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".

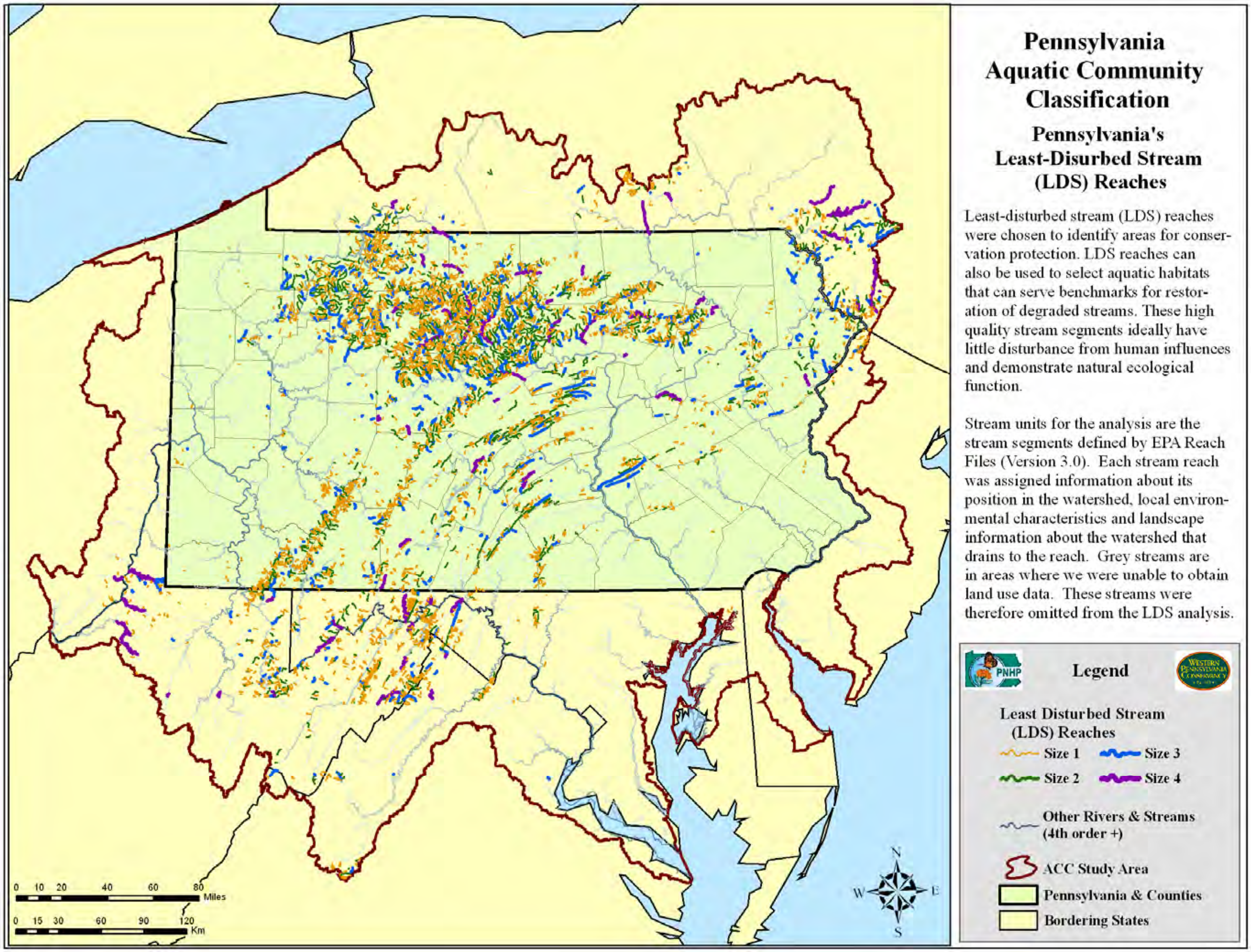

Figure 9-1. Least-Disturbed Stream (LDS) reaches for the ACC study area. See table 9-1 for listing of GIS variables used in the analysis.

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

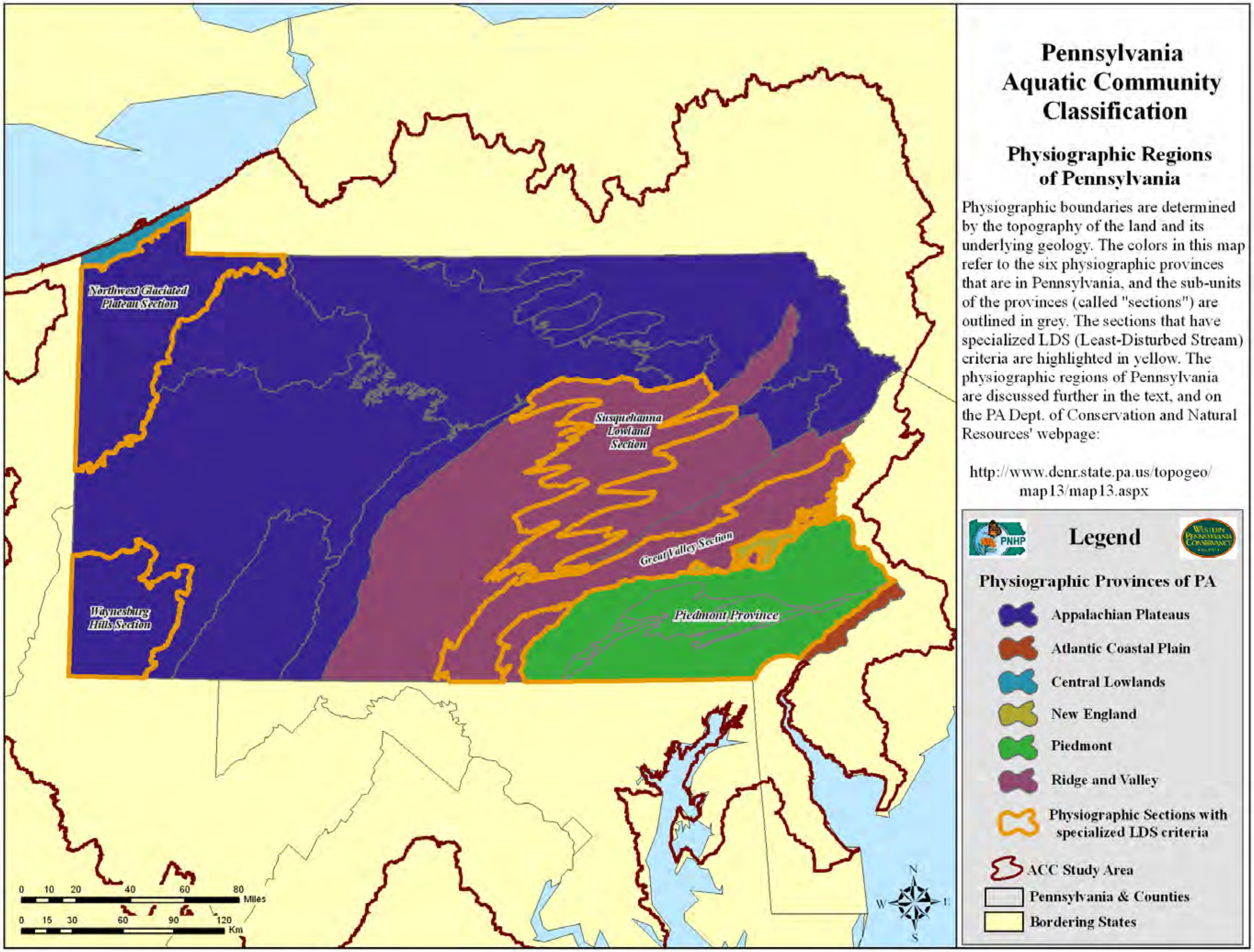

Figure 9-2. Physiographic Provinces of Pennsylvania. Physiographic regions relevant to the LDS analysis are highlighted and labeled.

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.

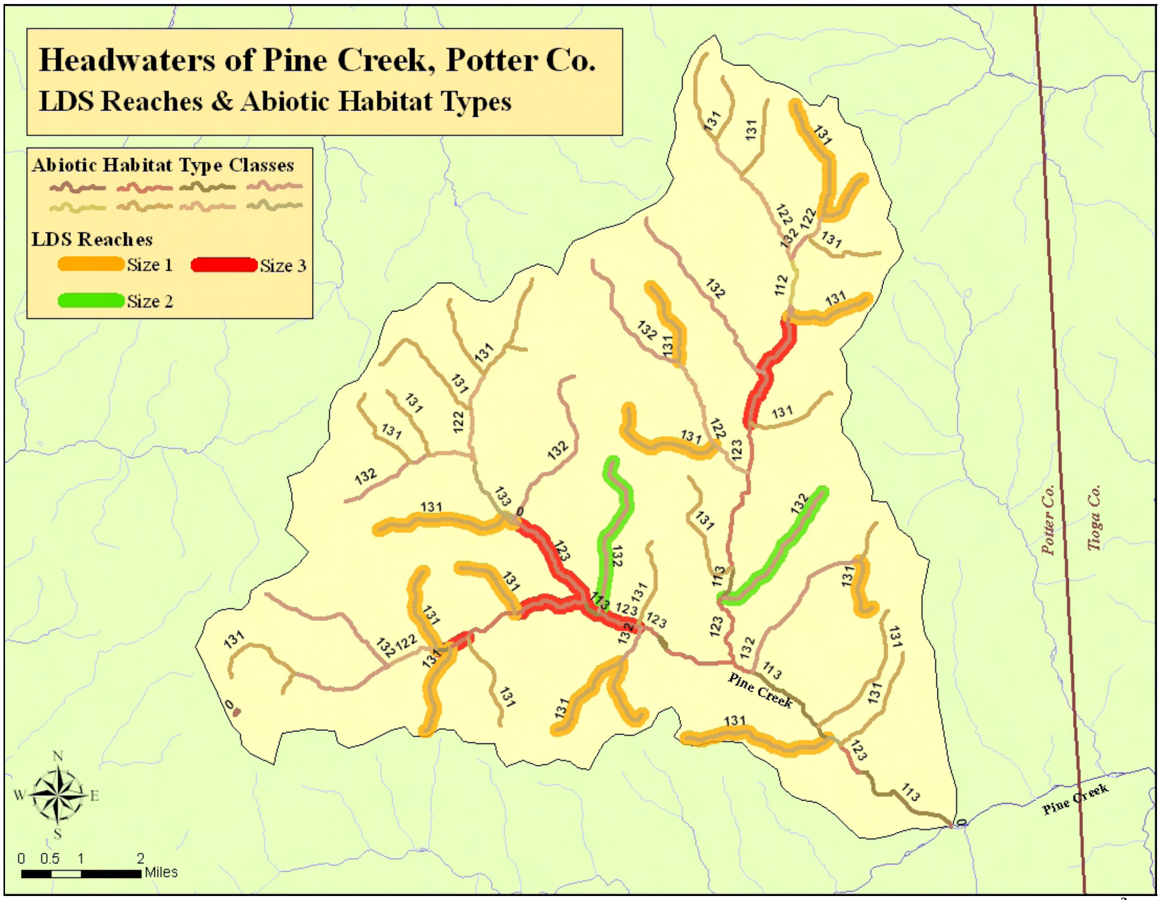

Figure 9-3. The headwaters of Pine Creek flow through Potter Co., PA. The pictured watershed totals approximately 95 mi^2 (246 km^2). Pine Creek ultimately joins the West Branch Susquehanna River near the Lycoming/Clinton county boundary. Physical stream habitat types (Chapter 8) and LDS reaches are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

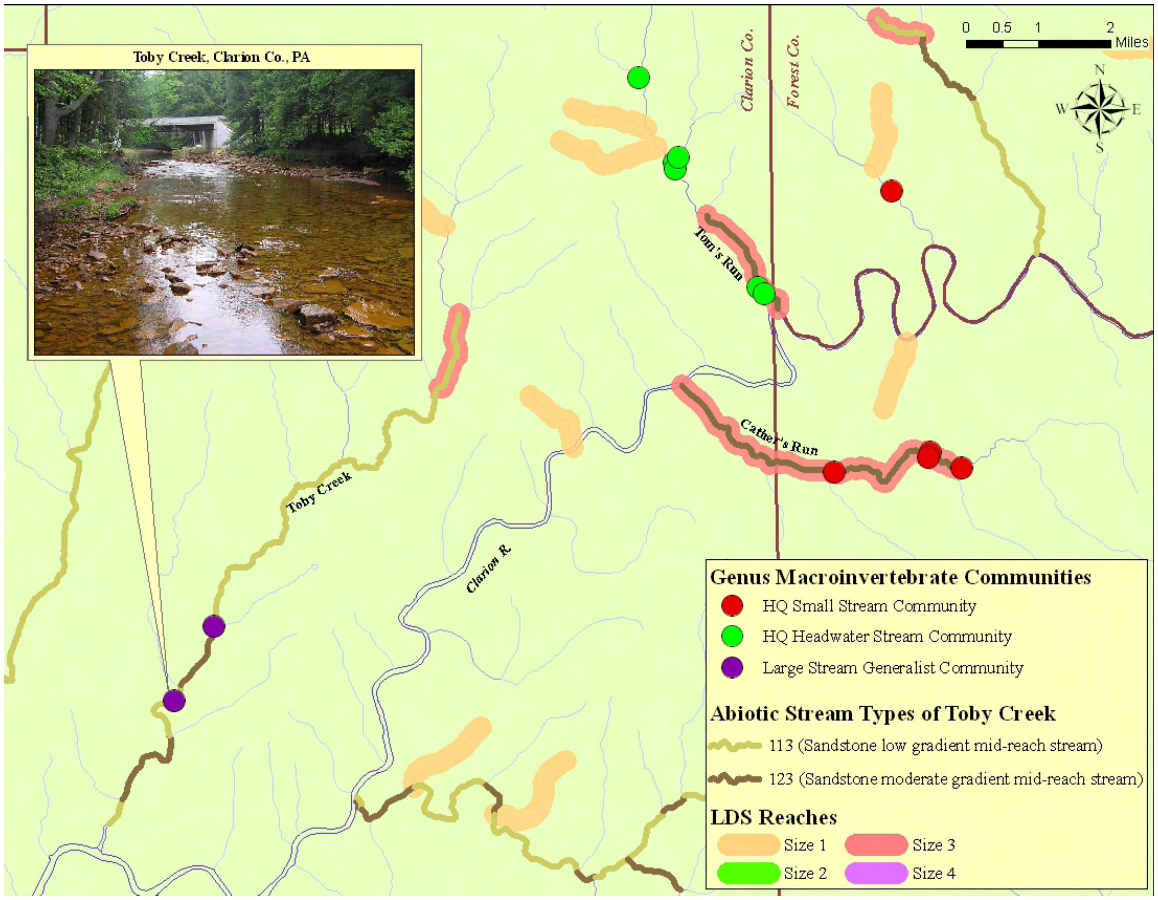

Figure 9-4. Toby Creek in Clarion Co., PA. Note the presence of the low-quality Large Stream Generalist macroinvertebrate community. The inset photograph was taken at this community's location. In the less-disturbed LDS streams (Cather's Run and Tom's Run), two high-quality (HQ) communities are supported. 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?

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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)*