly forested catchments ($\bar{x}$ = 81% forested area). The amount of urban land cover in the watersheds associated with this group is very low ($\bar{x}$ = 0.8%). Watershed agricultural land area is also low for streams of this size ($\bar{x}$ = 15.7%).

Biological community indicators confirm the description of high quality habitat. This macroinvertebrate community is very high in taxa richness and EPT richness ($\bar{x}$ = 16.2 and 9.0, respectively), and the community indicators are generally intolerant of organic pollution ($\bar{x}$ = 3.1 tolerance value). The habits of the strongest indicator taxa and the regional gradient statistics suggest that this community is found in stream run habitats more than in riffle habitats.

Stream Quality Rating: High

Community Rarity: No

Threats: Mid-reach streams usually exist below high quality headwaters and receive waters with little impairment. However, threats to water quality become more prevalent once streams reach valleys, where the landscape is subject to greater development pressure. Pollution and habitat alteration associated with poorly managed agricultural land (e.g., sedimentation, nutrient enrichment, changes in temperature regime) might affect this stream type. In addition, because of widespread coal mining in Pennsylvania, abandoned mine drainage (AMD) may also influence watersheds where this community occurs.

Strongest Indicators of Community Type

Blue-winged olive dun (*Drunella*)

Photo source: http://ceratium.ietc.wwu.edu/IWS

Acentrellan mayfly (*Acentrella*)

Photo source: http://ceratium.ietc.wwu.edu/IWS

Conservation Recommendations: High quality valley streams are valuable natural resources, as they are readily accessible and appealing for recreational use. Streams of this type support some of the state's designated coldwater fisheries. This community represents the highest quality mid-reach stream habitats in Pennsylvania, and should be a priority for conservation and protection.

To protect the recreational and intrinsic value of these streams, active conservation strategies should be implemented. In areas with intense agriculture, remediation of poorly managed agricultural land may be necessary. Stream bank fencing and riparian vegetation plantings will facilitate the mitigation of sedimentation and agricultural runoff that affect water quality.

Although urban areas do not appear to be prevalent in areas where this community occurs, retention and treatment of any municipal discharges helps improve stream water quality and habitat condition. Treating AMD can reduce acidity and metallic compounds in stream water, greatly improving water quality.

Genus MI High Quality Large Stream Community

Known Locations:

Example Habitats:

Kettle Creek, Potter County, PA

Bear Creek, Butler County, PA

Photo source: PNHP

Genus MI Limestone / Agricultural Stream Community

Community Indicators: sowbug (Isopoda) and aquatic worm (Oligochaeta)

Habitat: The Limestone / Agricultural Stream community is found in calcareous (limestone and dolomite) valleys across the study area (Figure 6-1). This community type occurs most commonly in medium to large-sized streams ($\bar{X}$ = 62.3 mi^2 watershed area) at intermediate elevations ($\bar{X}$ = 217 m) and moderate gradients ($\bar{X}$ = 0.9%).

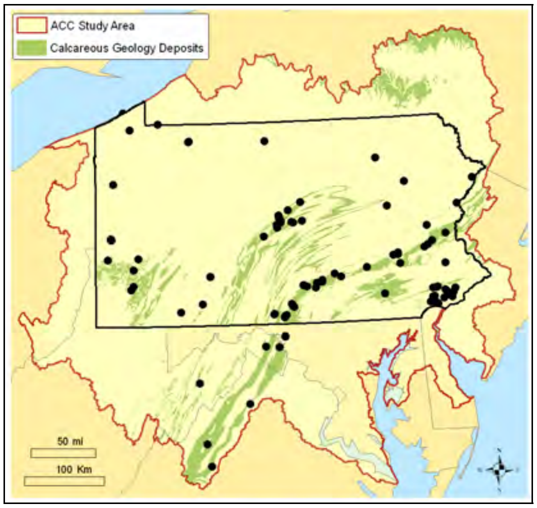


Figure 6-1. The locations of the Limestone / Agricultural Stream Community Locations are concentrated in areas of calcareous geology.

Calcareous geology is usually found in valleys with agriculture and urban or residential development, as this geology type generally results in land well suited for agriculture. Consequently, this community occurs in watersheds with large amounts of agriculture ($\bar{X}$ = 43.7%) and urbanization ($\bar{X}$ = 13.4%). Natural landcover types are relatively low ($\bar{X}$ = 40.9% forest cover). Streams affected by calcareous geology generally show high alkalinity and conductivity values, but the high values associated with this community ($\bar{X}_{alkalinity}$ = 127 mg/l; $\bar{X}_{conductivity}$ = 407 µS/cm) are likely inflated due to non-point source pollution from excessive agricultural and urban development. Water temperatures are generally cool ($\bar{X}$ = 14.4°C).

Taxa richness values ($\bar{X}$ = 11.5) and the number of pollution-intolerant taxa ($\bar{X}$ = 1.4) are relatively low for this community, showing that taxa found in this community type are generally tolerant to organic pollution. Factors shaping the structure of this community are compounded by both watershed disturbance and calcareous geology.

Strongest Indicators of Community Type

Sowbug (Isopoda)

Photo source: www.troutnut.com

Aquatic worm (Oligochaeta)

Photo source: www.troutnut.com

Stream Quality Rating: Low

Community Rarity: No

Threats: Biological assemblages face a variety of significant water quality and habitat degradations where this community is found. Excess nutrients and sediments congest these streams in agricultural valleys, smothering substrate used for habitat. Additionally, modifications in habitat, stream bank structure, and flow regime all pose threats to the streams that support this community. In urban areas, runoff from impervious surfaces can also impair streams.

Conservation Recommendations: This community type occurs in a fairly unique environment in the study area. Calcareous rock can exert a strong effect on streams that flow through this type of geology. Limestone streams that remain in good condition are few; restoration of calcareous streams and conservation of high quality limestone systems should be priorities for aquatic resource managers.

Watersheds with large amounts of agriculture have considerable potential for non-point source pollution. In these areas, runoff and stream bank erosion can be controlled by installing riparian buffers along pastures and crop fields and excluding livestock from streams and riparian zones. In urban areas, management of stormwater and mitigation of any direct stream discharges are recommended. Improvements and upgrades to municipal discharge systems will improve stream condition.

Genus MI Limestone / Agricultural Stream Community

Known locations:

Example Habitats:

Squaw Run, Allegheny County, PA

Pigeon Creek, Washington County, PA

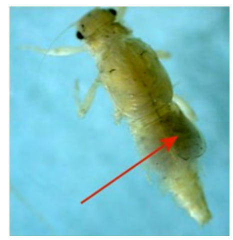
Photo source: PNHP

Genus MI Common Large Stream Community

Strongest Indicators of Community Type

Dubiraphian riffle beetle (*Dubiraphia*)

Photo sources: www.waterbugkey.vcsu.edu (larvae); www.xerces.org (adult)



Little white mayfly (*Caenis*)

Photo source: www.epa.gov

Community Indicators: dubiraphian riffle beetle (*Dubiraphia*), little white mayfly (*Caenis*), brown dun (*Ephemera*), optioservian riffle beetle (*Optioservus*), biting midge (*Probezzia*), common stonefly (*Perlesta*)

Habitat: The Common Large Stream Community represents larger streams ($\bar{x}$ = 191.3 mi^2 watershed area) with high quality habitats, relative to other streams of similar size. This community is found in moderate elevations ($\bar{x}$ = 308 m) and gradients ($\bar{x}$ = 0.9%) across the region. Streams are generally alkaline ($\bar{x}$ = 76.2 mg/l) with high conductivity ($\bar{x}$ = 340.1 µS/cm).

There are substantial amounts of agricultural land ($\bar{x}$ = 31.4% watershed area) associated with this community type, but little disturbance from urban landcover ($\bar{x}$ = 4.0%) compared to similarly sized streams. Forested area ($\bar{x}$ = 61.4%) accounts for a large portion of these watersheds.

The biological assemblage in this group appears relatively intact. Taxa richness is high ($\bar{x}$ = 19.0), and EPT richness and number of pollution-intolerant taxa ($\bar{x}$ = 9.7 and 4.2, respectively) indicate quality large-stream habitats. Water chemistry conditions suggest some watershed alteration. This community type may represent the best examples of quality large stream and river habitat in the region.

Stream Quality Rating: Medium (higher in larger streams)

Community Rarity: No

Threats: This community generally indicates quality streams of larger catchment size. These watersheds, however, are still subject to threats similar to other valley streams. Abandoned mine drainage (AMD), urbanization, and agricultural development all pose threats to stream habitat condition in these watersheds. These streams may be subject to a variety of upstream point and non-point pollution sources as well.

Conservation Recommendations: This community is representative of quality streams of large catchment size, which makes the community a unique attribute of any landscape. This community type may be useful as a benchmark community for the restoration of degraded streams with larger catchments, potentially streams that currently support the Genus MI Generalist Community (pg. 6-21).

Restoring or installing riparian buffers along streams near pastures and crop fields can control non-point source pollution and stream bank erosion, which are usually prevalent in areas with large amounts of agricultural land. Excluding livestock from streams and riparian zones will also help to protect and restore stream habitat. Treating AMD can reduce levels of acidity and metals in the stream and greatly improve water quality and habitat condition for this community.

The Common Large Stream Community also faces pressure from urban development. Urban effluents can carry a range of pollutants and toxins, including petroleum-based materials, pesticides, herbicides, road salts, and sewer treatment plant discharges. Management of stormwater and mitigation of any direct discharges to streams are recommended. Keeping sewer treatment facilities updated and working properly is also important in alleviating the effects of urbanization on stream systems.

Genus MI Common Large Stream Community

Known Locations:

Example Habitats:

Deer Creek, Allegheny County, PA

Pucketa Creek, Allegheny County, PA

Photo source: PNHP

Genus MI Large Stream Generalist Community

Community members: No macroinvertebrates are significant indicators for this group, but midges (Chironomidae) and aquatic worms (Oligochaeta) are common associates.

Habitat: This community type represents large streams and rivers ($\bar{x}$ = 835 mi^2 watershed area) that are severely degraded by pollution. Moderate gradient ($\bar{x}$ = 1.2%) and moderate elevation ($\bar{x}$ = 322 m) suggest that this community generally occurs in the middle to lower reaches of a watershed. This group is found in portions of the study area where streams are impaired by a variety of pollutants.

Water chemistry data suggest that these streams can be very acidic ($\bar{x}_{pH}$ = 4.3) and have high concentrations of dissolved ions ($\bar{x}_{alkalinity}$ = 56.4 mg/l; $\bar{x}_{conductivity}$ = 286 mg/l). Coal mining occurs frequently in watersheds containing the Large Stream Generalist Community; the resulting abandoned mine drainage (AMD) in the area may be the greatest source of acidification. Agricultural land cover is also common in the watersheds where this community is found ($\bar{x}$ = 33.0%). Urbanization likely affects the biota of these streams as well, as urban land accounts for an average of 4.4% of watershed area. Forest cover remains slightly over half in these watersheds ($\bar{x}$ = 60.4%).

Midges and aquatic worms, the most common community associates, are generally very tolerant of organic and other types of pollution. The community shows low values for both taxa richness and EPT richness ($\bar{x}$ = 3.8 and 1.3, respectively).

Stream Quality Rating: Low

Community Rarity: Uncommon, but not a conservation priority.

Threats: Although the causes of stream impairment appear to vary across community locations, presence of this community type generally indicates very poor water quality. Siltation, erosion, organic enrichment and municipal wastewater discharges are all potentially causing habitat degradation. Abandoned mine drainage (AMD) from coal mines and runoff from surface mining are also associated with streams where the Large Stream Generalist Community occurs.

Common Associates of Community Type

Midge (Chironomidae)

Photo source: http://ceratium.ietc.wwu.edu/IWS

Aquatic worm (Oligochaeta)

Photo source: www.troutnut.com

Conservation Recommendations: Locations where this community occurs are in great need of habitat restoration. Large amounts of agriculture, urban development, and roads in these watersheds can contribute non-point source pollutants to these streams. Establishing and maintaining healthy riparian buffers of an adequate width along streams in the tributaries will enhance water quality in the headwaters and the lower reaches where the Large Stream Generalist Community is found. In urban environments, management of stormwater and mitigation of any direct municipal discharges (such as wastewater treatment facilities) to streams are recommended.

Treatment of AMD can reduce the acidity and metallic compounds in the discharges from coal mined areas, greatly improving water quality and habitat condition of streams. For more information on AMD and its remediation, see the Pennsylvania DEP's Bureau of Abandoned Mine Reclamation webpage:

http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm

Genus MI Large Stream Generalist Community

Known Locations:

Example Habitats:

UNT Mill Creek, Berks County, PA

Toby Creek, Clarion County, PA
(*Note reddish color of stream bottom, an indicator of AMD*)

Photo source: PNHP

Genus MI Ohio River Community

Strongest Indicators of Community Type

Netspinner caddisfly (*Cyrnellus*)

Photo source: www.waterbugkey.vcsu.edu

Scud (Amphipoda)

Photo source: http://www.usask.ca/biology/skabugs

Community Indicators: netspinner caddisfly (*Cyrnellus*), scud (Amphipoda), microcaddisfly (*Hydroptila*), leptohypid mayfly (*Tricorythodes*)

Habitat: Except for two locations in the lower Schuylkill drainage, this group is found exclusively in the Ohio River and the Allegheny River near Pittsburgh. Elevation ($\bar{x}$ = 206 m) and gradient ($\bar{x}$ < 0.01%) are both low in these large river locations ($\bar{x}$ = 18,194 mi^2 watershed area). The water is generally alkaline ($\bar{x}$ = 69 mg/l), with high conductivity ($\bar{x}$ = 457 µS/cm) and pH ($\bar{x}$ = 7.63). Water temperatures are warm ($\bar{x}$ = 22.5°C). The deep-water habitats indicated by this community type are uncommon in the remainder of the study area.

The slow waters maintained by the lock and dam system in these large rivers offer specialized habitats that lie somewhere in between riverine and lacustrine conditions. The indicator taxa of this community are fairly general in their habitat requirements, but all are capable of inhabiting both lotic and lentic environments. Total taxa and EPT richness are low among community types ($\bar{x}$ = 4.3 and 2.1, respectively). Macroin-vertebrates associated with this community type are generally tolerant to organic pollution.

Large river environments near urban centers like Pittsburgh are certainly influenced by surround-ding development. Watershed land cover averages 5% urban and 23% agriculture where this community occurs. In the local drainage basins (HUC12), urbanized land accounts for more than 33% of the contributing basin.

Stream Quality Rating: Medium

Community Rarity: Yes

Threats: Large river habitats in the Ohio and Allegheny River basins have been fundamentally altered by a long history of industrial pollution, hydrologic alteration, and dredging. The manage-ment of industrial pollution discharges has been largely improved in recent decades. An extensive lock and dam system remains that creates navigational pools but disrupts the hydrologic regime and habitats within the river system. Combined sewer overflows are common in the Ohio and lower Allegheny River basins. Runoff from impervious areas also impairs local streams and rivers. Additionally, many of the tributaries to the Ohio, Monongahela and Allegheny River watersheds are impaired by abandoned mine drainage.

Conservation Recommendations: Ameliorating water quality impairments on tributaries to these large rivers will improve conditions in the main channels. Retaining and treating stormwater before it enters the large rivers will also create better conditions for the Ohio River community.

The Ohio and Allegheny River basins are part of the biologically diverse Mississippi River watershed. These river basins offer specialized habitats to a unique faunal assemblage of macroinvertebrates. Other unique community types in the large river system include several mussel and fish groups. Restoration of large river ecological function and habitats is a lofty conservation goal that may be undertaken in small steps. To facilitate this, the dams could be used to mimic the natural flooding and scouring activity that river systems depend on by staging large, periodic flow discharges. Another option is to establish portions of the rivers to be targeted for patch-scale habitat preservation.

Genus MI Ohio River Community

Known locations:

Example Habitats:

Ohio River at Neville Island, Allegheny County, PA

Ohio River at Merrill Station, Beaver County, PA

Photo source: PNHP

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http://bio-ditrl.sunsite.ualberta.ca. Bio-DiTRL, University of Alberta.

http://www.dfg.ca.gov/. California Department of Fish and Game.

http://ceratium.ietc.wwu.edu/IWS. Western Washington University, Institute for Watershed Studies

Pennsylvania Natural Heritage Program (PNHP), all rights reserved.

www.epa.gov. United States Environmental Protection Agency.

www.lrca.org. Copyright © 2006 Lackawanna River Corridor Association, Scranton, PA

Richards, Brady. Personal Communication, 2006.

www.troutnut.com. Copyright © 2007 Jason Neuswanger.

www.usask.ca/biology/skabugs. Department of Biology, University of Saskatchewan. Photos by Dale Parker, AquaTax Consulting.

www.utsc.utoronto.ca. University of Toronto. Photo by D.D. Williams.

www.waterbugkey.vcsu.edu. Valley City State University, Valley City, ND 58072

www.xerces.org. ©2006 The Xerces Society for Invertebrate Conservation.

Chapter 7.

Fish Community Descriptions

Ohio – Great Lakes Basins Fish: Coldwater Community

Strongest Indicators of Community Type

Brook trout (*Salvelinus fontinalis*)

Photo Source: http://www.cnr.vt.edu/efish/

Mottled sculpin (*Cottus bairdii*)

Photo Source: http://www.clemson.edu

Community Indicators: brook trout (*Salvelinus fontinalis*) mottled sculpin (*Cottus bairdii*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*)

Species of Conservation Concern: none

Habitat: This headwater stream community ($\bar{X}$ = 10.8 mi^2 watershed area) occurs in high gradients ($\bar{X}$ = 2.1%) flowing from ridges at relatively high elevations ($\bar{X}$ = 510 m). Water temperatures are the coldest among the fish communities. The Coldwater Community indicates headwater streams with brook trout and sculpin and slightly larger streams with brook or brown trout only. Some locations will also have rainbow trout. The community is less common in urbanized streams than in watersheds with natural landcover.

These small headwater streams tend to have fewer disturbances than larger waters flowing through valleys. High amounts of forested area appear to be associated with the catchments that support this community ($\bar{X}$ = 89.9% of the upstream watershed). These systems often flow from sandstone or shale ridges and have a unique water chemistry signature with few dissolved ions and low buffering capacity. Streams have low alkalinity ($\bar{X}$ = 26 mg/l) and conductivity ($\bar{X}$ = 182 µS/cm) values, and water temperatures are cold. These streams may be acidic at the headwaters; pH is lower than that found with other community types ($\bar{X}$ = 6.7).

Prediction analyses with the Coldwater Community found that high elevation streams, geology, and landcover were the most important variables in determining the locations of this community type. A low number of stream links and a low proportion of row-crop landcover in the local watershed were also strong predictors of the community distribution. Additionally, rather high elevations and large deposits of sandstone geology were highly associated with the habitats of this community type.

Stream Quality Rating: High

Community Rarity: No

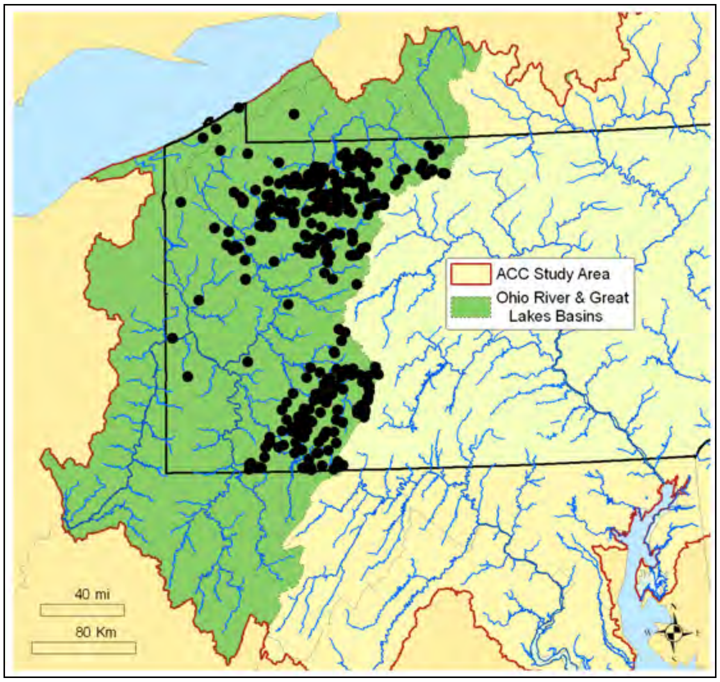
Threats: Streams in Pennsylvania may be acidic from two major pollution sources: abandoned mine drainage (AMD) and acid deposition. Coal mining often occurs near Coldwater Community habitats and may contribute acidic and metal-laden discharges to these streams. Pollutants in the form of acid precipitation can fall on headwater stream watersheds and leach away the natural buffering capacity of soils. This can result in the reduction of stream pH to levels stressfully low to aquatic organisms.

Although trout fisheries are valued as a recreational resource, trout streams in Pennsylvania have been greatly altered since the transplantation of brown trout from Europe and rainbow trout from western North America. Habitats for native brook trout have been restricted by competition with non-native trout species.

Conservation Recommendations: Streams in these watersheds may have wild, reproducing populations of brook and brown trout and may be a fisheries resource. Because cold headwater streams often occur in terrain unsuitable for human development, they are not usually subject to the same types of water pollution issues as valley streams. However, addressing water pollution from AMD and acid deposition are critical for headwater streams. Where populations of native brook trout occur, care should be taken to avoid introductions of non-native trout species.

Ohio – Great Lakes Basins Fish: Coldwater Community

Known Locations:



Example Habitats:

Small, high gradient streams with forested watersheds are typical of the Coldwater Community habitat.

Photo source: PHNP

Ohio – Great Lakes Basins Fish: Coolwater Stream Community

Community Indicators: blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), brown trout (*Salmo trutta*, stocked), white sucker (*Catostomus commersoni*), redside dace (*Clinostomus elongatus*), longnose dace (*Rhinichthys cataractae*), fathead minnow (*Pimephales promelas*), pearl dace (*Margariscus margarita*)

Species of Conservation Concern: none

Habitat: This community type occurs in small to medium-sized streams ($\bar{x}$ = 70.9 mi^2) at moderate to high elevations ($\bar{x}$ = 393 m). Streams are generally faster ($\bar{x}$ = 1.0% gradient) than warmwater streams and have intermediate temperature between warm and cold streams. Water quality profiles for these streams show relatively high alkalinity ($\bar{x}$ = 65 mg/l) and conductivity ($\bar{x}$ = 348 µS/cm) compared to other fish communities. Values of pH are typically neutral ($\bar{x}$ = 7.2).

Fish in the Coolwater Stream Community are habitat generalists and generally pollution tolerant. This community type may represent small, coolwater streams that occur in agricultural landscapes ($\bar{x}$ = 24% agricultural land in watershed). This community also occurs in watersheds where urbanization may be altering water quality.

Predictive modeling of community stream types reveals that both local and total upstream land cover types are strongly related to the habitat of this community type. Specifically, high amounts of total pasture, low amounts of open water (lakes or large rivers) and low proportions of urban land were all shown to be important factors shaping these habitats.

Stream Quality Rating: Low

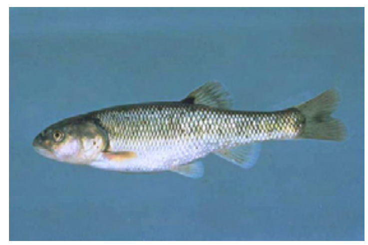
Community Rarity: No

Threats: This community occurs downstream of headwaters that are not usually protected from human alterations. A number of pollution types are found in watersheds where this community occurs. Abandoned mine drainage (AMD) is common in watersheds containing the Ohio Coolwater Community, suggesting that this community can tolerate some poor water quality conditions.

Strongest Indicators of Community Type

Blacknose dace (*Rhinichthys atratulus*)

Photo Source: http://www.ohiodnr.com/dnap



Creek chub (*Semotilus atromaculatus*)

Photo Source: http://www.cnr.vt.edu/efish/

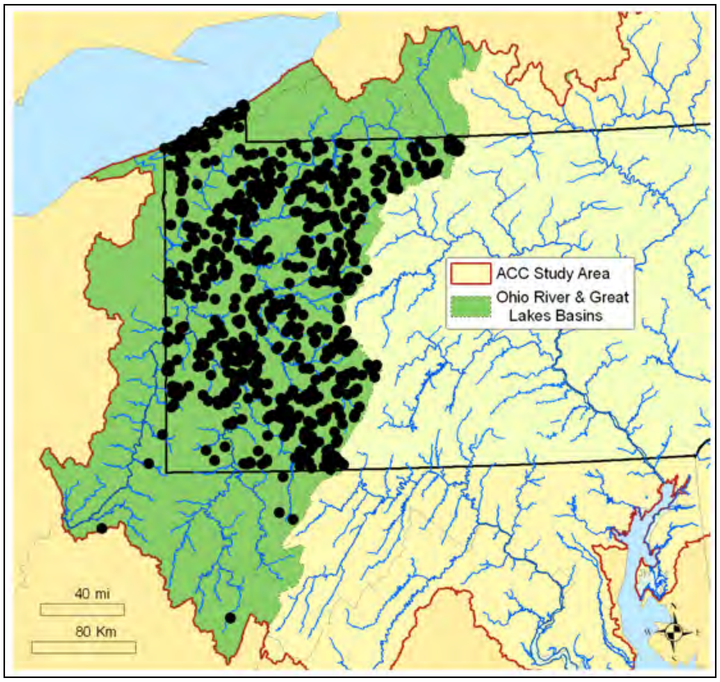
This community occurs in streams impaired by agricultural runoff and municipal discharges in urban areas. Stream temperature may be warmer than natural temperatures because protective vegetation on stream banks has been removed.

Conservation Recommendations: The habitat for the Coolwater Stream Community represents an important transition between cold headwater streams and warm larger streams. This habitat is distinct among other habitat types and should be protected and restored.

Where this community occurs, restoration of stream temperature, habitat, and water quality to natural conditions is recommended. Management of storm water runoff and riparian vegetation restoration are critical to improvement of stream habitat conditions. Treating AMD will reduce stream acidity and toxic metal concentrations. Where stocking of non-native fish is occurring in the same areas as the Ohio Coolwater Community, native fish are being displaced. Return of the fish assemblages to native species is recommended.

Ohio – Great Lakes Basins Fish: Coolwater Stream Community

Known Locations:



Example Habitats:

Valley streams with moderate gradients are typical of Coolwater Stream Community habitats. Fast, rocky-bottom sections alternate with slower pool habitats.

Photo source: PNHP

Ohio – Great Lakes Basins Fish: Warmwater Community

Strongest Indicators of Community Type

Greenside darter (*Etheostoma blennioides*)

Photo Source: http://www.ohiodnr.com/dnap

Northern hogsucker (*Hypentelium nigricans*)

Photo Source: http://www.cnr.vt.edu/efish/

Community Indicators: greenside darter (*Etheostoma blennioides*), northern hogsucker (*Hypentelium nigricans*), river chub (*Nocomis micropogon*), bluntnose minnow (*Pimephales notatus*), central stoneroller (*Campostoma anomalum*), rainbow darter (*Etheostoma caeruleum*), rosyface shiner (*Notropis rubellus*), banded darter (*Etheostoma zonale*), smallmouth bass (*Micropterus dolomieu*), common shiner (*Luxilus cornutus*), rock bass (*Ambloplites rupestris*), johnny darter (*Etheostoma nigrum*), fantail darter (*Etheostoma flabellare*), variegate darter (*Etheostoma variatum*), logperch (*Percina caprodes*), stonecat (*Noturus flavus*), silver shiner (*Notropis photogenis*), blackside darter (*Percina maculata*), striped shiner (*Luxilus chrysocephalus*), golden redhorse (*Moxostoma erythrurum*), sand shiner (*Notropis stramineus*), mimic shiner (*Notropis volucellus*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), spotfin shiner (*Cyprinella spiloptera*)

Species of Conservation Concern: None

Habitat: The Warmwater Community usually occurs in medium to large watersheds ($\bar{X}$ = 91 mi^2). Habitats include Allegheny Plateau streams that occur at relatively high elevations ($\bar{X}$ = 340 m) and streams with lower than 1% gradient. Agricultural land ($\bar{X}$ = 29% of watershed) is prevalent in these watersheds.

Streams have intermediate alkalinity ($\bar{X}$ = 79 mg/l) and conductivity ($\bar{X}$ = 375 µS/cm) values and slightly basic pH values ($\bar{X}$ = 7.4) relative to the waters that other communities inhabit. Warm water temperatures are also characteristic of this community group. Consequently, thermal tolerances of fish in this community are higher than those fish found in cold- and coolwater communities. Habitats of indicator taxa represent a range of conditions, but this community is generally found in small to medium-sized warmwater systems with little silt and turbidity. On a watershed scale, this community appears to be associated with watershed position, land use (especially commercial/industrial and agricultural land uses), geology (namely sandstone and shale) and the number of stream links.

Stream Quality Rating: Medium

Community Rarity: No

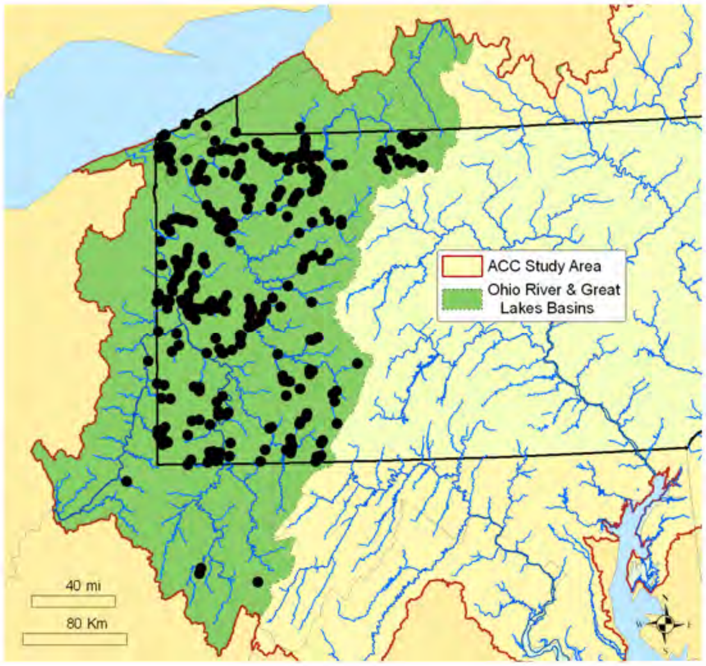
Threats: Water and habitat quality may be influenced by non-point source pollution where this community occurs. Runoff from poorly managed agricultural areas can threaten this community, as these watersheds are usually associated with large amount of agricultural land. A number of potential point sources from municipal, industrial, and mining sources may occur in valley streams with this community type, including abandoned mine drainage (AMD).

Conservation Recommendations: This community is a high conservation priority since quality warmwater streams are uncommon. The fish in this community type are not especially rare individually, but this group represents habitats in need of protection.

Since warmwater streams mainly occur in valleys downstream of human influences, they are often subject to pollution from non-point sources such as agriculture and urban runoff. Stormwater management, restoration of riparian buffer zones and exclusion of livestock from streams are some mitigation techniques for non-point source pollution. AMD continues to be problematic in many warmwater streams in the Ohio River Basin. The effects of AMD and other ants can be minimized by treatment systems which will improve water quality conditions.

Ohio – Great Lakes Basins Fish: Warmwater Community

Known Locations:



Example Habitats:

The Warmwater Community is found in warmwater streams in good condition with adequate riparian vegetation. Rocky and sandy-bottom substrates provide habitat for fish and other stream organisms.

Photo source: PNHP

Ohio – Great Lakes Basins Fish: Large River Community

Community Indicators: channel catfish (*Ictalurus punctatus*), sauger (*Sander canadensis*), common carp (*Cyprinus carpio*), gizzard shad (*Dorosoma cepedianum),* freshwater drum (*Aplodinotus grunniens*), walleye (*Stizostedion vitreus),* white bass (*Morone chrysops),* shorthead redhorse (*Moxostoma macrolepidotum*), spotted bass (*Micropterus punctulatus*), silver redhorse (*Moxostoma anisurum),* quillback carpsucker (*Carpiodes cyprinus*), emerald shiner (*Notropis atherinoides),* flathead catfish (*Pylodictis olivaris*), black crappie (*Pomoxis nigromaculatus*), smallmouth buffalo (*Ictiobus bubalus*), river redhorse (*Moxostoma carinatum*), mooneye (*Hiodon tergisus*)

Species of Conservation Concern: mooneye (S2?/G5), smallmouth buffalo (S2/G5), longnose gar S2S3/G5), river redhorse (S3/G4), channel darter (S1S2/G4)

Habitat: The Large River Community occurs in the largest streams and rivers ($\bar{X}$ = 7,024 mi^2 watershed area) in our study area. Habitats are mainly the Monongahela, Allegheny, Youghiogheny, and Ohio Rivers at moderate elevations ($\bar{X}$ = 232 m) with relatively low gradient (< 1%). Water temperatures in these habitats are the warmest of all fish communities. Dissolved ions in the large rivers result in alkaline waters ($\bar{X}_{pH} = 7.4$, $\bar{X}_{Alkalinity} =$ 55.7 mg/l) with high conductivity values ($\bar{X}$ = 480.2 µS/cm).

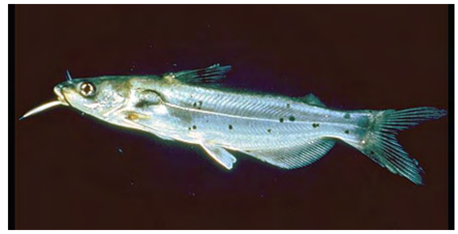
The preferred habitats of fish in the Large River Community generally exist in rivers, including impounded sections. Large rivers offer varied habitats including shallow shorelines, deep channels and slow or non-flowing impoundments behind dams. The fish species richness in Ohio River Basin streams has been augmented by the addition of stocked or introduced game fish, many of which can displace native fishes.

Landcover and geology appear to be important watershed variables influencing the distribution of this community type. Urban development in the riparian zone and little pastureland cover in the local watershed were the strongest predictors of habitat for the large river community, likely due to the close proximity of urban centers to large rivers in western Pennsylvania. Dam storage capacity and proportion of upstream shale geology were also related to the occurrence of this community.

Stream Quality Rating: Medium

Community Rarity: Yes

Strongest Indicators of Community Type



Channel catfish (*Ictalurus punctatus*)

Photo Source: http://www.cnr.vt.edu/efish/

Sauger (*Sander canadensis*)

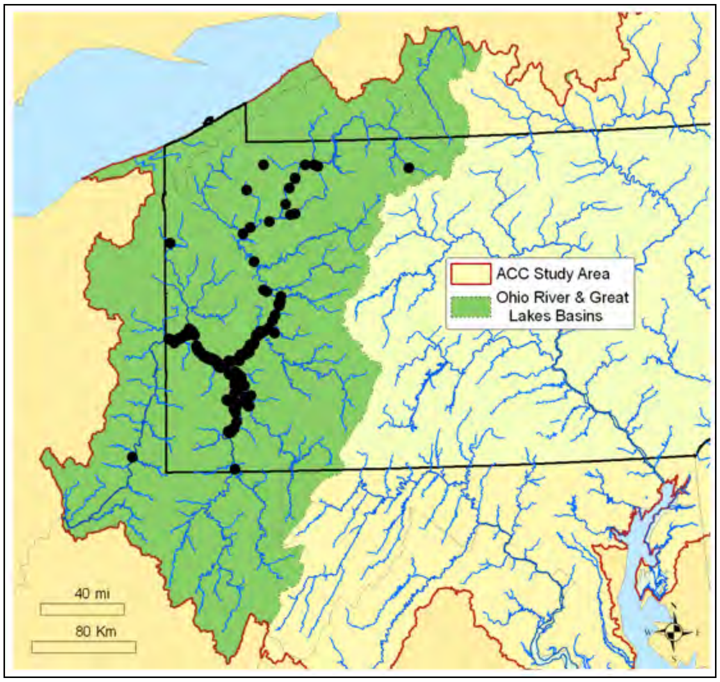
Image Source: http://sites.state.pa.us/PA_Exec/Fish_Boat

Threats: The water quality of large rivers in the Ohio River Basin has vastly improved in recent decades. However, detriments to water quality and habitat conditions remain. Non-point source pollution contributes excess nutrients, sediments, and pesticide runoff to river systems. Additional threats from stormwater runoff and municipal discharges are concentrated around urbanized areas. Tributaries can contribute pollution from abandoned mine drainage (AMD), urban runoff and agricultural non-point source pollution to large rivers. Additionally, a number of dams occur in the Ohio River and its tributaries. Dams interrupt the continuity of flowing waters, altering flow patterns and sediment transport regimes. The movement of fishes is restricted by dams, which may segregate populations. These augmentations in hydrology can damage riverine habitats disrupt river functions.

Conservation Recommendations: Reducing pollution in the upper Ohio River watershed would improve water quality in its lower sections. Reducing point source discharges and stormwater runoff to these large rivers will improve water and habitat quality. Additionally, minimizing habitat destruction from sand and gravel dredging and other disturbances will improve habitat condition. Managers of large river habitats and dam operators should coordinate efforts to maintain the habitats of large river fish.

Ohio – Great Lakes Basins Fish: Large River Community

Known Locations:



Example Habitats:

Wide, deep channel habitats are common in the larger rivers of the Ohio River Basin, and are characteristic of the areas where the Large River Community is found.

Photo source: PNHP

Atlantic Basin Fish: Coldwater Community

Strongest Indicators of Community Type

Brook trout (*Salvelinus fontinalis*)

Photo Source: http://www.cnr.vt.edu/efish

Brown trout (*Salmo trutta*)

Photo Source: http://www.cnr.vt.edu/efish

Community Indicators: brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*)

Species of Conservation Concern: none

Habitat: This headwater stream community occurs in small streams ($\bar{X}$ = 17.6 mi^2 watershed area) at high elevations ($\bar{X}$ = 383 m) and high gradients ($\bar{X}$ = 2.5%). Water temperatures are the coldest among all fish communities. The Atlantic Coldwater Community represents small, swift streams with brook trout and slightly larger streams with both brook and brown trout or brown trout only.

The small streams that support the Atlantic Coldwater Community tend to have fewer disturbances than larger waters flowing through valleys. These systems often flow from sandstone or shale ridges and have a unique water chemistry signature with few dissolved cations and low buffering capacity. Streams have low alkalinity ($\bar{X}$ = 27 mg/l) and conductivity ($\bar{X}$ = 140 μS/cm). Water temperatures are generally cold and pH is usually lower than that of other community types ($\bar{X}$ = 6.7).

Predictive habitat modeling showed that large amounts of forest cover ($\bar{X}$ = 89.4%), little agriculture ($\bar{X}$ = 8.2%) and little open water area ($\bar{X}$ = 0.2%) in the watershed appeared to be the most important factors in shaping habitat for the Coldwater Community. The amounts of bedrock sandstone and shale geology in the watershed were also important habitat attributes. In addition, low amounts of urbanization and few road stream crossings in the watershed were all positively associated with the occurrence of this community.

Stream Quality Rating: High

Community Rarity: No

Threats: Streams in Pennsylvania may be acidic from two major pollution sources: abandoned mine drainage (AMD) and acid deposition. Coal mining often occurs in watersheds containing the Coldwater Community and may contribute acidic and metal-laden discharges to these streams. Pollutants in the form of acid precipitation can fall on headwater stream watersheds and leach away the natural buffering capacity of soils, reducing stream pH to levels stressfully low for aquatic organisms.

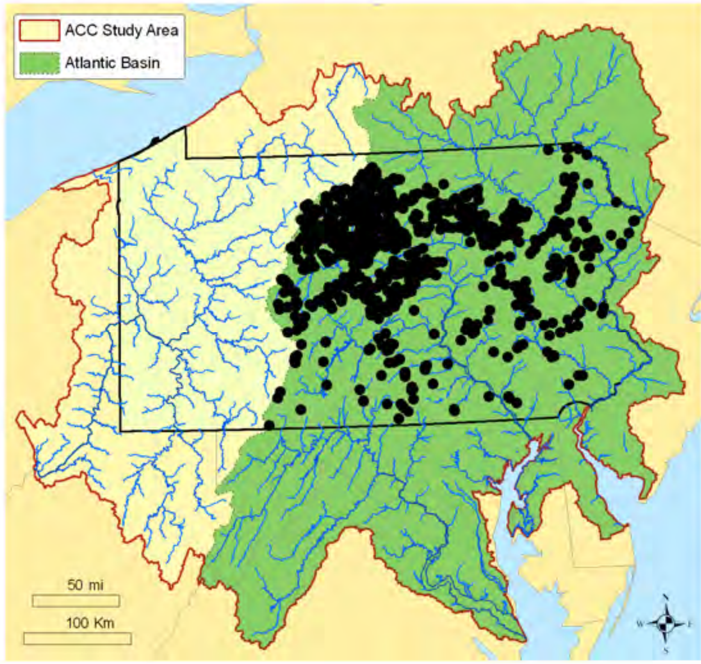
Conservation Recommendations: Streams in these watersheds may have wild-reproducing populations of brook and brown trout and may be a fishery resource. Because cold, headwater streams often occur in terrain unsuitable for most types of human developments, they are not usually subject to the same types of water pollution issues as valley streams. Streams like this should be preserved as a unique resource for the region.

Addressing water pollution from AMD and acid deposition are critical for headwater, coldwater streams. Adequate treatment of AMD can reduce the acidity and concentrations of toxic metals in the discharge that enters streams. Liming watersheds and/or streams is one option for minimizing the effects of acid deposition or AMD. In lieu of liming activities, mitigated wetlands may offer a more cost-effective way to treat AMD.

Trout streams in Pennsylvania are highly valued by fisherman, but have been greatly altered by the transplantation of brown trout from Europe and rainbow trout from western North America. Where populations of native brook trout occur, care should be taken to avoid introductions of non-native trout species. These introduces species can out-compete native fishes for vital habitat and food resources.

Atlantic Basin Fish: Coldwater Community

Known Locations:



Example Habitats:

Small, high-gradient streams with forested watersheds are typical of the Coldwater Community habitat.

Photo source: PHNP

Atlantic Basin Fish: Coolwater Community 1

Strongest Indicators of Community Type

Slimy sculpin (*Cottus cognatus*)

Photo Source: www.nj.gov/dep

Fathead minnow (*Pimephales promelas*)

Photo Source: http://www.cnr.vt.edu/efish

Community Indicators: slimy sculpin (*Cottus cognatus*), brown trout (*Salmo trutta*, stocked), fathead minnow (*Pimephales promelas*), pearl dace (*Margariscus margarita*)

Species of Conservation Concern: none

Habitat: This community generally occurs in high gradient ($\bar{X}$ = 2.0%), mid-reach streams ($\bar{X}$ = 54 mi^2 watershed area) potentially in high elevations ($\bar{X}$ = 367 m). Habitats may be disturbed by human influences.

Water chemistry is similar to the warmwater community types with relatively high alkalinity ($\bar{X}$ = 54 mg/l) and conductivity ($\bar{X}$ = 225 µS/cm); pH ($\bar{X}$ = 7.0) values are neutral. Water temperatures are cooler than the norm for warmwater streams, but not as low as coldwater streams. Agricultural land cover is a large proportion ($\bar{X}$ = 19.0%) of the watershed and urbanized land cover averages about 3.0% in these catchments.

The fish that indicate this community type prefer cool waters with rocky substrates, likely occurring in transitional areas between cold- and warmwater streams. The Coolwater Community 1 may represent streams with put-and-take trout fisheries or cool streams with seasonally warm temperatures. Fish in this community type may tolerate acidic conditions, low dissolved oxygen, suspended sediments or other water quality impairments.

Predictive modeling of stream habitats suggested that community distribution is related strongly to stream gradient and land use type. Low proportions of total emergent wetland in the local and upstream watersheds, high amounts of mixed (hardwood and deciduous) forests in the local watershed, and high stream gradients best predicted the locations of the Coolwater Community 1. Since this community occurs in the uplands, there are few riparian and floodplain wetlands. Agricultural area in the watershed was not a strong predictor of the community habitat, but large amounts of watershed forest cover was.

Stream Quality Rating: Low

Community Rarity: No

Threats: This community occurs downstream of headwaters and exists in streams not usually protected from human influences. The most common insults to water quality in Coolwater Community 1 watersheds are abandoned mine drainage (AMD) and non-point source pollution from poorly managed agricultural areas. AMD contributes metal-laden waters that are very low in pH to streams and can increase the acidity of stream waters to levels unhealthy for aquatic organisms.

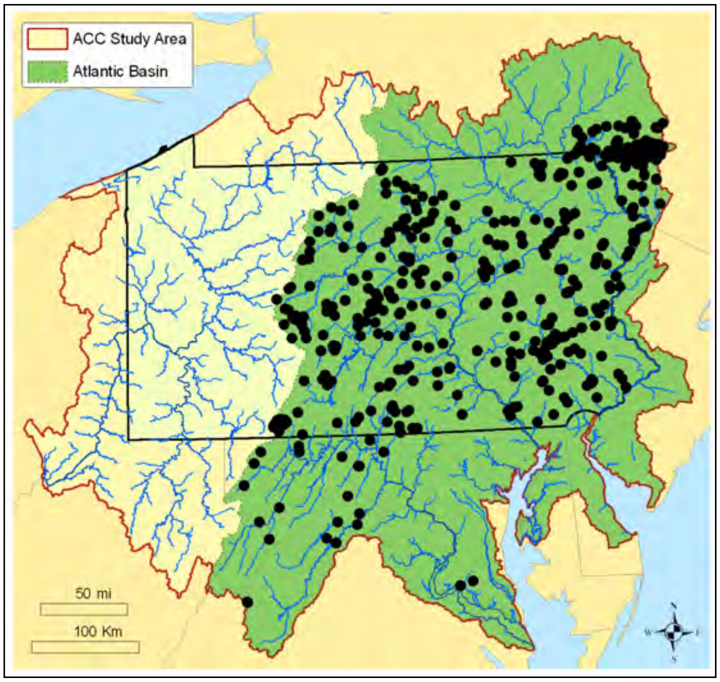
Removal of stream bank vegetation contributes to poor water quality and habitat condition by allowing excess levels of sediments and nutrients to enter streams, especially in agricultural areas. As a result of these impairments, water temperatures may be warmer than usual in these streams.

Conservation Recommendations: The habitat for the Coolwater Community 1 represents an important transition between cold headwater streams and warm, larger streams; the habitat is distinct among other habitat types and should be protected and restored.

Restoration of stream habitat and water quality to a natural condition is recommended. Management of storm water runoff and riparian vegetation restoration are critical to improvement of in-stream habitat. Excess nutrient runoff and sedimentation impair some locations where this community occurs. Where stocking of non-native fish is happening, native fish can be displaced. Restoration of the fish community to native species is recommended.

Atlantic Basin Fish: Coolwater Community 1

Known Locations:



Example Habitats:

Medium-sized streams like Marsh Creek (left) and the faster flowing Wilson Creek (right) are examples of streams characterized by the Coolwater Community 1.

Photo source: PNHP

Atlantic Basin Fish: Coolwater Community 2

Strongest Indicators of Community Type

Blacknose dace (*Rhinichthys atratulus*)

Photo Source: http://www.ohiodnr.com/dnap

White sucker (*Catostomus commersoni*)

Photo Source: www.nj.gov/dep

Community Indicators: blacknose dace (*Rhinichthys atratulus*), white sucker (*Catostomus commersoni*), golden shiner (*Notemigonus crysoleucas*)

Species of Conservation Concern: none

Habitat: This community type is similar to Atlantic Basin Coolwater Community 1 since it occurs in small to medium size streams ($\bar{x}$ = 46 mi^2) at moderate to relatively high elevation ($\bar{x}$ = 243 m) and gradient ($\bar{x}$ = 1.0%). Streams are faster than warmwater streams and are intermediate in temperature between warm and cold streams. Water quality profiles show relatively high values of alkalinity ($\bar{x}$ = 55.6 mg/l) and conductivity ($\bar{x}$ = 213 µS/cm) compared to other community groups. pH values are typically neutral ($\bar{x}$ = 7.2).

Fish found in this community type are habitat generalists and generally pollution tolerant. There are a comparatively small number of fish species associated with the Atlantic Coolwater Community 2. This community type may represent small coolwater streams that are more degraded, perhaps by urbanization or agricultural non-point source pollution in the watershed, than those that support the Atlantic Basin Coolwater Community 1 type. Proportionately high amounts of urban land cover ($\bar{x}$ = 4.6% watershed area) and agriculture ($\bar{x}$ = 26.1%) indicate more potential pollution sources.

A predictive modeling analysis confirmed that large amounts of disturbance in urban settings, particularly from commercial and industrial sources, were associated with this community type. Positive relationships with emergent and total wetland landcover types in the local watershed suggest that the community occurs in valleys where riparian and floodplain wetlands are common.

Stream Quality Rating: Low

Community Rarity: No

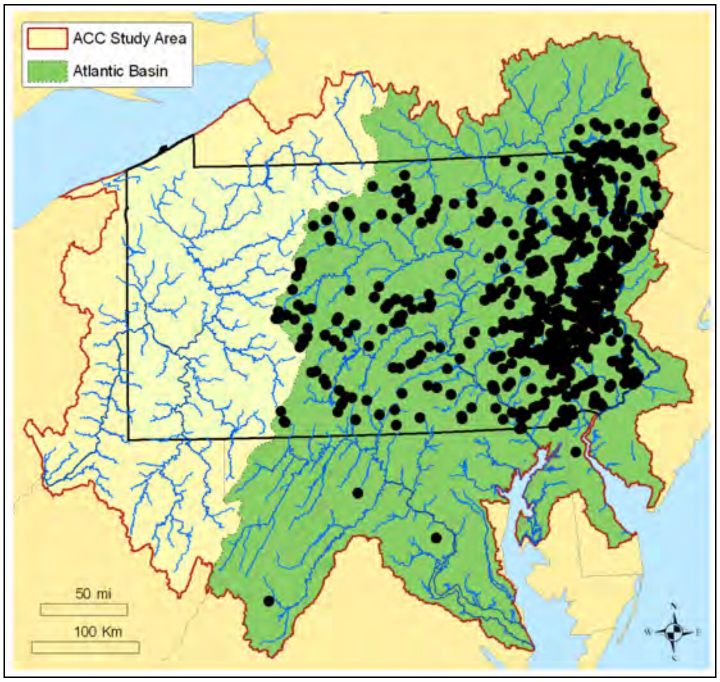
Threats: Poorly managed agricultural practices are the most pressing threat to the Atlantic Coolwater Community 2. Excess siltation and nutrients contributed from crop fields and livestock grazing lead to degraded stream conditions. In some locations, urban runoff also leads to poor habitat and water quality. Point sources from industry and municipal sources, like sewage treatment plants, may also occur in watersheds supporting this community.

Conservation Recommendations: This community is indicative of stream habitats resembling those of Atlantic Coolwater Community 1, but water quality and habitat condition are likely inferior. The occurrence of Atlantic Coolwater Community 2 should signify poor stream conditions that should be restored, potentially to support Atlantic Basin Coolwater Community 1.

Restoration of stream temperature may be particularly important to improving the habitats for this community type. Restoring or establishing natural vegetation in riparian zones and restoration of in-stream habitats will return more natural conditions where the Atlantic Coolwater Community 2 occurs. Mitigating runoff from crops and livestock pastures will reduce sedimentation and nutrient loading. Upgrades or enhancements in treatment systems for hazardous effluents from industrial and municipal point sources can vastly improve water quality.

Atlantic Basin Fish: Coolwater Community 2

Known Locations:



Example Habitats:

Atlantic Coolwater Community 2 is found in a variety of habitats in medium-sized streams and small rivers. Habitat-generalist fish can tolerate slow and silty streams.

Photo source: PNHP

Atlantic Basin Fish: Warmwater Community 1

Strongest Indicators of Community Type

Central stoneroller
(*Campostoma anomalum*)

Photo Source: http://www.ohiodnr.com/dnap

Northern hogsucker
(*Hypentelium nigricans*)

Photo Source: http://www.ohiodnr.com/dnap

Community Indicators: central stoneroller (*Campostoma anomalum*), northern hogsucker (*Hypentelium nigricans*), river chub (*Nocomis micropogon*), longnose dace (*Rhinichthys cataractae*), cutlips minnow (*Exoglossum maxilingua*), mottled sculpin (*Cottus bairdii*), margined madtom (*Noturus insignis*), creek chub (*Semotilus atromaculatus*), rosyface shiner (*Notropis rubellus*), fantail darter (*Etheostoma fabellare*), greenside darter (*Etheostoma blenniodes*)

Species of Conservation Concern: none

Habitat: The Warmwater Community 1 occurs in small to medium size watersheds ($\bar{x}$ = 128 mi^2 watershed area) at moderate elevation ($\bar{x}$ = 255 m) and low gradient ($\bar{x}$ < 1%).

Streams have moderate alkalinity ($\bar{x}$ = 50 mg/l) and conductivity ($\bar{x}$ = 175 µS/cm) relative to other groups, and nearly neutral pH values ($\bar{x}$ = 7.2). Warm water temperatures are also characteristic of these habitats; consequently, thermal tolerances of fish in this community group are higher than those of fish from the cold and cool-water communities. Habitat preferences of indicator taxa suggest this community occurs in warmwater streams with moderate to high currents and little silt.

Community prediction analysis demonstrated that local and upstream watershed landcover as well as position in the watershed were important variables for community distribution. Elevation, high number of upstream first order streams and high number of stream links suggest that communities occurred below headwater streams. High amounts of pasture ($\bar{x}$ = 22.1% of the watershed), row-crop agriculture ($\bar{x}$ = 5.2%) and non-row crop agriculture ($\bar{x}$ = 22.2%) were also related to community distribution.

Stream Quality Rating: Medium

Community Rarity: No

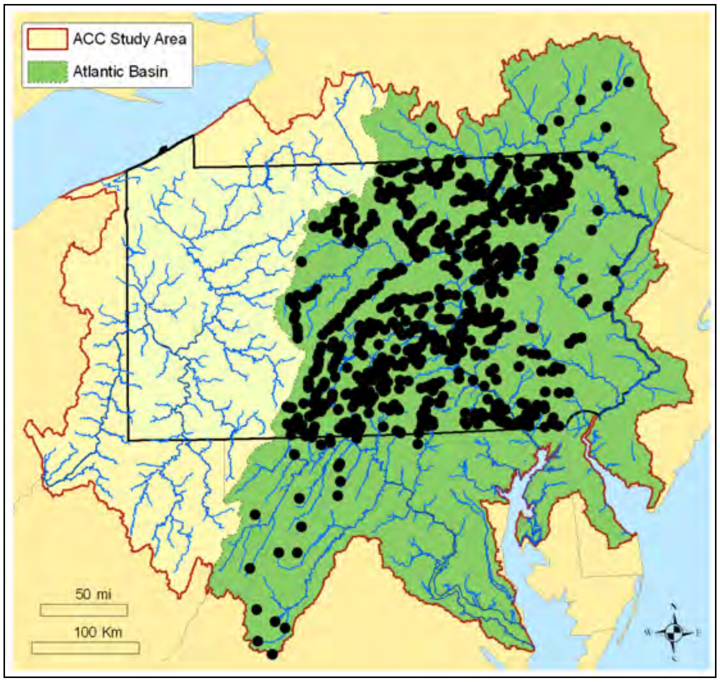
Threats: Water quality and habitat may be influenced by non-point source pollution where the Warmwater Community 1 exists. Poorly managed agricultural land is likely the most prominent threat to the habitat of this community. In most locations where this community occurs, about one-third of the watershed is in agricultural practices. Nutrient enrichment and excess sedimentation of streams from mismanaged agricultural practices impair many streams in watersheds with this community type. Low pH and dissolved and precipitated metals from abandoned mine drainage (AMD) influence some warmwater watersheds in the Anthracite coal region in eastern Pennsylvania.

Conservation Recommendations: This community is a high conservation priority. Warmwater streams in good condition are not common in the region. The fish associates of this community type are not especially rare individually, but this community represents habitats in need of protection and restoration.

Since warmwater streams mainly occur in valleys downstream of human influences, they are often subject to pollution from non-point sources such as AMD, agricultural runoff and urban pollutants. Adequate remediation of AMD helps to alleviate its effects. Storm water management, restoration of riparian buffer zones, and exclusion of livestock from streams are some mitigation techniques for non-point source pollution.

Atlantic Basin Fish: Warmwater Community 1

Known Locations:



Example Habitats:

Medium-sized streams without many groundwater inputs are typical of Warmwater Community 1 streams. Stream sequences of pools (slow-moving habitats), riffles (swift current habitats), and runs (intermediate current habitats) provide a variety of habitats and support warmwater fish communities.

Photo source: PHNP

Atlantic Basin Fish: Warmwater Community 2

Strongest Indicators of Community Type

Redbreast sunfish (*Lepomis auritus*)

Photo Source: http://www.ohiodnr.com/dnap

Rock bass (*Ambloplites rupestris*)

Photo source: www.nj.gov/dep

Community Indicators: redbreast sunfish (*Lepomis auritus*), rock bass (*Ambloplites rupestris*), spotfin shiner (*Cyprinella spiloptera*), fallfish (*Semotilus corporalis*), smallmouth bass (*Micropterus dolomieu*), spottail shiner (*Notropis hudsonius*), common shiner (*Luxilus cornutus*), tessellated darter (*Etheostoma olmstedi*), pumpkinseed (*Lepomis gibbosus*), bluntnose minnow (*Pimephales notatus*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), satinfin shiner (*Cyprinella analostana*), swallowtail shiner (*Notropis procne*), yellow bullhead (*Ameiurus natalis*), shield darter (*Percina peltata*), American eel (*Anguilla rostrata*), largemouth bass (*Micropterus salmoides*), common carp (*Cyprinus carpio*)

Species of Conservation Concern: none

Habitat: The Warmwater Community 2 is found in larger streams than the Atlantic Warmwater Community 1. Typical habitat occurs in low gradient ($\bar{X}$ = 1.1%), medium-to-large sized streams ($\bar{X}$ = 626 mi^2 watershed area) at low elevations ($\bar{X}$ = 96 m). Water chemistry values are generally moderate for alkalinity ($\bar{X}$ = 47 mg/l) and conductivity ($\bar{X}$ = 237 µS/cm). pH is neutral and water temperatures are usually warm.

Fish in this community type prefer pools in warm streams or ponds. Some indicator fish are tolerant of low dissolved oxygen levels or turbid waters. Many of these fish are habitat generalists. This group also includes game fish like smallmouth bass and bluegill, which were likely stocked in many locations and have potentially become naturalized.

Community distribution modeling showed that position in the watershed and both local and upstream landcover are strongly related to community locations. Low elevation, gradient, high numbers of upstream first order streams and high numbers of stream links were also good predictors of habitat. Amount of pastureland in the local and upstream ($\bar{X}$ = 25.6%) watersheds, amount of total wetlands ($\bar{X}$ = 0.9%), and wide, open stream channels were positively related to the streams containing the Warmwater Community 2.

Stream Quality Rating: Medium

Community Rarity: No

Threats: Similar to the Atlantic Basin Warmwater Community 1, non-point source pollution is a significant threat to the habitats of Warmwater Community 2. Large amounts of watershed agricultural land cover (~ 33%) typically occur with this community group. Nutrient enrichment and excess sedimentation of streams from mismanaged agricultural practices impair many streams in watersheds containing this community type.

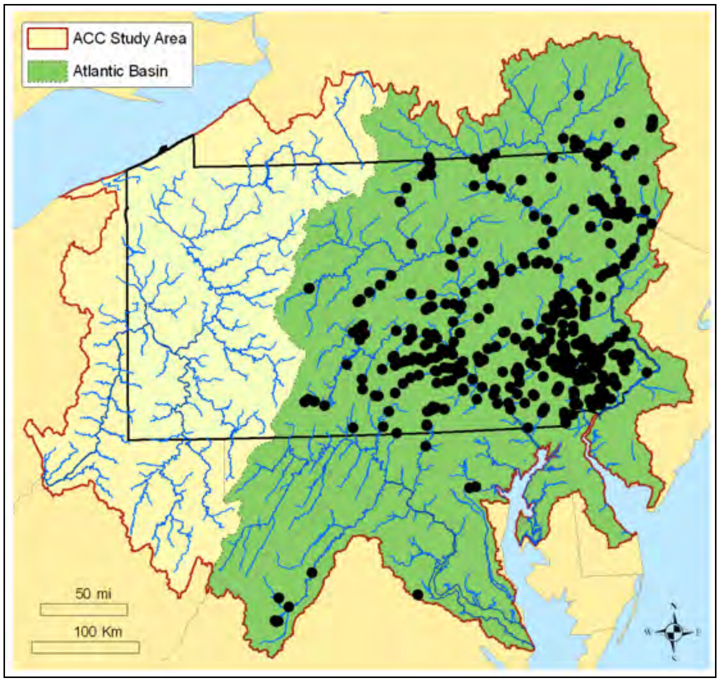
Some streams where this community is found are impaired from residential or municipal discharges. Urban runoff and sewer discharges can contain silt, high levels of nutrients, and other pollutants that damage fish habitats. River modifications through dams, channelization and bridge construction also threaten the habitats of aquatic communities.

Conservation Recommendations: This community is found downstream of many populated areas and exists in habitats that have been altered from their natural condition. Protection of the variety of habitats in small rivers is essential to maintaining a diverse fish community.

Management of combined sewer overflows, road runoff, and vegetated riparian areas will improve stream habitats in urban streams. Alternatively, the restoration of riparian buffers and exclusion of livestock from streams are techniques to control non-point source pollution in agricultural streams.

Atlantic Basin Fish: Warmwater Community 2

Known Locations:



Example Habitat:

In large streams and rivers with warm waters, the diverse Warmwater Community 2 is supported by a variety of habitats.

Photo source: PHNP

Atlantic Basin Fish: River and Impoundment Community

Community Indicators: walleye (*Stizostedion vitreus*), yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaulatus*), goldfish (*Carassius auratus*)

Species of Conservation Concern: None

Habitat: The River and Impoundment Community habitat is represented by relatively low gradient ($\bar{x}$ < 0.5%) large streams and rivers ($\bar{x}$ = 325 mi^2 watershed area) at low elevations ($\bar{x}$ = 203 m). Dam impoundments along rivers generate deep pools with soft stream bottoms to create this habitat.

Streams are characterized by warm waters ($\bar{x}$ = 18.6°C) with relatively high conductivity ($\bar{x}$ = 256 µS/cm) and alkalinity ($\bar{x}$ = 60 mg/l). pH values are slightly alkaline ($\bar{x}$ = 7.4).

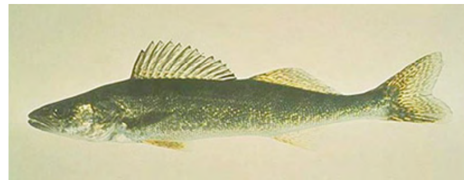
Landscape variables typically associated with large streams and rivers were the best predictors of habitat for the Atlantic River and Impoundment Community in distribution models. This community was highly related to amounts of pastureland ($\bar{x}$ = 16.6%), non row-crop agriculture ($\bar{x}$ = 16.7%), total agriculture ($\bar{x}$ = 21.0%), emergent wetlands ($\bar{x}$ = 0.2%), and the number of road-stream crossings in the watershed.

Stream Quality Rating: Medium

Community Rarity: No

Threats: Large streams and rivers are subject to many types of pollution. Tributaries to the main-stem of the lower Susquehanna River, Schuylkill River and Delaware River are impaired from a number of sources. These locations are where many examples of this community are found. Large rivers receive effluent from industrial discharges, sewage treatment plants and storm water runoff. The Schuylkill watershed receives polluted waters from abandoned mine drainage (AMD) resulting from coal mining practices in the watershed. Non-point source pollution from agriculture can contribute excessive silt and nutrients to rivers. Runoff from impervious surfaces in urban areas can carry road contaminants. Lastly, the presence of dams on the Susquehanna River fundamentally alters river habitat and changes natural flow patterns.

Strongest Indicators of Community Type



Walleye (*Stizostedion vitreus*)

Photo Source: http://www.cnr.vt.edu/efish

Yellow perch (*Perca flavescens*)

Photo source: www.nj.gov/dep

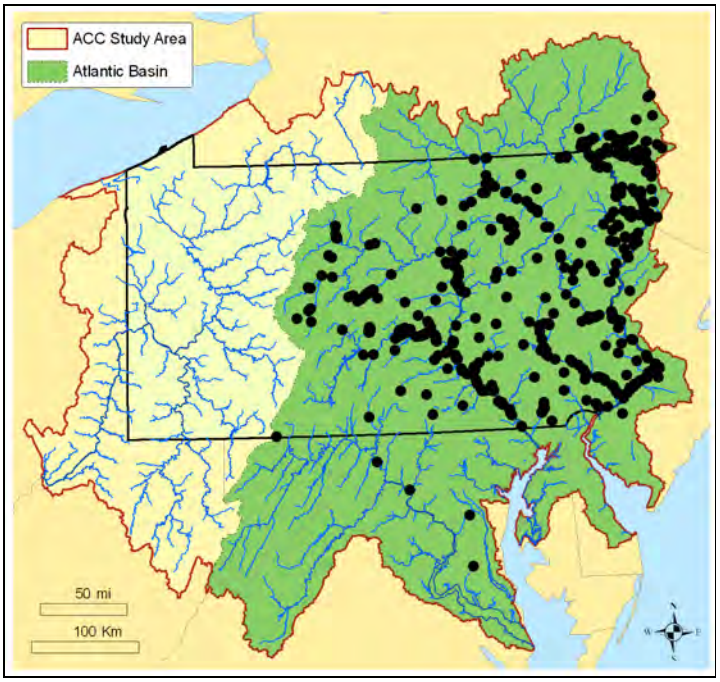
This community is primarily composed of fish that are not native to the Susquehanna or Delaware River watersheds. Walleye, black crappie, and goldfish are introduced species to the Atlantic Basins in eastern and central Pennsylvania. Many game fish, like walleye and yellow perch, have been introduced and may be actively stocked around Pennsylvania. Fish may have naturalized in many locations.

Conservation Recommendations: Large stream and river habitats in good condition are rare. Most large rivers have dams for flood control, navigational or recreation. Special consideration to dam removal should be made where possible because dams alter riverine functions like flow regime, habitat structure and connectivity. The damming of rivers has many ecological effects on aquatic species, including the disruption of migration and dispersal activities.

Although the potential sources of pollution to the river and impoundment community are many, remediation of these pollution problems is possible. Reducing pollution impacts from storm sewers, AMD, sewage treatment plants and industrial point sources can improve even the most severe water quality issues. Additionally, non-point source pollution from agricultural and urban areas should be addressed.

Atlantic Basin Fish: River and Impoundment Community

Known Locations:



Example Habitat:

Large rivers like the Susquehanna River (above) and impoundments
Provide the habitats for the River and Impoundment Community.

Photo source: PNHP

Atlantic Basin Fish: Lower Delaware River Community

Other community members: white perch (*Morone americana*), channel catfish (*Ictalurus punctatus*), blueback herring (*Alosa aestivalis*), eastern silvery minnow (*Hybognathus regius*), white catfish (*Ameiurus catus*), striped bass (*Morone saxatilis*), gizzard shad (*Dorosoma cepedianum*), American shad (*Alosa sapidissima*), banded killifish (*Fundulus diaphanus*)

Species of Conservation Concern: None

Habitat: This community mainly occurs in the lower Delaware River ($\bar{x}$ = 7,200 mi^2 watershed area) and its tributaries at low elevation ($\bar{x}$ = 5 m) in the coastal plain where stream gradients are low ($\bar{x}$ < 0.5%).

The Delaware River provides a unique riverine habitat in Pennsylvania. One of the only large, free-flowing rivers in North America, it meets its estuary near Morrisville, PA and Trenton, NJ. Consequently, the Delaware River has a suite of fauna suited to its coastal environment. The Lower Delaware River Community represents coastal fish that spawn in the lower Delaware River and associated freshwater fish. Several fish like the white perch, blueback herring, striped bass and American shad migrate into the Delaware River for spawning. Other community fish, like the channel catfish, are common in larger rivers.

Predictions of community distribution were negatively associated with stream elevation and gradient. A large number of dams, point sources and road stream crossings in the upstream watershed were good predictors of habitat for the Lower Delaware River Community. Although the mainstem of the river is unimpounded, the number of accumulated dams in the upstream watershed on its tributaries is large. A number of riparian, local and total watershed landcover associates are related to the habitat for this community. Low proportions of riparian forest ($\bar{x}$ = 12.4%), relatively high amounts of upstream woody wetlands ($\bar{x}$ = 3.0%), and relatively high amounts of low intensity urban development ($\bar{x}$ = 4.9%) were among the strongest predictors of this community type.

Stream Quality Rating: Moderate to low

Strongest Indicators of Community Type

White perch (*Morone americana*)

Photo Source: http://www.cnr.vt.edu/efish

Channel catfish (*Ictalurus punctatus*)

Photo source: www.nj.gov/dep

Community Rarity: Yes

Threats: Because of dense human populations surrounding the lower Delaware River, it is subject to typical urban threats such as combined sewer overflows, runoff from residential areas, stormwater discharges and road runoff. In addition, the shipping and commercial industries on the river can contribute to habitat destruction and pollution from dredging and discharges or spills from boats and barges.

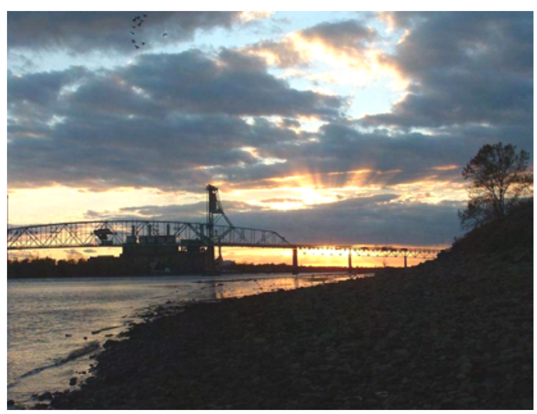
Conservation Recommendations: Current levels of low human disturbance in the upper Delaware watershed translate to good water quality as the river flows into its lower section. Minimizing point source effluence, stormwater runoff and combined sewer overflows will maintain water quality as the Delaware River flows out to its estuary.

Additionally, preventing major habitat destruction from dredging and other in-stream projects will allow fish species habitat to exist in a natural state.

Atlantic Lower Delaware River Community

Known Locations:

Example Habitat:



The lower Delaware River is one of the few un-impounded rivers in North America, and provides a home to the unique Lower Delaware River Community.

Photo source: PNHP

Fish Photo Credits – *all photos used with permission*

http://sites.state.pa.us/PA_Exec/Fish_Boat. Pennsylvania Fish and Boat Commission.

http://www.clemson.edu. Clemson University, Clemson Experimental Forest.

http://www.cnr.vt.edu/efish. Dr. Lou Helfrich, Dr. Tammy Newcomb, Dr. Eric Hallerman, and Dr. Ken Stein. EFISH: The Virtual Aquarium; Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University.

http://www.ohiodnr.com/dnap. Ohio Department of Natural Resources, Division of Natural Areas and Preserves.

www.nj.gov/dep. New Jersey Deparment of Environmental Protection.

8. Physical Stream Type Classification

Classifying streams by physical (non-biological) characteristics allows researchers to examine and categorize streams by the habitat type and the variety of biological assemblages that the stream can support. An examination of stream habitat types and their distribution across the region should help to inform and advance aquatic conservation work in the study area. In the past, conservation work has largely been limited to a focus on rare and endangered species. An approach such as this can often exclude more common species and habitats, leaving out integral parts of ecosystems. A so-called "coarse-filter" approach, such as this Physical Stream Type classification, focuses on habitat variability and encompasses all organisms that depend on certain habitat types (Higgins et al. 2005). The intention of this approach is to protect the network of habitats found in entire aquatic systems. It is not a surrogate for targeted rare species conservation.

For our physical stream classification we chose to use landscape variables that influence in-stream biological habitat (a "bottom-up" approach to habitat classification; Higgins et al. 2005) and were also readily available in GIS data for most of the study area: geology type, watershed size, and stream gradient (Table 8-1). These three types of data were linked to individual stream reaches using GIS. The data were divided into categories based on the effect of the variable on aquatic biota (Table 8-2); while this habitat classification is based solely on physical criteria, it was our objective that the habitat types developed be biologically meaningful.

Table 8-1. Data that were associated with stream reaches to create the Physical Stream Type Classification. Table adapted from Higgins et al. (2005).

Abiotic Attribute	Rationale for Inclusion
Geology	Geology classes can capture the influence of rock types on many stream attributes: water source (ground or surface), temperature, chemistry, substrate, stream geomorphology, and hydrological regime
Stream Gradient	Correlated with flow velocity, substrate material, channel morphology and stream habitat types (pools, riffles, runs, etc.)
Stream Size	Measured in drainage area: correlated with channel morphology, habitat types, habitat stability and flow volume.

Bear Creek, in Butler Co., PA, is an example of Physical Stream Type '123', or a sandstone geology, moderate gradient, mid-reach stream.

Geology

Geology classes were based on work done by The Nature Conservancy (TNC; Anderson and Olivero 2003). TNC's research combined factors that influence water chemistry and hydrologic regime into categories based on bedrock geology types. In order to create a similar classification based on watershed geology, we decided that six geology classes adequately reflected chemical and hydrological variables for Pennsylvania (Table 8-2). We assigned these geology classes to the geology information from Pennsylvania's bordering states (see *References* section of this chapter) in order to create seamless geological classes across the study area. Unfortunately, we were unable to obtain digital geological information for Maryland.

To perform the joining of geological data to stream reaches, the geology type that was most dominant in the upstream watershed was associated with each stream reach. Using dominant upstream geology accounts for the cumulative effects of upstream geology on water chemistry and substrate material at a location, rather than localized effects of underlying geology at a single stream reach.

Stream Gradient

Stream gradient was calculated as a measure of change in elevation from the start to end of an individual stream reach. Stream segments were defined by RF3 (Reach File, Version 3.0) stream reaches, published by the U.S. Environmental Protection Agency (Dewald and Olsen 1994).

Three gradient categories were used that reflect patterns in biological assemblages as well as patterns in the stream gradient dataset (Table 8-2), and were based on work done by The Nature Conservancy (Anderson and Olivero 2003). These classes reflect a slightly skewed distribution in gradient types, as there are many low-gradient valley streams and a lower number of high-gradient ridge-top streams in the study area. These classes also reflect patterns in biological communities. For example, some communities found in low-gradient streams showed a general affinity to gradients less than 0.5%. Alternatively, some high-gradient communities were commonly found in streams with gradients over 2.0%.

Watershed Size

Watershed area was calculated for each RF3 stream reach by summing the land area that contributes to the basin of each stream reach (Anderson and Olivero 2003). We delineated four categories of watershed size that reflect patterns in biological assemblages as well as patterns in the watershed size dataset (Table 8-2).

Table 8-2. The three variables used to determine Physical Stream Type and the categories within them. See text for further explanation of variables and data sources.

	Physical Variables and Categories	Description
Geology Classes		
1	Sandstone	Most common type in study area; comprised of sand-sized particles; moderate/variable stream flashiness; low conductivity, can have acidic pH
2	Shale	A fine-grained sedimentary rock, the second-most common geology type in study area; generally flashy streams; often occurs in coal regions; can have calcareous deposits, but generally has an acidic effect on streams; variable conductivity
3	Calcareous	Limestone and dolomite rock types; even small amounts of calcareous geology can have a disproportionate effect on water chemistry and biotic assemblages; flow is more stable in these streams because of porosity and fracturing; base-cation rich; relatively high pH, conductivity, alkalinity, and TDS.
4	Crystalline Silicic	Igneous or metamorphic rock containing silica ions; formed under low heat and pressure; hard rock that weathers slowly; generally has lower ion concentrations, less influence on stream chemistry than other geology types
5	Crystalline Mafic	Igneous or metamorphic rock containing calcium, sodium, iron and magnesium ions; hard rock that weathers slowly; generally has lower ion concentrations, less influence on stream chemistry than other geology types
6	Unconsolidated materials	Sands and gravels (mainly along coastal zones and larger rivers); geological characteristics derived from surrounding rocks types in the area
Stream Gradient		
1	Low Gradient	Stream slope is 0.0 - 0.5%
2	Medium Gradient	Stream slope is 0.51 – 2.0%
3	High Gradient	Stream slope is over 2.0%
Watershed Size		
1	Headwater stream	0 – 2 mi^2 (0 – 5.2 km^2)
2	Small stream	2 – 10 mi^2 (5.2 – 25.9 km^2)
3	Mid-reach stream	10 – 100 mi^2 (25.9 – 259.0 km^2)
4	Large Streams and Rivers	Over 100 mi^2 (259.0 km^2)

Size 1 watersheds represent the smallest headwater streams (0-2 mi^2 watershed area; 19,000 stream reaches). These streams hold mainly headwater macroinvertebrate communities. Size 2 watersheds (2-10 mi^2; 13,000 reaches) are still small in size, but support a greater diversity of macroinvertebrate and small-stream fish communities. Watersheds in the Size 3 category (11-100 mi^2; 12,000 reaches) represent mid-reach streams and generally maintain many types of macroinvertebrate and fish communities. Size 4 streams (100+ mi^2; 7,000 reaches) represent the larger streams and rivers of the study area. They commonly hold nearly all mussel communities and the large river fish communities.

Data Processing

The geological, gradient and watershed size data were combined for every stream reach in the study area using GIS. In order to name the physical classes developed, the numbers accompanying each variable category from Table 1 were used. For example, a sandstone-dominant ('1'), moderate gradient ('2') small stream ('2') would receive an physical classification of '122'.

Once the physical stream classes were defined, the biological community groups were assigned to stream types.

Results & Discussion

The Physical Stream Type classification revealed a total of 64 stream habitat categories, with 45 classes being represented by more than 100 stream reaches in the study area. Nineteen common classes had more than 1,000 stream reaches in the study area (Table 8-3). The two most common stream types were both high-gradient headwater streams with sandstone or shale geology, respectively.

Many biological communities showed preferences towards certain physical stream types (Table 8-4). Most notable are the genus- and family-level macroinvertebrate communities that are commonly found in calcareous geology; these communities were consistently found in physical stream classes with this unique geology type. Macroinvertebrate communities indicative of either high or low stream gradients were also related to physical types that reflected these differences.

Table 8-3. Most common physical stream types in the study area.

Physical Stream Type ID	# Stream Reaches in Study Area	Physical Stream Type Name
131	11,536	Sandstone geology high gradient headwater stream
231	7,300	Shale geology high gradient headwater stream
113	4,656	Sandstone geology low gradient mid-reach stream
111	4,309	Sandstone geology low gradient headwater stream
114	4,051	Sandstone geology low gradient large stream
122	3,924	Sandstone geology moderate gradient small stream
121	3,391	Sandstone geology moderate gradient headwater stream
132	3,027	Sandstone geology high gradient small stream
123	2,895	Sandstone geology moderate gradient mid-reach stream
112	2,888	Sandstone geology low gradient small stream
221	2,626	Shale geology moderate gradient headwater stream
214	2,529	Shale geology low gradient large stream
222	2,512	Shale geology moderate gradient small stream
213	2,362	Shale geology low gradient mid-reach stream
223	1,619	Shale geology moderate gradient mid-reach stream
211	1,561	Shale geology low gradient headwater stream
212	1,450	Shale geology low gradient small stream
232	1,270	Shale geology high gradient small stream
331	1,267	Calcareous geology high gradient headwater stream

Fish communities also appeared to be different-tiated among physical types. The coldwater trout stream communities were found in higher gradient smaller streams, exclusively in sandstone-dominated geology streams. The warmwater groups were in slightly larger streams with lower gradients. Lastly, the large river and impoundment groups were associated mainly with lower gradients and large streams (Size 4).

The mussel communities were almost exclusively associated with physical classes indicating large streams, lower gradients and either sandstone or shale geologies. Since this physical stream classification seemed to explain differences among fish and macroinvertebrate communities, but not mussel communities, it is likely that these physical stream types do not reflect site-specific substrate variation that is important to mussel viability and distribution. However, it does appear that the classification may be effective at describing large-scale variables that influence distribution patterns of fish and macroinvertebrate assemblages. Perhaps a more detailed classification, incorporating such variables as elevation or hydrologic regime (*sensu* Higgins et al. 2005) would further elucidate relationships between stream types and resident biological communities.

Utility of Physical Stream Types

Combining the Physical Stream Type Classification with the LDS (Least-Disturbed Stream) Reaches

In conservation work, it is important to preserve stream systems that are as close to naturally functioning as possible. It is also important to protect unique stream habitats that may not be adequately represented in standard analyses (Higgins et al. 2005). By combining the Physical Stream Type Classification with the Least-Disturbed Stream (LDS) analysis (Chapter 9), the best examples of various stream habitat types can be readily identified. This will allow researchers to determine the locations where different types of stream habitats are functioning as naturally as possible. Associating the biological community information (Chapters 4-7) with LDS reaches and physical stream types will provide information as to what biological assemblages exist in these distinctive habitats.

Stream Conservation Using Physical Stream Types & LDS

Stream conservation efforts can be easily streamlined with the use of the LDS and Physical Stream Type tools. After a project area (i.e., a watershed) has been defined, the habitat types within that project area may be assessed. Knowing what stream types exist within a project area will help researchers to identify the conservation needs of the area. The best examples of stream types are easily identified by overlaying the LDS information. If there are physical stream types that are not represented by an LDS designation in the project area, knowledge of the area and streams within the area will be critical. Combining LDS and Physical Stream Type information will ensure that the best examples of each stream habitat are represented in watershed conservation work (see the Pine Creek example in “Utilities of LDS Analysis” section of Chapter 9).

Stream Restoration Using Physical Classification & LDS Reaches

The ACC tools described in this chapter should make stream restoration efforts more efficient and measurable. Target conditions for study streams (degraded streams in need of restoration action) may be established by finding an LDS stream of the same physical habitat type. The LDS stream will serve as a benchmark stream, which can be used to measure the success of restoration efforts in the study stream. This may be done through a condition analysis of the LDS stream. Gathering information from the LDS stream (water chemistry profiles, resident biological communities, etc.) will provide information about what biological and chemical qualities the study stream should exhibit if its water quality issues are remedied (see Toby Creek restoration example in “Utilities of LDS Analysis” section of Chapter 9).

References

Anderson, M.A. and A.P. Olivero. 2003. TNC Stream Macrohabitat, Lower New England Ecoregional Plan. The Nature Conservancy.

Higgins, J.V., M.T. Bryer, M.L. Khoury, and T.W. Fitzhugh. 2005. A freshwater classification approach for biodiversity conservation planning. *Conservation Biology*, 19 (2): 432-445.

Dewald, T.G. and M. V. Olsen. 1994. The EPA Reach File: A National Spatial Data Resource. SEPA, May 1994.

Reese, S.O. and Podniesinski, G. *personal communications*.

Geology Data Sources:

Delaware: www.udel.edu/dgs
New Jersey: www.state.nj.us/dep/njgs
New York: www.nysm.nysed.gov/gis
Ohio: www.dnr.state.oh.us/geosurvey
Pennsylvania: www.dcnr.state.pa.us/topogeo
Virginia: www.mme.state.va.us/dmr
West Virginia: wvgis.wvu.edu/data/data.php

Related Shapefiles

ACC_Physical_Stream_Types.shp
ACC_Geology_Classes.shp

Example Restoration Action Plan Using LDS Reaches & Physical Stream Types:

1. Select study stream; determine abiotic class type.
2. Find streams of same abiotic type, preferably in same drainage basin.
3. Identify stream of same abiotic type that is an LDS reach – this is the benchmark stream. Multiple benchmark streams may be useful, if time and funding allow.
4. Complete a condition analysis of benchmark stream – determine resident biological communities, water chemistry profile, etc; compare to LDS stream.
    a. Determine what sets the benchmark stream apart from the study stream
        i. Threats analysis – what is degrading the study stream?
5. Perform necessary restoration measures on study stream (AMD remediation, streambank fencing, etc.)
6. Measurement of restoration success:
    a. Assess new biological communities in study stream – are they like that found in the benchmark stream?
    b. Assess new water chemistry profile in study stream – is it similar to that found in the benchmark stream?

Table 8-4. Biological communities and their commonly associated physical stream types.

Community Name	Representative Taxa	Common Physical Stream Types
Mussels		
Delaware Basin		
Eastern Elliptio	*Elliptio complanata*, *Villosa iris*	114, 214
Alewife Floater	*Anodonta implicata*	114
Other	rare mussel species	222
Ohio - Great Lakes Basin		
Pink Heelsplitter	*Potamilus alatus*	114
Fluted Shell	*Lasmigona costata*, *Ptychobranchus fasciolaris*	114, 113
Fatmucket	*Lampsilis siliquoidea*, *Pyganodon grandis*	114, 113
Spike	*Elliptio dilatata*, *Ligumia recta*	114, 113
Susquehanna - Potomac Basin		
Lanceolate Elliptio	Lanceolate *Elliptio* complex	214, 113
Squawfoot	*Strophitus undulatus*	114, 213, 113, 313
Yellow Lampmussel	*Lampsilis cariosa*	214, 114, 223, 113
Elktoe	*Alasmidonta marginata*	214, 213, 231
Eastern elliptio	*Elliptio complanata*	214, 114, 213, 113
Eastern floater	*Pyganadon cataracta*	114, 124, 214, 322
Macroinvertebrates		
Genus-level		
High Quality Small Stream	*Epeorus*, *Oulimnius*	132, 131, 122, 123
High Quality Headwater Stream	*Amphinemura*, *Lepidostoma*	131, 132, 122, 231
High Quality Large Stream	*Drunella*, *Acentrella*	123, 122, 113, 223, 132
Sluggish Headwater Stream	*Physidae, Hirudinea*	121, 221, 122, 313, 322
Common Large Stream	*Dubiraphia, Caenis*	122, 113, 123, 213, 222
Limestone / Agricultural Stream	Isopoda, Oligochaeta	313, 231, 312, 322, 323
Small Urban Stream	*Cheumatopsyche, Stenelimis*	421, 413, 113, 131
Large Stream Generalist	Generalist Taxa	213, 221, 113, 222, 114
Forested Headwater Stream	*Alloperla*, *Tipula*	131, 122, 132
Common Small Stream	*Stenonema, Psephenus*	522, 213, 221, 113, 123
Ohio River	*Cyrnellus, Amphipoda*	114
Mixed Land Use Stream	*Hydropsyche, Nigronia*	123, 331, 221, 232
Family-level		
Low Gradient Valley Stream	Elmidae, Psephenidae	222, 122, 113, 221, 213
High Quality Mid-Sized Stream	Isonychiidae, Philopotamidae	122, 123, 222, 131, 113
Common Headwater Stream	Lepidostomatidae, Capniidae	131, 132, 231, 122
Limestone / Agricultural Stream	Amphipoda, Simuliidae	313, 322, 122, 114, 331
High Quality Small Stream	Leuctridae, Baetidae	131, 122, 132, 231, 222
Common Large Stream	Nemouridae, Ameletidae	131, 231, 122, 221, 222
High Quality Headwater Stream	Chloroperlidae, Pteronarcyidae	131, 132, 122, 123, 231
AMD Stream	Sialidae, Empididae	122, 132, 231

Table 8-4., Cont.

Community Name	Representative Taxa	Common Physical Stream Types
Fish		
Atlantic Basin		
Warmwater Community 1	central stoneroller, northern hogsucker	113, 123, 114, 213
Warmwater Community2	redbreast sunfish, rock bass	214, 213, 113, 114
Coolwater Community 1	slimy sculpin, fathead minnow	132, 123, 122
Coolwater Community 2	blacknose dace, white sucker	123, 122, 313
Coldwater Community	brook trout, brown trout	132, 123, 131, 122
River and Impoundment	walleye, yellow perch	114, 214, 113
Lower Del. River Community	white perch, channel catfish	114, 214, 213
Ohio - Great Lakes Basins		
Warmwater Community	greenside darter, northern hogsucker	114, 113, 123, 213
Coldwater Community	brook trout, mottled sculpin	122, 132, 123, 131, 113
Coolwater Community	blacknose dace, creek chub	113, 122, 123, 213, 223
Large River Community	channel catfish, sauger	114

Belted Kingfisher, Ten Mile Creek, Greene Co., PA.

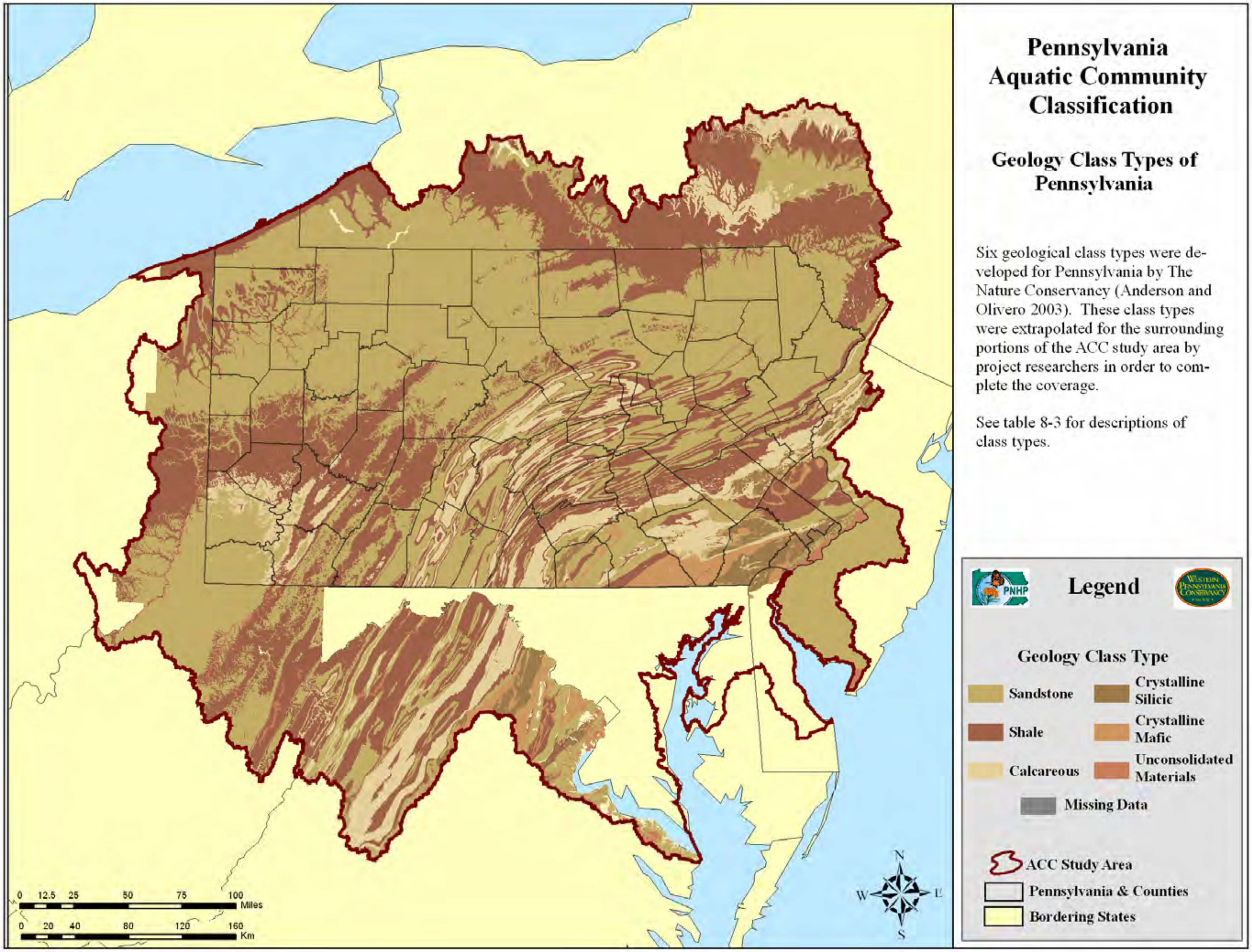


Figure 8-1. Geology type classes for the ACC study area.

9. Least-Disturbed Stream (LDS) Reaches

High-quality stream reaches, sometimes called "reference streams," are often used to identify aquatic habitats that are representative of the best possible stream condition. Reference streams, generally identified using biological assemblages, ideally have little disturbance from human influences, and the biota found there demonstrate natural ecological function. A drawback to this type of analysis is that only streams that have biological samples can be considered for reference streams. In our study, we used landscape-level attributes of watersheds to select streams with the least amount of relative disturbance in the ACC study area (Figure 9-1). This allowed for an all-inclusive assessment of stream quality which was not limited to locations where biological data have been collected. These streams are referred to here as "Least-Disturbed Streams" (LDS).

To select LDS reaches systematically across our study region, we chose a suite of 10 landscape-level variables that serve as indicators of overall watershed quality. This method acts as a surrogate for time-consuming and costly on-the-ground field visits to individual stream locations. A key benefit of landscape-level analysis, as opposed to field visits, is that every stream reach in the study area receives the same standardized level of information.

The variables used in our study were chosen for two reasons: 1) the data were available for the entire study area and 2) the variables provide information about the degree of disturbance and the ecological integrity of stream systems. Ten variables were chosen that represent variations in point and non-point source pollution, hydrologic regime, stream connectivity and quality of riparian habitat (Table 9-1).

Table 9-1. Landscape-level variables associated with RF3 stream reaches in GIS used to select least-disturbed stream (LDS) reaches. See text for descriptions of data and sources.

Catchment Urbanization (impervious)	Riparian Urbanization (impervious)
Catchment Agriculture (non-row crop)	Riparian Agriculture
Catchment Agriculture (row crop)	Riparian Forest Cover
Catchment Forest Cover	# Catchment Road Crossings
# Catchment Point Sources	# Catchment Dams

Stream reaches for the LDS analysis are the stream segments defined by EPA Reach Files version 3.0 or "RF3 stream reaches" (Dewald and Olsen 1994). Using GIS, each stream reach was joined with information about its position in the watershed, local environmental characteristics and landscape information about the watershed that drains to each stream reach.

Limestone Run in Fayette Co., PA is an example of a size 2 Least-Disturbed Stream (LDS).

Data Used

Catchment land cover variables

Different types of land use (agricultural, urban, forested, etc.) within a watershed often influence water quality, habitat quality, channel condition and the hydrology of streams. The land cover metrics used in this analysis were derived from the 1992 National Land Cover Dataset (NLCD), obtained from USGS (http://seamless. usgs.gov). Using totals of catchment land cover type, proportions of land cover categories were calculated for the catchment of each stream reach. The categories were:

- Catchment Urbanization – This category of land cover was categorized as the sum of "Low Intensity Residential", "High Intensity Residential" and "Commercial/ Industrial/ Transportation" land cover categories.

- Catchment Agriculture – Land cover in this category was divided into two types:

  1. Non-row crops – NLCD categories "pasture/hay", "small grains", "fallow" and "urban/recreational grasses".

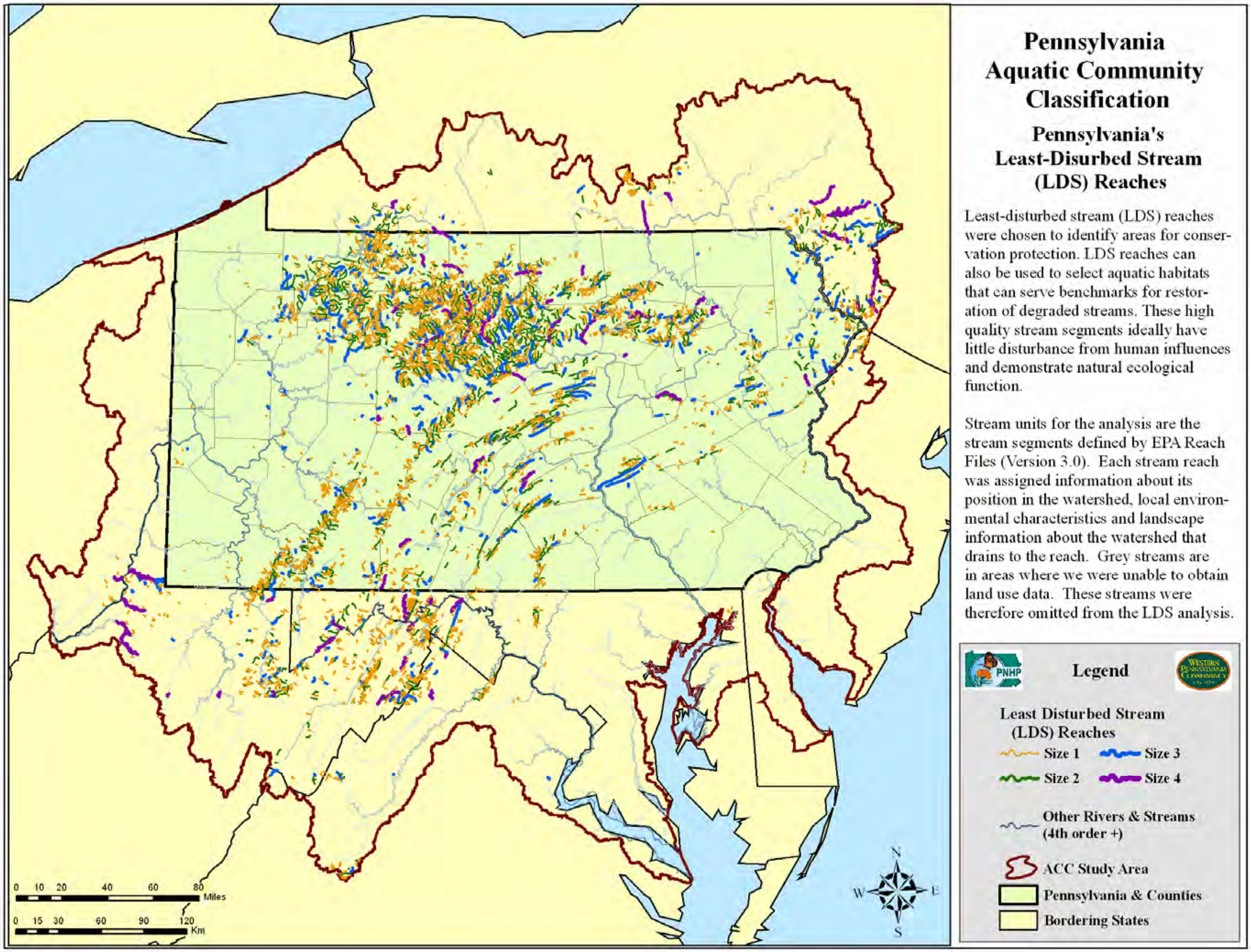


Figure 9-1. Least-Disturbed Stream (LDS) reaches for the ACC study area. See table 9-1 for listing of GIS variables used in the analysis.

2. Row crops – From the "row crop" NLCD land cover class. Row crops were used as a separate land cover class because of their potential to contribute different kinds and levels of pollutants to stream systems than non-row crop agriculture.

- Catchment Forest Cover – This land cover type represents the sum of different forest types in NLCD: "deciduous forest", "evergreen forest" and "mixed forest".

Riparian land cover variables

The types of vegetation and land use in riparian zones can have localized effects on water quality, habitat condition, channel alteration and hydrologic regime in streams. The proportion of land cover types in a 100-m buffer for each stream reach was also calculated using the 1992 NLCD layer (http://seamless.usgs.gov). Riparian statistics were not used in the determination of size 4 LDS reaches.

- Riparian Agriculture – Collective proportion of NLCD agricultural categories - "row crops", "pasture/hay", "small grains", "fallow and urban/recreational grasses".

- Riparian Urbanization (Impervious) – Collective proportion of NLCD urbanization/impervious surface categories: "low intensity residential", "high intensity residential" and "commercial/ industrial/transportation".

- Riparian Forest Cover – Collective proportion of NLCD forest categories: "deciduous forest", "evergreen forest" and "mixed forest".

Number of catchment road-stream crossings

Runoff from roads leads to pollution from petroleum products, metals and other toxins. In small headwater streams, otherwise intact water-sheds may be disturbed by sediment runoff from roads. Improperly maintained bridges and culverts at road-stream crossings may lead to habitat and channel alteration.

The number of intersections of roads and streams in the upstream catchment were summarized for each stream reach. Roads identified in the Census 2000 Tiger line files (http://www.census.gov/geo/www/tiger) were used in the analysis.

Number of catchment point sources

The number of point-source pollution discharges in the upstream catchment was enumerated for each stream reach. Point sources were identified as mines, industrial discharges and permitted discharges. Any of these point sources may contribute potential toxins to the watershed, degrade water quality and alter stream habitats. Although toxin type and amount may differ from source to source, the number of point sources can be an indicator of overall watershed health.

Datasets used for point source information (see Appendix A for more information):

- Mines – USBM Mineral Availability System (http://minerals.er.usgs.gov/ minerals/pubs)

- Industrial point sources:
  - Superfund/CERCLIS (EPA Comprehensive Environmental Response, Compensation, and Liability Information System**,** www.epa.gov/superfund)
  - IFD (Industrial Facilities Discharge, www.epa.gov/ost/ basins)
  - TRI (Toxic Release Inventory Facilities, www.epa.gov/enviro/ html/tris/tris_overview.html)
  - Permitted discharges - PCS (EPA/OW Permit Compliance System, www.epa.gov/owmitnet/ pcsguide.htm)

Number of catchment dams

The presence of dams can alter natural process of lotic systems such as temperature dynamics, flow regimes and the transport of nutrients and sediments. In-stream habitats are altered and connectivity among aquatic habitats is disrupted. The total number of dams in the catchment catchment areas was counted for each stream reach. Data on dam locations were acquired from the National Inventory of Dams (www.epa.gov/OST/ BASINS).

LDS Calculations

Stream reaches were separated into four size classes (based on watershed area; Table 9-2), so that reference criteria could be assigned to each size class independently.

In order to identify the Least-Disturbed Streams (LDS) in the study area regardless of physical habitat or ecological regions, we applied one set of criteria to all stream reaches in the region. This was done by finding the cut-off values that showed the top 10% least disturbed streams for each of the 10 different metrics individually (for each size class). These cut-off values were then applied to all reaches simultaneously and relaxed accordingly until 10% (± 0.3%) of stream reaches were selected (Table 9-3, Figure 9-1).

Table 9-2. Size class categories used in the ACC project. Classes were adapted from those used by The Nature Conservancy for stream conservation work (Anderson and Olivero 2003).

Size Class	Watershed Size
1. Headwater stream	0 – 2 mi^2 (0 – 5.2 km^2)
2. Small stream	3 – 10 mi^2 (5.2 – 25.9 km^2)
3. Mid-reach stream	11 – 100 mi^2 (25.9 – 259.0 km^2)
4. Large streams and rivers	Over 100 mi^2 (>259.0 km^2)

Specialized LDS Criteria

Because human settlement, land use and pollution patterns can follow regional boundaries, some areas of the study region had few or no reference streams identified in the first analysis (Figure 9.1). To identify the best remaining conditions in these underrepresented areas, we performed the same analysis for these areas in a second iteration of the LDS reach selection process. This includes areas of unique geologies; namely calcareous, crystalline mafic and crystalline silicic geology-dominated streams (Figure 8-1); streams in the Piedmont physiographic province and streams in the Waynesburg Hills, Northwest Glaciated Plateau, Great Valley and Susquehanna Lowland physiographic sections (Figure 9-2; Appendix B).

Calcareous Geology Streams: Calcareous geology (limestone and dolomite) is common in valleys across southern Pennsylvania. In the ACC study area, it is also found in sections of the upper Susquehanna River drainage in New York (Figure 8-1). Calcareous geology usually leaves unique chemical signatures in stream water that flows through it, altering water chemistry and the resulting biological assemblages. Streams affected by calcareous geology generally show high alkalinity and conductivity values. Com-pounding these natural variations, calcareous geology generally leaves land well suited for agriculture; therefore these chemistry values can be inflated due to advanced agricultural and urban development in the watershed. For these reasons, we have separated calcareous streams out to determine where the least-disturbed examples of this unique stream type exist.

Crystalline Silicic and Crystalline Mafic Geology Streams: These two geology types are found in the southeast corner of Pennsylvania (Figure 8-1). Crystalline rocks are formed from solution, such as igneous rock. This is in contrast to sedimentary rock like sandstone, which is formed from the layering and compaction of sediments. Both crystalline rock types contain certain elements that can leave unique signatures in stream water; crystalline silicic rock contains high amounts of silica, while crystalline mafic rocks can leave traces of calcium, sodium, iron and magnesium in surface water. Furthermore, these geology types are found in highly populated areas of southeastern Pennsylvania; water quality issues associated with urban streams (e.g., stormwater runoff and municipal discharges) may compound or mask the effects of these unique geologies.

Kettle Creek, in Potter Co., PA, is an example of a size 4 least-disturbed stream (LDS).

Piedmont Streams: The Piedmont physiographic region is located in the southeast corner of Pennsylvania (Figure 9-2). It is an area that has a long history of human habitation and consequent alteration of the landscape and watersheds. Streams in this region have undergone a widespread removal of native streamside vegetation. This disturbance has occurred either directly via timber harvest or land development, or indirectly through events related to human habitation such as the introduction of invasive species or disease-driven changes like American Chestnut Blight or American Elm Disease (Sweeny, 1992).

Agricultural land is prominent in the Piedmont region. Agricultural lands that are poorly buffered can add excess nutrients and sediments

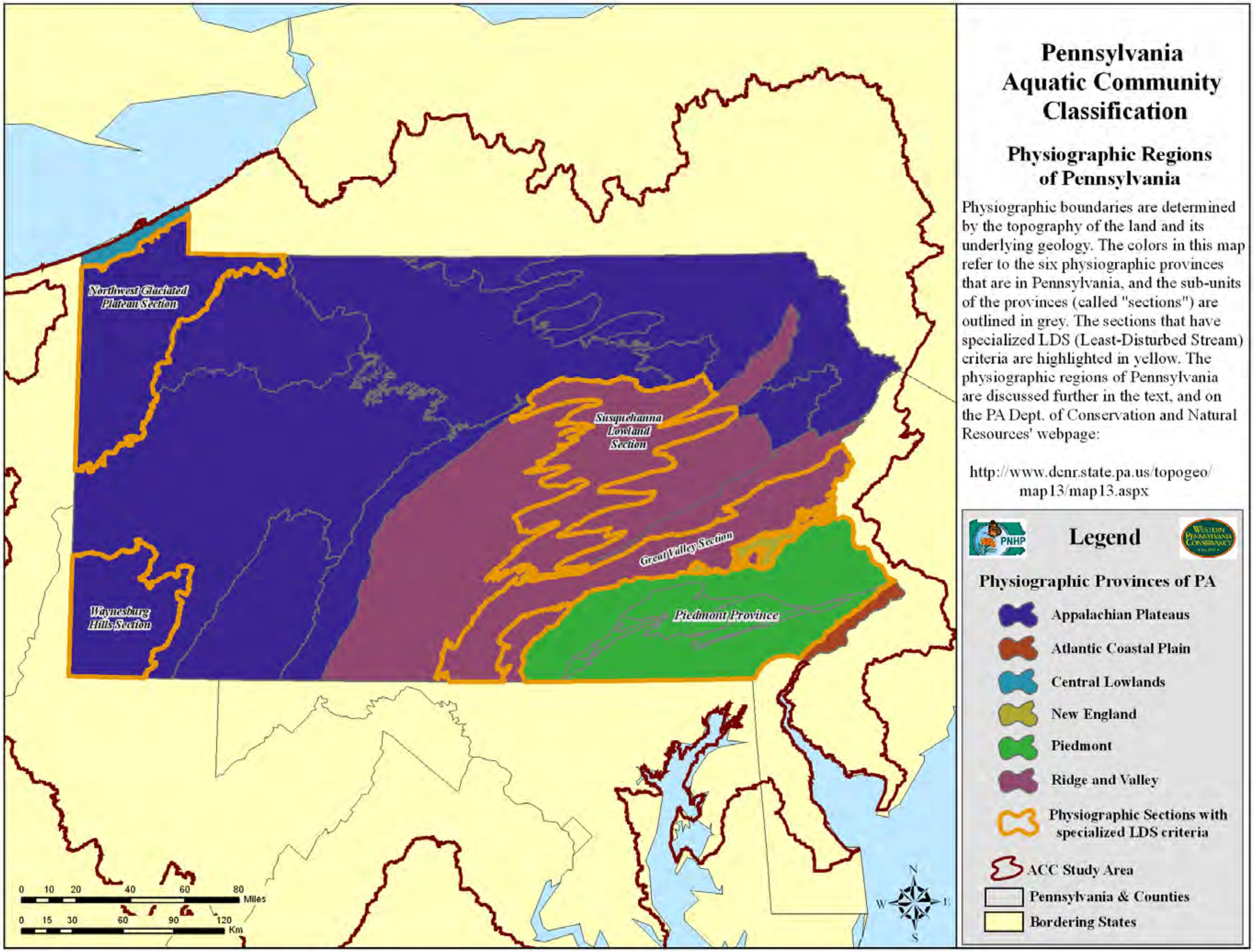


Figure 9-2. Physiographic Provinces of Pennsylvania. Physiographic regions relevant to the LDS analysis are highlighted and labeled.

to streams, which can degrade water quality and habitat condition for stream organisms. We chose this area for a separate LDS analysis due to the increased levels of land development in the Piedmont, which is coupled with unique geology types (Figure 8-1).

Waynesburg Hills Streams: The Waynesburg Hills Physiographic Section is located in southwest Pennsylvania (Figure 9-2). This area (namely Greene and Washington Counties and part of Fayette County) has a history of coal mining and agriculture that has left streams in this region in a state of nearly ubiquitous degradation, mainly in the form of abandoned mine drainage (AMD). In addition to other alterations to the landscape, calcareous geology is also prominent in this area. This type of geology leads to a host of other water quality and condition issues, as discussed above.

Northwest Glaciated Plateau, Great Valley and Susquehanna Lowland Streams: Streams in these three physiographic regions are faced with degradation problems stemming mainly from poorly maintained agricultural land. Agricultural activity is prevalent in these areas, all of which showed very little or no LDS streams from the original analysis.

For more information on Pennsylvania's physiographic provinces, see the PA Department of Conservation and Natural Resources webpage: http://www.dcnr.state.pa.us/topogeo/map13/map13.aspx.

Results

The LDS analysis selected over 8,000 stream reaches totaling nearly 9,800 stream miles (15,800 km). The quantity of streams in the four size classes are represented in descending order, with Size 1 streams being most numerous and Size 4 having the least representatives. There were roughly 3,400 Size 1 LDS reaches, totaling 4,650 stream miles (7,500 km); 1,800 Size 2 streams, totaling 2,900 miles (4,700 km); 1,450 Size 3 reaches, totaling 1,500 miles (2,400 km); and 850 Size 4 LDS reaches, adding up to greater than 700 stream miles (1,150 km).

The LDS reaches showed the greatest concentration in the north-central part of Pennsylvania, aggregating in the Allegheny National Forest and state forests in this region. The most notable LDS streams are the Size 4 reaches, since these are the lowest in number and high quality streams of larger size are often difficult to find.

Large rivers often flow through heavily populated areas and receive extremely high levels of pollutants that affect water quality, such as sewage treatment plant discharges and runoff from impervious surfaces. Consequently, large river segments were essentially absent from the results of the LDS analysis. To select large river reaches that are in the best relative condition, a separate biological-data-only analysis was completed. This analysis is detailed in the Conservation Prioritization Chapter (Chapter 10).

Utilities of LDS Analysis

By using LDS stream reaches, researchers will be able to determine which streams are the most intact in their area relative to streams across the greater Pennsylvania region. In areas where streams face a number of stresses (calcareous geology, Piedmont streams, etc.), the streams in the best condition relative to their specific area will be easily selected as a target for preservation or a goal for restoration.

In conservation work, it is important to preserve stream systems that are as close to naturally functioning as possible. It is also important to protect unique stream habitats that may not be adequately represented in standard analyses (Higgins et al. 2005). By combining the LDS analysis with the Physical Stream Type classification (Chapter 8), the least disturbed examples of various stream habitat classification types will be readily identified. Using the results of these two analyses in concert will allow researchers to determine where different types of stream habitats are functioning at or near natural condition. Associating the ACC biological community information with LDS reaches and Physical Stream Types will help to determine what sort of biological assemblages should be found in these each stream types.

Combining these various elements of the ACC project will help researchers to highlight important streams in their region and describe the assemblages of aquatic animals that are found there. Two examples of these techniques are detailed in the following section.

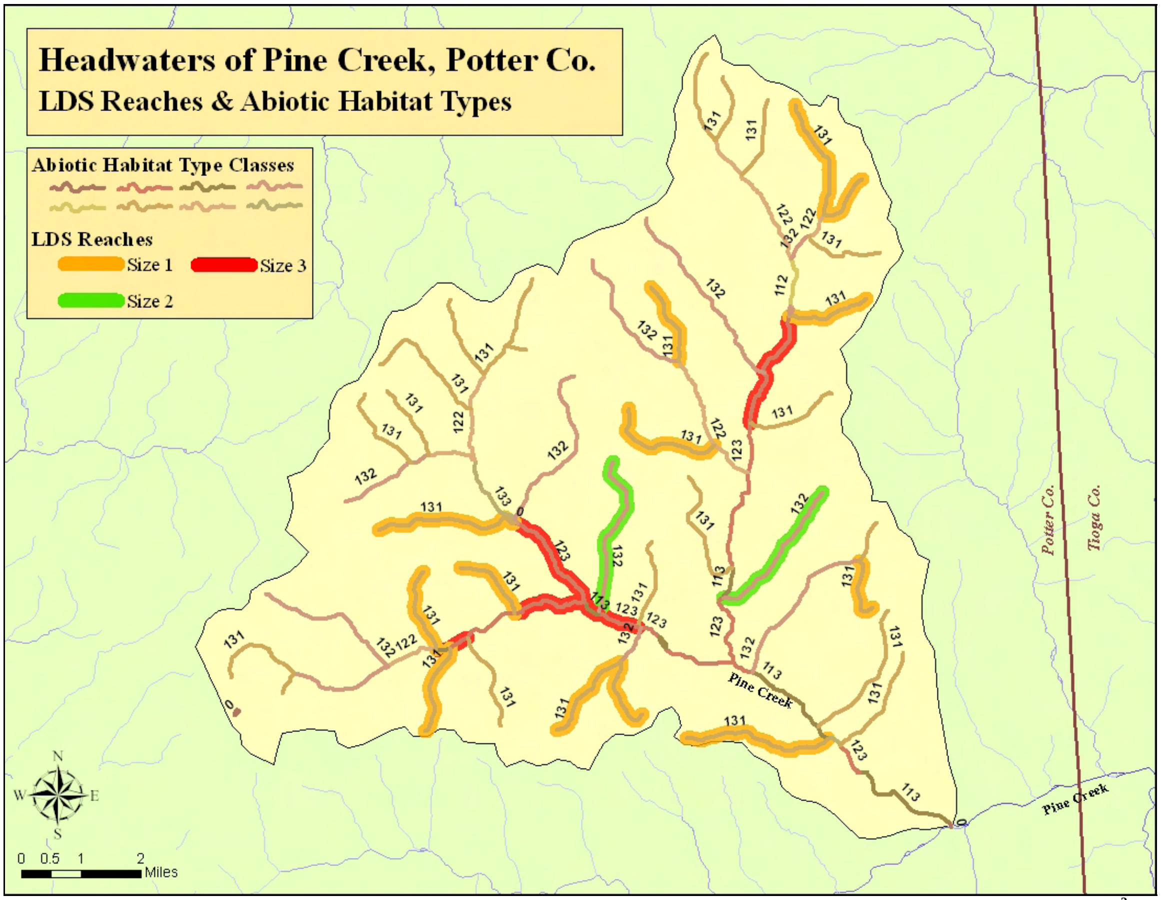


Figure 9-3. The headwaters of Pine Creek flow through Potter Co., PA. The pictured watershed totals approximately 95 mi^2 (246 km^2). Pine Creek ultimately joins the West Branch Susquehanna River near the Lycoming/Clinton county boundary. Physical stream habitat types (Chapter 8) and LDS reaches are displayed.

Stream Conservation using LDS & Physical Stream Types

Stream conservation efforts can be easily streamlined with the use of the ACC LDS and Physical Stream Habitat Classification tools. After a project area (i.e., a watershed) has been identified, the habitat types within that project area may be evaluated. Prior knowledge of streams within project areas will help researchers to identify the specific conservation needs of individual project areas.

Combining LDS and physical stream type information will readily point out the best examples of each stream habitat are represented in watershed conservation work.[1] If there are Abiotic stream types that not represented by LDS designnations in the project area, knowledge of the area and streams within the area will be helpful.

[1] It will likely be helpful to use the specialized LDS reaches if the work is being done in these areas (see the *Specialized LDS Criteria* section of this chapter).

Example Analysis: Pine Creek – The headwaters of Pine Creek flow through a high-quality watershed in Potter Co., PA (Figure 9-3). There are seven types of abiotic habitat stream types in the watershed (listed in descending order of frequency): 131, 123, 132, 122, 113, 133 and 112 (refer to Physical Stream Habitat Classification, Table 8-2, for description of codes). In order to preserve examples of all habitat types in the watershed, and therefore all functional biological assemblages that reside there, it would be most effective to preserve each Physical Stream Type. By overlaying the LDS reach information, the highest quality examples of each physical stream type may be identified. In this portion of the Pine Creek watershed, the most common Stream habitat types (131, 132 and 123) are all represented by LDS reaches. However, the less common types (122, 113, 133 and 112) are not (Figure 9-3). In this situation, knowledge of the watershed, available data and best professional judgment will be needed to select the best examples of streams of the less common types.

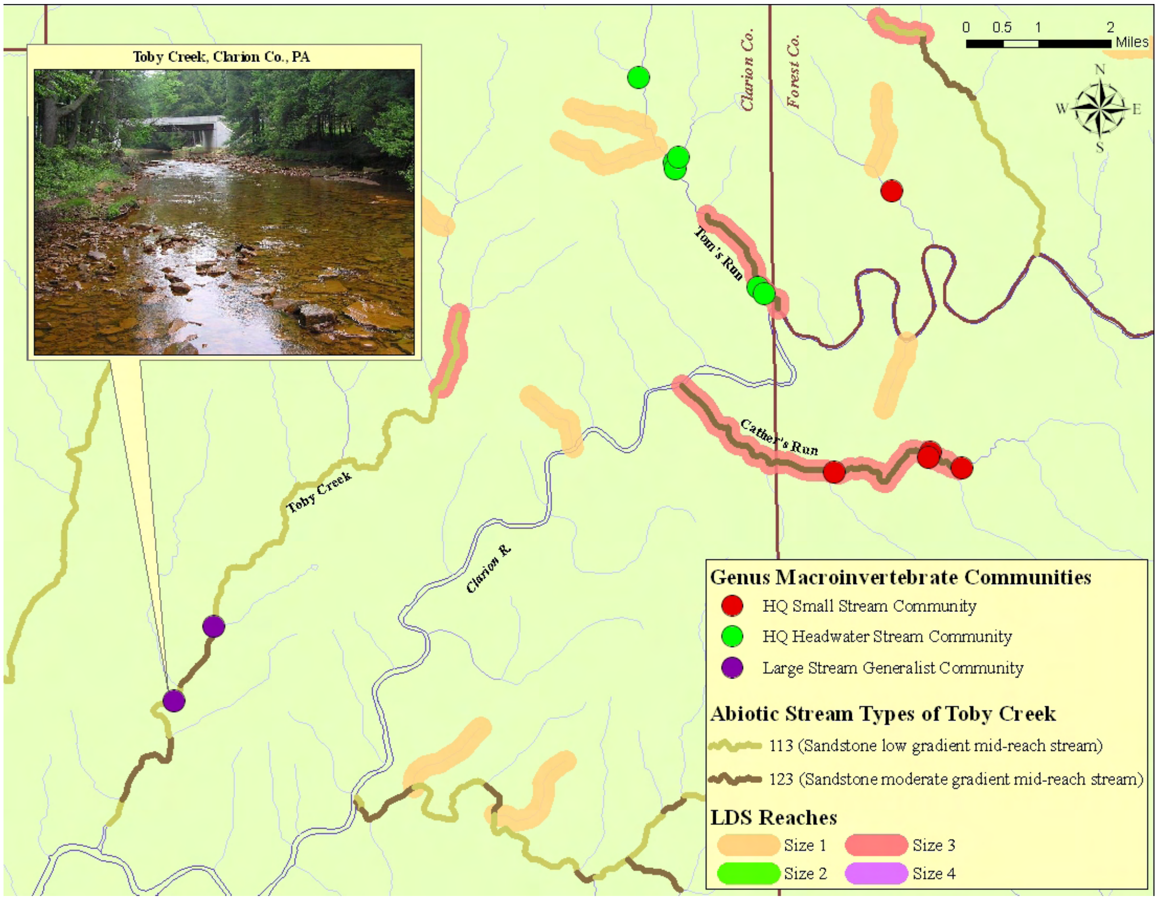


Figure 9-4. Toby Creek in Clarion Co., PA. Note the presence of the low-quality Large Stream Generalist macroinvertebrate community. The inset photograph was taken at this community's location. In the less-disturbed LDS streams (Cather's Run and Tom's Run), two high-quality (HQ) communities are supported. These LDS streams may represent the water quality and habitat conditions that Toby Creek might exhibit if water quality issues are improved.

Stream Restoration Using LDS & Physical Stream Types

These ACC tools should make stream restoration efforts more efficient and more measurable. Target conditions for study streams (degraded streams in need of restoration activity) may be established by finding an LDS stream of the same abiotic habitat type. The LDS stream will serve as a benchmark stream, which can be used to measure the success of restoration efforts in the study stream. Using one stream as a benchmark for another begins with a condition analysis of the LDS stream. Once information is gathered about the LDS stream (e.g., resident biological assemblages and water chemistry profiles, etc.), the information can be used to determine what the qualities of the study stream should be if quality issues are remedied.

Example Analysis: Toby Creek – Toby Creek is a major tributary to the Clarion River, and has a history of abandoned mine drainage (AMD) that has left the stream in poor condition (Figure 9-4). The Large Stream Generalist Community, which is indicative of poor quality streams and often associated with AMD, is found in Toby Creek. The abiotic habitat types found in this stream are 113 and 123 (sandstone geology, low gradient, mid-reach stream; and sandstone geology, moderate gradient, mid-reach stream).

Two streams of matching Physical Stream Type to Toby Creek (123) are Tom's Run and Cather's Run, both of which hold high quality genus-level macroinvertebrate community types (Figure 9-4; see Chapter 6 for information on genus-level macroinvertebrate communities). By overlaying LDS information, we see that these two streams are also Size 3 LDS reaches. The presence of high quality communities and designation as LDS reaches suggest that these streams may serve as the restoration benchmarks streams for Toby Creek.

Example Restoration Action Plan Using LDS Reaches & Physical Stream Types:

1. Select study stream; determine abiotic class type.
2. Find streams of same abiotic type, preferably in same drainage basin.
3. Identify stream of same abiotic type that is an LDS reach – this is the benchmark stream. Multiple benchmark streams may be useful, if time and funding allow.
4. Complete a condition analysis of benchmark stream – determine resident biological communities, water chemistry profile, etc; compare to LDS stream.
    a. Determine what sets the benchmark stream apart from the study stream
        i. Threats analysis – what is degrading the study stream?
5. Perform necessary restoration measures on study stream (AMD remediation, streambank fencing, etc.)
6. Measurement of restoration success:
    a. Assess new biological communities in study stream – are they like that found in the benchmark stream?
    b. Assess new water chemistry profile in study stream – is it similar to that found in the benchmark stream?

References

Anderson, M.A. and A.P. Olivero. 2003. TNC Stream Macrohabitat, Lower New England Ecoregional Plan. The Nature Conservancy.

Dewald, T.G. and M. V. Olsen. 1994. The EPA Reach File: A National Spatial Data Resource. USEPA.

Higgins, J.V., M.T. Bryer, M.L. Khoury, and T.W. Fitzhugh. 2005. A freshwater classification approach for biodiversity conservation planning. *Conservation Biology*, 19 (2): 432-445.

PA Dept. of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. 2007. Landforms of Pennsylvania. (www.dcnr.state.pa.us/topogeo/map13/map13.aspx.)

Sweeney, B. W. 1992. Streamside forests and the physical, chemical, and trophic characteristics of piedmont streams in Eastern North America. *Water Science and Technology.* 26: 2653-2673.

GIS Data Sources

IFD (Industrial Facilities Discharge, www.epa.gov/ost/basins)

National Inventory of Dams. (www.epa.gov/OST/ BASINS).

Permitted discharges – PCS. ,PA/OW Permit Compliance System. (www.epa.gov/owmitnet/pcsguide.htm)

Superfund/CERCLIS. EPA Comprehensive Environmental Response, Compensation, and Liability Information System, (www.epa.gov/superfund)

TRI (Toxic Release Inventory Facilities, www.epa.gov/enviro/html/tris/tris_overview.html)

Other Data Sources

USGS (http://seamless. usgs.gov).

USBM Mineral Availability System (http://minerals.er.usgs.gov/ minerals/pubs)

Physiographic provinces – Bureau of Topographic and Geologic Survey. (www.dcnr.state.pa.us/topogeo/map13/map13.aspx.)

Census 2000 Tiger line files (www.census.gov/geo/www/tiger)

Related Shapefiles

ACC_LDS_Reaches.shp
ACC_CalcareousGeol_LDS.shp
ACC_CrystallineSilicic_LDS.shp
ACC_CrystallineMafic_LDS.shp
ACC_WaynesburgHills_LDS.shp
ACC_NWGlaciatedPlateau_LDS.shp
ACC_Piedmont_LDS.shp
ACC_SusquehannaLowland_LDS.shp
ACC_GreatValley_LDS.shp

Table 9-3. Region-wide LDS criteria: all streams in study area

Reference Criterion	**Size 1 (0-3 mi^2 watershed area)**	**Size 2 (4-10 mi^2 watershed area)**	**Size 3 (11-100 mi^2 watershed area)**	**Size 4 (100+ mi^2 watershed area)**
Catchment developed (%)	<= 1	<= 1	<= 4	<= 4
Catchment Agriculture (non-row crop) (%)	<= 5	<= 10	<= 20	<= 25
Catchment Agriculture (row crop) (%)	<= 0.5	<= 1	<= 4	<= 4
Catchment Forest Cover (%)	>= 95	>= 90	>= 80	>= 75
Riparian Developed (%)	<= 2	<= 2	<= 2	--
Riparian Agriculture (%)	<= 4	<= 4	<= 12	--
Riparian Forest Cover (%)	>= 90	>= 85	>= 70	--
# Catchment Point Sources	<= 1	<= 3	<= 5	<= 15
# Catchment Dams	<= 1	<= 2	<= 3	<= 10
# Catchment Road Crossings	<= 4	<= 10	<= 40	<= 250
Example Streams	*Many in north-central forests, Laurel Highlands, ridges in Ridge & Valley province, also in upper Delaware River Basin*	*Many in north-central forests, Laurel Highlands, ridges in Ridge & Valley province, also in upper Delaware River Basin*	*Fish Creek - PA Fork & W VA Fork, Knob Fork, Proctor Creek (Ohio); Big Sandy Creek; Spring, Bear, Big Mill, Caldwell, Tionesta & N. Fork Redbank Creeks; Farnsworth Branch of Tionesta, East & West Hickory Creeks (Upper Allegheny); Young Womans Creek, Mosquito Creek, Pleasant Stream (W. Br. Susq.); E & W Branch. Neversink R.*	*Fishing & Sunfish Creeks (Ohio); Potato & Oswayo Crks (Alleg.); Allegheny River (PA headwaters); 1st Fork Sinnemahoning, Kettle, & Lycoming Crks (W. Br. Susq.); Cayuta, & Catawissa Crks (Susq.); W. Fork Delaware R, East Branch Delaware R, & Neversink Rivers (Delaware); Potomac R - N. Branch, Wills & Sideling Hill Crks (Potomac)*

10. Watershed Conservation Prioritization

By combining data from many parts of the Aquatic Community Classification project, we are able to highlight unique riverine conditions that designate certain watersheds to be of greater conservation concern than others. Conventional conservation prioritization may point to a single occurrence of a natural feature, such as the presence of a rare fish species or a high-quality mussel assemblage. However, watersheds that hold multiple traits of conservation value should be set apart as a higher protection priority.

We combined many aspects of stream condition to determine all-inclusive conservation values for watersheds across Pennsylvania. Information was integrated from the biological community classification, fish and macroinvertebrate biological metric scores, and results from our least-disturbed stream (LDS) reach analysis (Chapter 9).

The ACC biological community information provides a qualitative way to examine watersheds based on biological assemblages and the various stream habitat types that occur within it. We performed this analysis with only communities that indicate quality habitat conditions (Table 11-1), which allowed us to select stream reaches with relatively unaltered habitat condition. See chapters 4 through 7 for more information about community groups, their respective habitat types, and the water quality conditions in which they are found.

Biological metric calculations provide a way to quantitatively rank streams and watersheds related to habitat and water quality and how closely the biotic assemblages reflect natural ecological function. Both fish and macroinvertebrate data were used for metric scores in this analysis; these calculations are discussed in detail in the *Fish and Macroinvertebrate Metric Scores* section of this chapter. These metric calculations are similar to those used in Indices of Biotic Integrity (IBI), which are commonly used to synthesize data about water quality, biological diversity, and natural ecological function (Bode et al. 1996).

The results of the LDS analysis were used here to select watersheds that contained the greatest number of relatively undisturbed stream reaches in the study area. The stratification of LDS reaches by size allows for different criteria for various stream sizes. This way, the same criteria are not applied to both headwater streams and larger rivers, which generally face different types and levels of impairment. By using the LDS results in this conservation prioritization analysis, we are able to include qualitative data based solely on abiotic conditions of stream reaches in both local and total upstream catchment areas.

First Fork Sinnemahoning Creek in Potter Co., PA, is in an exceptionally high quality watershed. It is a prime example of a 'Tier 1' priority conservation area.

Methodology

For this investigation, we used the United States Geological Survey's HUC12 small watersheds (average size ~30 mi^2) as units of land to summarize data. Watersheds at this scale are small enough to have comparable stream types and biological assemblages, yet are still an appropriate size to be used for project areas. To determine which HUC12s were of greatest conservation priority, we associated three types of data with each: high quality biological communities (Table 10-1), fish and macroinvertebrate metric data, and information from LDS analysis (Chapter 9). All data were stratified by stream size (small, <10 mi^2 watershed area; medium, 11-100mi^2; and large, >100mi^2), so that watersheds that were unique for small-stream features could be separated from those that were unique because of large-stream features.

To select the watersheds that were of greatest conservation value, each watershed was categorized as 'Tier 1', 'Tier 2', or 'non-priority' for each of the three variables. Tier 1 status for a particular variable indicates that the watershed is in the 90th percentile or greater for that particular variable; i.e., tier 1 represents the best 10% of all stream reaches. Those in between the 80th-90th percentiles were identified as 'Tier 2'. Watersheds that fell below the 80th percentile for a variable did not receive a ranking for that particular variable.

The tier rankings for all four categories were combined to determine comprehensive tier designations for all watersheds. A watershed was designated as Tier 1 if it was represented by Tier 1 occurrences of quality communities, LDS reaches *and* fish or macroinvertebrate metric scores. Tier 2 watersheds were selected as such if they had either Tier 1 or Tier 2 occurrences of all three of these data types, but not Tier 1 occurrences in all three data types (Table 10-2, Figure 10-1). More details on tier calculations are given in the following sections.

Dataset Descriptions

High Quality Communities

A count of biological communities that indicate high-quality streams and watersheds (Table 10-1) were summarized by HUC12 watershed. The counts of communities in each HUC12 were used to designate tier rankings for each watershed. Mussel communities were only used in the large stream category, as that is where most of the mussel data were located.

Community types were assigned to the stream sizes that they commonly represent. This ensured that watersheds would be included if they exhibited quality small stream, quality medium-sized stream and/or quality large river habitats, which may not necessarily occur together (Table 10-1).

Fish and Macroinvertebrate Metric Scores

Fish and macroinvertebrate data were compiled from the ACC database and used to calculate metrics that reflect variations in biodiversity, water quality and stream function (Tables 10-3, 10-4). Fish data were only associated with streams having watersheds greater than 10 mi^2, since small streams do not usually sustain diverse fish assemblages.

The macroinvertebrate metric calculations were adapted from the New York state Index of Biological Integrity (Bode et al. 1996). An IBI is a way to score the quality of streams based on the resident biological assemblages. Generally, the index is made up of several metrics that provide information about various aspects of biological communities. At the time of completion of this report, Pennsylvania's IBI is in development by the PA Department of Environmental Protection. Bode's (et al. 1996) IBI is a widely accepted index and was used in the absence of a completed Pennsylvania version. The metrics calculated here were modified slightly, to accommodate the presence-only format of data used in this analysis (Table 10-4).

The fish and macroinvertebrate metric calculations were done separately and treated as independent measures of watershed condition. After calculation of individual metrics, the scores were normalized so that each metric would weigh equally into one composite multi-metric score for every stream reach. HUC12 watersheds containing fish or macroinvertebrate metric scores that ranked in the 90th percentile were given Tier 1 status, respectively. Watersheds in the 80th-90th percentile were given Tier 2 status in the biological metric category (Table 10-2).

Table 10-3. Metrics used in the calculations of fish data to determine the quality of habitat in HUC12 watersheds, and the response of each metric to increasing levels of disturbance (in parentheses).

Metric	Description
Total Taxa	Number of species of fish present in sample (decrease)
# Intolerant Taxa	Number of fish species generally intolerant to organic pollution (decrease)
# Tolerant Taxa	Number of fish species generally tolerant to organic pollution (increase)
Native Taxa	Number of fish species in sample that are native to the drainage (decrease)
Non-native Taxa	Number of fish species in sample that are not native to the drainage (increase)
Darter & Perch Taxa	Number of fish species in sample from the Darter and Perch group (Percidae) (decrease)
Minnow Taxa	Number of fish species in sample from the Minnow family (Cyprinidae) (decrease)
Sucker Taxa	Number of fish species in sample from the sucker family (Catostomidae) (decrease)
Sunfish Taxa	Number of fish species in sample from the sunfish family (Centrarchidae) (decrease)
% Similarity to Ref Reaches	Measure of similarity of the 9 above metrics to the mean metric scores of similar sized streams in the study area. (decrease)

Table 10-1. Biological communities used to indicate quality streams and watersheds in the conservation prioritization analysis. See the community summaries in Chapters 4-7 for more information on community types. The "Stream Size" field relates to the size of stream that each community is associated with for the conservation prioritization analysis. (HQ = high quality; MI = 'macroinvertebrate'; Stream Sizes refer to watershed size: Small, 0-10 mi^2; medium, 11-100 mi^2; large = >100 mi^2)

Community Name	Representative Taxa	Stream Size
Mussels		
Delaware Basin		
Eastern Elliptio	*Elliptio complanata*, *Villosa iris*	Large
Other	Rare mussel species	Small
Ohio – Great Lakes Basins		
Pink Heelsplitter	*Potamilus alatus*	Large
Fluted Shell	*Lasmigona costata, Ptychobranchus fasciolaris*	Large
Fatmucket	*Lampsilis siliquoidea, Pyganodon grandis*	Large
Spike	*Elliptio dilatata, Ligumia recta*	Large
Susquehanna – Potomac River Basins		
Lanceolate Elliptio	Lanceolate *Elliptio* complex	Large
Squawfoot	*Strophitus undulatus*	Large
Yellow Lampmussel	*Lampsilis cariosa*	Large
Macroinvertebrates		
Genus-level		
HQ Small Stream	*Epeorus, Oulimnius*	Medium
HQ Headwater Stream	*Amphinemura, Lepidostoma*	Small
HQ Large Stream	*Drunella, Acentrella*	Medium
Forested Headwater Stream	*Alloperla, Tipula*	Small
Family-level		
Mid-Sized HQ Stream	Isonychiidae, Philopotamidae	Medium
HQ Headwater Stream	Leuctridae, Baetidae	Medium
Common Large Stream	Nemouridae, Ameletidae	Medium
HQ Mid-Reach Stream	Chloroperlidae, Pteronarcyidae	Medium
Fish		
Atlantic Basin		
Warmwater Community 1	central stoneroller, northern hogsucker	Large
Warmwater Community2	redbreast sunfish, rock bass	Large
Coldwater Community	brook trout, brown trout	Small
Lower Del. River Community	white perch, channel catfish	Large
Ohio – Great Lakes Basin		
Large River Community	channel catfish, sauger	Large
Warmwater Community 1	greenside darter, northern hogsucker	Large
Coldwater Community	brook trout, mottled sculpin	Small

Table 10-2. Criteria used in ranking small watersheds and large river reaches for Tier 1 or Tier 2 conservation status. Fields containing "--" indicate that data were not calculated for that category; in French Creek, there were not enough LDS reaches to validate using them in the analysis, and there were no Tier 2 criteria calculated for the large river analysis. Tiers across all categories were developed so that each tier would represent the top 10% (90th – 100th percentile, Tier 1) and 80th-90th percentiles (Tier 2), respectively, for each category.

Conservation Target	Quality Community Tier Criteria		Fish & Macroinvertebrate Metric Tier Criteria		LDS Tier Criteria		Overall Criteria for Tier 1 Watershed/River Reach	Overall Criteria for Tier 2 Watershed/River Reach
	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2
Region-Wide Watersheds	Multiple stream reaches with quality community occurrences in watershed	At least one stream reach with quality community occurrences in watershed	At least one stream reach with either fish or MI metric score above 90th percentile in watershed	At least one stream reach with either fish or MI metric score in the 80th-90th percentile in watershed	Multiple LDS stream reaches of any size in watershed	At least one LDS reach of any size in watershed	Watershed has Tier 1 LDS, Tier 1 Metric and Tier 1 Community rankings	Watershed has Tier 1 or 2 LDS, Tier 1 or 2 Metric and Tier 1 or 2 Community rankings - no overlap w/ Tier 1 watersheds
French Creek	Multiple stream reaches with quality community occurrences in watershed	At least one stream reach with quality community occurrences in watershed	same as above	same as above	--	--	Watershed with 5 or more quality mussel communities and multiple Tier 1 fish or macroinvertebrate metrics; best professional judgment of French Creek ecologists	Watershed with quality mussel communities and at least one Tier 1 fish or macroinvertebrate metrics occurrence; best professional judgment of French Creek ecologists
Calcareous Geology	10 or more community occurrences per watershed	1-9 community occurrences per watershed	same as above	same as above	Multiple calcareous geology LDS stream reaches of any size in watershed	At least one calcareous geology LDS reach of any size in watershed	Watersheds with any Calcareous Geology LDS reaches of any size, at least one quality community occurrence of any taxa type and at least one Tier 1 biological metric score; or, watersheds with any region-wide LDS reaches	Watersheds with any two of the following three criteria: any calcareous geology LDS reaches, any Tier 1 biological metric reaches or any quality community occurrences
Piedmont Physiographic Region	Any occurrences of quality community types	--	same as above	same as above	Multiple LDS stream reaches of any size in watershed	At least one LDS reach of any size in watershed	Watersheds with region-wide LDS reaches of any size, Piedmont Community Tier 1 ranking and Peidmont Biological Metric Tier 1 Ranking; Or, and watersheds with size 3 or 4 Piedmont LDS reaches	Watersheds with either LDS reaches or with Tier 1 ranked Community occurrences and metric scores
Waynesburg Hills Physiographic Region	Multiple stream reaches with quality community occurrences in watershed	At least one stream reach with quality community occurrences in watershed	same as above	same as above	Greater than 7 Waynesburg Hills LDS reaches	Greater than 2 Waynesburg Hills LDS reaches	Watershed with more than one quality community occurrence, more than one Tier 1 biological metric stream reach and 7 or more Waynesburg Hills LDS reaches	Watershed with at least one quality community occurrence, at least one Tier 1 biological metric stream reach and 2 or more Waynesburg Hills LDS reaches
Large Rivers	All 3 community taxa types are present in river reach	--	Either fish or MI metric scores above 90th percentile for large river metric scores	--	--	--	Either Large River Tier 1 for both metric scores & community criteria or best professional judgement/ expert opinion	--

Table 10-4. Metrics used in the calculations of macroinvertebrate data to determine the quality of habitat in HUC12 watersheds, and the response of each metric to increasing levels of disturbance (in parentheses). Adapted from Bode et al. (1996.)

Bode (1996)	ACC (2007)	Description of ACC calc.
Species Richness, Species Diversity	Taxa Richness	# of different genera present. (decrease)
EPT Richness	EPT Richness	# of different EPT genera present. EPT stands for Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Individuals from these three insect classes are generally most sensitive to water pollution and habitat alteration. (decrease)
NCO Richness (number of Chironomidae and Oligochaeta taxa)	Proportion of class Insecta taxa	Relative proportion of organisms in class Insecta (alternative to a non-insect taxa metric). These taxa are generally less sensitive to water pollution and habitat alteration than many other groups of macroinvertebrates. (increase)
HBI	Modified HBI	The Hillsenhoff Biotic Index (Hillsenhoff, 1987) assigns a score to streams based on the tolerance of resident macroinvertebrates to organic pollution. The modified HBI here was calculated using presence data - each taxon present receiving a "1" for abundance. (increase)
PMA (% model affinity)	% Similarity to Reference stream scores	This metric was calculated by comparing the values of the above four metrics to the mean values of these metrics that are found in LDS reaches of the same size: small (0-10 mi^2 watershed area), medium (11-100 mi^2) or large (>100 mi^2). This is calculated with the assumption that biotic assemblages from LDS streams represent assemblages functioning as naturally as possible in the study area. (decrease)

Least Disturbed Streams (LDS)

LDS reaches were divided into the original four size classes (Chapter 9), plus an additional "large river" category that includes all stream segments with watersheds greater than 2000 mi^2. This was done to select relatively intact sections of large rivers, which were not well represented in the original size four LDS category. A separate set of LDS criteria were developed for the large river category (Table 10-5). Only 22 HUC12s had large river LDS segments in them; these watersheds all received a 'Tier 1' ranking in this category since a relatively undisturbed large river signifies a unique resource for this region.

Table 10-5. Least-Disturbed Stream (LDS) criteria for large rivers (watersheds greater than 2000 mi^2). See LDS Chapter (9) for more information about LDS analysis.

Variable	Criteria
% Catchment Urbanization	<1.5%
% Catchment Forest	>75%
% Catchment Agriculture (Non-row Crop)	<17%
% Catchment Agriculture (Row Crop)	<3.5%
# Catchment Point Sources	<200
# Catchment Road Crossings	<11,500
# Catchment Dams	<160

Alternative Conservation Prioritization Analyses

Some areas were not well represented in the results of the analysis described above. Separate investigations were done to capture these areas, which may be of unconventional conservation concern. These areas include the biologically significant French Creek watershed, which is known around the region as a resource of remarkable biological diversity. Areas that might face uncommon kinds or levels of disturbance were included as well: calcareous geology dominated stream systems, the Piedmont and Waynesburg Hills physiographic regions, and large river systems.

Large River Conservation

Large rivers are often used for cargo transport, drinking water supplies and recreation. They frequently receive sewage treatment plant effluent near cities and larger towns. Larger rivers are also the recipients of various insults to water quality that occur in their tributaries. For these reasons, an abiological approach to finding the best conditions becomes difficult. For example, the Ohio River below Pittsburgh, PA has roughly 7,000 point-source discharges and 37,000 road crossings in the entire catchment. However, despite having inflated abiotic disturbance values, large rivers can still sustain functioning biological communities that have adapted to adverse conditions such as these. This biological large river analysis provides different information than the abiotically driven LDS large river analysis described above (Table 10-5). This large-river biological analysis indicates where biological assemblages are functioning in a relatively natural way, regardless of abiotic stresses or water quality condition.

In order to select the best large river habitat remaining in the region, we used only biological data and excluded the abiotic data that was used for other streams in the LDS analysis. We divided large rivers (stream reaches with >2000 mi^2 watershed area) into segments defined by HUC12 watershed boundaries (232 segments in the study area). Biological community and metric data were joined with each river segment using GIS.

Large river reaches were selected as a conservation priority if they had 1) occurrences of quality community types from all three groups – mussels, macroinvertebrates and fish, and 2) fish or macroinvertebrate metric scores above the 90^{th} percentile for all large river reaches (Table 10-2). Alternatively, some reaches of large rivers were selected as a conservation priority as a result of the recommendations from regional experts that were familiar with individual river systems.

Nearly 40 river reaches were selected, totaling approximately 300 miles of high quality riverine habitat. The Allegheny River appears to hold the best large-river habitat in the region. This river has the greatest number of, and most continuous, high-quality large-river reaches (Figure 10-1).

French Creek

French Creek (Ohio River basin) is perhaps the most ecologically significant waterway in the region, containing the most diverse fish and mussel assemblages of any stream in the northeast United States. The watershed is known to harbor over 80 species of fish and 27 native species of freshwater mussels, in addition to numerous species of native plants and wildlife (WPC 2003).

Despite these facts, no parts of the French Creek mainstem or watershed were selected in our conservation prioritization analysis. This may be due to elevated levels of agriculture in northwest Pennsylvania. High amounts of agricultural land likely excluded these streams from the LDS criteria, as they are based on land cover statistics. Additionally, the entire French Creek watershed is roughly 1200 mi^2, which excluded this stream from the large river analysis.

We feel that there is ample evidence to justify the inclusion of French Creek as a conservation priority. The biological resources in the mainstem and several tributaries are far too exceptional to go unprotected. By conducting a separate analysis of the French Creek watershed, we hope to facilitate both ongoing and future conservation work in this immeasurably valuable river basin.

French Creek is one of the most biologically diverse aquatic systems in the region.

In order to select the most biologically important areas of the French Creek watershed, mussel community, fish metric and macroinvertebrate metric data were used (see *Fish and Macroinvertebrate Metric Scores* section in this chapter for description of metric calculations). HUC12 watersheds that had quality mussel community locations (Table 10-1), top 10% fish metric (Table 10-3) stream reaches *and* top 10% macroinvertebrate metric stream reaches (Table 10-4) were defined as Tier 1 (Table 10-2). Watersheds were designated as Tier 2 if they possessed two of those three attributes (Figure 10-2). Comments from PNHP aquatic ecologists familiar with the French Creek ecosystem were incorporated into this analysis as well.

The results of this analysis highlight nearly the entire mainstem of French Creek for protection. They also highlight some of the tributaries that are also important for their biological diversity. Muddy, LeBouf and Coneauttee Creeks, and French Creek – South Branch all appear to be tributaries that particularly contribute to the biodiversity and overall uniqueness of this system.

Calcareous Geology Streams

Calcareous geology (limestone and dolomite) is common in the valleys across southern Pennsylvania. In the ACC study area, it is also found in sections of the upper Susquehanna River drainage in New York (Figure 8-1). Calcareous geology generally leaves unique chemical signatures in stream water that flows through it, altering water chemistry and resident biological assemblages. Streams affected by calcareous geology generally show high alkalinity and conductivity values. However, since calcareous geology generally provides land well suited for agriculture, these values can be inflated due to advanced agricultural and urban development pressure in the watershed.

Because calcareous streams represent a unique condition of habitat almost always altered by human disturbance, we have separated them out for analysis to select watersheds holding the best calcareous-stream habitat that is left in the region. The same high quality community, biological metric, and LDS data were used in this analysis, but the rankings were modified to reflect the distinct conditions present in these watersheds. LDS reaches from the region-wide analysis were combined with the specialized calcareous geology LDS reaches (Chapter 9).

Out of 419 HUC12 watersheds that have greater than 25% calcareous geology, 30 were determined to be Tier 1, and 24 were selected as Tier 2 (Figure 10-3). Tier 1 watersheds have quality community occurrences, high-scoring fish or macroinvertebrate metric streams, and LDS stream reaches (either region-wide or calcareous geology LDS reaches). Tier 2 watersheds have streams that qualify in any two of these categories (Table 10-2).

Piedmont Streams

The Piedmont physiographic region (Figure 9-2) is located in the southeast corner of Pennsylvania. It is an area that has a long history of human habitation and, consequently, alteration of the landscape and watersheds. Streams in this region have undergone a widespread removal of native streamside vegetation. This has occurred either directly via timber harvest or land development, or indirectly through events related to human habitation such as the introduction of invasive species or disease-driven changes like American Chestnut Blight or American Elm Disease (Sweeny 1992). Agricultural practices are also prominent in the Piedmont region. Agricultural lands that are poorly buffered can add excess nutrients and sediments to streams, which can further degrade water quality and habitat condition for stream organisms.

The increased levels of land development in the Piedmont region, coupled with some unique geology types located there (namely crystalline silicic and crystalline mafic geology types), led us to a separate analysis to determine which streams and watersheds are the closest to naturally-functioning for this region.

HUC12 watersheds in the Piedmont region were designated as a Tier 1 conservation priority if they had Least-Disturbed Stream (LDS) reaches, high-scoring fish or macroinvertebrate biological metric stream reaches, and quality aquatic community occurrences within them. Tier 2 watersheds are represented by variables from two of these three categories. Watersheds were also included in the Tier 1 category if they held Size Large or Medium Piedmont-specific LDS reaches, since they are a rarity in the region (Figure 10-4). These cut-off values were selected so that quality aquatic habitats in the Piedmont region above the 90th percentile would be Tier 1 priority, and those values in the 80th-90th percentiles would be Tier 2 (Table 10-2).

Waynesburg Hills Streams

The Waynesburg Hills Physiographic section is located in southwest Pennsylvania (Figure 10-2). This area (namely Greene and Washington Counties and part of Fayette County) has a long history of coal mining and agriculture that has left streams in this region in a unique state of degradation. Washington County, for example, leads Pennsylvania in sheep and goat farming (WPC 2005). In addition to other alterations to the landscape, calcareous geology is also prominent in this area. This type of geology leads to a host of other water quality and condition issues, as discussed above.

Despite the prevalence of agriculture, coal mining may be the activity that best defines the Waynesburg Hills Physiographic region. Greene and Washington Counties are the first and second leading coal-producing counties in the state, respectively (WPC 2005; Greene County website 2007). The portion of Fayette County in the Waynesburg Hills section has a long history of coal production, as it was part of the "Connellsville Coke Region," which fueled the steel mills of Pittsburgh for roughly 100 years, ending in 1970 (www.coalandcokepsu.org).

Abandoned coal mines and other mining activities can cause acidic and/or metal-laden discharges (abandoned mine drainage, or AMD) to flow into streams. AMD streams are characterized by a reddish-orange appearance. This can often create toxic waters and pH values outside the range acceptable for most aquatic animals. Although some recovery is possible, AMD remediation in streams can be a very costly process.

Toby Creek in Clarion Co., PA, is an example of a stream that is affected by Abandoned Mine Drainage (AMD).

In order to find the best remaining quality streams and watersheds in the Waynesburg Hills Physiographic province, quality community locations were combined with high-scoring fish and macroinvertebrate metric stream reaches and the Waynesburg Hills LDS reaches. HUC12 watersheds were selected to be of Tier 1 conservation priority if they contained multiple stream reaches with a quality community, multiple reaches with high-scoring biological metric scores and seven or more Waynesburg Hills LDS reaches. A watershed was Tier 2 if it held at least one stream reach with a quality community, at least one reach with a quality biological metric score and two or more Waynesburg Hill LDS reaches. These cut-off values were chosen in order to determine the watersheds that held the top 10% quality aquatic habitat in the area (Tier 1) as well as those in the 80^{th}-90^{th} percentile (Tier 2) (Table 10-2, Figure 10-4).

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Related Shapefiles:

Conservation_HUC12s.shp
ACC_LDS_reaches.shp
Large_River_Conservation_reaches.shp
French_Creek_Conservation_HUC12s.shp
Piedmont_Conservation_HUC12s
Piedmont_LDS_reaches.shp
WaynesburgHills_Conservation_HUC12s
WaynesburgHills _LDS_reaches.shp
CalcareousGeol_Conservation_HUC12s
CalcareousGeol _LDS_reaches.shp
All biological community shapefiles

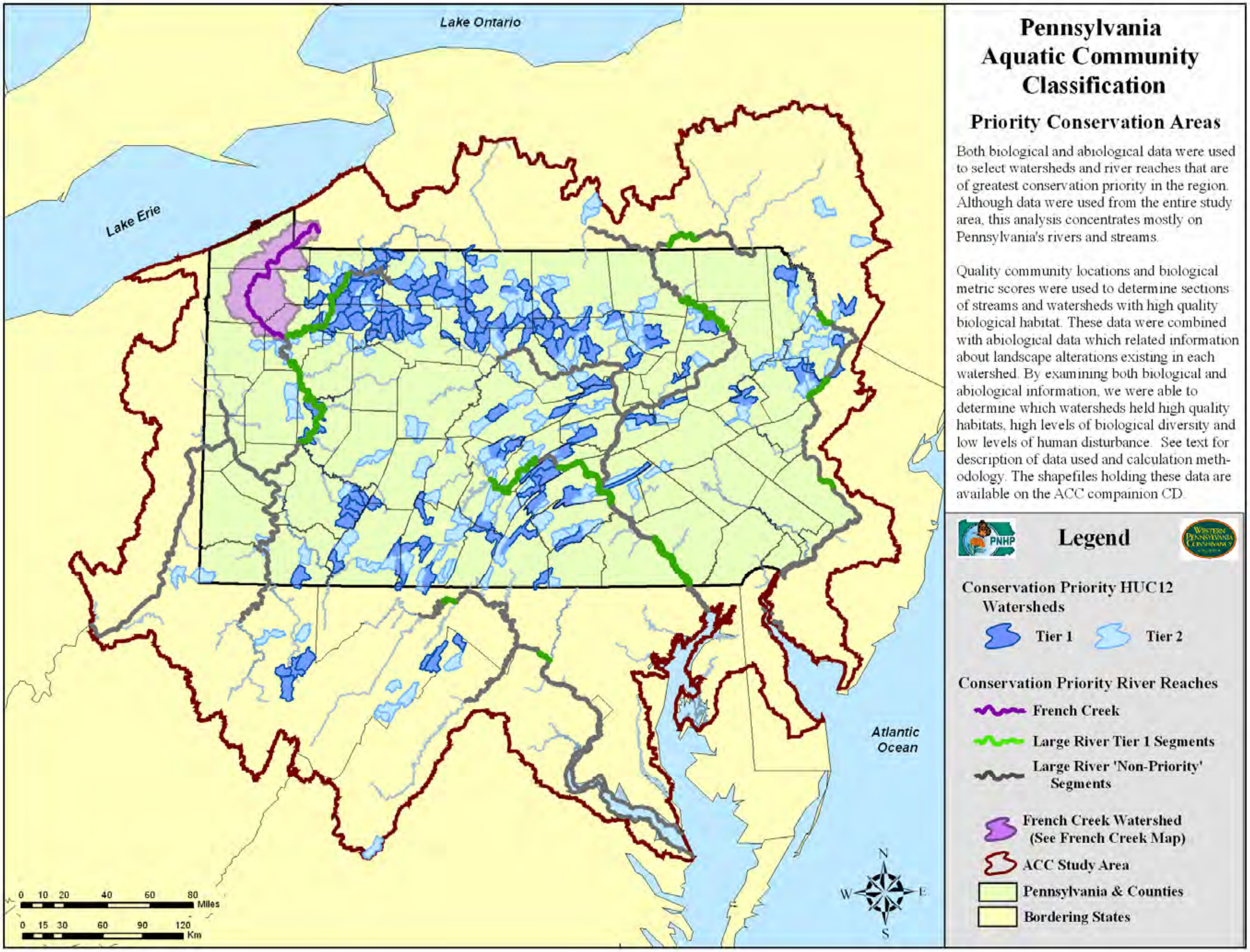

Figure 10-1. Conservation priority areas for Pennsylvania and surrounding watersheds. See text for description of analyses used to select priority HUC12s, large river segments, and the French Creek watershed.

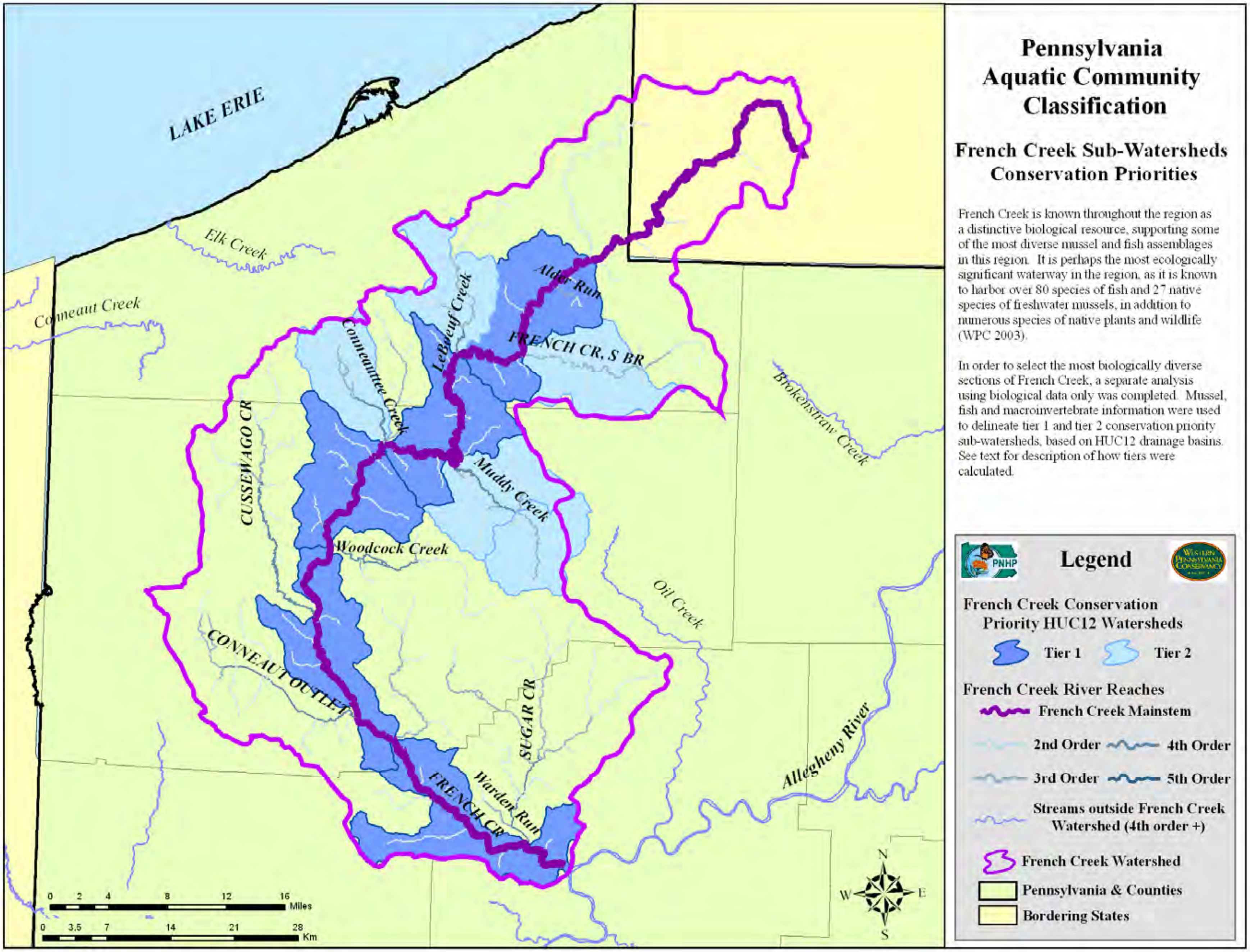

Figure 10-2. Conservation priority areas for the French Creek watershed. See text for description of separate analyses used to select priority HUC12s within this watershed.

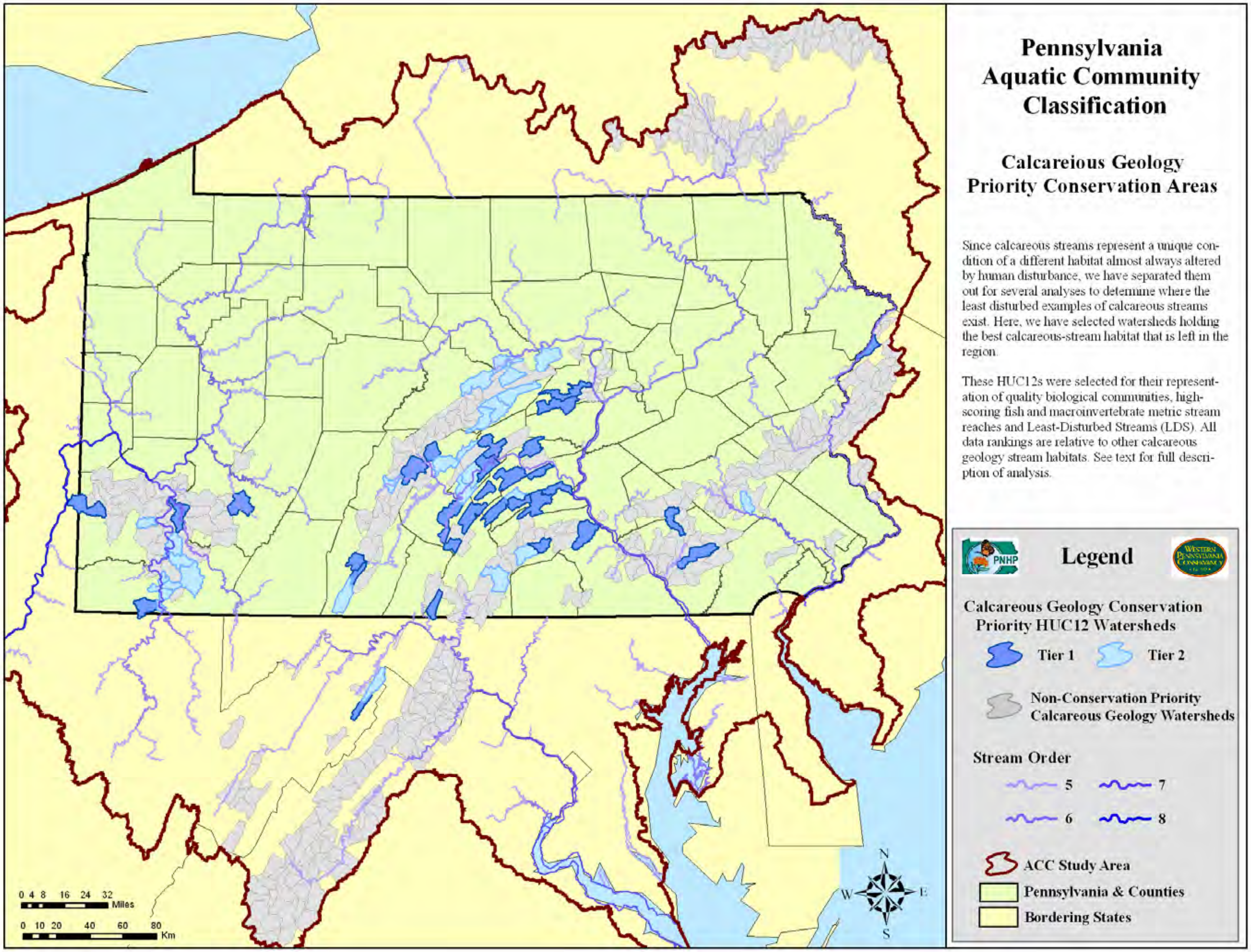

Figure 10-3. Conservation priority areas for calcareous geology watersheds. See text for description of separate analyses used to select priority HUC12s within this watershed.

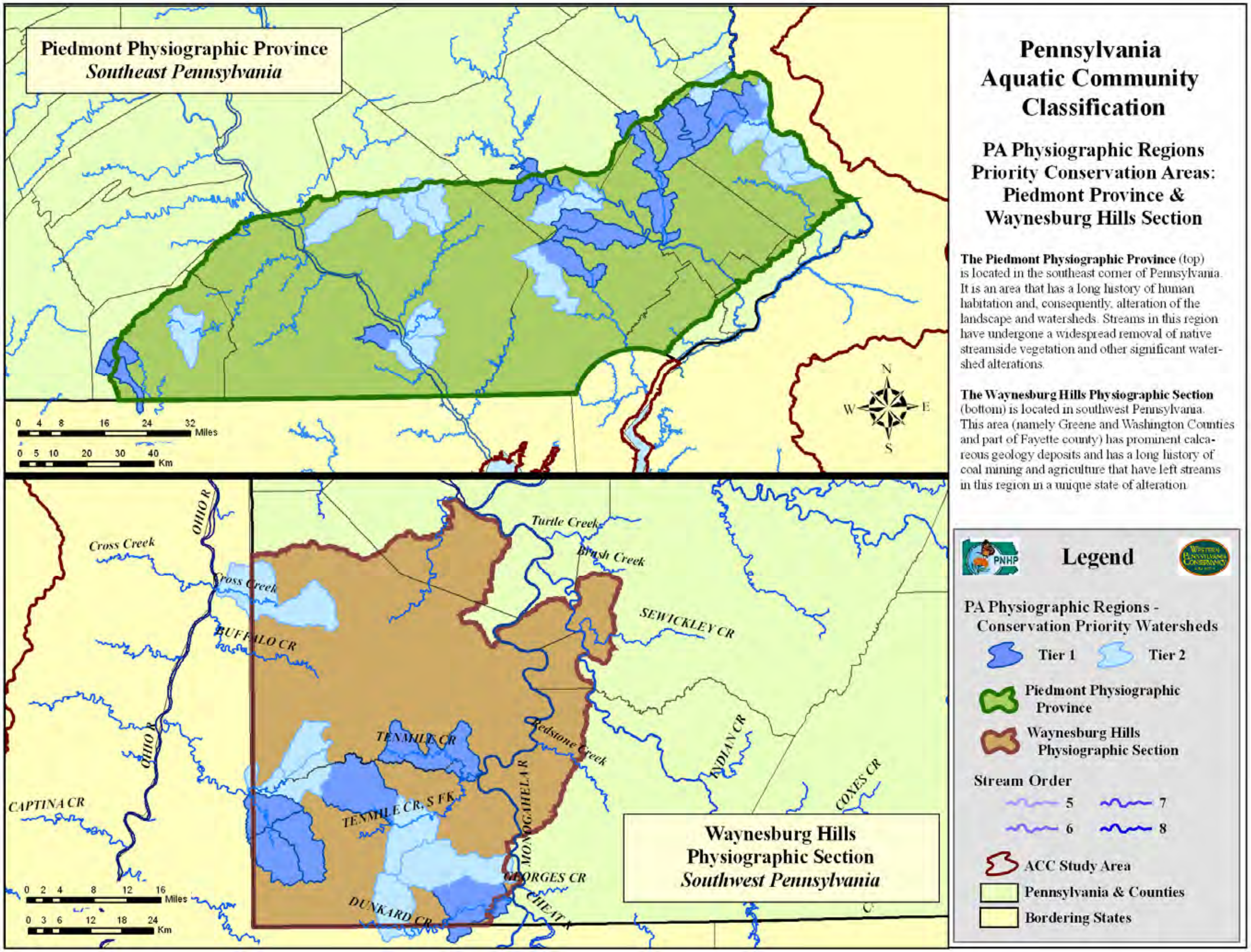

Figure 10-4. Conservation priority watersheds in the Piedmont and Waynesburg Hills Physiographic regions. See text for description of separate analyses used to select priority HUC12s within this watershed.

11. Watershed Restoration Prioritization

The goal of this portion of the study was to use data compiled in the ACC project to determine which watersheds are in the worst condition and are a priority for habitat restoration. To do so, we combined information from our Least-Disturbed Stream (LDS, Chapter 9) reach analysis, biological metric scoring (see Chapter 10) and locations of biological communities indicative of poor-quality stream habitat (Table 11-1). A multi-faceted approach such as this is more useful than simply examining developed land area in a watershed or the occurrence of pollution-tolerant taxa. By combining both biotic and abiotic features of the landscape we are able to highlight the watersheds where the functionality of biological assemblages is being altered by a variety of disturbances.

Table 11-1. Biological communities used in the watershed restoration prioritization analysis. These communities are indicative of poor quality stream habitat and various types of landscape disturbance.

Community Name	Representative Taxa
Macroinvertebrates	
Family-level	
Common Headwater Stream	Lepidostomatidae, Capniidae
Limestone/ Agricultural Stream	Amphipoda, Simuliidae
AMD Stream	Sialidae, Empididae
Genus-level	
Sluggish Headwater Stream	*Physidae, Hirudinea*
Limestone/ Agricultural Stream	Isopoda, Oligochaeta
Small Urban Stream	*Cheumatopsyche, Stenelimis*
Large Stream Generalist	Generalist Taxa
Fish	
Atlantic Basin	
Coolwater Community 1	Slimy sculpin, fathead minnow
Coolwater Community 2	Blacknose dace, white sucker
Ohio - Great Lakes Basins	
Coolwater community	Blacknose dace, creek chub

Methodology

A tiering system similar to that used in the watershed Conservation Prioritization analysis (Chapter 10) was used to indicate the state of impairment that each altered watershed is in. The 'Tier 1' category here represents the most disturbed watersheds that exist in Pennsylvania. There is much physical alteration in these watersheds, and the in-stream habitat supports only the most pollution-tolerant organisms. These watersheds are an immediate priority for restoration action. Watersheds that fall into the 'Tier 2' category are also impaired, but their need for restoration action may not be as immediate as those with 'Tier 1' status.

As in previously discussed sections of this document, HUC12 Watersheds (~30 mi^2) were used as sub-units of larger drainage basins. A watershed was categorized as a 'Tier 1' restoration priority if it had no LDS reaches, had multiple stream reaches that scored below the 20^{th} percentile for the fish or macroinvertebrate metric scores (Chapter 10), and had multiple occurrences of fish or macroinvertebrate communities (Chapters 4-7) that indicate poor-quality stream habitat (Table 11-1). Watersheds were classified as 'Tier 2' if they had no LDS reaches, one or more stream reaches that were below the 20^{th} percentile in either fish or macroinvertebrate metric scores and one or more occurrences of poor habitat fish or macro-invertebrate communities (Table 11-2).

Results & Discussion

In Pennsylvania, 83 watersheds were selected as a 'Tier 1' restoration priority and 140 were chosen as 'Tier 2'. The greatest concentrations of Tier 1 watersheds are found in the areas surrounding Pittsburgh and Philadelphia. The distribution of both types of restoration watersheds are aggregated around larger river systems, although there are some instances of these watersheds scattered across the state.

Interestingly, some of the Tier 1 restoration priority watersheds hold some of the Large-river reaches identified in the conservation priority analysis (Chapter 10). This duality may be because of a variety of habitats present in some of these watersheds. Where sections of the lower Allegheny River support quality biological assemblages and are examples of good large river habitat, in-stream mining of sand and gravel or point source discharges upstream may damage other sections. Furthermore, the Allegheny River receives much of the same insults to water quality as other large river systems, such as effluent from sewer treatment plants, runoff from urbanized areas and input of waters from many tributaries with water quality issues including AMD. However, the biological composition of the river remains remarkably intact, supporting diverse mussel and fish assemblages in many of its lower reaches (ACC database). It is apparent that the river is able to recover from various degradations to water and habitat quality, but the question remains of what makes rivers such as the Allegheny so resilient to disturbance. Further study and field research on large river systems may clarify some of these issues.

Table 11-2. Biotic and abiotic criteria used in the watershed restoration prioritization analysis. Tier 1 watersheds represent those that are in most immediate need of restoration action. Tier 2 watersheds may not need action as immediately, but should be strongly considered for restoration action. See text for description of variables. MI = Macroinvertebrate.

Variable	Tier 1 Criteria	Tier 2 Criteria
LDS	None of any size	None of any size
Biological Metric Score stream	Multiple stream reaches reaches below 20th percentile of fish or MI scores	One or more stream reaches reaches below 20th percentile of fish or MI scores
Fish & macro-invertebrate communities	Multiple stream reaches with poor quality fish or MI comm.	One or more reaches with poor quality fish or MI comm.

It is important to note that this analysis is meant to suggest which watersheds in the state may be in greatest need of restoration activity. The water quality issues that are affecting these watersheds may differ significantly; therefore the measures necessary to improve water quality will vary as well. Site visits and on-the-ground research by watershed managers and conservation planners will be help to explain the actions necessary in each watershed to fix the problems that are degrading water quality and stream habitat.

Common Water Quality Issues in Pennsylvania

Acidification of streams from abandoned mine drainage (AMD) and acid deposition are the most prominent water quality issues in Pennsylvania. Acidification of water pushes the pH outside the range that is acceptable to aquatic organisms. Additionally, AMD introduces a suite of toxic metals to ground and surface waters that further degrade aquatic habitat.

Treating AMD can reduce acidity and levels of dissolved metals in the water and greatly improve stream habitat quality. The application of alkaline materials, or "liming", streams raises the pH of the water to normal levels and decreases the solubility of the dissolved metals associated with AMD. This method can be expensive due to the costs of the materials and maintenance that is required post-liming; the alkaline materials used in liming produce a metal-laden sludge that must be removed from the stream and disposed of. Passive treatment of AMD, as in mitigated AMD wetlands, can offer a lower cost and maintenance alternative to active chemical application. For more information on AMD and its remediation, see the Pennsylvania DEP's Bureau of Abandoned Mine Reclamation webpage: http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm.

Agricultural streams may be in extremely poor condition if improperly managed. In this example, note the absence of a vegetated riparian buffer, which would help keep livestock out of the stream and slow down the input of nutrients from the row crops in the background of the photo. Streams such as this usually have unsuitable habitat and nutrient levels for most aquatic organisms.

Acid deposition (or "acid rain") is precipitation that has unnaturally high levels of acidity. This leads to the acidification of soils, streams and lakes and can also cause the decay of buildings, bridges and other structures. Acid deposition can be a natural occurrence, originating from compounds released from volcanoes or decaying vegetation. However, the elevated levels of acid deposition generally are due to the release of compounds like sulfer dioxide (SO_2) and nitrogen oxides (NO_x) that are introduced into the air from the combustion of fossil fuels. In the United States, a large portion of these compounds is introduced into our environment from electric power plants, especially those that burn coal (EPA, 2007). There are many of these plants along the Ohio River downstream of Pittsburgh, and prevailing winds often bring these air pollutants up the river valley and into Pennsylvania.

It is difficult to remedy the effects of acid deposition, since the issue of air quality occurs on such a large scale. Temporary fixes, such as liming, may provide short-term alleviation of the effects of acid deposition but a solution to the greater problem of air pollution is a universal one. Stricter controls on fossil fuel emissions, promoting renewable energy sources or simply using less energy would all help reduce acidic deposition. For more information on acid deposition, its causes and effects, see the EPA's webpage on acid rain: http://www.epa.gov/airmarkets/acidrain/.

Other major water quality issues in Pennsylvania relate to non-point source pollution. Non-point source pollution comes from the greater watershed, such as urban areas or poorly buffered agricultural fields. In agricultural fields without adequate vegetative buffers protecting streams, the streams can be inundated with elevated levels of nutrients and sediments. Sedimentation, often related to poorly managed agricultural practices, is a considerable water quality problem in Pennsylvania. Not only does sedimentation introduce pollutants and nutrients to water the were once immobilized in soil, but it also smothers stream bottoms and eliminates important habitat between and under rocks and debris that many aquatic organisms depend on for various stages of their life cycle. Sedimentation and nutrient enrichment in heavily agricultural areas can be controlled by installing riparian buffers of an adequate width along pastures and crop fields and excluding livestock from streams and riparian zones.

In urban environments, runoff carries different pollutants and water quality problems. Storm-water runoff from urbanized areas often contains hydrocarbon compounds from vehicles, road salts and other domestic pollutants. The rate at which stormwater is introduced to streams is sharply elevated in urban settings, since the amount of impervious surface (roads, parking lots, buildings, etc.) in these areas is often great. As a result, rainwater cannot be retained as it slowly percolates into soils; rather it is often collected in drainage channels and diverted directly into streams. This unnatural high-energy pulse of water is often enough to wash away aquatic organisms and destroy in-stream habitats, displacing organisms and delaying recolonization. Management of stormwater from roads and urban developments and mitigation of any direct stream discharges are recommended to remediate these effects.

Point-source pollution, such as direct stream discharges from sewer treatment plants or waste products from factories, is common near urban centers. Stricter controls on discharge permits and better remediation of discharges would eventually help to restore water quality in these areas. In addition, keeping sewage treatment systems up-to-date would help to improve stream habitats that support aquatic communities.

The Ohio River at Merrill Station, Allegheny Co., Pa. Rivers near urban centers often receive point-source discharges associated with populated areas, such as sewer treatment effluent and industrial waste discharges. Combining these issues with non-point source pollution from impervious areas, urban areas often exert a suite of habitat and water quality alterations that are unique to populated areas.

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Pennsylvania DEP, Bureau of Abandoned Mine Reclamation. 2007. http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm.

Related Shapefiles:

Restoration_HUC12s.shp

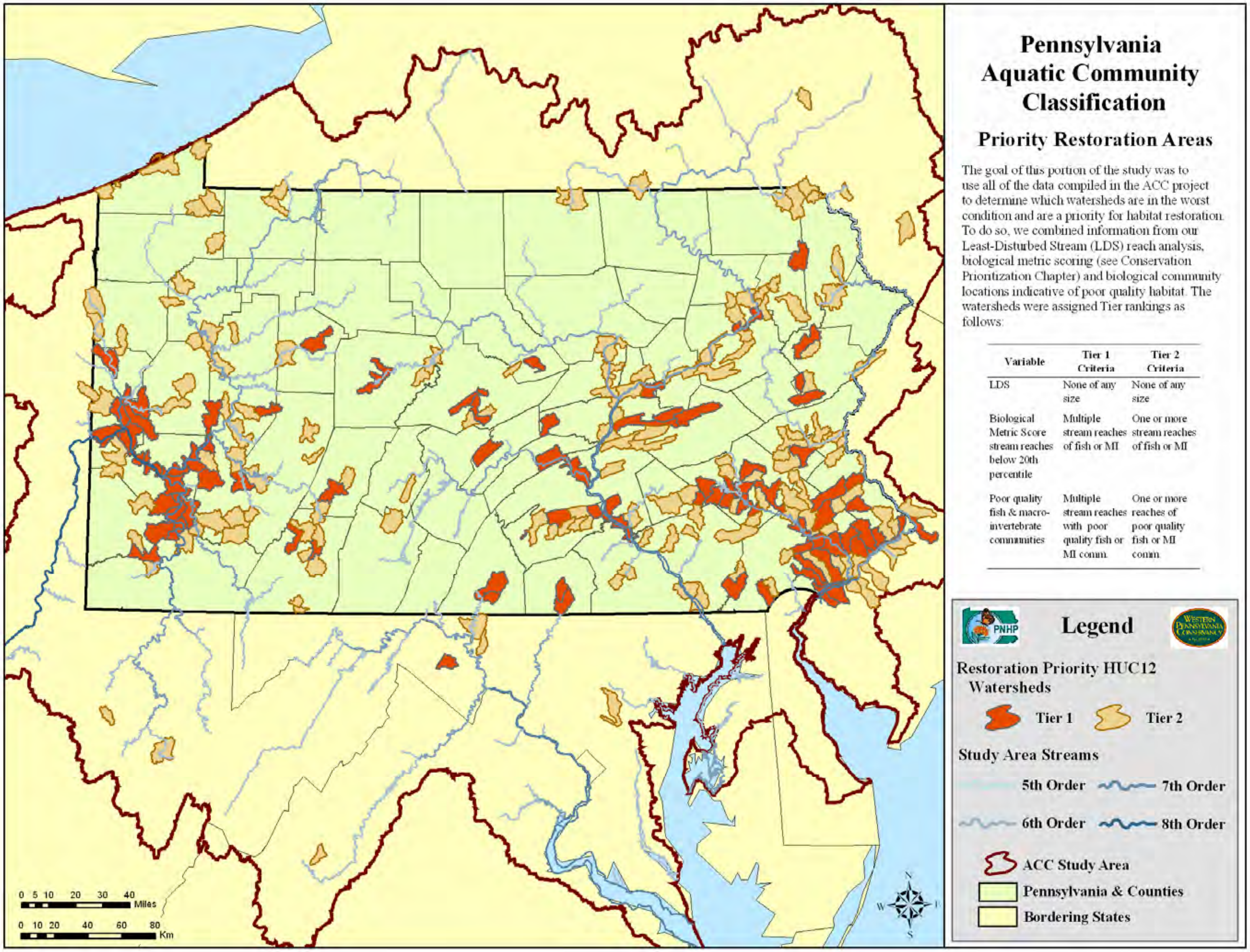


Figure 11-1. HUC12 watersheds that are a priority for restoration efforts. Although the entire study area was included, the analysis is focused on Pennsylvania's watersheds.

12. Watershed Enhancement Areas

The Watershed Conservation Analysis (Chapter 10) selected the top 20% high-quality watersheds in the Pennsylvania region in terms of high water quality and ecological value. The Watershed Restoration Analysis (Chapter 11) set apart the bottom 20% of watersheds in the region. These watersheds were determined to be in the worst condition of all watersheds in the region, and appear to be in need of immediate rehabilitation for a variety of reasons. This portion of the study, termed "Watershed Enhancement Areas," addresses the middle 60% of watersheds that cover the rest of Pennsylvania. These watersheds reflect conditions that are likely not pristine, and are prime candidates for restoration action because they are not as severely degraded as the Restoration watersheds (Chapter 11). The restoration of these Watershed Enhancement Areas will likely yield the most significant ecological gains for the amount of conservation dollars spent.

Watersheds in the Enhancement category are divided into two tiers (Figure 12-1), like watersheds discussed in the Preservation and Restoration chapters (10 and 11). Tier 1 watersheds represent areas of better water quality and watershed condition than those with Tier 2 status. The methodology for determining the tiers was similar to that applied in selecting the tiers in the Watershed Conservation analysis. Watersheds were selected for Tier 1 restoration status if they met at least two of the three following criteria:

- Have at least one Least-Disturbed Stream (LDS; Chapter 9) reach in the watershed
- Have at least one stream reach with a Biological Metric score above the 80th percentile for macroinvertebrates or fish
- Have at least one occurrence of a high-quality biological community (Table 10-1)

The Tier 1 criteria identified roughly half of these middle-category watersheds. The remaining watersheds in the Enhancement category were designated as Tier 2.

Tier 1 Enhancement watersheds represent areas that are in the top half of this middle category; they are likely in good condition but face some threats to water quality that should be addressed. These watersheds probably do not require immediate action but should be considered in restoration projects because they may only need a relatively small amount of effort to greatly enhance their water quality and biological condition.

Tier 2 Enhancement watersheds represent the bottom half of the Enhancement category. They are likely to have significant water quality and watershed condition issues and could benefit greatly from restoration action. Without restorative action, watersheds in this category will probably fall into the "Restoration" category over time. Because the Tier 2 category represents watersheds that are exceptionally close to the worst conditions found in the region, these catchments are likely in the most immediate need of restoration action.

It is important to note that these Enhancement watersheds, like any of the other watersheds discussed in this report, may be degraded at different levels of severity for a variety of reasons. The watersheds listed as part of this Enhancement category should be used only to guide conservation efforts; on-the-ground site visits and knowledge of specific streams and watersheds will be needed to verify conditions that have been described here. The most common water quality problems in Pennsylvania are discussed in Chapter 11.

Related Shapefiles:
Watershed_Enhancement_Areas.shp

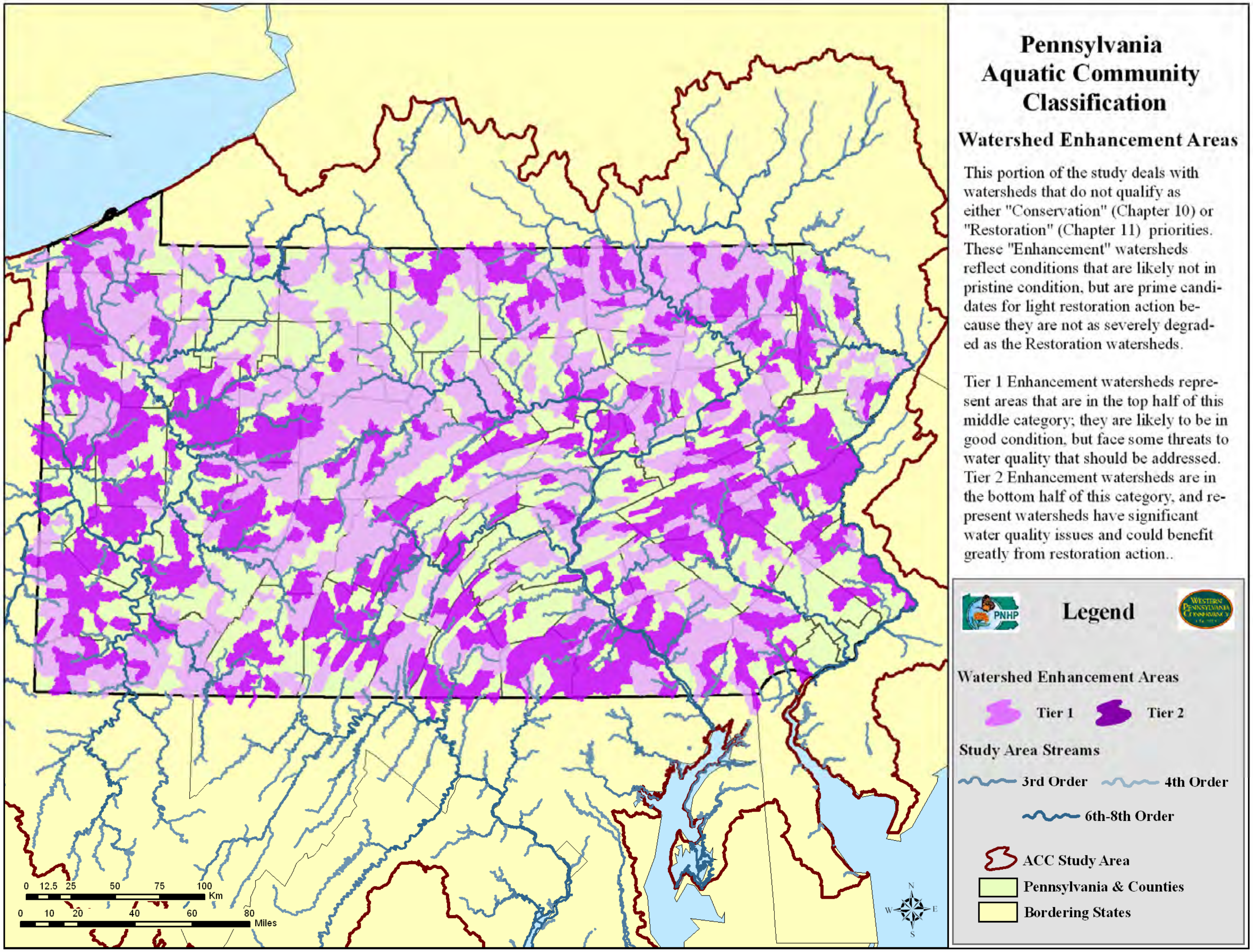


Figure 12-1. Watershed Enhancement Areas for Pennsylvania.

13. Data Product Descriptions

We created Aquatic Community Classification (ACC) data products that are now made publicly available in this report. Data products are described and documented in this section. Please see the product metadata for specific details.

Aquatic community, physical stream type, water quality, and watershed conservation and prioritization data are available and desribed here.

Community types and descriptions

User's Manual, Chapters 4-7

Community types were developed for three taxa groups: mussels, fish and macroinvertebrates. Because zoogeographic ranges for mussel and fish species were limited by watershed boundaries, community types were developed within three basins for mussels and two basins for fish. The mussel classifications were developed separately for: 1) the Delaware River Basin, 2) the Susquehanna and Potomac River Basins, 3) the Ohio River and Great Lakes Basins. Fish assemblage classes were developed for 1) the Ohio River and Great Lakes Basins, 2) the Atlantic Slope Basins, or Atlantic Basins, that include the Delaware, Susquehanna, and Potomac River Basins.

Each type of aquatic community taxa provides a different perspective on aquatic habitats. Macroinvertebrate assemblages are particularly sensitive to changes in water quality and character and in-stream habitats. Assemblages represent habitats in watersheds up to 200 mi^2 for most communities with the exception of one community associated with larger streams and rivers. Macroinvertebrate communities are based on organisms that are found in spring months (April through June).

The mussel communities tend to occur in larger streams and rivers, where the watershed area was over 100 mi^2; they do not tend to occur in waters with non-organic pollution and severe habitat alteration. Assemblages of fish classes are found from small headwater streams to large river habitats. Thermal tolerance, water quality, and habitats most influence fish communities.

We recommend that use of aquatic community classes be tailored to the particular application. Large watersheds and regions may encompass all taxa assemblages; mid-size to large streams also are likely to contain communities of fish, mussels, and macroinvertebrates. Data users interested in small stream systems may wish to consider only fish and macroinvertebrate communities. We urge new ACC data users to explore all information about the communities in their area of interest.

The use of different taxonomic levels of macroinvertebrates in both community classification and biological monitoring are subject of debate in the aquatic science community (Reynoldson et al. 2001, Waite et al. 2004). An exploratory part of this project was to investigate differences between macroinvertebrate community classifications at two taxonomic levels: family and genus. These taxonomic levels are both commonly used in stream analyses for developing macroinvertebrate community groups and general aquatic research. Upon final analysis of the results from the communities at each taxonomic level, we determined that the genus macroinvertebrate classes were the most meaningful statistically and biologically. Therefore, we are endorsing our genus-level macroinvertebrate classification for use in applications related to ACC products and tools. In order to show the results of our community analyses and present users with the differences between classifications, both family and genus macroinvertebrate community classifications are described in the community descriptions (Chapters 5 and 6).

Community descriptions contain information about the species and taxa, called community indicators, which are typically found with each community type. The habitat occupied by the community is described by stream channel, watershed characteristics, and water chemistry characteristics. The stream quality and community rarity ratings indicated by the community are also noted.

Community locations

File names and locations:

Reach-Community Shapefiles:
FishCommunitiesAtlanticBasin_RF3_NAD83
FishCommunitiesOhGrLakesBasin_RF3_NAD83
MacroinvertFamilyCommunities_RF3_NAD83
MacroinvertGenusCommunities_RF3_NAD83

MusselCommunitiesDelawareBasin_RF3_NAD83
MusselCommunitiesOhGrLakesBasin_RF3_NAD83
MusselCommunitiesSusqPotomacBasin_RF3_NAD83

Metadata:
FishCommunitiesAtlanticBasin_RF3_NAD83.xml
FishCommunitiesOhGrLakesBasin_RF3_NAD83.xml
MacroinvertFamilyCommunities_RF3_NAD83.xml
MacroinvertGenusCommunities_RF3_NAD83.xml
MusselCommunitiesDelawareBasin_RF3_NAD83.xml
MusselCommunitiesOhGrLakesBasin_RF3_NAD83.xml
MusselCommunitiesSusqPotomacBasin_RF3_NAD83.xml

Community locations can be mapped as occurrences and predicted occurrences within stream reaches. Community types for mussels, fish, and macroinvertebrate assemblages are represented at the stream reach scale. The top one or two species most strongly associated with the community are included in the community scientific names. Descriptive names are also given to describe general habitat conditions associated with the community. Scientific and descriptive community names in this file refer to those listed in the *Community Descriptions* (*Chapters 4-7*). In addition to the community locations, predicted locations in stream reaches for community habitats are also available in the file. Model prediction probabilities vary for each stream reach and are noted for each community prediction. Community prediction probabilities and model error rates should be evaluated when considering model predictions. Please see Chapter 5 of the *Classifying Lotic Systems for Conservation: Methods and Results of the Pennsylvania Aquatic Community Classification Project* document for descriptions of the community prediction habitat models.

HUC-12 – Communities Shapefile:
huc12_community_NAD83.dbf

Metadata:
huc12_community_NAD83.shp.xml

Additionally, community habitats can be viewed at a watershed scale. The most frequently occurring community type for each of the mussel, fish, and macroinvertebrate classification are attributed to the HUC 12 watershed. The number of actual community sample locations was counted in this analysis, but predicted community locations were not used. Data users interested in looking at large scale patterns of biodiversity may be interested in communities summarized by watershed.

Stream reaches

Shapefiles:
RF3_Line_NAD83

Metadata:
RF3_Line_NAD83.shp.xml

Stream reach data files are provided to accompany reach-community shapefiles and Least-Disturbed Stream shapefiles.

Abiotic data

Shapefile:
RF3_Polygon_Abiotic_NAD83

Metadata:
RF3_Polygon_Abiotic_NAD83.shp.xml

Also, see the metadata for original data sources.

Geology:
DE_Geol_Metadata.html
NJ_Geol_Metadata.html
PA_Geol_Metadata.html
VA_Geol_Metadata.html
WV_Geol_Metadata.html

Dams:
Dams.html
Dam_heightclass.html
Dam_heighttypes.html

Landcover
LandCoverClasses.html

Roads:
Roads_tigerlines.pdf
Roads_tigerlines_metadata.html

Point sources and mines:
Cerclis.html (point source data)
IFD.html (point source data)
TRI.html (point source data)
Mines.html

Landscape, watershed and stream channel information are attributed to stream reach polygons in this dataset. Polygons correspond to stream reaches in the reach-community shapefiles and the stream reach shapefiles. Polygons were defined by GIS analysts at The Nature Conservancy for the 2003 Lower New England Ecoregional Plan (Anderson and Olivero 2003). Each polygon has reach, riparian buffer, reach watershed, and catchment attributes data summarized (Table 13-1, Figure 13-1).

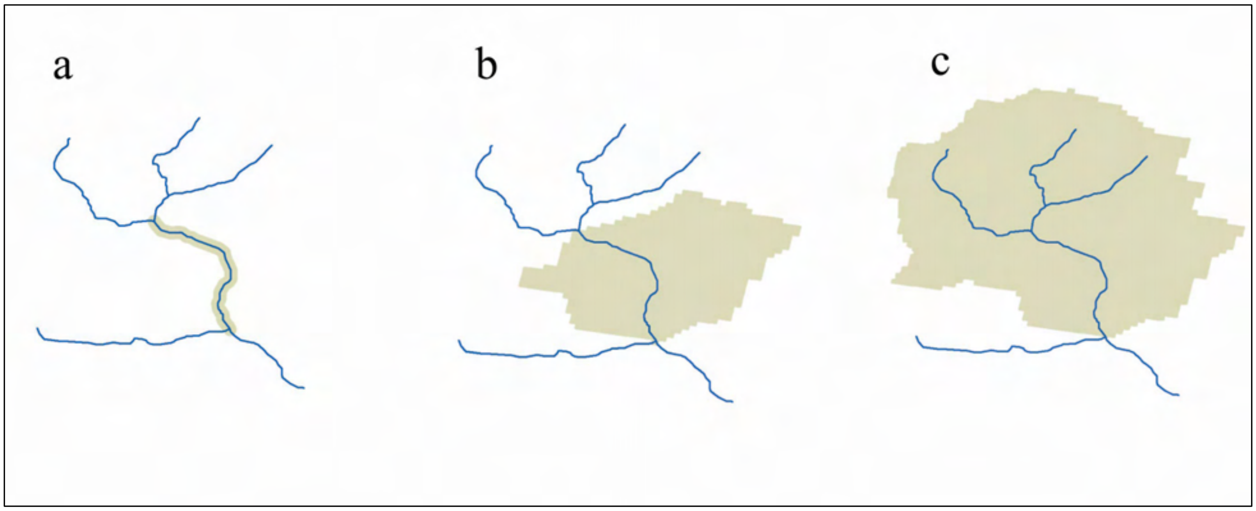
Data include riparian and watershed landcover, geology, watershed area, reach gradient, elevation, stream order, stream link, arbolate sum, road stream crossings, dams, and industrial and mining point sources. Calculated attributes were developed by the report authors and by GIS analysts at The Nature Conservancy for the 2003 Lower New England Ecoregional Plan (Anderson and Olivero 2003). Methods for attributing stream reaches with for many types of calculated data are documented in Fitzhugh (2000). Information about datasets analyzed in the calculated attributes is available in the file metadata.

Physical stream types developed for the study area based on methods and approaches outlined in Higgins (2005). Physical stream types were identified by classes of reach gradient, watershed size, and dominant geology. Habitat types, gradient classes, watershed size classes, and dominant geology classes are attributes of this dataset. See Chapter 8 for descriptions of the approach, methods, and results of the stream types.

Table 13-1. Attributes summarized for reaches, riparian buffers, reach watersheds, and catchments.

Reach	Riparian buffer	Reach watershed	Catchment
Arbolate sum	Land cover	Dams	Dams
Elevation		Geology	Geology
Gradient		Landcover	Landcover
Link		Point sources	Point sources
Strahler order		Mines	Mines
		Road – stream crossings	Road – stream crossings
		Physical stream type	Catchment area
		Geology class	
		Gradient class	
		Watershed size class	

Figure 13-1 (a-c). Spatial boundaries of a riparian buffer surrounding a stream reach, a reach watershed, and a catchment. Areas are shaded for a) a riparian buffer, b) a reach watershed, and c) a catchment (Adapted from Brenden et al. 2006).



Least Disturbed Stream (LDS) condition analysis

Shapefiles:*
RegionWide_LDS.shp
CalcareousGeol_LDS.shp
CrystallineMaficGeol_LDS.shp,
CrystallineSilicicGeol_LDS.shp
Piedmont_LDS.shp
GreatValley_LDS.shp
SusquehannaLowland_LDS.shp
WaynesburgHills_LDS.shp
NWGlaciatedPlateau_LDS.shp

Metadata:
RegionWide_LDS_Metadata.html
CalcareousGeol_LDS_Metadata.htm,
CrystallineMaficGeol_LDS_Metadata.htm,
CrystallineSilicicGeol_LDS_Metadata.htm,
Piedmont_LDS_Metadata.html
GreatValley_LDS_Metadata.htm
SusquehannaLowland_LDS_Metadata.html
WaynesburgHills_LDS_Metadata.html
NWGlaciatedPlateau_LDS_Metadata.html

**In order to minimize duplicity and file size, only the watershed size class field was retained in the specialized LDS shapefiles. To see more information about stream reaches in these shapefiles, overlay them with the complete stream layer, found in the shapefile. RF3_Line_NAD83.*

Stream reaches with the least amounts of human disturbances were selected as potentially high quality habitats. Human disturbance indicators included watershed and riparian landcover types indicating non-point source pollution for agriculture and urban sources, point sources from municipal, industrial, and mining sources, road-stream crossings, and number of watershed dams. Primary stream reaches selected indicate those meeting criteria for human disturbance indicator varia-les. A secondary analysis, using relaxed criteria, selected reaches in ecological regions and habitats that may face more human disturbance than other areas. We captured the best remaining examples of streams in watersheds with calcareous, crystalline silic, and crystalline mafic geologies and streams from watersheds in the Great Valley, Northwest Glaciated Plateau, Piedmont, Waynesburg Hills and Susquehanna Lowlands physiographic regions. See LDS chapter (9) for more information.

Conservation priority results

Shapefiles:
Conservation_HUC12s.shp
French_Creek_Conservation_HUC12s.shp
Piedmont_Conservation_HUC12s.shp
WaynesburgHills_Conservation_HUC12s.shp
CalcareousGeol_Conservation_HUC12s.shp

Metadata:
Conservation_HUC12s_Metadata.html
French_Creek_Conservation_HUC12s_Metadata.html
Piedmont_Conservation_HUC12s_Metadata.html
WaynesburgHills_Conservation_HUC12s_Metadata.html
CalcareousGeol_Conservation_HUC12s_Metadata.html

Conservation priority watersheds for Pennsylvania were determined as those having habitat for high quality biological communities, scoring high community biological metrics, and having a high proportion of least-disturbed streams in the watershed. The Tier 1 and 2 watersheds represent those meeting the most stringent criteria. Watersheds receiving Tier 1 status have highest amounts of community habitat, have biological indicators that suggest good habitat, and have few human disturbance indicators. Tier 2 watersheds score secondarily in one or all of the criteria variables. Additional, watershed prioritization occurred for areas in the Piedmont Physiographic Province, Waynesburg Hills Physiographic Section, watersheds dominated by calcareous geology, great rivers (watershed area >2000 sq. mi.), and the French Creek watershed in the Allegheny River basin.

Restoration priority results

Shapefiles:
Restoration_HUC12s.shp

Metadata:
Restoration_HUC12s_Metadata.html

A tiering system similar to that used in the watershed Conservation Prioritization analysis was used to indicate the state of impairment that each altered watershed is in. The ‘Tier 1’ category here represents the most disturbed watersheds that exist in Pennsylvania. The ‘Tier 2’ category also represents a condition of impairment, but the need for restoration action in these areas may not be as immediate as those with ‘Tier 1’ status.

These watersheds are an immediate priority for restoration action. Watersheds fell into the a restoration priority category if it had no LDS reaches, had low-scoring macroinvertebrate metrics, and had multiple occurrences of fish or macroinvertebrate communities that indicate poor-quality stream habitat.

Watershed Enhancement Areas

Shapefiles:
Watershed_Enhancement_Areas.shp

Metadata:
Watershed_Enhancement_Areas.html

Watersheds that did not fall into either the Conservation or Restoration priorities were identified as "Enhancement" watersheds. These watersheds reflect conditions that are likely not pristine, and are prime candidates for restoration action because they are not as severely degraded as the Restoration watersheds. The restoration of these Watershed Enhancement Areas will likely yield the most significant ecological gains for the amount of conservation dollars spent.

Pennsylvania Aquatic Database

Database:
PAD.mdb

Metadata:
PADfieldlist.xls

The database contains aquatic habitat, water chemistry, and biological data for the study area. Biological datasets include mussel, fish and macroinvertebrate surveys. Most datasets gathered for the project from a number of sources, including state and federal agencies, watershed groups, river basin commissions, and universities, are made publicly available in this database. The database is organized by data station, samples, replicates, and survey data with many supporting tables.

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APPENDIX A – LDS CRITIERA FOR SELECTED REGIONS OF THE STUDY AREA.

Calcareous Geology-Dominated Streams

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	<= 1	<= 2.4	<= 2	<= 3
Catchment Agriculture (non-row crop) (%)	<= 36	<= 56	<= 59	<= 30
Catchment Agriculture (row crop) (%)	<= 16	<= 22	<= 14.1	<= 15.7
Catchment Forest Cover (%)	>= 60	>= 41	>= 31	>= 56
Riparian Developed (%)	<= 2	<= 2	<= 2	--
Riparian Agriculture (%)	<= 20	<= 40	<= 50	--
Riparian Forest Cover (%)	>= 78	>= 41	>= 37.5	--
# Catchment Point Sources	<= 4	<= 6	<= 10	<= 8
# Catchment Dams	= 0	= 0	<= 1	<= 2
# Catchment Road Crossings	<= 7	<= 19	<= 60	<= 330
Example Streams	*HW of W & E Branches Owego Creek (NY); Tribs to Cross Creek below confluence of North & Middle Forks; Tribs to Brush Run (Raccoon Creek); some tribs to Blacklegs Creek; small tribs to Monongahela & Cheat Rivers near their confluence; almost all tribs to Evitts creek draining ridge to east;* tribs to Horn Run (Standing Stone Creek); *tribs to Basher Kill, just above Neversink R confluence (NY)*	*HW Tribs of W & E Branches Owego Creek (NY); Scott Run (Cross Creek); Big, Harpers & Whiskey Runs (Blacklegs Creek); Perry Mill Run (Monongahela R); Gander Run (Clear Creek); Rocky Gap Run (Evitts Creek); Shobers Run; Hiett Run (North R –WV); upper N. Branch Little Aughwick Run; Beaverdam Run (Juniata R); Thomson Creek (Conodoguinet Creek); Wickecheoke Creek and Plum Brook (NJ)*	*W & E Branches Owego Creek (NY); Bradley Creek (NY); Upper Raccoon Creek; York Run (Georges Creek); Georges Run (Monongahela R); Evitts Creek, above impoundment; Shobers Run; Little Juniata Creek; Bixler Run (Sherman Creek); Fort Run (Aughwick Creek); Beaverdam Run (Juniata R); Wickecheoke Creek (NJ); Moores Run (Cacapon R - WV)*	*Fishing Creek, below Little Fishing Creek (Bald Eagle Creek); Penns Creek, btw Pine Creek and Big Poe Creek; lower Spruce Creek (Little Juniata River)*

Crystalline Silicic Geology-Dominated Streams

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	6	6	6	12
Catchment Agriculture (non-row crop) (%)	25	40	55	43
Catchment Agriculture (row crop) (%)	10	8	12.5	9
Catchment Forest Cover (%)	59	55	37	35
Riparian Developed (%)	5	4.9	6.9	--
Riparian Agriculture (%)	20	15	48.5	--
Riparian Forest Cover (%)	60	55	25	--
# Catchment Point Sources	4	6	16	35
# Catchment Dams	1	2	1	4
# Catchment Road Crossings	11	19	54	290
Example Streams	*HW of Rocky Mountain Creek & Carbaugh Run (Conococheague Creek); HW of Little Lehigh, Swabia & Manatawny Creeks; Mountain Lake Brook (Pequest R)*	*HW tribs to Yellow Breeches Creek; portions of Manatawny Creek; Sacony Creek and Beaver Run*	*W. Br. Brandywine Creek; S. Br. French Creek; W. Br. Perkiomen Creek*	*Brandywine Creek; Musconetcong River (NJ)*

Crystalline Mafic Geology-Dominated Streams

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	6	2.1	6	4.5
Catchment Agriculture (non-row crop) (%)	22	25	55	43
Catchment Agriculture (row crop) (%)	7	8.5	18	10
Catchment Forest Cover (%)	68	67	29	36
Riparian Developed (%)	3.5	3.5	4	--
Riparian Agriculture (%)	10	14.5	13	--
Riparian Forest Cover (%)	65	64	85	--
# Catchment Point Sources	3	4	10	13
# Catchment Dams	0	0	0	0
# Catchment Road Crossings	5	15	110	250
Example Streams	*Tribs to Tohickon Creek; Butter Creek (Unami Creek); Headwaters of Toms Creek*	*Ridge Valley Creek (Unami Creek); Dimple Creek (Tohickon Creek); Rapp & Beaver Creeks (Tinicum Creek)*	*Muddy, Otter & Fishing Creeks (Susquehanna R); W. Br. Brandywine Creek (near mouth)*	*Brandywine Creek, below Buck Run confluence*

Appalachian Plateau Physiographic Province - Waynesburg Hills Section

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	<= 1	<= 3.7	<=0.9	<= 1.4
Catchment Agriculture (non-row crop) (%)	<= 28	<= 37	<= 40	<= 41.5
Catchment Agriculture (row crop) (%)	<= 3.5	<= 4	<= 0.55	<= 1
Catchment Forest Cover (%)	>= 70	>= 60	>= 59	>= 56
Riparian Developed (%)	<= 1.75	<= 3	<= 2	--
Riparian Agriculture (%)	<= 18	<= 25	<= 36.5	--
Riparian Forest Cover (%)	>= 80	>= 75	>= 61	--
# Catchment Point Sources	<= 2	<= 2	<= 2	<= 21
# Catchment Dams	<= 1	<= 1	<= 1	<= 9
# Catchment Road Crossings	<= 6	<= 22	<= 53	<= 300
Example Streams	*Many tribs to Fish Creek PA Fork; many Tribs to Wheeling Creek, both Robinson & Enlow forks, near PA border); many tribs to Meadow Run; Woods Run (Whiteley Creek); tribs to little Whiteley Creek (Monongahela R); all tribs to Middle Run (Monongahela R); Meadow & Bates Runs (Monongahela R)*	*Owens Run (Wheeling Creek, Enlow Fork); Wharton Run (Wheeling Creek, Dunkard Fork); Crabapple Creek; Bissett Run (Fish Creek, PA Fork); Barneys Run (S. Fork Dunkard Run); Kent Run (Wheeling Creek, Dunkard Fork); Sharp Run (Dunkard Creek)*	*S. Fork Dunkard Fork; Wheeling Creek, Dunkard Fork; Fish Creek, PA fork (btw Knob and Pigeon Runs); Dunkard Creek (btw Toms Run & PA Fork Dunkard Creek); PA fork Dunkard Creek (below Clawson Run); Roberts Run (btw Rush & Sheppards Runs); mid Browns Creek; mid Bates Fork (Browns Run); Sections of Wheeling Creek, Robinson Fork; Wheeling Creek, Templeton Fork (btw Rocky Run & Wheeling Creek, Enlow Fork)*	*S. Fork Tenmile Creek (btw Browns Creek & Grimes Run); Tenmile Creek (btw Daniels Creek & Plum Run); Dunkard Creek (btw Miracle Run & Wrights Run)*

Appalachian Plateau Physiographic Province – Northwest Glaciated Plateau Section

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	<= 1	<= 0.65	<= 1.5	<= 2.1
Catchment Agriculture (non-row crop) (%)	<= 30	<= 37	<= 45	<= 35.5
Catchment Agriculture (row crop) (%)	<= 14	<= 13.5	<= 19	<= 13
Catchment Forest Cover (%)	>= 70	>= 50	>= 43	>= 39
Riparian Developed (%)	<= 0.9	<= 1	<= 1.5	--
Riparian Agriculture (%)	<= 29	<= 30	<= 34	--
Riparian Forest Cover (%)	>= 70.5	>= 66	>= 60	--
# Catchment Point Sources	<= 2	<= 3	<= 5	<= 15
# Catchment Dams	<= 1	<= 2	<= 2	<= 4
# Catchment Road Crossings	<= 6	<= 12	<= 44	<= 300
Example Streams	Conneaut Creek & W. Br. Conneaut HW tribs; McConnell Run & Tribs (Sandy Creek); lower Mill Creek tribs (French Creek); Woodcock Creek HW; Sugar Creek HW tribs; lower small tribs to Oil Creek; HW Tribs so Spring Creek (Brokenstraw Creek); some HW tribs to Little Conneauttee Creek	*Middle/East Branches Conneaut Creek; Inlet/Pine Runs (above Conneaut impoundment); HW Watson Run (Conneaut Outlet); Little Sandy Creek tribs; W Br. Sugar Creek; Sugar Creek headwaters; Mackey/Temple Runs (Sandy Creek); many tribs to Oil Creek; Townly Run & Bailey Brook (W. Br. French Creek); Spencer Creek & Baskin Run (S. Br. French Creek); North Br. Akeley & Storehouse Runs (Conewango Creek); Stony Creek (Little Brokenstraw Creek*	*West/Middle Branches Conneaut Creek; Little Elk Creek; North Deer and Mill Creeks (French Creek); middle Lake Creek; middle Little Sugar Creek; Woodcock Creek above impoundment; Muddy Creek btw Potash Run & Federal Run; mid Thompson Run; Spring Creek (Brokenstraw Creek); Little Brokenstraw Creek; Shenango R above Pymatuning*	*Sugar Creek (below Lake Creek Confluence); lower NWGP section of Oil Creek; French Creek, above confluence with S. Br. French Creek; Shenango R, btw Pymatuning & Little Shenango confluence.; Conneaut Creek, below W. Br. Conneaut confluence.*

Piedmont Physiographic Province – All Sections

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	<= 6	<= 6	<= 5.5	<= 5.5
Catchment Agriculture (non-row crop) (%)	<= 40	<= 45	<= 50	<= 40
Catchment Agriculture (row crop) (%)	<= 17.5	<= 15	<= 17	<= 7
Catchment Forest Cover (%)	>= 50	>= 40	>= 32	>= 49
Riparian Developed (%)	<= 2.5	<= 3	<= 3	--
Riparian Agriculture (%)	<= 25	<= 35	<= 45	--
Riparian Forest Cover (%)	>= 55	>= 40	>= 22	--
# Catchment Point Sources	<= 2	<= 2	<= 10	<= 40
# Catchment Dams	= 0	<= 1	<= 2	<= 4
# Catchment Road Crossings	<= 10	<= 20	<= 55	<= 815
Example Streams	*Sawmill Run; Furnace Run (Sawmill Run); Counselman Run (Susquehanna R.); Oakland Run, Huber Run; Trout Run (Climbers Run); Shearers Creek headwaters; headwater tribs of Hammer Creek, above impoundment; Tribs to Allegheny, Sixpenny & Seidel Creeks (Schuylkill R); Tribs to Jehrico Creek*	*Beaver Creek; Tucquan Creek; upper Conewago Creek; upper Chickens Cree/Shearers Creek; Furnace & Segloch Runs of upper Middle Creek; upper Black Creek (Muddy Creek); N. Branch Indian Run (E. Br. Brandywine Creek); Rock, Beaver and Birch Runs (French Creek); Deep Creek (Perkiomen Creek); Ridge Valley Creek (Unami, Perkiomen Creeks); Threemile Run & Haycock Creek (Tohickon Creek); Beaver and Rapp Creeks (Tinicum Creek); Jerhico Creek*	*lower Otter Creek; Middle Creek; upper Hammer Creek; mid Cocalico Creek; upper East Branch Brandywine Creek; S. Branch French Creek & French Creek above S. Branch; W. Branch Perkiomen Creek; Tinicum Creek*	*Perkiomen Creek (Unami Creek confluence to Skippack Creek confluence); Tohickon Creek (Geddes Run to Del. R.)*

Ridge & Valley Physiographic Province – Susquehanna Lowland Section

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	<= 0.75	<= 0.75	<= 1.5	<= 0.75
Catchment Agriculture (non-row crop) (%)	<= 22.5	<= 22	<= 25	<= 20
Catchment Agriculture (row crop) (%)	<= 10	<= 6	<= 10	<= 10
Catchment Forest Cover (%)	>= 75	>= 70	>= 70	>= 70
Riparian Developed (%)	<= 1	<= 1	<= 1.5	--
Riparian Agriculture (%)	<= 15	<= 20	<= 25	--
Riparian Forest Cover (%)	>= 80	>= 75	>= 70	--
# Catchment Point Sources	= 0	= 0	<= 2	<= 3
# Catchment Dams	= 0	= 0	<= 2	<= 2
# Catchment Road Crossings	<= 4	<= 10	<= 35	<= 400
Example Streams	*Tributaries to Big Run (Muncy Run); Tributaries to Lick Run (Muncy Run); Headwaters of West Creek (Fishing Creek); Headwaters of Pine Creek; Laurel Run (Huntington Creek); Headwaters of Spruce Run; Boyers Run (Susquehanna River); Headwaters of South Fork Powell Creek;*	*North & South Forks of Powell Creek; Big Run (to Lost Creek); Big Run and Roaring Run (both to Muncy Creek); Pine Creek (above Bell Creek); Rayburn Creek (to Shickshinny Creek); Roaring Brook (to Hunlock Creek)*	*White Deer Creek (above impoundment); Spruce Run (above Black Run); Rapid Run; Kitchen Creek; Huntington Creek (Laurel Run to Kitchen Creek)*	*Fishing Creek (above Little Fishing Creek and below Raven Creek); Huntington Creek (below Pine Creek); Muncy Creek (below Sugar Run to Susquehanna River); Lycoming Creek (above Bottle Run)*

Ridge & Valley Physiographic Province – Great Valley Section

Reference Criterion	Size 1 (0-3 mi^2 watershed area)	Size 2 (4-10 mi^2 watershed area)	Size 3 (11-100 mi^2 watershed area)	Size 4 (100+ mi^2 watershed area)
Catchment developed (%)	<= 1	<= 1.75	<= 1.5	<= 6
Catchment Agriculture (non-row crop) (%)	<= 50	<= 55	<= 55	<= 40
Catchment Agriculture (row crop) (%)	<= 12	<= 15	<= 17	<= 11
Catchment Forest Cover (%)	>= 40	>= 35	>= 30	>= 50
Riparian Developed (%)	<= 2	<= 2.5	<= 1.5	--
Riparian Agriculture (%)	<= 40	<= 40	<= 45	--
Riparian Forest Cover (%)	>= 40	>= 35	>= 45	--
# Catchment Point Sources	= 0	<= 3	<= 1	<= 20
# Catchment Dams	= 0	= 0	<= 2	<= 5
# Catchment Road Crossings	<= 10	<= 20	<= 55	<= 280
Example Streams	*Headwaters of Keasey Run; Headwaters of Paxton Run; Headwaters of Phillaman Run; Headwaters of Bore Mill Run; Tribs to Locust Creek; Trib to Wertz Run; Headwaters of Crosskill Creek; Headwaters of East Fork Martins Creek; Slateford Creek*	*Headwaters of Doubling Gap Creek; Headwaters of Locust Creek; Headwaters of Monroe Creek; Headwaters of Northkill Creek; Headwaters of Trout Creek; Headwaters of Hokendauqua Creeks - Indian & Hokendauqua*	*Mill Creek; Maiden Creek above Kistler Creek; Indian & Hokendauqua Creeks, above confluence*	*West Branch Conococheague Creek; Conodoguinet Creek between Muddy Run and Paxton Run*

APPENDIX B: POINT SOURCE DATASET DESCRIPTIONS

- **Superfund/CERCLIS (EPA Comprehensive Environmental Response, Compensation, and Liability Information System)**

CERCLIS is a national computerized management information system that automates entry, updating, and retrieval of Comprehensive Environmental Response, Compensation, and Liability Information System data and tracks site and non-site specific Superfund data in support of the Comprehensive Environmental Response, Compensation, and Liability Act. It contains information on hazardous waste site assessment and remediation.

Data source time period: 1983-1997
http://www.epa.gov/superfund

- **IFD**

The major components of the IFD are the Permit Compliance System (PCS), the National Pollution Discharge Elimination System (NPDES), the Construction Grants Needs Survey, the Publicly Owned Treatment Works Study, the regulations and standards from EPA/OW Effluent Guidelines Division, EPA's Duluth Laboratory's Complex Effluent Toxicity Information System (CETIS) database, the Organic Chemical Producer's (OCP) database, EPA Enforcement Form 2C data in STORET, the Hazardous

Data source time period: 1978-1994
http://www.epa.gov/ost/basins

- **TRI (Release Inventory Facilities)**

The TRI data for chemical releases to land are limited to releases within the boundary of a facility. Releases to land include: landfills; land treatment/application farming; and surface impoundments, such as topographic depressions, man-made excavations, or diked areas. Air releases are identified as either point source releases or as non-point (i.e. fugitive) releases, such as those occurring from vents, ducts, pipes, or any confined air stream. Surface water releases included discharges to rivers, lakes, streams, and other bodies of water. In addition, the database covers releases to underground injection wells (where chemicals are injected into the groundwater) and off-site transfers of chemicals to either publicly owned treatment works (POTWs) or any other disposal, treatment, storage, or recycling facility.

Data source time period: 1987-1995
http://www.epa.gov/enviro/html/tris/tris_overview.html

- **PCS (EPA/OW Permit Compliance System)**

PCS is a national computerized management information system that automates entry, updating, and retrieval of National Pollutant Discharge Elimination System (NPDES) data and tracks permit issuance, permit limits and monitoring data, and other data pertaining to facilities regulated under NPDES. PCS records water-discharge permit data on more than 75,000 facilities nationwide.

The NPDES permit program regulates direct discharges from municipal and industrial wastewater treatment facilities that discharge into the navigable waters of the United States. Wastewater treatment facilities (also called "point sources") are issued NPDES permits regulating their discharge. For distribution with BASINS v.2.0, the spatial attributes of the database were prepared in Arcview shape file format while selected relational attributes were prepared in Arcview DBF file format.

Data source time period: 1987-1995
http://www.epa.gov/owmitnet/pcsguide.htm

- **Mines (USBM Mineral Availability System)**

This dataset lists known mining operations, mineral deposits/occurrences and processing plants, and identifies more than 221,000 mineral locations and processing plants. This dataset was derived from the Mineral Availability System (MAS)/Mineral Industry Location System (MILS) CD-Rom.

Data source time period: 1974-1995
http://minerals.er.usgs.gov/minerals/pubs

APPENDIX C: OTHER PA STREAM CLASSIFICATIONS

The state of Pennsylvania protects aquatic life using a "designated use" classification of waters in the Commonwealth under the federal Clean Water Act. Four types of aquatic life should be propagated and maintained based on their designation in Pennsylvania (PA Code 93.3; http://www.pacode.com/secure/data/025/chapter93/s93.3.html):

Cold Water Fishes (CWF): Fishes and associated aquatic flora and fauna preferring colder waters (included in the cold water fishes are trout species).

Warm Water Fishes (WWF): Fishes and associated aquatic flora and fauna preferring warmer waters.

Trout Stocked Fishes (TSF): Stocked trout species (maintained from Feb 15 to July 31) and warm-water flora and fauna .

Migratory Fishes (MF): Fishes (those having anadromous, catadromous, or similar life histories) which must migrate through flowing waters to their breeding habitats.

Additionally, some waterbodies receive additional special protections as "Exception Value" or "High Quality" waters because they are especially valued for aquatic life, water quality, and/or recreation. Meeting relatively high water quality and other standards qualify the water bodies for additional protections from degradation beyond the aquatic life uses (PA Code 93.4b, www.pacode.com/secure/data/025/chapter93/s93.4b.html).

The purpose and meanings differ between the classes defined in Pennsylvania aquatic life use/special protection designations and aquatic fish assemblages from the Pennsylvania Aquatic Community Classification. The similar nomenclature of both classifications may be confusing, but in both cases it is meant to relatively define the organisms and aquatic habitats along a gradient of water temperatures (and associated stream size). The PA stream designations broadly encompass habitats occupied by several ACC fish assemblages (Table 3-2) and are used in water quality regulation.

PA Aquatic Life Uses Designation

- Four types: Warm- and Cold-Water Fishes, Trout-Stocked Fishes, and Migratory Fishes
- Represent general conditions and aquatic habitats
- Water quality standards are set by PA DEP to maintain Aquatic Life Uses

PA ACC Fish Communities

- Eleven types in two basins
- Represent river reach conditions and aquatic habitats based on aquatic fauna characteristics
- Created to describe aquatic assemblages and flowing-water diversity

The most common classes are compared below:

PA CWF vs. ACC Coldwater Fish Communities

CWF

- Often designates a brown trout fishery (and, in some locations, there are brook trout, rainbow trout and other salmonid fisheries). Brown trout are introduced species with widespread distribution in Pennsylvania and have tolerances for warmer temperatures than other trout species (PA FBC, PA Fishes, http://sites.state.pa.us/PA_Exec/Fish_Boat/pubonl.htm, accessed 4/17/2007)
- Includes many large valley streams (watershed areas may exceed 300 sq mi.) that are (likely) seasonally warm (e.g., Tuscarora Creek in Juniata County)
- May also included stocked trout

ACC Coldwater Fish Communities

- Indicated by the presence of cold-water fish like, native brook trout and brown trout
- More narrowly defined small stream habitats than CWF
- Occur small, headwater stream habitats (watershed area usually < 20 sq mi.) on mountain slopes
- Do not include stocked trout

PA WWF vs. ACC Warmwater Fish Communities

WWF

- Habitats include broad range flowing water in the valleys, including small, headwater streams and large rivers
- May also have a Stocked-Trout Fishes designation

ACC Warmwater Fish Communities

- Several warmwater fish communities are defined in the Atlantic and Ohio-Great Lakes Basins; communities indicate small to large warm water valley streams. Each warmwater community type has more narrowly-defined warm-water habitats than the PA WWF designation (Chapter 7).

- Indicated by the presence of warmwater fish in some valley streams and small rivers; however, large river habitats typically have fish community assemblages classified as the Ohio Large River Community, the Atlantic River and Impoundment Community, or the Atlantic Lower Delaware River Community. (Chapter 7)