Conneaut Creek Conservation Plan

By

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With Contributions By

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Contents

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1. Executive Summary

The Conneaut Creek watershed (see following photo tour) on the southern shore of Lake Erie is the largest subwatershed within Pennsylvania's portion of the Great Lakes Basin, and occupies portions of Erie and Crawford Counties in Pennsylvania and Ashtabula County, Ohio. The stream was distinguished in the Pennsylvania Lake Erie Watershed Plan (LERC 2008) as the only stream supporting populations of native freshwater mussels, and contained the watershed's largest continuous tract of forest (Pennsylvania State Game Land 101 [also known as "Jumbo Woods"]), which includes extensive wetlands. Game Land 101 is approximately 7 miles south of the Roderick Wildlife Preserve (PA Game Land 314), and other undeveloped tracts along Pennsylvania's Lake Erie shore, so the northern part of the Conneaut Creek watershed could lynchpin for restoring core forest in the northwestern corner of the Commonwealth.

The State of Ohio recognized the exceptional qualities of Conneaut Creek in 2005 by designating most of the Ohio portion, beginning at the Pennsylvania–Ohio line, as a State Wild and Scenic River. The Nature Conservancy has identified Conneaut Creek as one of the twenty most important watersheds for conservation in the Great Lakes basin. Significant conservation actions to protect the important biological resources of Conneaut Creek in the Ohio portion of the watershed include the recently amassed collection of six different properties totaling about 500 acres by the Cleveland Museum of Natural History (CMNH). Placing the highest priority on conservation and protection actions in the northern main stem area of the Conneaut Creek watershed will help enhance the excellent progress already made in Ohio; it also makes the most sense from the standpoint of improving connectedness among major protected habitats already established on the Pennsylvania side.

Heritage resources of special concern in Pennsylvania, including populations of nearly two dozen species of rare plants, fish, native mussels, and birds, are concentrated in areas along the main stem of Conneaut Creek, especially in the northern half of the watershed. Known archaeological sites follow a similar spatial pattern. Several of the specific conservation projects advanced herein are centered around the concept of building/expanding a core forest corridor along the Pennsylvania–Ohio line between Game Land 101 and Game Land 314; this would be accomplished by conservation easements, property acquisition, or forest restoration efforts on approximately a dozen properties in the northern main stem area of the watershed. Several other projects are also defined that target protection of areas of importance to known heritage and cultural resources in portions of the watershed outside the northern main stem corridor.

The collective impact of implementing the projects highlighted by this plan would provide conservation benefits to nearly 20 miles of stream channel and several thousand acres in the Pennsylvania portion of the Lake Erie watershed. The plan also emphasizes pre-emptive actions to address invasive species and impending climate change in the watershed.

Photo Tour 1. The main stem of Conneaut Creek at the former site of a bridge on McKee Road, facing east. *(Credit: Cathy Pedler)*

Photo Tour 2. The main stem of Conneaut Creek just west of the Pennsylvania portion of the watershed, on Furnace Road in Clark Corners, Ohio, facing east. (Credit: Cathy Pedler)

Photo Tour 3. The West Branch of Conneaut Creek at its crossing with Shadeland Road, facing north. *(Credit: Cathy Pedler)*

Photo Tour 4. The Middle Branch of the East Branch of Conneaut Creek at its crossing with Shadeland Road, facing south. *(Credit: Cathy Pedler)*

Photo Tour 5. The East Branch of the West Branch of Conneaut Creek at its crossing with Shadeland Road, facing south. *(Credit: Cathy Pedler)*

Photo Tour 6. Mud Run at its crossing with Shadeland Road, facing south. *(Credit: Cathy Pedler)*

Photo Tour 7. Stone Run at its crossing with Shadeland Road near Beaver Center, Pennsylvania, facing south. *(Credit: Cathy Pedler)*

Photo Tour 8.The main stem of Conneaut Creek at its crossing with Shadeland Road north of Sprinboro, Pennsylvania, facing north. *(Credit: Cathy Pedler)*

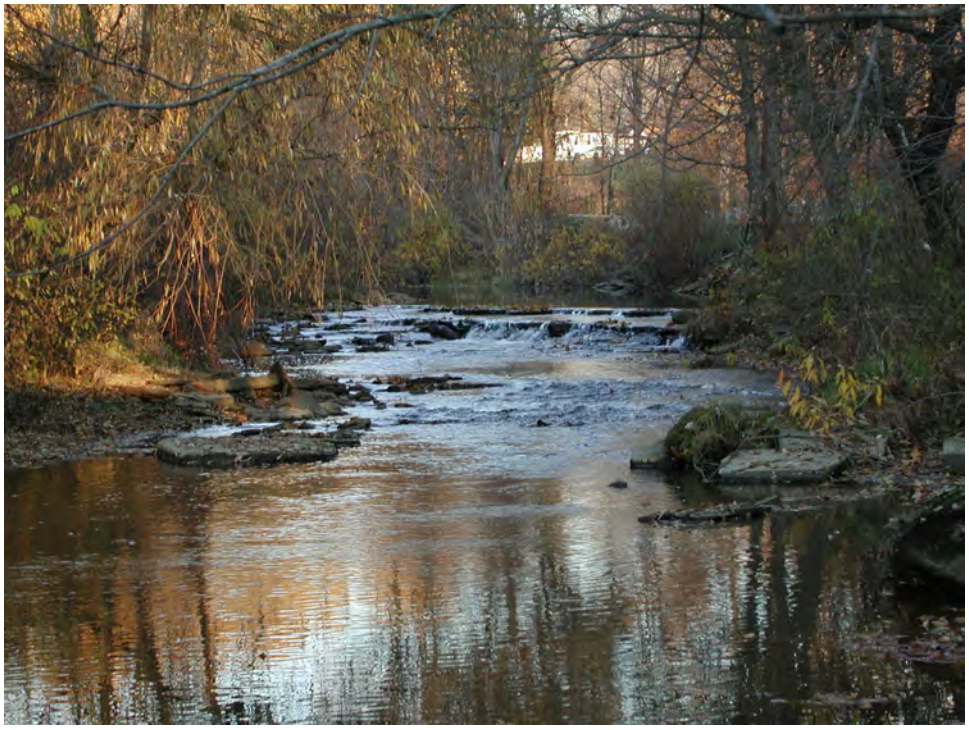


Photo Tour 9. The East Branch of Conneaut Creek in Albion, Pennsylvania, facing east. *(Credit: Cathy Pedler)*

Photo Tour 10. Pond at the head of unnamed tributary to main stem of Conneaut Creek on Thrasher Road just northwest of Cranesville, Pennsylvania, facing north. *(Credit: Cathy Pedler)*

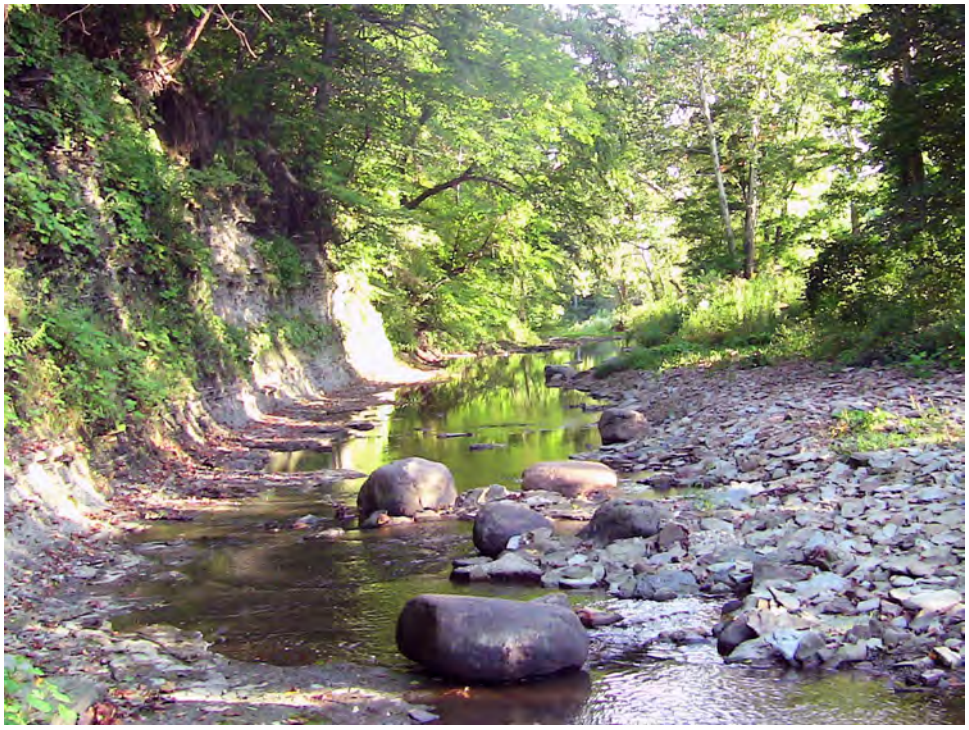
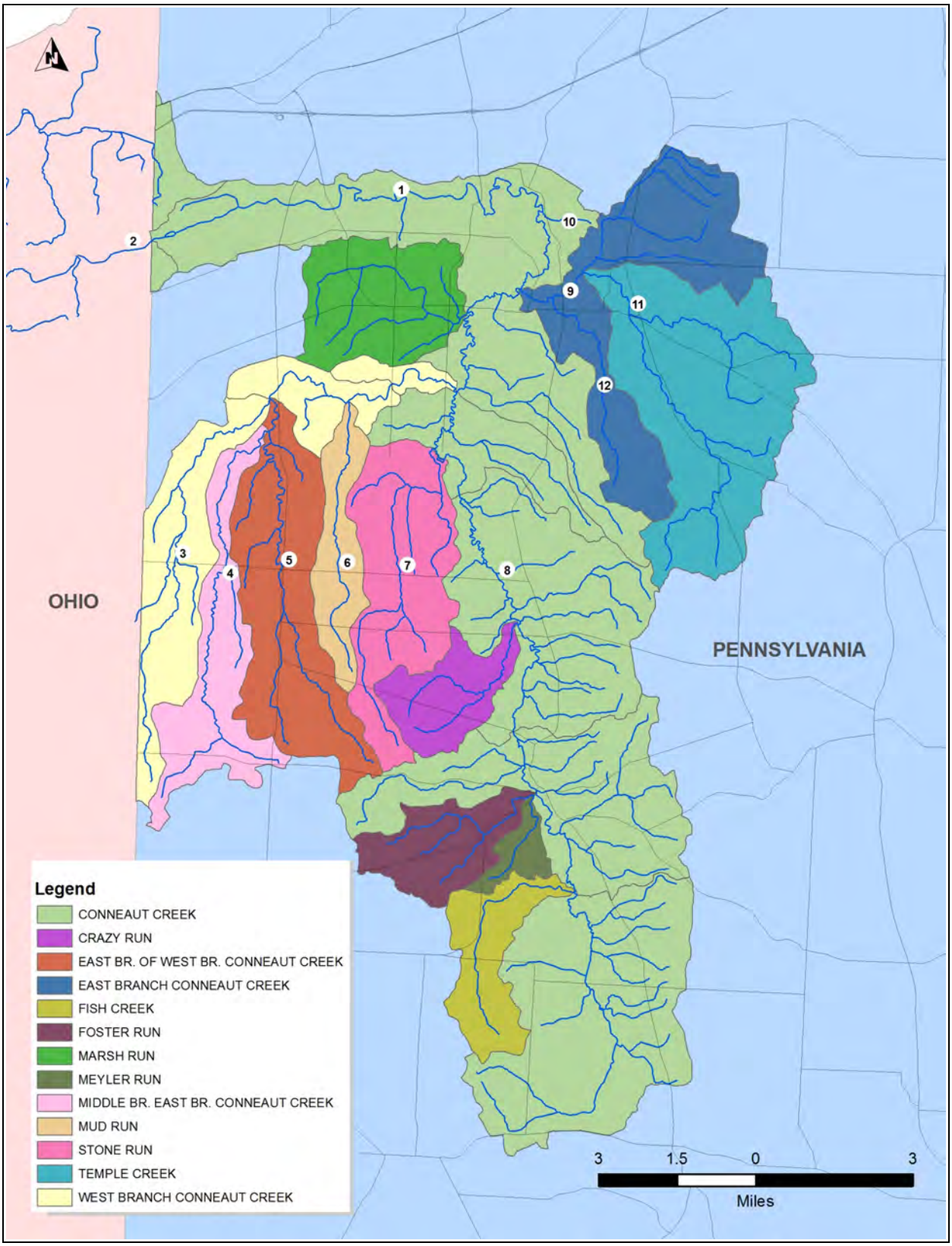


Photo Tour 11. Temple Creek north of US Route 6N and east of Albion, Pennsylvania, facing south. *(Credit: J. Michael Campbell)*

Photo Tour 12. Tributary to the East Branch of Conneaut Creek along Reservoir Road south of Albion, Pennsylvania, facing west. Note old growth Eastern Hemlock forest. *(Credit: J. Michael Campbell)*



Plan map of the Conneaut Creek watershed showing the locations of preceding photo tour stops.

2. The Physical Context of the Conneaut Creek Watershed

The Great Lakes Watershed

The Great Lakes watershed has played an integral role in the history and development of North America. Home to over 10 percent of the United States' population and over 25 percent of Canada's population, the region spans more than 950 mi east-west and 730 mi north-south (Figure 2.1). The Great Lakes basin lies within the boundaries of 8 American states and 2 Canadian provinces, and encompasses a total area of 295,710 mi^2. Of this total area, over 94,000 mi^2 is water surface and 201,460 mi^2 is land area. Combined, the water volume of the Great Lakes is about 5,500 mi^3, which makes it the largest surficial fresh water system on the Earth, accounting for roughly 18 percent of the world supply (United States Environmental Protection Agency [EPA] 2005).

The Great Lakes basin's very large size makes for considerable variations in climate, physiography, soils, and vegetational regimes, to name just a few environmental factors. The basin's northern reaches are dominated by the Canadian Shield—a Precambrian granitic rock formation that underlies the world's greatest concentration of lakes and rivers—and is characterized by a Subarctic climate, relatively shallow acidic soils, and middle taiga to southern taiga floral communities that take the form of moist subarctic forests dominated by conifers (e.g., spruces, firs) bounded on the north by tundra. The basin's southern reaches are characterized by a humid continental climate; relatively deep, glacially derived soils composed of clays, silts, and sands mixed with gravels, and boulders; and an original deciduous forest that in many areas has been superseded by agriculture and sprawling urban development.

The Lake Erie Watershed

Lake Erie, whose watershed includes the Conneaut Creek catchment area as a sub-watershed, has the smallest volume of any of the Great Lakes, measuring about 116 mi^3 and covering an area of about 9,922 mi^2 or about 10.5 percent of the Great Lakes water surface. The Lake Erie watershed covers about 30,115 mi^2 or about 15 percent of the entire Great Lakes watershed's land drainage area. Lake Erie is also the shallowest of the Great Lakes, with a maximum depth of 210 ft and a mean depth of 62 ft, or roughly 25 percent of the mean depth of about 240 ft for the Great Lakes collectively.

Because of its relatively small size, Lake Erie is considered by the EPA to have suffered the greatest exposure to the effects of urbanization and agriculture (United States Environmental Protection Agency [EPA] 2005). Specifically, the watershed's generally fertile—and, hence, intensively farmed—soils contribute very large amounts of agricultural runoff (i.e., nonpoint source water pollution, including herbicides, fungicides, insecticides, as well as the nitrate and phosphate components of fertilizers and animal wastes) to the lake itself. The impacts from

Figure 2.1. The Great Lakes basin, showing the position of the Lake Erie and Conneaut Creek subwatersheds.

agriculture—combined with the industrial, commercial, and municipal impacts from the Lake Erie basin's 17 metropolitan areas with populations over 50,000—have led to alarming levels of pollution, habitat loss, and infiltration by exotic plant and animal species, to name just a few of the more prominent problems.

Although Lake Erie covers about 10,000 mi^2, its average depth is only about 62 ft, making it the shallowest of the five Great Lakes. Due to its small size, the lake warms rapidly in the spring and summer, frequently freezes over in winter, and has the shortest retention time (2.6 years) of any of the Great Lakes. Lake Erie's western basin, comprising about one-fifth of the lake's surface, is very shallow with an mean depth of 24 ft and a maximum depth of 62 ft (USEPA 2005).

The Pennsylvania portion of the Lake Erie watershed is located in on the southern shore of Lake Erie between Ohio on the west and New York State on the east. The watershed extends a minimum of 6.1 mi and a maximum of 25 mi south of Lake Erie, encompassing portions of two counties and either portions or the full extent of 33 municipalities and townships. The land drainage area of the Pennsylvania portion of the Lake Erie watershed covers ca. 508 mi^2, or about 1.7 percent and 0.2 percent of the total land drainage areas of the Lake Erie watershed and Great Lakes basin, respectively. This greater watershed is composed 19 major subwatersheds, 66 discrete subwatersheds, 39 named streams, and 1,338 discrete mapped stream segments (LERC 2008). The Conneaut Creek subwatershed is the largest of Pennsylvania's Great Lakes subwatersheds.

The Conneaut Creek Watershed

The Conneaut Creek watershed is the largest of Pennsylvania's Lake Erie subwatersheds. The entire watershed, including the portion in Ohio, encompasses 190.7 mi^2. The Pennsylvania portion of the watershed, which represents the study area for this plan, encompasses153.1 mi^2. and traverses eight townships and four boroughs (Figure 2..2, Table 2.1). The watershed is composed of 13 discrete subwatersheds, 13 named streams, and 268 discrete mapped stream segments totaling about 332 mi in lineal extent (National Hydrography Dataset 2009). The largest subwatershed by far is the main stem of Conneaut Creek, which encompasses 66.8 mi^2, followed by Temple Creek (15.4 mi^2) and the West Branch of Conneaut Creek (11.1 mi^2).

Geologic Framework of the Conneaut Creek Watershed

by Todd Grote

Physiography and Topography

The main stem of Conneaut Creek originates in northwestern Pennsylvania on the glaciated portion of the Appalachian Plateau (locally called the Allegheny Plateau) within Crawford County, and flows northward into Erie County, where it turns abruptly westward, flowing into northeastern Ohio, where it again flows northward through the Eastern Lakes section of Central Lowlands physiographic province to enter Lake Erie (Briggs, 1999:376; Kaktins and Delano 1999:388–389; White and Totten1979:3–5) (Figure 2.3). The provinces are separated topographically by the the Escarpment, a prominent linear feature that trends roughly parallel to the south shore of modern-day Lake Erie (Briggs 1999:376; Schooler 1974:3–4; White and

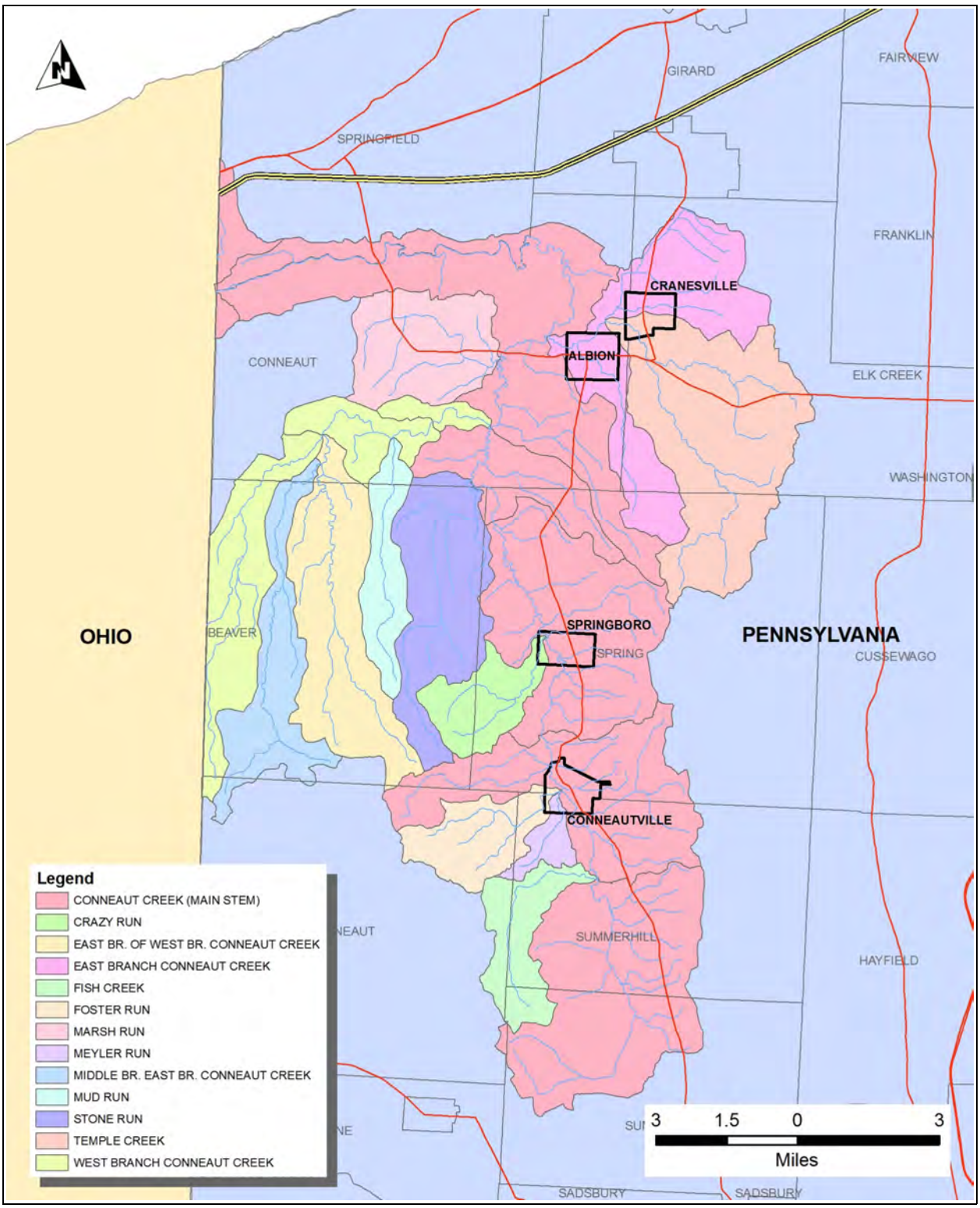


Figure 2.2. The Pennsylvania portion of the Conneaut Creek watershed, showing subwatersheds, streams, and political boundaries.

Table 2.1. The Pennsylvania Conneaut Creek Watershed's Major Sub-Basins, by Area, and Municipalities Traversed.

Subwatershed	Area		Municipalities Traversed
	mi^2	Rank	
Conneaut Creek (Main Stem)	66.8	1	Albion, Beaver, Conneaut, Conneautville, Cranesville, Elk Creek, Spring, Springboro, Springfield, Summerhill, Summit
Crazy Run	3.7	11	Beaver, Spring, Springboro
East Branch of West Branch Conneaut Creek	10.5	5	Beaver, Conneaut
East Branch Conneaut Creek	10.9	4	Albion, Conneaut, Cranesville, Elk Creek, Spring
Fish Creek	4.1	9	Conneaut, Summerhill, Summit
Foster Run	4.1	10	Conneaut, Conneautville, Spring, Summerhill
Marsh Run	6.6	8	Conneaut
Meyler Run	1.2	13	Conneaut, Conneautville, Spring, Summerhill
Middle Branch of East Branch Conneaut Creek	6.6	7	Conneaut, Beaver
Mud Run	3.6	12	Conneaut, Beaver
Stone Run	8.7	6	Conneaut, Beaver, Spring
Temple Creek	15.4	2	Albion, Conneaut, Cranesville, Elk Creek
West Branch Conneaut Creek	11.1	3	Conneaut, Beaver

Totten 1979:3). The Escarpment consists of bedrock at the base, overlain by till associated with end moraines that is discontinuously capped by glacial lake clays (White and Totten, 1979: 4)

The watershed's topography is directly related to the Paleozoic bedrock geology of the region as well as the direct and profound effects of Pleistocene glaciations on the pre-glacial landscape (Briggs 1999:376; Fleeger 2005:3; Schooler 1974:1; White and Totten 1979:9–10). The most profound effect of the multiple Pleistocene glaciations is the widening and deepening of pre-glacial river valleys that are now buried by Quaternary (Pleistocene and Holocene) sediments and host the many underfit streams flowing through the modern landscape. Remnants of several buried pre-glacial river valleys exist throughout New York, Pennsylvania, and Ohio (Beauchamp et al. 2008; Briggs 1999; Fleeger 2005:5; Kaktins and Delano 1999:88;White and Totten 1979). The overall relief of the watershed from the headwaters at the Ohio River-Lake Erie drainage divide (elevation=1,345 ft above msl) to Conneaut Creek's confluence with Lake Erie (elevation=571 ft above msl) is 774 ft. The drainage pattern of Conneaut Creek Watershed is primarily dendritic to sub-dendritic and influenced by the numerous linear morainal landforms that cross-cut the watershed. Conneaut Creek flows through these morainal systems until entering a Pleistocene outwash channel, which in turn permits the stream course to again turn northward and ultimately drain into Lake Erie. Joint and fracture systems developed in the underlying Paleozoic bedrock also possibly influence the watershed's drainage pattern.

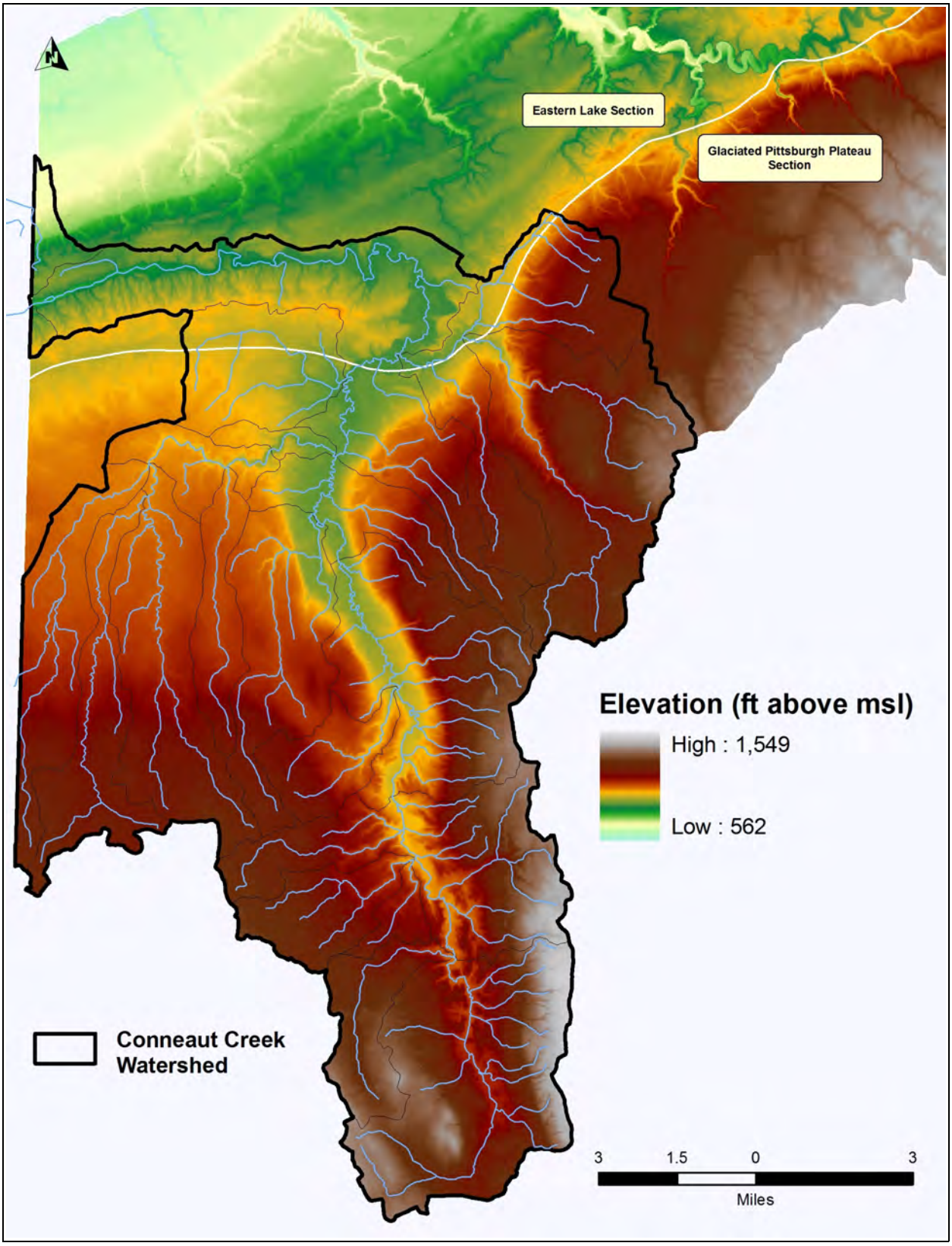


Figure 2.3. Digital elevation model of the Conneaut Creek watershed and surrounding area, showing generalized boundaries of the region's physiographic provinces (demarcated by white line).

Bedrock Geology

The bedrock geology underlying the majority of the Conneaut Creek watershed represents ancient terrestrial and marine sedimentary environments. Bedrock preserved in northwestern Pennsylvania and northeastern Ohio dominantly belongs to the Devonian System, and to a lesser degree the Mississippian System in portions of the headwater regions in Crawford County. The age of the bedrock increases to the northwest. The majority of bedrock within the watershed is a thick series of interbedded shale, siltstone, and sandstone, with lesser amounts limestone and chert that are horizontally bedded and gently tilted to the south and southeast (Harper 1999; Schooler 1974:4; Shepps et al. 1959; Tomikel and Shepps 1967:25–33; White et al. 1969; White and Totten 1979:3–7). No coal is present within the watershed. Bedrock is rarely exposed at the surface of the watershed except locally in stream channels, on steep slopes that descent into stream valleys, and within bluffs flanking Lake Erie. The amount of Devonian bedrock (primarily shale) exposed in stream channels and within lake bluffs increases towards Lake Erie (Briggs 1999:376; Schooler 1974:3–4; White and Totten 1979:4, 41).

Surficial Geology

Quaternary Glacial Deposits: Northwestern Pennsylvania and northeastern Ohio were affected by advances and retreats of the Laurentide Ice Sheet, specifically the Grand River sublobe of the Erie lobe (Braun 2004; Fleeger 2005; White et al. 1969; White and Totten 1979) . The long-lasting effects of glaciation can be seen in the landforms and underlying deposits present within the landscape today. To date, four glacial advances into the region are currently recognized, including (from oldest to youngest) Early Pleistocene (pre-Illinoian), middle Pleistocene (pre-Illinoian), middle middle Pleistocene (pre-Illinoian) or late middle Pleistocene (Illinoian), and Late Pleistocene (Wisconsinan) (see Braun 2004: 231).

Till is a poorly-sorted deposit that is emplaced directly by glacial ice. Only tills associated with the Woodfordian substage (25ka–10 ka) of the Wisconsinan glacial episode are present on the surface of the Conneaut Creek watershed. The Woodfordian tills within the watershed, which include (from oldest to youngest) the Kent, Lavery, Hiram and Ashtabula Tills (Schooler 1974; Shepps et al. 1959; Szabo 1992; White and Totten 1979), are generally thicker in lowland (valley) settings and thinner on uplands. Older tills associated with Illinoian (Titusville Till) and pre-Illinoian (Keefus, Mapledale, and Slippery Rock tills) glacial episodes are most likely buried in the subsurface below the above-mentioned Woodfordian till sheets (Braun 2004; Fleeger 2005; Shepps et al. 1959; White et al.1969). In fact, White et al. (1969) and Fleeger (2005) suggest that many of the morainal landforms are actually palimpsest landforms composed of multiple till sheets stacked vertically one on top of the other. The absolute ages of tills found throughout northwestern Pennsylvania and northeastern Ohio have been the focus of much debate (e.g., Braun 2004; Fleeger, 2005).

Because glaciers advanced and retreated across northwestern Pennsylvania multiple times during the Pleistocene, stratified glacial outwash, kame (ice contact features), lacustrine (proglacial lake), and palustrine (wetland) deposits are intermingled with the various tills and represent landscape conditions beyond the ice margin. Outwash, kame, and lacustrine deposits are typically restricted to lowland settings, reflecting the control of topography and glacial ice

position on meltwater processes, whereas palustrine deposits are found on both upland and lowland settings, typically peat within in-filled kettle features (Shepps et al. 1959; White and Totten 1979). The only glacial outwash (or "valley train deposits") and proglacial lake deposits known to exist within the Conneaut Creek watershed are related to repeated ice advance and retreat associated with Woodfordian deglaciation, most of which are probably less than 15–16 ka years old. Glacial outwash deposits are restricted to the glaciated Allegheny Plateau and are currently not recognized within the lower Conneaut Creek Valley beyond the Escarpment in Ashtabula County, Ohio (White and Totten 1979).

The position of the retreating ice sheet would have significantly influenced the routing of glacial meltwater, and also the formation and demise of large proglacial lakes adjacent to the ice sheet (Larson and Schaetzl 2001). Several proglacial lakes existed within the ancestral Lake Erie basin (Larson and Schaetzl 2001; Schooler1974; White and Totten 1979), of which several remnants such as raised beach ridges (lake bluffs), sand dunes, and fine-grained lake sediments associated with older proglacial lakes that still exist on the Lake Plain landscape today. Although no evidence of older proglacial lake deposits are known within the Conneaut Creek Watershed, evidence of early and/or middle Pleistocene proglacial lakes exists throughout southwestern Pennsylvania, Ohio, and northern West Virginia (e.g., see Kaktins and Delano 1999:285–389; Braun 2004:231).

Post-Glacial Deposits: Post-glacial deposits within the Conneaut Creek watershed are the product of streams, lakes, and wetlands that are now established on the relatively stable Holocene (10ka–present) landscape. The most common Holocene sediments are alluvium associated with active, and inset, floodplains and low terraces along Conneaut Creek (NRCS 2009). The fine-grained texture of the post-glacial alluvium is in stark contrast to the generally coarse-grained texture of the glacial outwash and kame deposits. Small lakes, wetlands, and alluvial fans also occur throughout the watershed, but do not significantly contribute to the total area of the watershed.

Soils: Soils develop on relatively stable landforms, and relate directly to the environmental history and surficial geology of a given area (Birkeland 1999). In the glaciated Great Lakes region, soils are a direct reflection of the youthful nature of the landscape. Soil orders present within the watershed are typically: (1) weakly developed entisols on active floodplains, sandy deposits of the Lake Plain and in other poorly drained landscape positions; (2) inceptisols on better drained portions of floodplains, river terraces, and poorly to well drained tills and proglacial lakes; and (3) alfisols on well drained till, outwash, and proglacial lake deposits (NRCS 2009). The progression from entisols to inceptisols then to alfisols demonstrates the effect of time on soil formation and is indicative of increasing landscape age. Histisols, which are organic soils, are present within peat wetlands throughout the watershed. Limited quantities of mollisols also exist in areas of poor drainage on floodplains and clay-rich proglacial lake and till sediments (NRCS, 2009). Variations in soil order-landform relationships should be expected due to the inherent spatial variability in soil forming processes (climate, organisms, relief, parent material, and time) (Birkeland 1999).

3. Cultural Context of the Conneaut Creek Drainage

LERC's mission to promote the identification, conservation, and protection of the Lake Erie region's cultural and historical resources—in addition, obviously, to the region's natural resources—stems in part from the professional archaeological backgrounds of LERC's key personnel. To that end, we feel it is necessary that this plan should address the Conneaut Creek watershed's unique position in the cultural record of northwestern Pennsylvania, northeastern Ohio, and the north-central margin of the Appalachian Plateau. In early prehistoric times, the watershed witnessed the retreat of the Wisconsinan glacier followed by the greater region's gradual peopling by some of the continent's earliest cultures. In later prehistoric times, as native communities transitioned from bands of hunter-gatherers to more sedentary groups with larger populations, horticultural economies, elaborated ceremonialism, and more complex and far-reaching trade and exchange systems, the watershed served as an effective boundary between two major cultural groups whose focus and influence lay to the east and west.

Intriguingly, however, extremely little is known about the Conneaut Creek watershed's prehistoric record—despite the very well known prehistories that have been established for literally all of the major watershed areas that surround it. As such, the Conneaut Creek watershed presents a rare opportunity to explore key geographic, culture-historical relationships in a very dynamic time in the region's prehistory. What follows is a brief summary of the known archaeological data for the greater watershed, which have been gathered by personnel of Mercyhurst Archaeological Institute over the course of 20 years of research. This summary is in turn followed by brief summaries of regional pre-settlement vegetation human-watershed interaction since the beginning of the Historic era. As the broader strokes of the region's history are widely available in a myriad of published sources, they have been omitted from this discussion.

Prehistoric Background

by Allen Quinn

Paleoindian Period

The Great Lakes watershed has been glaciated partially or totally at least six times in the last 780,000 years. These glaciers were massive: it is estimated that they were some 2,000 to 8,000 feet thick, and their successive advances and retreats had profound implications for the hydrology, topography, flora, fauna, and timing of the initial human occupation of the Great Lakes region, including what is today the area of the Conneaut Creek watershed. The final glaciation of the Pleistocene epoch is known as the Wisconsinan, whose “last gasps” occurred between about 25,000-10,000 years ago and mantled much of northeastern Ohio and

northwestern Pennsylvania with glacial till (see Geologic Framework of the Conneaut Creek Watershed). The Wisconsinan glacier withdrew to the north of the Lake Erie basin by 13,000-14,000 years ago, creating ice-free environments in the Conneaut Creek watershed suitable for human habitation shortly thereafter. With glacial retreat, vegetation in the region changed successively from tundra to spruce parkland and forest, to deciduous woodland and forest, to a pine and spruce forest mix, and finally to oak-dominated deciduous forest.

The prehistoric human occupation of northeastern North America is conventionally divided by archaeologists into three broad, sequent, and overlapping cultural/chronological episodes known as the Paleoindian, Archaic, and Woodland periods. The initial episode--- Paleoindian--- refers to human populations in the New World during the late Pleistocene epoch. The earliest widely accepted Paleoindian site in Pennsylvania is Meadowcroft Rockshelter, (36WH297), located 29 miles southwest of Pittsburgh and approximately 95 miles south of the Conneaut Creek watershed. Meadowcroft is situated about 47 miles south of the southern terminus of the last glacial advance of the Pleistocene. That is to say, the closest Wisconsinan ice ever got to Meadowcroft was about 47 miles to the north, at present-day Moraine State Park. This sandstone rockshelter, situated on the north bank of Cross Creek, a tributary of the Ohio River, demonstrates well-defined stratigraphy, artifacts of indisputable human manufacture, cultural features, such as fire pits, and some 52 internally consistent radiocarbon dates for these artifacts and features. The most recent reviews by the site's principal investigator, Dr. James Adovasio, note that even when conservatively interpreted, the radiocarbon data indicate that the earliest definitive human presence at Meadowcroft falls between ca. 13,955 BP and 14,555 BP (12,005 BC and 12,605 BC). The stone tool assemblage from the earliest levels of Meadowcroft is characterized by the production of small, prismatic blades that were detached from prepared cores reflecting an early and sophisticated knowledge of flaked stone tool manufacture.

The few known very early Paleoindian sites like Meadowcroft are succeeded by the Clovis horizon, recognized as the earliest highly visible, widespread, and undisputed Paleoindian archaeological culture in North America. Characterized by the production of finely made projectile points with a flute or channel flake removed from the base of the point, Clovis was originally defined in the 1930s in the western High Plains and the desert Southwest. By the 1950s Clovis was accepted as a truly continental horizon, with Clovis projectile points recovered from the Pacific Northwest to the Atlantic seaboard in contexts consistently dated to between 11,500 and 10,800 BP (9,550 and 8,850 BC). Clovis points were believed to have been manufactured by highly mobile populations of specialized big-game hunters preying on mammoth, mastodon, camel, horse, and other Pleistocene megafauna. This interpretation emerged from the excavation and analysis of western Clovis sites, which often consisted of communal kill sites of large extinct mammals. The interpretation of Clovis as an exclusively big game hunting adaptation has been called into question in recent years, and it seems most likely that Clovis and subsequent Paleoindian groups in at least eastern North America were more generalized foragers, with a possible focus on the hunting of caribou in the Great Lakes basin. In the lower Great Lakes region, Clovis is succeeded by a series of distinctive and time-sequential fluted (Gainey, Barnes, and Crowfield) and later unfluted (Holcombe and Hi-Lo) Paleoindian biface types, with the sequence terminating around 9,600 BP (7,650 BC).

Archaic Period

Most archaeologists would agree that the beginning of the Archaic period is roughly coincident with the end of the Pleistocene and the gradual replacement of Pleistocene flora and fauna with Holocene biota. The Archaic period adaptation was based upon a temperate forest hunting-fishing-gathering economy, with tool assemblages that include characteristic ground stone tools, net sinkers, and stemmed and notched projectile points, among other artifact forms, which reflect these environmental and subsistence changes. The traditional chronology for the Archaic divides the period into sequent Early, Middle, Late, and Terminal or Transitional subperiods. These internal divisions have primarily been based upon changes in diagnostic artifacts, particularly projectile points.

With the final retreat of the late Wisconsinan glacier, the climate of northwestern Pennsylvania began to ameliorate, and warmer, dryer conditions supported a more temperate mixed deciduous-coniferous forest by Early Archaic (ca. 9,900 BP – 8,900 BP [7,950 BC – 6,950 BC]) times. These environmental changes presumably would have provided a broader subsistence base for human populations and may account for an apparent population increase in northwestern Pennsylvania at this time, as suggested by the greater numbers of Early Archaic lithic artifacts artifacts and known sites over the preceding Paleoindian period. Early Archaic cultural patterns are generally viewed as elaborations of earlier Paleoindian ones, without significant discontinuities in subsistence practices or settlement patterns. A broad spectrum economy appears to have been gradually adopted throughout the mosaic of biotic and ecological zones of the lower Great Lakes region and the Northeast in general at this time.

The Middle Archaic (ca. 8,900–5,500 BP [6,950–3,550 BC]) of northwestern Pennsylvania and the Northeast generally, has been somewhat of an enigma, with widely varying interpretations among researchers regarding the definition, chronology, and significance of the period. In terms of material culture, the beginning of the Middle Archaic is marked by the appearance of distinctive bifurcate base projectile points and their replacement by later Middle Archaic stemmed and notched forms. Along with these changes in technology, the Middle Archaic in Pennsylvania seems to be marked by significant increases in population, decreased residential mobility and the repeated re-occupation of specific base camps, and a shift in lithic use patterns involving a greater variety of lithic types often of lesser quality and cobble origin, perhaps coupled with a decline in tool curation.

The Late Archaic period (ca. 5,950–3,650 BP [4,000–1,700 BC]) is characterized by increased sedentism, the development of intensified subsistence systems with a frequent focus on riverine and estuarine settings, increased reliance on food storage, and the attainment of hitherto unprecedented population sizes over much of the Northeast. These adjustments in subsistence strategies and socio-political organization are usually interpreted as responses to changing environmental conditions. In northwestern Pennsylvania, this apparent cultural elaboration may correlate with the spread of oak-hickory forest, with a concomitant increase in the availability of harvestable nuts and white-tailed deer (*Odocoileus virginianus*).

Late Archaic sites tend to be larger and richer in cultural remains, with evidence for seasonal hunting and gathering strategies in areas of maximum resource potential. Sites from this period typically include seasonal base camps as well as a variety of special-purpose loci used for

hunting, fishing, gathering, food processing, or raw material acquisition. In the Lake Erie basin, Late Archaic settlement seems to be characterized by the aggregation of local populations into large settlements in the spring and summer in lowland, lakeside, and riverine environments with abundant lacustrine or riparian resources, and dispersal into smaller groups or family units in the fall and winter in order to exploit more limited upland resources.

The Terminal Archaic (ca. 3,650–2,950 BP [1,700–1,000 BC]) in the Northeast is sometimes delineated as a separate transitional phase characterized principally by a series of stemmed projectile points manufactured by populations variously referred to as the Susquehanna Soapstone culture, Susquehanna culture/tradition, or Susquehanna phase of the Broadspear tradition. These diagnostic point types often occur in association with steatite (i.e., soapstone) cooking and serving vessels. The most commonly encountered lithic artifacts for this period in the region's watersheds are frequently manufactured from nonlocal materials, including rhyollite (probably from Adams County, Pennsylvania), jasper, and argillite. The presence of such exotic materials at Transitional Archaic sites is usually interpreted as evidence of interregional exchange linked to higher population density, more circumscribed territories, and greater social complexity at this time. Some archaeologists, however, argue that the appearance of broad points manufactured from nonlocal materials may indicate an actual population movement into northwestern Pennsylvania from the lower Susquehanna River drainage.

Woodland Period

The Archaic period is succeeded by the Woodland period, which is conventionally subdivided into Early, Middle, and Late subperiods. The Early Woodland (ca. 1000 BC–AD 1) encompasses a time of significant cultural change over much of Eastern North America, with the development of horticulture, semi-permanent and permanent villages, often elaborate mortuary ceremonialism including the construction of mounds, ossuaries and formal cemeteries, and more complex and far-reaching trade and exchange systems. By the Early Woodland, the gradual, intensified tending and collection of local wild flora that had begun in the Archaic resulted in the domestication of most of the members of the suite of plants often referred to as the Eastern Agricultural Complex—that is, squash, marshelder, goosefoot, sunflower, erect knotweed, maygrass, and little barley. These native cultigens still played only a minor role in subsistence strategies, augmenting a foraging system based on wild plant and animal resources until Middle Woodland times.

The major technological advance of the Early Woodland was the development of ceramic vessels for cooking and storage. Although isolated finds of pottery dating to the Terminal Archaic are reported for Pennsylvania, this technology appears to become widespread in the Commonwealth only after ca. 1000 BC. These early ceramic vessels are quite similar in design to the generally earlier steatite vessels, with straight sides, flat bottoms, and lug handles, and both may have functioned primarily in ritual or social contexts as containers for stone boiling of food and food serving.

The Early Woodland of the Middle and Upper Ohio Valley, including southern Ohio, northern Kentucky, southeastern Indiana, western West Virginia, and southwestern Pennsylvania, is generally associated with Adena societies, well known for their mortuary ceremonialism,

especially the construction of conical, accretional burial mounds containing exotic grave goods. The influence of Adena on northwestern Pennsylvania seems to have been minimal, however, with Adena-related phenomenon generally restricted to variations of the Ohio Valley Adena stemmed projectile point. In addition to Adena-influenced societies, at least two other Early Woodland cultural complexes are represented in the archaeological record of northwestern Pennsylvania: the Forest Notched complex and the Meadowood phase.

In much the same way as the Early Woodland of the Ohio Valley and adjacent areas is associated with Adena, the Middle Woodland (ca. A.D. 1–1000) is associated with manifestations of Hopewell over a much broader area of eastern North America. Although Hopewell and Hopewell-related sites distinguished by sometimes extravagant burial mound ceremonialism, diversified craft arts, and inter-regional exchange are widely distributed throughout the eastern woodlands from the Deep South to Ontario, Canada, the Hopewell "heartlands" are in the Ohio River Valley, especially in the Scioto Valley, near Chillicothe, Ohio, and near Marietta, in southwestern Ohio, along the Mississippi and Illinois River Valleys in Illinois, and in southwestern Indiana.

Artifacts that repeatedly occur at Hopewell sites and that have tended to mesmerize archaeologists and collectors alike include small, squat, highly decorated and highly standardized ceramic jars, hand-held and stationary smoking pipes sometimes in the form of anthropomorphic or zoomorphic effigies, clay human figurines, conch shell containers and "dippers," sheet mica cutouts and mirrors, panpipes, various non-utilitarian stone celts, awls, and projectile points, modified human remains, body ornaments including earspools, headplates, breastplates, rings, bracelets, necklaces, pendants, and gorgets, fabrics for clothing and wrapping, clothing ornaments and attachments such as buttons, beads, cutouts, and tinklers.

A wide range of exotic materials whose sources were far from where they eventually ended up as finished products were used in the manufacture of some of these items, including copper, meteoric iron, galena, hematite, silver and gold (both rare), mica, quartz crystals, chalcedony, hornstone, pipestone, sandstone, steatite, gypsum, cannel coal, obsidian, antler, bone, teeth (especially bear, alligator and fossil shark teeth), marine and freshwater pearls, marine and freshwater shell, feather, hair, and skin.

In addition to distinctive artifacts made from exotic materials, Hopewell is renowned for the construction of burial and platform mounds as well as geometric earthen enclosures. The Hopewell mortuary program continued earlier practices, including flexed and extended inhumation, bundle burial, and cremation burial. Remains were placed on the ground surface, within mound fill, in a crypt, or in an above ground, roofed charnel house, all of which might eventually be covered by a mound. Flat-topped platform mounds were also constructed, and are found in the Southeast as well as at Scioto tradition Hopewell sites in Ohio. The best known examples of Hopewell geometric earthwork enclosures occur in southern Ohio, but were also widely distributed in a band extending from western New York along the western escarpment of the Appalachian Plateau and into southeastern Indiana, and examples are also found in the Southeast. Many of the earthworks are associated with burial mounds while others appear to have been constructed independent of any mortuary structures, and many were clearly the result of multiple construction episodes.

Between AD 300 and AD 500 Middle Woodland groups in northwestern Pennsylvania and southwestern New York—especially those groups along the Allegheny River and its major tributaries—were participants in the Hopewell Interaction Sphere. During this time Hopewellian artifacts and materials occur in the Allegheny Valley, and at a number of Middle Woodland sites these exotic materials and artifacts are associated with burial mounds whose construction is reminiscent of the classic Hopewell mounds of central Ohio, with earth-fill construction, stone slab retaining walls, stone-slab-lined cists, and covered burial pits. Two of the most significant complexes of Hopewell-influenced Middle Woodland sites in northwestern Pennsylvania are those at Sugar Run Flats and Irvine Flats, both situated along the Allegheny River in Warren County. By ca. AD 500, participation in the Hopewell Interaction Sphere apparently ceased in northwestern Pennsylvania, as diagnostic Hopewell artifacts, materials, and traits disappear from the archaeological record of the Allegheny Valley.

Although our knowledge of the subsistence practices and settlement patterns of the Middle Woodland occupants of northwestern Pennsylvania is limited, the available evidence suggests a pattern of spring-summer macroband aggregation at lakeshore, riverine, and marshland environments to exploit spawning fish and shellfish, and fall-winter disaggregation into microbands for deer hunting and nut harvesting. At least some tending of locally available native cultigens also seems likely.

Following the decline of Hopewell influence, a distinctive late Middle Woodland adaptation termed the Allegheny River phase occurred in northwestern Pennsylvania. By its termination ca. AD 950, the Allegheny River phase attained a distribution in the upper Allegheny Valley from Warren, Pennsylvania, upriver to Olean, New York, and northwest toward Lake Erie. Three major Allegheny River phase regional centers have been defined in northwestern Pennsylvania, each associated with numerous smaller ancillary sites utilized for hunting and gathering or the procurement of raw materials. Each of the three centers (i.e., Sugar Run Flats and Irvine Flats on the Allegheny River in Warren County and French Creek Flats on French Creek near Waterford in Erie County) occupies an extensive terrace with a large catchment zone. A settlement system of village removal was probably utilized, with each village abandoned for a new location several miles away when firewood was exhausted, houses rotted or flooded, or soil was depleted at the original locale.

While most researchers would agree that the transition from the Middle Woodland to the Late Woodland occurred ca. AD 500–1100 in the lower Great Lakes region, disagreement prevails over a more precise date for this boundary, in large part because of the different criteria employed to delineate it. For some scholars, the start of the Late Woodland period is defined as much by the disappearance of Hopewellian traits as by the emergence of new ones. Others define the transition on the basis of changes in technical and stylistic ceramic attributes. Probably the most widely accepted criteria for the start of the Late Woodland period is the appearance of maize horticulture and large village settlements. In northwestern Pennsylvania, northeastern Ohio, and western New York, specifically, the Late Woodland is often considered to begin around AD 1000. The end of the Late Woodland period is placed at European contact, the exact timing of which obviously varied from one Native American society to another. Hence, the Late Woodland is often considered to cease with the appearance of European trade goods at Native

American sites, such as glass beads or metal items, or in the absence of such items, to the terminal sixteenth through early seventeenth centuries.

The ca. 500-600 year span of the Late Woodland in the glaciated Allegheny Plateau portion of the Conneaut Creek watershed is subdivided into three successive phases that are collectively known as the Glaciated Allegheny Plateau (GAP) tradition. The first GAP phase is termed the Mahoning phase, and is characterized by pottery that is tempered with igneous rock with cord-marked exterior surfaces and low collars. At approximately AD 1250-1275, pulverized mussel shell replaces igneous rock as the principal tempering agent for Mahoning ware, and marks the end of the Mahoning phase. The succeeding French Creek phase is recognizable from ca. AD 1275-1400 and is characterized by Chautauqua Cord-Marked vessels, which are shell-tempered and otherwise undecorated except for cord-wrapped paddle edge-stamped impressions or incisions on vessel lips. During this time, nucleated and palisaded villages appear within the French Creek valley south of the study area at the Wilson Shutes (36CW5) and McFate (36CW1) sites, while small hamlets and/or farmsteads have been identified in the Pymatuning Marsh area.

In the initial decades of the fifteenth century, a distinctive form of ceramics referred to as McFate Incised appears on the glaciated Allegheny Plateau and the Eastern Lake section to the north. The appearance of this ware marks the final McFate phase of the GAP tradition, which is dated to ca. AD 1400-1550. The McFate Incised ceramic type is characterized by rectilinear incised decoration in the form of opposed triangles filled with parallel horizontal lines separated by plats of parallel oblique lines. This decoration appears below the lip or on the collar of McFate vessels. The base of the motif is frequently underlined with a horizontal band of parallel oblique or vertical punctations or short incised lines. The McFate decorative motif is similar to late Middleport horizon Ontario Iroquoian tradition ceramic types, and the genesis of McFate pottery was apparently on the Lake Erie plain. McFate Incised and related ceramic types have a rather broad distribution, perhaps reflecting population movement and/or economic cooperation between neighboring groups. McFate phase components are documented at sites along the Lake Erie Plain from northeast Ohio to Chautauqua County, New York. Among these sites—and especially germane to the Conneaut Creek watershed—is the East Wall site (33AB41), a multi-component, primarily Ontario Iroquoian tradition and McFate phase fishing station dating to AD 1448 that overlooks the confluence of Conneaut Creek and Lake Erie in the City of Conneaut, Ashtabula County, Ohio.

There seems to have been a gradual dispersal of McFate phase people from the glaciated Allegheny Plateau by the mid- to late fifteenth century. Indeed, the glaciated reaches of the Allegheny Plateau in northwestern Pennsylvania, including the Conneaut Creek watershed, seem to have been largely abandoned by village horticulturalists by the beginning of the sixteenth century, perhaps in response to the colder, drier conditions of the Neo-Boreal climatic episode. The deteriorating climatic conditions of the Neo-Boreal may well have rendered a maize-based subsistence strategy unreliable, at best, in northwestern Pennsylvania.

In addition to McFate, two other Late Woodland cultures—Whittlesey and Erie—have been documented within the Eastern Lake section in the northern portion of the Conneaut Creek watershed. Between AD 1250 and AD 1450, a number of ceramic innovations appear in northeastern Ohio as far east as the Conneaut Creek watershed that archaeologists use to define

the Whittlesey Tradition. By AD 1450, Whittlesey populations were concentrated in small villages of up to five subrectangular houses on high river bluffs. Corn and squash are extensively cultivated and beans were apparently added to the diet. By Late Whittlesey times (ca. AD 1450–1640) there is evidence of an evolution from semi-permanent occupation sites to larger, fortified, permanent villages; the introduction of new crops; intensification of maize-beans-squash agriculture; and population increase. No European materials have been documented from any Whittlesey tradition context, and Whittlesey people appear to have abandoned the southern shores of Lake Erie by AD 1570–1640, before indirect trade of European artifacts penetrated far northwestern Pennsylvania and northeastern Ohio.

The Erie or *Eriechronon* were an alliance of several tribes/villages situated south of Lake Erie who were linguistically and culturally related to other northern Iroquoian groups such as the Huron, Petun, Neutral, Wenro, Susquehannock, and Five Nations Iroquois. The geographic distribution of the Late Woodland-Protohistoric Erie is imperfectly understood at present, and has been a subject of considerable debate. Much of the uncertainty about the range of the Erie is due to vague and sometimes contradictory ethnohistoric accounts by seventeenth century French Jesuits who, lacking direct contact with the Erie, obtained their information about this group secondhand from other Iroquoian peoples. Although some authors have speculated that the Erie ranged across the southern shore of Lake Erie from Buffalo, New York, to Toledo, Ohio, and ranged as far south as Virginia, the most reliable cartographic, ethnohistoric, and archaeological data limit Erie settlement to the Niagara Frontier region of western New York (i.e., the relatively low land lying between Lake Erie and Lake Ontario) west through Erie, Pennsylvania, and as far west as the Conneaut Creek watershed.

As with other northern Iroquoian peoples, the Erie were semi-sedentary maize horticulturists who also relied on hunting, gathering of wild plant foods, and fishing. Erie villages would relocate several miles every 10-20 years upon exhausting suitable wood and other vital natural resources. Like the Huron and Neutral, the Erie may have practiced secondary ossuary burial. In this mortuary protocol, as the members of a particular community died they were buried in temporary graves either outside the village or within the longhouses or left outside on raised scaffolds until the flesh had rotted from the bones. Children were often buried along the middle of the longhouses or along frequently traveled village paths, reflecting the widespread Iroquoian belief that the souls of dead children could climb into the wombs of passing women and be reborn. When the time arrived for a mass burial ceremony—usually when it was time to move the village—the remains of those who had died since the previous ceremony were retrieved and reinterred together in an ossuary pit.

Jesuit accounts depict the demise of the Erie following a brief war with the Five Nations Iroquois in the mid-seventeenth century. An economic motive is generally suggested for this conflict, in that the location of the Erie may have impeded the Five Nations from hunting for beaver in the Ohio Valley, and may have also blocked them from participating in the Neutral Chesapeake Bay whelk shell trade. Such scenarios imply that the Five Nations Iroquois attacked the Erie largely in order to remove them as an impediment to trade opportunities. A number of researchers now believe, however, that the Iroquois' seventeenth century conflicts with the Erie and other native neighbors cannot be explained solely or even primarily in terms of the

economics of the fur trade. Rather, the escalating conflict between the Five Nations and the Erie, Huron, Petun, Susquehannock, Neutral, and Wenro must be understood in the context of European introduced virgin soil epidemics of smallpox, measles, influenza, and other diseases that decimated Iroquoia beginning in the seventeenth century. The horrendous losses suffered by these groups as a result of European diseases led to a cycle of retribution against real and imagined enemies, in which the goal was not only blood revenge for the loss of family members but also physical replacement of those relatives through capture and adoption of the members of neighboring tribes. As these "mourning wars" intensified in the face of new epidemics many Iroquois villages became populated not only by the indigenous survivors of disease but also by increasing numbers of captive adoptees.

The Five Nations had dispersed the Wenro by 1638 and successively assimilated and/or dispersed the Huron and Petun by 1650 and the Neutral by 1651. Attention was then directed toward the Erie, with a large Iroquois force entering Erie territory in 1654 and destroying several Erie villages, taking numerous captives. Although fighting may have continued between the Five Nations and Erie for several more years, this campaign effectively marks the end of the Erie as a distinct cultural entity. The Five Nations probably absorbed many of the Erie, while others took refuge to the southeast with the Susquehannock.

Prehistoric Archaeological Sites in the Conneaut Creek Watershed

A total of nine prehistoric sites are registered by the Pennsylvania Bureau for Historic Preservation within the Pennsylvania portion of the Conneaut Creek watershed. Given the significantly greater densities of recorded sites in adjacent drainages in northwestern Pennsylvania and northeastern Ohio, this low number of recorded sites for the study area probably reflects the lack of systematic archaeological survey and excavation within the drainage rather than a consistently low level of aboriginal utilization over time.

No sites dating to the Paleoindian period are recorded for the watershed. Paleoindian sites *are* recorded in the adjacent French Creek drainage, and are most frequently associated with glacial features such as Pleistocene lakes, strandlines, wetlands, outwash plains, moraines, and kame terraces, a pattern witnessed in the glaciated Allegheny Plateau and throughout the Great Lakes region, generally. It is expected that Paleoindian sites within the Conneaut Creek watershed would most likely to be situated in these same topographic and geologic settings.

A single Early Archaic site (36CW243), which yielded a diagnostic Kirk Stemmed projectile point, is recorded on the Allegheny Plateau on the main stem of Conneaut Creek in Summerhill Township, south of Conneautville. This same site also contains a Woodland component, as evidenced by the recovery of pottery. A second Woodland site (Albion Park [36ER242]) is recorded inside the southern boundary the Eastern Lake section on the East Branch of Conneaut Creek in Albion. The presence of an Adena stemmed projectile point indicates the Albion Park site dates to the Early Woodland period.

Given the presently available data, the remaining seven registered prehistoric sites within the study area cannot be assigned to a specific time period because they lack sufficient temporally diagnostic artifacts to permit ascription. Of these seven, four (36ER5, 36ER300, 36ER302, 36ER303) are situated within the Eastern Lake section along the main stem of

Conneaut Creek and, thus, the shared boundary of Conneaut and Springfield Townships. The remaining three sites (36ER190, 36ER0351 and 36ER0377) are within the Allegheny Plateau.

Historical Background

As the early Euro-American exploration and settlement of northwestern Pennsylvania is more or less well known and readily available from numerous widely published sources, it will not be reviewed here. The interested reader is directed to the following bibliographic entries for more information (Claridge 1991; Nelson 1987; Reed 1925; Sanford 1894; Spencer 1962; Warner et al. 1884; Wellejus 1980). Moreover, because of this document's focus as a conservation plan, the brief historical review provided herein deals primarily with human-watershed interaction and modification to the pre-settlement landscape.

The premise underlying the following analysis is that defining the pre-settlement condition of the Conneaut Creek watershed will provide an estimate of the region's baseline condition for any future conservation and restoration planning efforts that might me undertaken. It is recommended that the primary conservation goals that should be worked toward are: (1) the protection of water habitats and related "natural heritage" resources (including cultural resources, species, and habitats of special concern) and (2) the restoration of conditions in degraded areas to ensure future sustainability of the watershed's aquatic and natural resources. It must be acknowledged, however, that pre-settlement natural conditions in the entire watershed landscape can never be reconstituted, nor even maintained given that at least some of the land must be utilized for enterprises that sustain the economic well-being of the watershed's residents. That said, on the other hand, the establishment of realistic and objective goals for restoration may profit from knowledge of pre-settlement conditions, as it would provide the best approximation of the land's natural self-sustaining "capacity." By protecting and restoring the watershed's natural heritage, future generations will at least have the possibility to experience connected, viable spaces that demonstrate the landscape's natural beauty rather than just receive history lessons regarding the original condition of the watershed and its streams.

Concerning the watershed's pre-settlement conditions, a modest degree of uncertainty exists with respect to the precise nature of the "original" vegetation, condition of streams, and how human activities (by both Native Americans and Euro-American settlers) influenced the environment. However, considering the magnitude of the well-documented environmental degradation that the watershed has endured since its initial Euro-American settlement in the mid- to late eighteenth century, we think that it is important to continue efforts to conserve landscape elements that may contain the remnants of less-damaged natural ecosystems. Since no natural terrestrial ecosystem exists in a vacuum untouched by perturbations that generate adaptation and evolutionary change, the following analysis of pre-settlement condition includes information regarding the natural disturbances which likely affected the study area.

Deforestation and Hydrology

Bates (1884) described the pre-settlement condition of the vegetation in northwestern Pennsylvania (including the watershed) as "covered with a dense forest consisting mainly of pine, hemlock, chestnut, walnut, cucumber, beech and maple." Taylor (1957), citing Hicks (1934), similarly reported that the original vegetation was "nearly all forest," and suggested that most of the trees were hardwoods, including "some pines and hemlocks." Taylor indicated that "beech-sugar maple and beech-red maple forest types" were dominant, and that "white elm-oak, northeast conifer, and oak-hickory" forests were "less important." Taylor further suggested that chestnut grew mainly on gravelly soils of the lake plain, and that beech, maple, and white pine dominated on the slopes south of the divide between the Lake Erie and French Creek watersheds. Whitney's (1982) review regarding pre-settlement forests of northeastern Ohio indicated a "predominance of beech-maple forests" with "outliers" of white pine and hemlock. Trautman's (1957) review for northeastern Ohio reinforced the foregoing views of a beech-maple association dominating on the "hills and intervales" of the glaciated areas, with a "chestnut association on the more overdrained portions." The most recent available scientific review by Abrams (2001) for the pre-settlement forest condition of northwestern Pennsylvania indicates beech, hemlock, sugar maple, and white pine as the primary species, based on Lutz (1930).

Most of the original forest was cleared in the early 1800s primarily to support the timber industry and agricultural development. Lechner (1994) suggested that early loggers had no interest in conserving this renewable resource, as "mills were constructed throughout the area in the nineteenth century, providing services until timber was exhausted." The region's first grist mill was built on Conneaut Creek by Alexander Power, and the advent of the local extraction of salt in the early 1800s. Power's first grist mill was replaced by a second mill built a ¼ mile away in 1805, and augmented by a third grist mill (also built by Power) in 1829–1830. In 1801, Samuel Fisher erected another grist mill and the first saw mill in the county on Conneaut Creek about 1 mile north of Conneautville. This grist mill ended up doing most of the grain grinding of northwestern Crawford and southwestern Erie Counties. In 1820, Ark Jenks erected another saw and grist mill on Conneaut Creek near the Erie County line and Robert Foster built a grist mill 1 mile south of Spring Corners. Another saw mill was built by one Mr. Holmes at Spring Corners. The first saw mill in the eastern part of Spring Township was constructed under the direction of Platt Rogers in 1820.

Bates reported that by 1884 "little good timber [was]left." Apparently, pine and hemlock from the French Creek valley was rafted to Pittsburgh, and "that of the lake shore was shipped to Cleveland, Buffalo, and New York markets." Bates (1884) lamented that "the county [Erie] does not furnish building material enough now for home use, and at the rate the forests are disappearing it will not be long until there will be barely sufficient for ordinary farm purposes."

The destruction of the forest was thought to have had negative effects on local hydrology. Sanford's (1894) description of Mill Creek (east of the Conneaut Creek but still within the Great Lakes watershed) indicated "that in 1810 it contained four times the quantity of water that it does at present and was quite a large turbulent stream." Sanford attributed the reduction of (base) flow to "increased evaporation occasioned by the removal of trees, and also by the plowed ground, which absorbs large quantities of water." An observation of the reduction in stream flow of a

tributary of Walnut Creek (also east of the Conneaut Creek but also within the Great Lakes watershed) was recorded as early as 1845 (Sanford 1894) in a "memoranda" of Mr. Richard Barnett, who noted "the Beaverdam Run (is) dry in many places, which was never known before by the oldest inhabitants." Bates (1884) had noted that "all of the streams in the county were formerly much larger and more reliable,"and he attributed the "drying up of the streams" to "the cutting off of the timber." Bates further indicates that "the seasons of high water which were once of two or three weeks' duration now last only a few days." He further notes "there being no forests to retain the rain, the water runs off very rapidly, causing floods that sometimes do considerable damage."

Hydrological changes had regional economic consequences, since the streams had been the primary source of power for manufacturing (Sanford 1894) and most of the important towns and settlements developed on streams "in consequence of the early establishment of mills" (Bates, 1884). Beates (2000) reported that reduction in stream flow led to conversion to other energy sources (notably steam) for industry, since "streams which could supply water power before deforestation sometimes could not do so after the land was cleared." Beates (2000) indicated that some mills tried to compensate for reduced stream flow by "creating or enlarging their mill ponds." Mill operators who needed additional or more consistent power found it necessary to change to steam power.

The changes in stream hydrology observed in the 1800s cannot definitively be attributed to deforestation, however, as coincidental changes in climate may have also contributed to decreases in stream flow. Climatologists have documented "widespread climatic anomalies" independent of human influence within the last 1,000 years—including a "Medieval Warm Period" (MWP) ranging A.D. 1000–1300 AD and the "Little Ice Age" (LIA) ranging A.D. 1400–1850 (Legates, 2003; Pederson et al. 2005). These climate changes have been shown to have accompanied prehistoric changes in vegetation of the Hudson River watershed in New York (Pederson et al. 2005). If we assume that the end of the LIA affected the southern shore of Lake Erie and northwestern Pennsylvania in ways similar to what was documented for the Hudson River watershed, then it is possible that the transition from cooler, moister conditions in the early 1800s to warmer, dryer conditions by 1900 contributed to the drying of springs and reduction of stream flow noted by Bates (1884) and Sanford (1894).

Non-forest Habitats and Prehistoric Disturbances

Although forests were the most prominent vegetation feature in the region, prehistoric disturbances and hydrological phenomena likely resulted in some areas characterized by more open (i.e., early successional) vegetation. The presence of grass-dominated meadows was suggested by an early account regarding the French forts in Erie County. A 1755 letter by Governor DuQuesne from Quebec indicated that "at Presqu' isle the hay is abundant and good." Duquesne further reported that at Fort LeBoeuf "the prairies which are extensive, furnish only bad hay, but it is easy to get rid of it" (Reed 1927).

Unverifiable accounts of certain wildlife species in northwestern Pennsylvania indicate a possible early presence of relict prairie habitats. Nelson (1896) reported "there were some wild cattle or buffalo," and it has been claimed that LeBoeuf Creek was named by the French ("La

Rivière aux Boeufs") for the large number of buffalo apparently found grazing on the flats below Waterford in the adjacent French Creek watershed, a situation which, though undocumented, also may have obtained in some portions of the Conneaut Creek watershed.

Open habitat would have been expected in some wetland areas. Whitney's (1982) review concerning the pre-settlement vegetation of northeastern Ohio notes that "prairies were inevitably associated with low-lying areas and very poorly to poorly drained soils," apparently associated with floodplains (of streams) and former locations of post-glacial lakes. Whitney (1982) explained that fine-textured lacustrine deposits and the low runoff potential of the lake plains (features present also in the study area) resulted in "seasonally ponded habitat, largely devoid of trees." Whitney (1982) indicated that monocot-dominated communities including sedges, rushes, and grasses were prevalent in the pre-settlement "prairie or swampy prairie" sites. Trautman's (1957) review concerning the pre-settlement vegetation of Ohio suggests that an "oak-hickory association" was prevalent in the "prairie areas" of the Appalachian Plateau, with the oaks forming "oak islands" in areas "surrounded by wet prairie openings." Taylor's (1957) notation regarding "oak-hickory" as one of several "less important forest types" in Erie County indicates the possibility that the study area's original plant communities contained some representation of the Ohio "prairie" vegetation.

Direct evidence of fire disturbance (actual observation of burns) was extremely rare in the records of late 1700s surveyors in Western New York, although records of pitch-pine-dominated forest areas offered indirect evidence of recurrent fires (Seichab and Orwig 1991). None of the pitch pine sites noted by Seichab and Orwig occurred near Pennsylvania or the southern shore of Lake Erie in New York. Grasslands (also referred to as "prairies" and "plains") in late 1700s Western New York were noted in the till plains of the Buffalo, New York, region (on the perimeter of the Cattaraugus Indian Reservation) and were attributed to "anthropogenic disturbances," such as burning, by native Americans (Seichab and Orwig, 1991).

Whitney's (1982) review concerning the pre-settlement forests of northeastern Ohio suggests that fire did not appear to have played "a major role" in the development of that region's vegetation, and that "major disturbances were relatively infrequent." A general indication of infrequent fire on the southern shore of Lake Erie is the apparent dominance of sugar maple, red maple, and American beech, which are apparently "fire-intolerant species" (Whitney, 1982). Greater prominence of white and black oaks in these forests would have been more indicative of repeated fires (Whitney 1982). Taylor's (1957) suggestion that white, red, black, scarlet, and chestnut oaks grew throughout Erie County on the "better drained soils" may be an indicator of fire having some effect on the pre-settlement development of the region's forests.

Open areas called "barrens" dominated by "scrubby" white or black oak were noted to occur in many localized sections of pre-settlement northeastern Ohio. Also referred to as "barren burnt hills" or "barren burnt plains," these sites were attributed to "the result of burning by Indians in pursuit of game" (Whitney 1982). All of the direct references to "fires or barrens" found in the pre-settlement survey records analyzed by Whitney (1982) were known centers of "Indian activity" as indicated by corresponding citations regarding major Native American trails or villages. It seems likely that fire was also used in our area and was a potentially important disturbance affecting the development of the pre-settlement vegetation.

Changes in Wildlife and Fisheries

The original forest of northwestern Pennsylvania apparently supported populations of large predatory mammals—such as bears, wolves, martens, and cougar—which were eliminated by the region's early settlers (Bates 1884). Wolves caused serious concern to the settlers, as "packs of these animals often surrounded the cabins and kept their inmates awake with their howling" (Bates 1884). There were reports of "sheep being killed by wolves as late as 1813," and occasionally a panther or wild cat terrified whole neighborhoods by its screaming" (Bates 1884). It apparently was not long before these threats were eliminated, as a bounty of "$10 to $12 per head" was offered for the scalps of wolves, and "the last panther was shot" in 1857 (Bates 1884).

Bates indicates that wild fowl (including pigeons, ducks, geese, partridges, and turkeys) were abundant "in their season" and were readily harvested by the settlers, since the game birds "were more tame than now, and fell easy victims to the guns or traps of the pioneers." According to Reed (1925), "great flights" of wild (passenger) pigeons occurred "all through this region" until the 1870s. Reed also indicated that elk and bison were originally present in Erie County, "although the bison had retired from this county very soon after the French came upon its soil." Apparently, nearby Elk Creek was named for the former conspicuous presence of elk, which is confirmed by a specimen (a single elk antler) currently housed in the Biology Department of Mercyhurst College (obtained with a collection formerly held by the Erie Historical Museum). The tag on the antler (dated February 1903) indicates the antler came from an elk shot in 1802 by Conrad Coffman on the West Branch of Elk Creek (Little Elk Creek).

The various versions of the History of Erie County indicate that at the time of original settlement, all of the streams had abundant fish (Bates 1884; Reed 1925; Sanford 1894). Bates (1884) reported that "most of the small streams abounded in trout." Sanford (1894) claimed that "all of them contained many brook trout." An early report of the Pennsylvania State Commissioners of Fisheries (Busch 1896) confirms that brook trout were common in all of the streams of Erie County (prior to 1850). The region's fisheries apparently declined concurrently with deforestation in the first half of the 1800s. Trautman's (1957) review regarding changes on the southern shore of Lake Erie between 1797 and 1850 indicated that dam construction on streams to operate mills prevented upstream migration of many important "food species." Reduced stream flow associated with "overdraining of marshes….timber removal on stream banks, burning of vegetation and other agricultural practices" also destroyed the habitats of stream fishes (Trautman 1957). Furthermore, sawdust dumped into streams from lumber mills harmed fish directly by clogging their gills and degrading spawning substrate (Trautman 1957).

Wetlands and Development

Wetlands affected several aspects of the historical development of northwestern Pennsylvania. Bates (1884) indicated that an extensive half-mile wide swamp "originally extended along the Lake Shore Plain in an east and west direction, from Twelvemile Creek to the Ohio boundary." By 1884, most of the wetland had been drained for conversion to "fertile land (agricultural use)," although the parts east of Mill Creek were apparently not as effectively modified because "the rock comes nearer to the surface" (Bates 1884). The westernmost portion of the swamp in Springfield Township (near Raccoon Creek) was also problematic, as "numerous

stretches of sand are met with that hardly pay for cultivation, and other parts are cold, swampy and difficult of drainage" (Bates 1884). The position of wetlands affected some property boundary decisions. Apparently the boundary of the 2,797-acre Moravian Grant in Springfield and Conneaut Townships was constricted at Ridge Road (U.S. Route 20) because the original surveyors encountered a "formidable beaver swamp at that point, which has since been mostly reclaimed by drainage" (Bates 1884).

Inspection of the location indicated for the former swamps west of Peach Street on Millcreek Township and City maps in the Atlas of Erie County (Beers et al. 1865) indicates that the path of the Beaver and Erie Canal (and, later, railroad tracks) approached the port of Erie through the swamps. Canal and railroad construction projects apparently contributed to the drainage of wetlands and changed the course of streams and/or severed streams from their headwaters.

Inspection of the current agricultural landscape across the region commonly evinces alteration of original drainage patterns in headwaters by installation of tile drains and ditches to make wet areas arable, and the relocation and straightening of small stream channels. Such alterations, which are notably common throughout the Conneaut Creek watershed, have improved the utility of the land for agriculture but also have most likely decreased the amount of precipitation reaching groundwater and thereby adversely affected the base flow of streams. Although much less damaging than the large-scale addition of impervious surfaces in the region's developed urban and suburban areas, agricultural drainage alterations have a similar effect on speeding-up the entry of surface water into receiving channels during snowmelt periods and rainstorms.

Historical Importance of Streams for Transportation

The earliest documented exploitation of the Great Lakes watershed in the northwestern Pennsylvania region was that of the French, who attempted to develop and protect trade routes between eastern Ontario and the Mississippi Valley (Taylor 1891; Reed 1925). After LaSalle passed through Lake Erie in 1678, the French recognized the strategic importance of establishing a line of military posts along western side of the Alleghenies. Securing these outposts required links between water transportation routes on the Great Lakes and the Ohio River (Taylor 1891; Reed 1925). As the portage distances between the southern shore of Lake Erie and navigable tributaries of the Allegheny and Ohio Rivers increase from east to west, the Conneaut Creek watershed appears not to have been exploited in this manner. Instead, early French explorers appeared to preferred access to the Allegheny and Ohio Rivers via Chautauqua Creek in western New York and Mill Creek in the City of Erie.

During the early 1800s, canals were viewed as remedies to difficulties associated with transportation and commerce. Spurred by New York's Erie Canal, which by 1824 connected the Hudson River with Lake Erie, Pennsylvania began construction of a canal that would join Philadelphia and Pittsburgh. Construction of the Beaver-Lake Erie Canal, which would connect Pittsburgh with Lake Erie, began in 1831. The Beaver-Lake Erie Canal was composed of three major divisions: The Beaver Division (connecting the Ohio River at Beaver to Pulaski in Lawrence County), the Shenango Division (connecting Pulaski to Conneaut Lake), and the

Conneaut Division or Erie Extension Canal (connecting Conneaut Lake to the City of Erie). Construction of the southernmost Beaver Division Canal began in 1831, and administrative approvals for the Shenango Division and Erie Extension Canals were obtained in 1836 and 1838, respectively. Although there was initial disagreement over the precise route that the northern reaches of the Beaver-Lake Erie Canal should take, it was virtually certain that it would pass through Crawford County, and the role to be played by Conneaut Lake as a reservoir appears to have been a critical determining factor in its final course. When the Beaver-Lake Erie Canal was opened upon completion of its northernmost Erie Extension Canal section in 1844, it extended a total of 136 mi (219 km) and employed 137 locks to overcome a total rise of 977 ft ([298 m] Shank 1981:56).

In its Crawford County extent, the Erie Extension Canal portion of the Beaver-Lake Erie Canal more or less followed the course of Conneaut Creek as far as a point just south of Penside, Erie County. The canal entered Erie County in Conneaut Township, passing through Albion to Lockport (present-day Platea) in Girard Township, and then to Girard on Elk Creek. From Girard the canal turned east into Millcreek Township and entered Erie along the approximate route of present-day West 18th Street. The canal, at that point, ran through the city from southwest to northeast, terminating at the foot of Sassafras Street (Reed 1925:348). Many locks were required to navigate the elevation difference between the lake plain and upper hills. Lockport had 28 locks within a 2 mi (3.2 km) stretch of the canal, and the City of Erie had 15 locks alone (Spencer 1962:138).

Western Pennsylvania's economy was significantly influenced by canal traffic, both in terms of the shipment of goods and the passage of migrants passed bound west via the Ohio River (Wellejus 1980:34). The opening of the canal stimulated the region's lumber trade and the construction water- and steam-powered saw mills, sometimes at the expense of traditional agricultural land use. However, as with all of the canals built in Pennsylvania, Ohio, and New York at this time, its success was short-lived. Competition from railroads rapidly displaced canal use, and canal systems either fell into disrepair or replaced by railroad lines. The Erie Canal Company, with Charles M. Reed as president, was sold in 1856 to the Erie and Pittsburgh Railroad Company (also headed by Charles M. Reed). The canal was operated by the railroad company until its abandonment in 1871, when a portion of the canal's aqueduct over Elk Creek was destroyed during a storm (Nelson 1987:180; Spencer 1962:140).

Streams as Energy Sources

When Euro-American settlers first arrived, the region's streams were the principal source of energy for a wide variety of industrial enterprises, including saw mills, grist mills, woolen factories, tanneries, and breweries. Because of critical importance of hydropower, streams and mills became centers for the growth of early communities in the study area (Claridge 1991), and some of the mills continued to work into the early twentieth century. According to Sanford (1894), Conneaut Creek was one of the principal streams identified in the region for hydropower. Sanford conveys a sense of the prevailing attitude of humans toward the resource in the accompanying remark, that "these streams afford abundant water power for manufacturing; and

while the valleys and rivers are sometimes wild and picture-like, as at Elk, Walnut and Twenty Mile Creeks, the broken and unproductive areas of Erie County are few indeed."

The first recorded settlers to Conneaut Creek watershed appear to have arrived in the 1790s, the earliest being Alexander and William Power, who settled in present-day Spring Township in 1794 and 1795, respectively. These early settlers imported commodities such flour, meal, and salt from Pittsburgh until 1799, when the region's first grist mill was built on Conneaut Creek by Alexander Power, and the advent of the local extraction of salt in the early 1800s. Power's first grist mill was replaced by a second mill built a ¼ mile away in 1805, and augmented by a third grist mill (also built by Power) in 1829–1830.

The pace of mill construction increased through the early nineteenth century. In 1801, Samuel Fisher erected another grist mill, which performed most of the grain processing for northwestern Crawford and southwestern Erie Counties, and built the first saw mill in the county on Conneaut Creek about 1 mile north of Conneautville. In 1820, Ark Jenks erected another saw and grist mill on Conneaut Creek near the Erie County line and Robert Foster built a grist mill a mile south of Spring Corners. Another saw mill was built by one Mr. Holmes at Spring Corners. The first saw mill in the eastern part of Spring Township was constructed under the direction of Platt Rogers in 1820. The region's first distillery was built by Christopher Ford before the 1800s. John Foster erected a second distillery and Luther Rundel built another at Rundeltown in 1820. Gurdon and R. B. Wood in 1817 and 1818 built the first wool-carding and cloth-dressing establishment on Conneaut Creek 2 miles north of Conneautville. Summerhill Township's first saw mill was built along Conneaut Creek in 1820, followed by a second built by George Dickson, who also owned a grist mill at Dicksonburg, and then by additional saw, steam, and carding mills soon thereafter. James Fetterman built the first distillery in what is now Summerhill and a second was built by John McDowell, the township's first settler, who died in 1858 at the age of 80 years. In the watershed's western reaches, the first saw mill in Beaver Township was built by William Plymate and the second was built by Elihu Griswold. In 1831, Robert Foster built the first grist mill. The practice of deep boring to produce higher yields of the township's locally abundant salt led to the discovery of oil, and the salt works were consequently abandoned in favor of the higher commercial value of oil. Conneaut Township's first grist and saw mill was built on Paden's Run prior to 1810, and was followed by a second grist mill, a carding mill, and in 1818, the township's first schoolhouse.

Historical Sites in the Conneaut Creek Watershed

A total of 165 historic sites are registered by the Pennsylvania Bureau for Historic Preservation within the townships and boroughs of the Conneaut Creek watershed. Of these properties only 6 are considered eligible for the National Register of Historic Places (NRHP) and only 1, the Harrington Covered Bridge, is listed on the NRHP. Located on the West Branch of Conneaut Creek at that stream's crossing by Barney Road in Conneaut Township, this wooden structure is through truss covered bridge that was built by William Sherman in 1870. It was listed in the NRHP on September 17, 1980.

4. Water and Biotic Resources

Modern Watershed Features and Hydrology

The principle surface water resources of the 153.1 mi^2 Pennsylvania portion of the Conneaut Creek watershed are its extensive network of streams (Figure 4.1), including a dozen named tributaries. The East and West Branches constitute the main side branches of the northern half of the main stem, besides Marsh and Stone Runs. The southern half of the main stem has several named tributaries draining from the west (Crazy, Foster, Myler Runs and Fish Creek).The East Branch includes Temple Creek as a major secondary tributary, and the West Branch has several tributaries, including Mud Run and Middle and East Branches. Recent aerial photography of the watershed (Figure 4.2) presents a checkerboard mix of agricultural and forested tracts. The only noticeable (although limited) patch of urban-type development is the Borough of Albion located at the junction of Routes 18 and 6N, on the lower reaches of the East Branch within Erie County.

A USGS stream gauging station had been operated for awhile on the main channel of Conneaut Creek at Route 6N, approximately 3 mi east of the Pennsylvania–Ohio line served as a source of streamflow data (Figure 4.3) for the period from 1988–1997. Two consistent trends are apparent in seasonal patterns variation in stream flow: (1) a more or less prolonged period of high discharge occurring in the late fall and winter and (2) a period of sometimes prolonged low flow occurring in mid-late summer. In many years, the stream shows an episode of lower discharge within the winter high-flow period, which likely corresponded to periods of extremely cold weather, when runoff entering the channel from snow melt and other forms of precipitation ceased. Comparative hydrological data for streams in the Pennsylvania Lake Erie watershed in Mangan et al. (1952) and Buckwalter et al. (1996) indicates that Conneaut Creek has the highest low-flow discharge (2–5 cubic ft/sec). This is an important measurement, because low-flow discharge sustains aquatic life during the worst-case drought conditions, and it is important to determine specific amounts of point-source pollutants a stream can receive without exceeding harmful concentrations.

The stream channel along the main stem varies considerably along its length, presenting some straight, shallow segments with riffle-type habitats, and other sections with torturous meanders and deep, slow-moving pools. Aerial photographs of the main stem valley of Conneaut Creek reveal abundant evidence (in the form of remnant oxbow features) that the stream has actively migrated across its floodplain in the past. Faint traces of these features are apparent as far south as Springboro; they appear to become more distinct on the west side of the stream channel just south of the confluence with the West Branch and are very prominent in the meandering stretch northwest of Albion.Clusters of these oxbow features correspond to locations

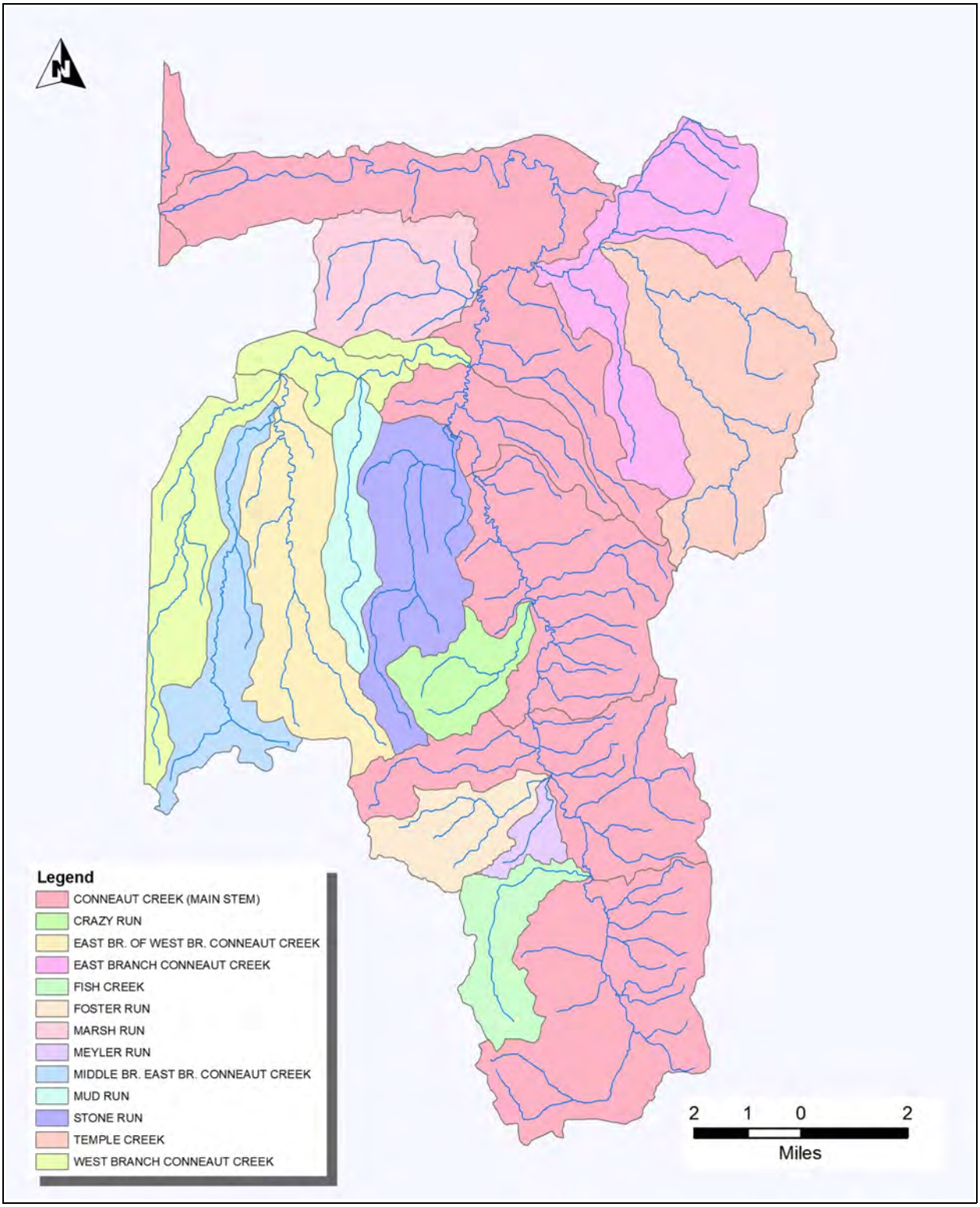


Figure 4.1. Pennsylvania portion of the Conneaut Creek watershed showing locations of stream channels and subwatershed boundaries of major tributaries.

Figure 4.2. Recent (2006) aerial photograph of Pennsylvania portion of the Conneaut Creek watershed (outlined in white).

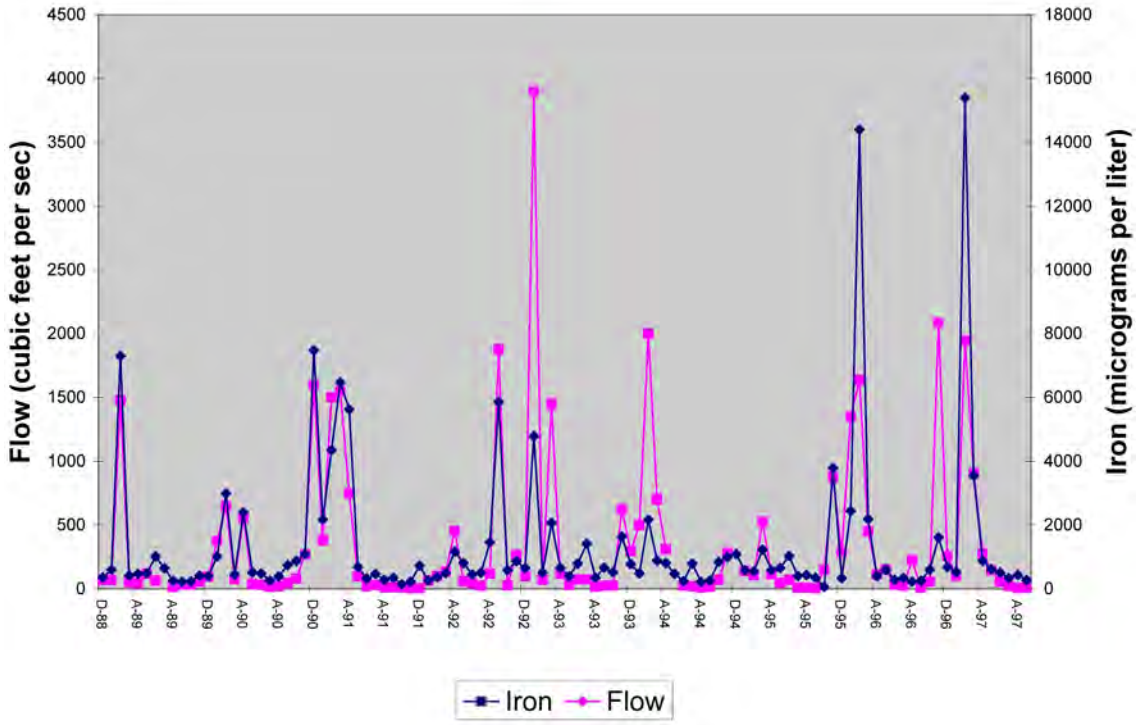


Figure 4.3. Graphical analysis of STORET legacy data for Conneaut Creek, 1988–1997.

of large wetland systems within the creek's floodplain (Figure 4.4). The wetlands of the Conneaut Creek watershed are its second-most prominent surface water features, besides streams, and appear to be more numerous on the west side of the main channel. Forested wetlands are concentrated in the West Branch and Marsh Run subwatersheds, and the floodplain along the main channel contains a diverse selection of emergent, shrub-scrub, and forested types. The wetlands are extremely important as habitats for plants and wildlife, including a number of plant species of special concern. The diversity of stream morphologies found in the Conneaut Creek watershed are shown in the photographs included in this document (see 1. Executive Summary).

Comprehensive descriptions of the groundwater resources are provided by Richards et al. (1987) and Buckwalter et al. (1996) for the Erie County portion of the Conneaut Creek watershed, and by Schiner and Gallagher (1979) for the Crawford County portion, including maps and records of physical characteristics and water quality of residential wells. The availability of groundwater from the area's surficial aquifer system is dependent upon the relative amounts of discharge (i.e., outflow to springs, streams, and wells) and recharge (i.e., inflow from infiltrated precipitation). Richards et al. (1987) indicated that water levels in wells in Erie County are generally highest in March and April, and lowest in September and October. Reduced groundwater availability in the summer is attributable to reduced infiltration from precipitation due to higher rates of plant water use via evapotranspiration (Richards et al. 1987).

Groundwater is the principle source for most human water uses throughout the Conneaut Creek watershed, including public supply systems in Cranesville, Albion, Springboro, and

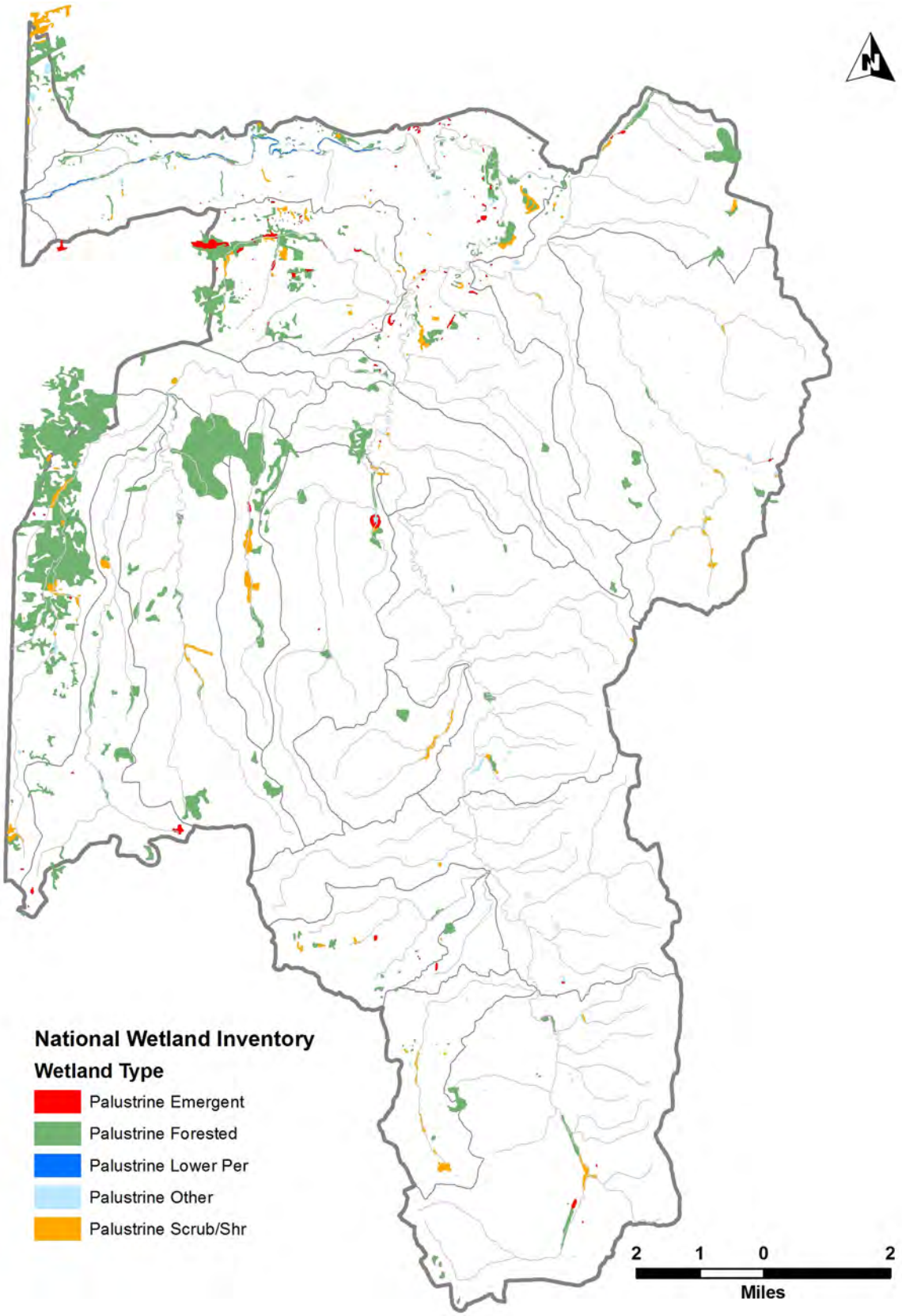


Figure 4.4. National Wetland Inventory map for the Conneaut Creek watershed, also showing locations of stream channels and subwatershed boundaries.

Conneautville. Groundwater is also critical for sustaining base flow of streams. Forecasts regarding hydrological phenomena expected to accompany climate change in the next 50–100 years predict that groundwater supplies will decrease due to reduced summer precipitation, increased evaporation, and reduced groundwater recharge rates (Kling and Wuebbles 2003). A forecast of reduced groundwater availability in the future suggests a need for regional planning to educate the public about likely future changes in water availability, and to develop strategies for implementing a water conservation and use plan that will address the future needs. Concern about future water availability in the Temple Creek portion of the East Branch subdivision of the Conneaut Creek watershed has resulted in that area being nominated as a "Critical Water Planning Area" by the Pennsylvania Department of Environmental Protection (PA DEP 2009).

Water Quality and Pollution

For each stream in the Commonwealth, Pennsylvania state law (Pennsylvania Code [Chapter 93]) establishes "protected water uses" which are the basis for specific water quality criteria that identify allowable ranges of physical and chemical characteristics (e.g., temperature, dissolved oxygen, etc.) which must be maintained for each water body. These criteria then limit the specific amounts of pollutants that may be released to the stream under permits issued to entities that discharge wastewater to the water body. The criteria are most stringent for water bodies designated for use as potable water supply (PWS).This designation applies to a 1.3 mi section of Conneaut Creek near the borough of Albion. All of the other streams in the Conneaut Creek watershed have designated water uses related to the kind of aquatic life the water bodies support, including warm water fish (WWF) and cold water fish (CWF). The main stem of Conneaut Creek from its source to the Pennsylvania–Ohio border is designated as supporting warm water (WWF) and migratory fish (MF). Conneaut Creek's tributaries are all classified as supporting cold water and migratory fish (CWF, MF).

The "protected water uses" designated by Pennsylvania for individual stream segments within the Conneaut Creek watershed were evaluated by the state several years ago, and streams that failed to meet their designated use due to pollution (a condition known as "non-attainment") were identified on a list known as the "303(d)" list. Currently, Marsh Run (Figure 4.5) is the only stream in the Conneaut Creek watershed listed on the 303(d) list (Category 5) in the state's most recent assessment report (PADEP 2010a). The cause of impairment is identified as "natural sources cause unknown," and the stream is scheduled for development of a Total Maximum Daily Load (TMDL) in 2011 to bring the stream into compliance with water quality standards (see PADEP 2010a for details).

The two basic types of water pollution sources are "point" and "non point." Sites considered "point-source" discharges are regulated by state and federal laws through the National Pollutant Discharge Elimination System or NPDES (USEPA 2006e). Point sources are defined as "discrete conveyances such as pipes or man-made ditches" (USEPA 2006e). NPDES permits are *not* needed for all discharges to water, such as individual home-owners and businesses that have septic tanks, or residential properties that are connected to municipal sewage systems. In Pennsylvania, the NPDES permit program is administered by the Pennsylvania Department of Environmental Protection, which also publishes geospatial data and maintains records on all

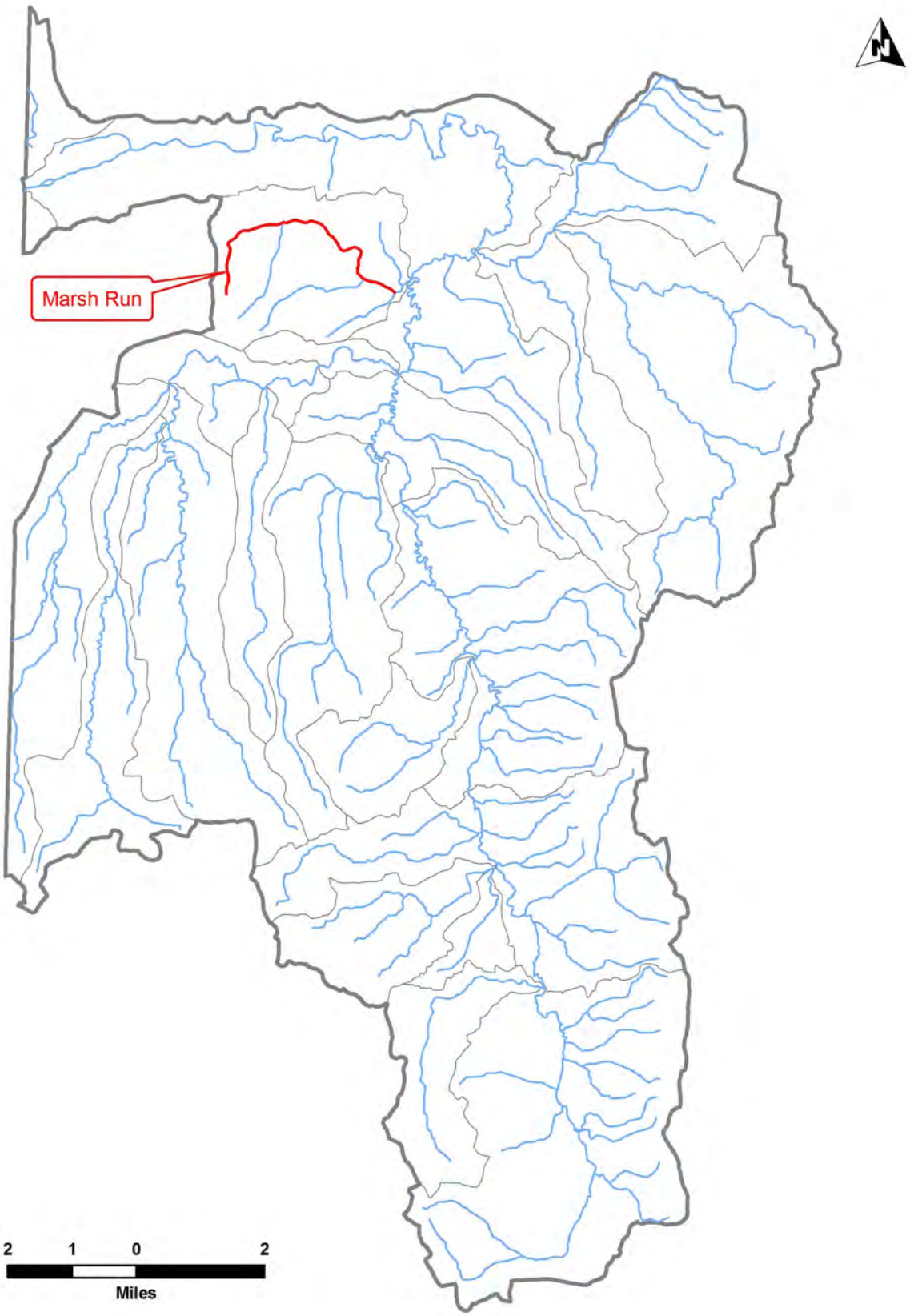


Figure 4.5. Map showing location of Conneaut Creek's non-attainment stream section (2010), Marsh Run.

NPDES-permitted discharges to water (PADEP 2008). NPDES-permitted discharges to Conneaut Creek and its tributaries include sewage treatment plants in Cranesville, Albion, Springboro, and Conneautville, several manufacturing/business entities in Albion and Conneautville, and over two dozen residential and church sewage treatment systems scattered throughout the watershed. It cannot be assumed that all of these facilities are always operating in compliance with their permits. The wastewater at treatment plant at Albion has a record of effluent violations for fecal coliform bacteria, ammonia, phosphorus, and total suspended solids discharged to Conneaut Creek between April 2007 and December 2009 (US EPA 2010), and is currently operating under the terms of a consent order (FRS ID 110000978210 dated 10/24/2008).

Nonpoint-source pollution (NPSP) is not as readily controlled as point-source pollution. NPSP differs from point source pollution in not being "easily traced back to a particular location" and originating from "everyday land use activities such as agriculture, residential development, construction and forestry" (PADEP 2000). In the mostly rural Conneaut Creek watershed, the commonest form of NPSP occurs with physical disturbance from agricultural and timber-harvesting activities in the riparian zone of small streams and from contaminants entering streams from roads. Sediment particles entering streams from eroding stream banks and exposed agricultural soils are often associated with nutrients (including phosphorus and nitrogen compounds) that may contribute to excessive plant growth in receiving waters (Prepas and Charette 2003). Considerable effort is being focused in the Great Lakes Basin on reducing phosphorus-loading from NPSP (USEPA 2006a, 2006b). Pesticides from agriculture are another NPSP contaminant of potential concern in the Conneaut Creek watershed (Buckwalter et al. 1996; Myers et al. 2000).

Detailed discussion regarding sulfate, nitrate and mercury in the waters of Conneaut Creek, originating from air pollutants discharged from coal-fired power plants and other industries located west of the study area, is found in LERC (2008). Although sulfate and nitrate deposition rates have decreased across Pennsylvania since 1994 due to implementation of Title IV of 1990 amendments of the Clean Air Act (Lynch et al. 2005a), the study area and the rest of western Pennsylvania have remained hot-spots for deposition of nitrate. Trend analysis of sulfate data for Conneaut Creek carried out by PADEP (2006c) indicated that sulfate concentrations decreased significantly from 1995 to 2005. Unfortunately, PADEP's (2006c) trend analysis indicated no improvement in nitrate concentration for Conneaut Creek for the period 1995–2005. Mercury entering the watershed results in contamination of fish and wildlife with methylmercury, which bioaccumulates in the food chain and can cause nervous system and reproductive problems in animals at the top of aquatic food chains. Children born to women whose bodies contained elevated levels of methylmercury have been found in several studies to have demonstrable neuro-developmental defects (Trasande et al. 2005). Due to the known health threat of mercury to people who eat fish, Pennsylvania issued a consumption advisory due to mercury dated August 26, 2009, for smallmouth bass (two meals per month) in Conneaut Creek from Route 215 to the Pennsylvania–Ohio border (PADEP 2010).

Currently, the most effective strategy for abatement of NPSP involves the implementation of best management practices (BMPs), which include a wide variety of structural, non-structural, and institutional methods that control and prevent erosion, sedimentation, and contaminant

transport in storm water runoff (PADEP 2000). For example, conservation tillage is a reduced cultivation method that has been proven effective at decreasing soil erosion and suspended sediment in streams draining crop fields in northwestern Ohio (Myers et al. 2000). Implementation of appropriate BMPs in some agricultural areas of the Conneaut Creek watershed is already underway, with support of personnel in the Erie and Crawford County Conservation Districts and the U.S. Natural Resources Conservation Service (NRCS).

Forest Communities

According to the most widely accepted system for classifying upland vegetation within the United States, developed by Robert G. Bailey of the U.S. Forest Service (USDA 1995), the Conneaut Creek watershed lies at the interface of the Eastern Broadleaf Forest Continental Province and the Eastern Broadleaf Forest Oceanic Province. Bailey's description of the vegetation nearer Lake Erie identifies American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) as the dominant trees, with oak and hickory (*Quercus* and *Carya*) "on poor sites." The "mixed mesophytic vegetation" in the higher elevations ecoregion (USDA 1995) includes also tuliptree (*Liriodendron tulipifera*), basswood (*Tilia americana*), red oak (*Quercus rubra*), white oak (*Quercus alba*), and eastern hemlock (*Tsuga canadensis*) among the dominant species.

The plant community classification system developed by Pennsylvania's Bureau of Forestry (Fike 1999) identifies many different types of terrestrial forests classified into several broad categories, including "coniferous" (also referred to as "evergreen" forests), "coniferous-broadleaf" (herein referred to as "mixed" forests), and "broadleaf" (also referred to as "deciduous" forests). Under the coniferous category, Fike (1999) lists "hemlock (white pine) forest" as the only type. In the study area, eastern hemlock is the dominant conifer and white pine (*Pinus strobus*) is secondary. In coniferous forests, cover by these species exceeds 75 percent, and the less abundant deciduous trees usually include yellow birch (*Betula alleghaniensis*), sugar maple, red maple (*Acer rubrum*), red oak, American beech, and tuliptree (Fike 1999). Mixed forests contain 25–75 percent conifer cover. Mature coniferous and mixed forest types have special importance for conservation purposes because evergreens provide year-round cover and shade beneficial to wildlife and fisheries, and intercept precipitation that could otherwise contribute to soil erosion and runoff in areas with steep slopes.

Evergreen forest, indicated by dark green shading in Figure 4.6, occurs in small scattered pockets with mixed forest (lighter green shading) throughout the Conneaut Creek watershed. In some areas, stands of conifer and mixed forest include larger stands of white pine (*Pinus strobus*), which is unusual elsewhere in the Pennsylvania Lake Erie watershed (LERC 2008). Mixed forest in the Conneaut Creek watershed is found in association with the moist slopes along stream channels and on higher ground, usually surrounded by larger areas of deciduous forest. Mixed forest stands are better developed in the northern half of the watershed (in Erie County) than in the southern (Crawford County) portion (Figure 4.6). Deciduous terrestrial forests (brown shading in Figure 4.6) contain less than 25 percent conifer cover, and are often found on dryer sites. These forests are dominated by oaks, hickory (*Carya*) species, and varying

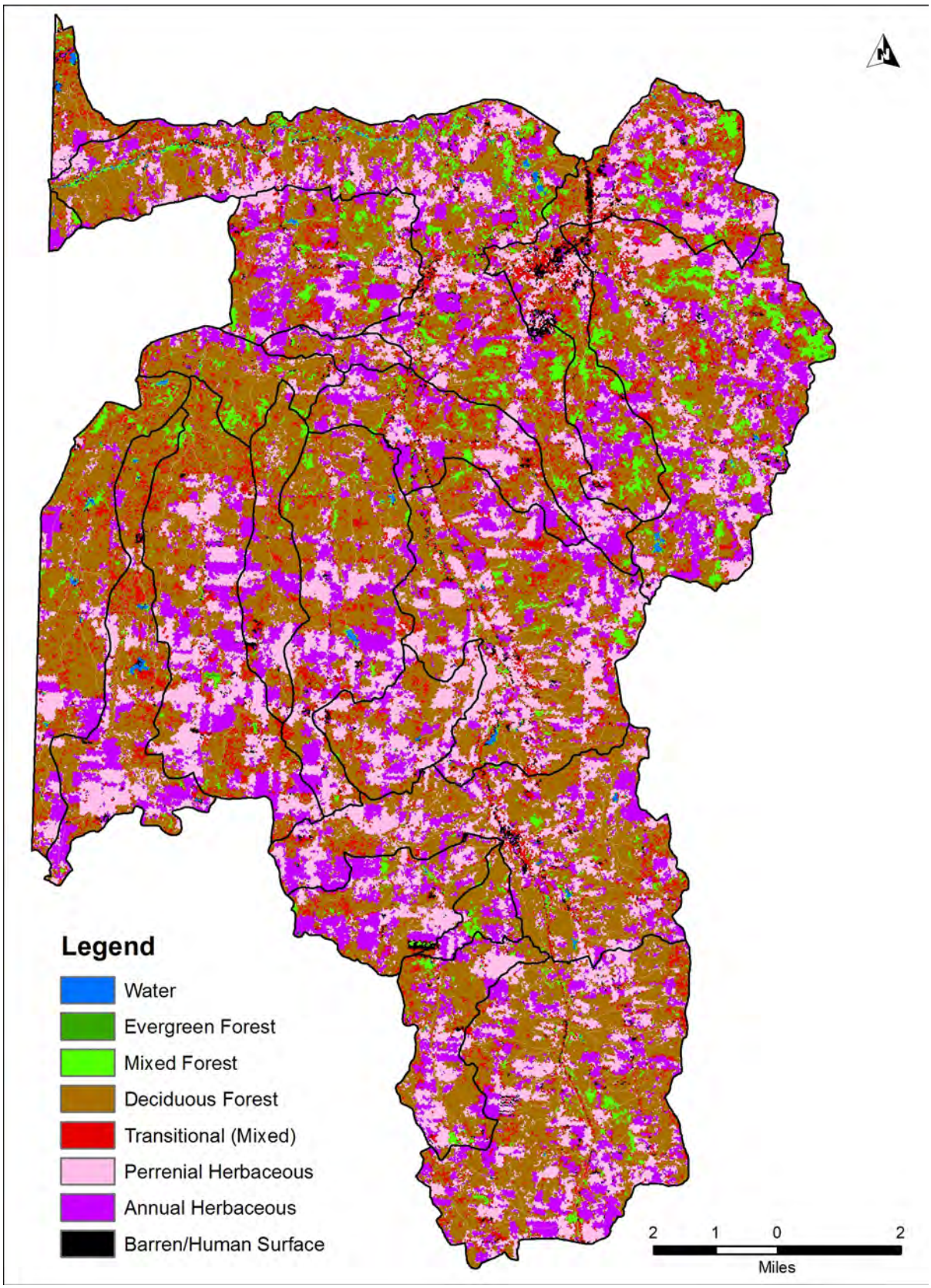


Figure 4.6. Land cover (vegetation) in the Conneaut Creek watershed, employing data from Pennsylvania State University (2007).

combinations of maples, white ash, other deciduous species previously mentioned, plus black cherry (*Prunus serotina*). Eastern hemlock may occur as a secondary species (Fike 1999). Transitional forests (red shading in Figure 4.6) occur in disturbed areas and may include red maple and aspen/birch forests—both early-successional types that occur on former agricultural lands (Fike 1999). The red maple forest may include also red oak, tuliptree, hickories, white ash, and black cherry. The aspen/birch forest type in the study area is usually dominated by bigtooth or quaking aspen (*Populus grandidentata* and *tremuloides*), and may also include gray birch (*Betula populifolia*), sassafras (*Sassafras albidum*), maples, and cherry.

Several of the forested wetlands along the main stem channel between the Pennsylvania–Ohio line and Springboro, and the West Branch subwatershed in and near Game Land 101 contain plant species of special concern that are specialists of bottomland forest habitats (discussed in greater detail below). The Pennsylvania Lake Erie Watershed Conservation Plan (LERC 2008) recommended designating portions of the Conneaut Creek watershed and Ashtabula River headwaters surrounding Game Land 101 as a "Forest Heritage Protection Area." Such a designation could provide a conservation planning "umbrella" to restore and expand "core forest" in northwestern Pennsylvania. Core forest areas provide critical habitat for a wide variety of wildlife, and are virtually non-existent in the heavily developed Lake Erie Basin (Kavanagh et al. 2001). As shown in Figure 4.7, the western part of Erie County at the Ohio line has two large areas of forest, in the area of Game Land 101 (at the Erie/Crawford County boundary) and Game Land 314 (along Lake Erie). If these two major forested tracts could be connected via a restored forest corridor near the Ohio line to join with forested areas on the Ohio side, the resulting feature could have singular significance for the larger Lake Erie basin.

Avian resources

In the Pennsylvania Lake Erie Watershed Conservation Plan (LERC 2008), bird species counts collected from 1989 to 1998 by the USGS Patuxent Wildlife Research Center (2006) plus records from the first edition of the Pennsylvania Breeding Bird Atlas (Brauning 1992) were used as evidence that the Conneaut Creek watershed harbored breeding populations of 20 different bird species of conservation concern to the US Fish & Wildlife Service and Pennsylvania Game Commission. The list included species associated with both wetland and upland habitats. Several of breeding birds identified in the Conneaut Creek watershed by LERC's (2008) data review were "interior forest" specialists (e.g., black-billed cuckoo and cerulean warbler) that require large tracts of uninterrupted forest in order to breed successfully (Brauning 1992).

The cerulean warbler is a specialist for mature forests bordering streams or rivers. Roads or other clearings cut into a forest create microclimate differences (e.g., lower moisture, elevated winds, higher temperature, more light) that cause changes in vegetation composition and increased invasion of species typical of open habitat (Cottrell 1997). The depth of this "edge effect" in mixed hardwood forests ranges 40–60 m (131–197 ft). The shape of a forest patch affects how much of it will be affected by edge effect (Cottrell 1997). Fragmentation of forests by roads or development activities that reduce large forested tracts smaller patches contribute to decline of forest interior birds partly because edge communities offer excellent feeding and nesting sites for opportunistic animals, including nest predators (e.g., blue jays, crows, squirrels,

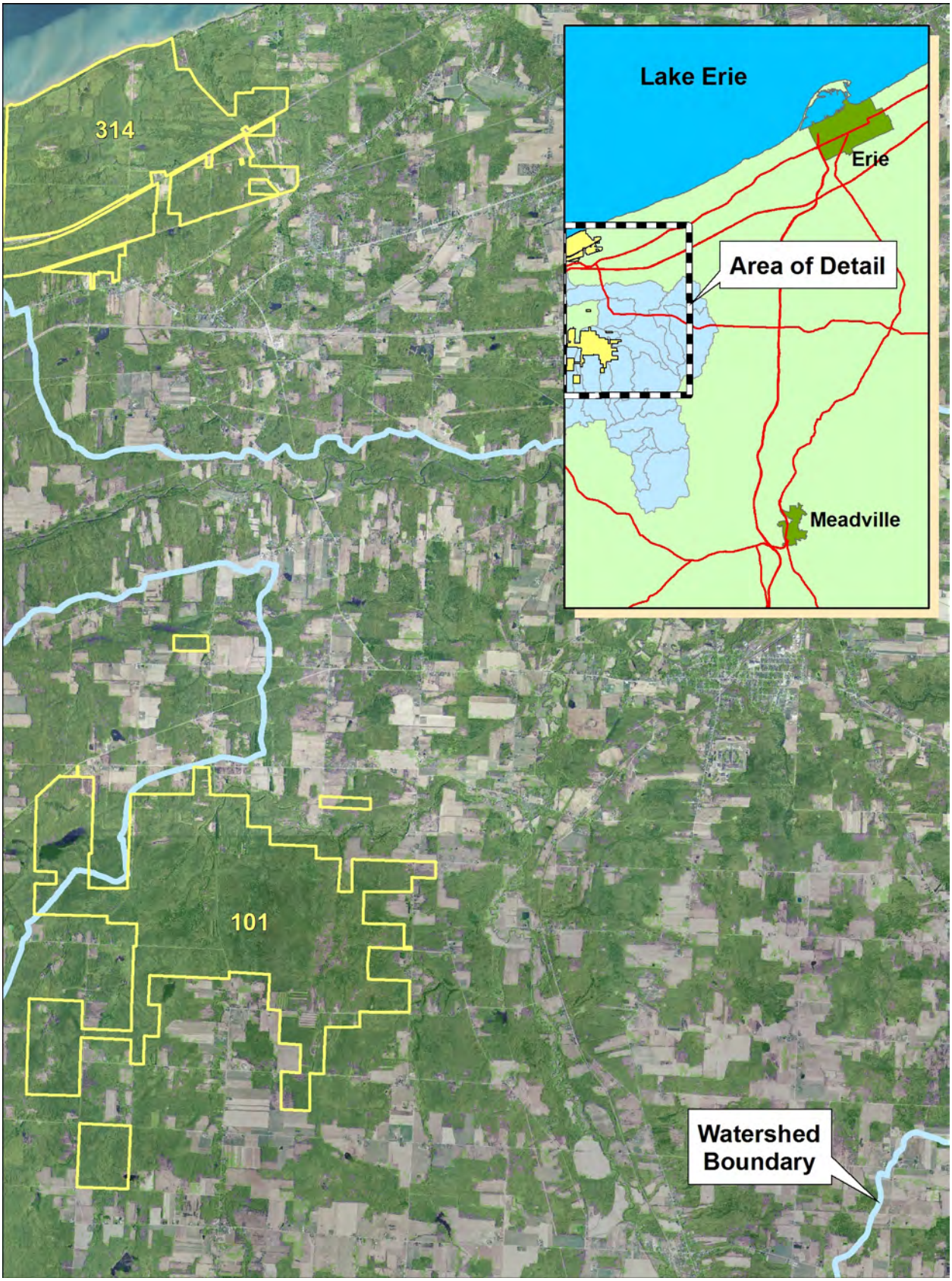


Figure 4.7. Recent aerial photograph of northwestern Pennsylvania, showing boundaries of Game Lands 314 and 101 and area in between, proposed for restoring a "core forest" corridor.

chipmunks and shrews) and brood parasites such as brown headed cowbirds (Cottrell 1997; Gross 2002).

The recently published records of the 2nd Pennsylvania Breeding Bird Atlas (Cornell Lab of Ornithology 2009) were accessed to evaluate the current records for forest interior birds using the northwestern portion of the Conneaut Creek watershed (Table 4.1). Data was tallied for 22 bird species considered interior forest specialists (PA DCNR 2010; Therres 1992) for 14 contiguous 5 km by 5 km (3.1 mi by 3.1 mi) survey blocks near the Pennsylvania–Ohio border between the southern edge of Game Land 314 and the area immediately south of Game Land 101. For our purposes here, each bird species was valued according to the degree of certainty that it was actually breeding in the block (1=possible, 2=probably, 3=confirmed), and the values were summed by species over the 14 blocks.

Table 4.1. Tallied Records For Interior Forest Birds In Conneaut Creek Watershed, From 2nd PA Breeding Bird Atlas.

Species	Occurrence Score
Eastern wood peewee	18
Acadian flycatcher	17
Great-crested flycatcher	16
Blue-gray gnatcatcher	7
Veery	20
Wood thrush'	21
Yellow-throated vireo	11
Red-eyed vireo	22
Northern parula	1
Black-throated blue warbler	2
Black-throated green warbler	3
Blackburnian warbler	1
Cerulean warbler	5
Black-and-white warbler'	2
American redstart	28
Ovenbird	22
Louisiana waterthrush	2
Hooded warbler	19
Scarlet tanager	17
Black-billed cuckoo	8
Yellow-billed cuckoo	8
Barred owl	2

Evidence of at least possible breeding activity by 10 or more interior forest bird species was found in each of the survey blocks. The two survey blocks that contained the highest numbers of probable and confirmed breeding Forest interior birds included the block containing most of Game Land 101, and the block located at the northernmost corner of the Conneaut Creek watershed just east of the Pennsylvania–Ohio border. Breeding Bird Survey blocks along the main stem channel of Conneaut Creek from the Ohio line to Albion collectively produced probable or confirmed breeding records of 12 different forest interior species and "possible" breeding records for an additional 7 species. Cerulean warblers were in the two survey blocks bracketing the main stem channel of Conneaut Creek at the Ohio line, and in several of the blocks containing or adjoining Game Land 101.This species is considered a high priority for protection and conservation by the National Audubon Society (2002) and The Nature Conservancy (2009), and could serve as an excellent "umbrella" conservation target for restoring and monitoring core forest in northwestern Pennsylvania.

It is noteworthy that several of the Breeding Bird Survey blocks closer to Albion and east of Game Land 101 produced records of breeding activity of Pennsylvania Threatened Bald eagle; and in the survey block including the main stem of Conneaut Creek near Albion, two other wetland-associated Pennsylvania species of special concern—Sora and Marsh wren—were observed during the 2004–2008 surveys. Records of over a dozen other breeding populations of aquatic- and wetland-specialist birds (e.g., Wood duck, Great blue heron, Virginia rail, Willow flycatcher) are also included in the 2004–2008 Breeding Bird Survey blocks used to produce Table 4.1., underscoring the rich diversity of high quality wildlife habitat already present in the northern half of the Conneaut Creek watershed, besides forests.

Pennsylvania Natural Heritage Resources

Occurrences of "special concern" species tracked by the Pennsylvania Natural Heritage Program (PNHP) at specific sites within the Conneaut Creek watershed were initially determined by a PNHP database search using the entire Conneaut Creek watershed as the search area, conducted by Kierstin Carlson (Pittsburgh Office of Western Pennsylvania Conservancy) on June 23, 2008.These results were then updated by 30 separate smaller "area searches" in contiguous blocks, conducted by J.M. Campbell using the PNHP/PNDI on-line search system (PNHP 2010) during July and August 2010 (center points of search blocks shown in Figure 4.8). The detailed search results conducted in 2010 are included in the Appendix of this report, and the collective findings are summarized in Table 4.2, omitting historical species and taxa not confirmed in the most recent area searches. The frequency occurrence of special concern species "hits" were tallied for the 30 area searches, grouped into four different major subwatershed regions: (1) Main Channel between Springboro to the Pennsylvania–Ohio boundary, (2)Main Channel from Springboro to the Southern Headwaters, (3) East Brach, and (4) West Branch. A total of at least 6 searches were conducted in each of the subwatershed regions.

In addition to Pennsylvania Threatened Bald eagle, the list special concern species for the Conneaut Creek watershed included 11, 6, and 4 species of plants, fish, and freshwater mussels, respectively (see Table 4.2). The "hits" produced during the 30 area searches were concentrated in the northern main stem channel section of the watershed, between the Ohio state line and

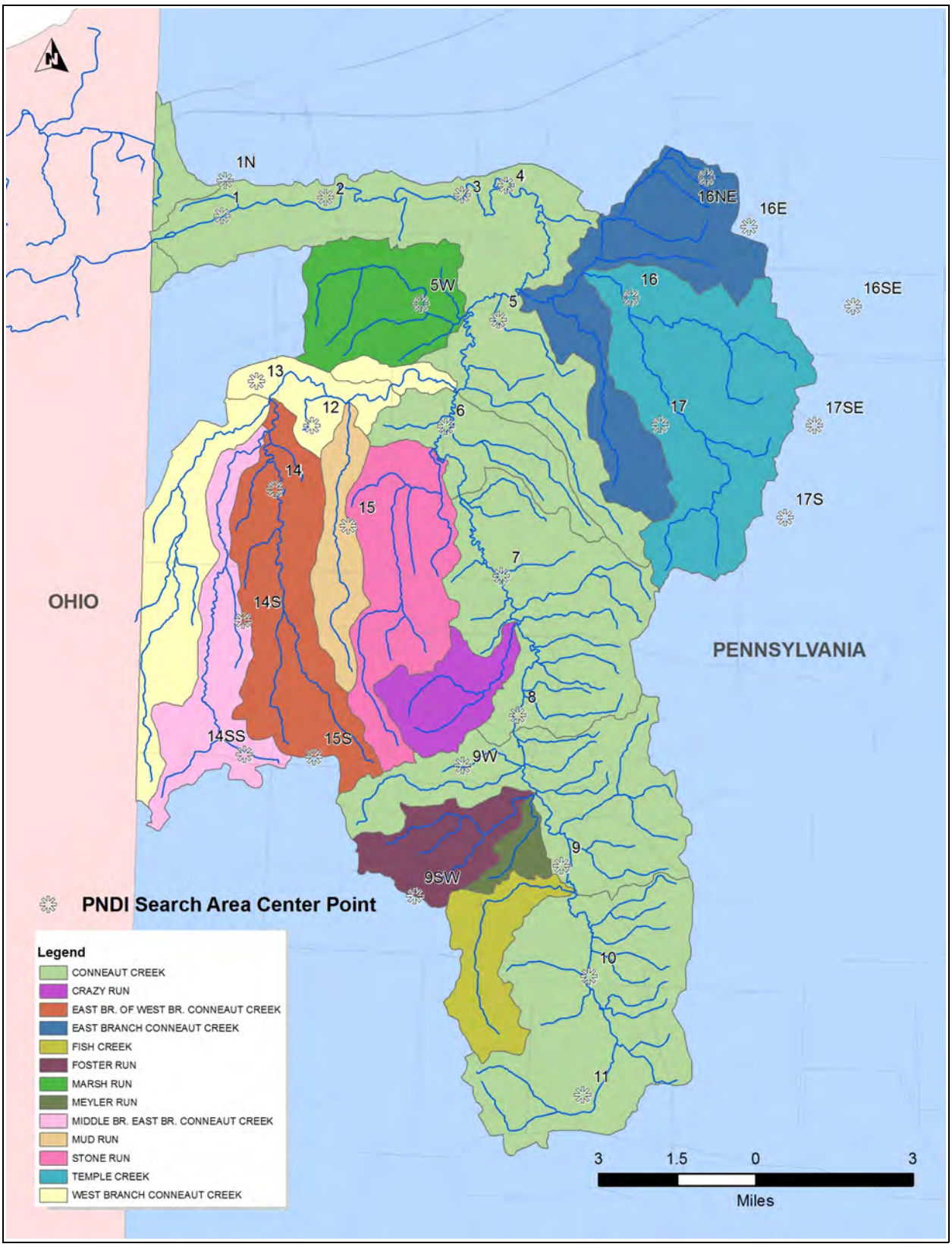


Figure 4.8. Map of Conneaut Creek watershed showing center points of 29 separate "area searches" of the Pennsylvania Natural Heritage Resource database on-line search system (PNHP 2010) during July and August 2010.

Table 4.2. Results Of 29 Different "area Searches" Of The PA Natural Heritage Resource Database (PNHP 2010), With Frequency Occurrence Of Special Concern Species "hits" Tallied For Searches Grouped By Major Subwatershed Regions (see detailed explanation in text).

			Frequency of Occurrence in Area Searches			
Scientific Name	Common Name	PA Biological Survey Status	Northern Main Stem from PA/OH line to Shadeland	Southern Main Stem South of Shadeland	East Branch	West Branch
Haliaeetus leucocephalus	Bald Eagle	PT	2	—	1	—
Ichthyomyzon fossor	Northern Brook Lamprey	PE	—	1	1	—
Lampetra appendix	American Brook Lamprey	CP	—	1	1	—
Umbra limi	Central Mudminnow	CP	2	—	1	2
Nocomis biguttatus	Hornyhead Chub	CR	1	1	—	—
Noturus miurus	Brindled Madtom	PT	2	—	—	—
Culaea inconstans	Brook Stickleback	CP	—	1	—	—
Alismidonta marginata	Elktoe	PN	7	—	—	—
Lasmigona compressa	Creek heelsplitter	CR	4	—	—	—
Pleurobema sintoxia	Round Pigtoe	PE	5	—	—	—
Villosa iris	Rainbow Mussel	PE	7	—	—	—
Bidens discoidea	Small Beggar-ticks	PR	1	—	—	—
Erigenia bulbosa	Harbinger-of-spring	PT	2	1	1	—
Quercus shumardii	Shumard's Oak	PE	1	—	—	2
Ribes triste	Red Currant	PT	—	—	—	1
Fraxinus profunda	Pumpkin Ash	PE	1	—	—	4
Samolus parviflorus	Pineland Pimpernel	PE	4	—	—	2
Carex lupuliformis	False Hop Sedge	PE	—	—	—	1
Iris virginica	Virginia Blue Flag	PE	3	—	1	—
Hypericum majus	Larger Canadian St. Johnswort	PT	1	—	—	—
Dryopteris clintoniana	Clinton's Wood Fern	PT	—	—	—	1
Polygonum setaceum var. interjectum	Swamp Smartweed	PE	—	—	1	—
	Total "hits"		43	5	7	13

Springboro (northern Crawford County). The 15 total species indicated for that subwatershed area included all of the records for freshwater mussels and about half of the fish records; this result is evidence of the high quality stream resources in the northern half of the watershed's main stem area. The confinement of native freshwater mussel species of special concern to the northern half of the main stem area of Conneaut Creek is consistent with findings of field surveys conducted in the Pennsylvania portion of the Conneaut Creek watershed by Weber and Campbell (2005).

The other three subwatershed regions had considerably fewer hits tallied, and indications of less than half as many different special concern species. It is noteworthy that a few special concern fish species were unique to the East Branch and southern main channel subwatershed areas—Northern brook lamprey and American brook lamprey (see Table 4.2). The West Banch subwatershed was distinguished by the occurrence of several plant species of special concern, including Shumard's oak, Pumpkin ash, Red currant, and False hop sedge (see Table 4.2). The

Crawford County Natural Heritage Inventory (PNHP 2008) was consulted to confirm details about locations of special concern species identified in the area searches summarized in see Table 4.2. That document was also utilized to inform development of final recommendations herein.

The PNHP provides detailed fact sheets about the specific habitat requirements and recommended conservation measures for many of the species listed in Table 4.2 (PNHP 2010), and those details will not be reproduced here, except for taxa for which recommended conservation actions serve to benefit the larger communities they inhabit (including other special concern species). Site specific recommendations for areas of the Conneaut Creek watershed that may contain species of concern listed in Table 4.2 will be addressed in the final chapter of this report, in the context of the priority conservation projects and restoration recommendations described therein.

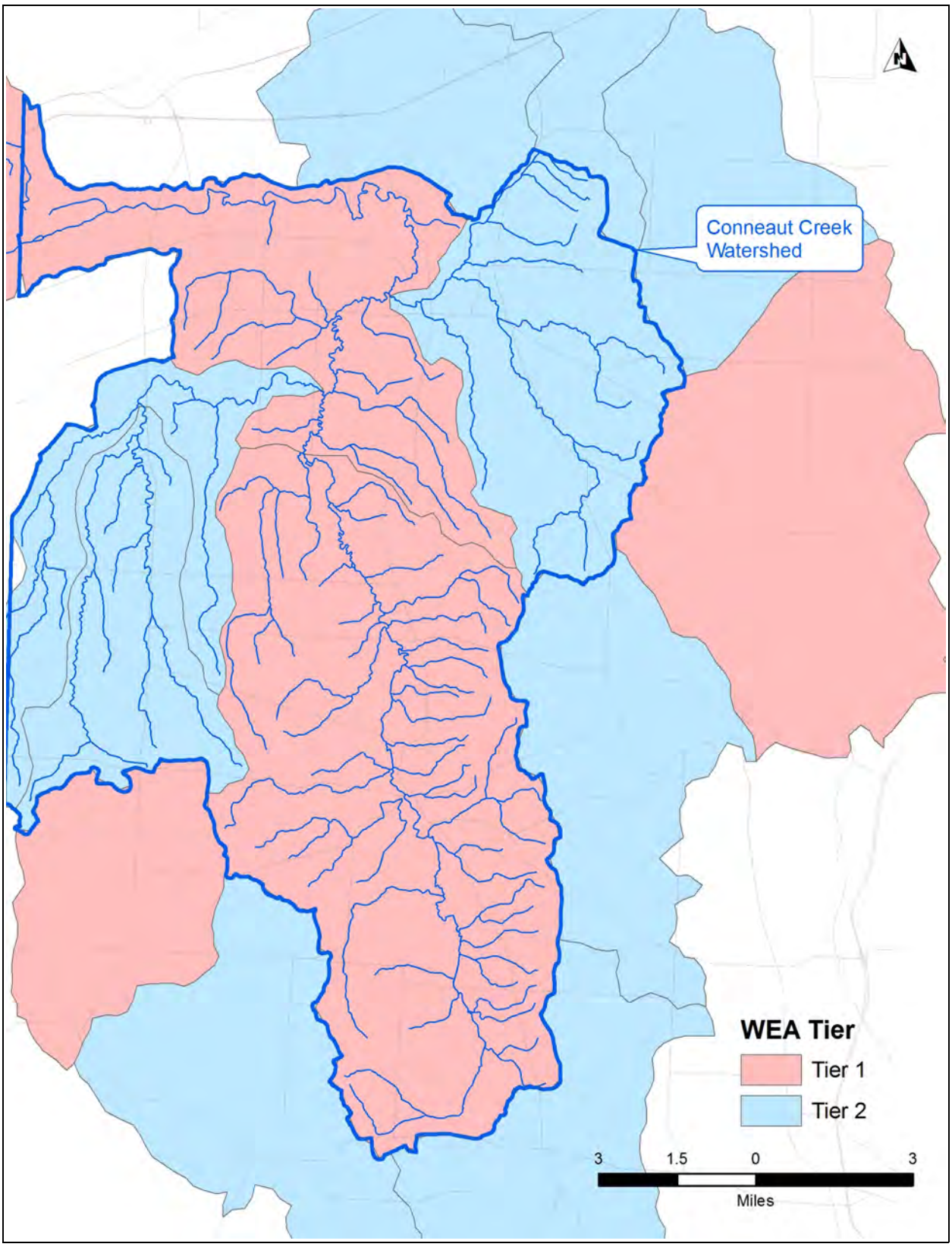
Pennsylvania Aquatic Community Assessment

The PNHP and WPC's recent Pennsylvania Aquatic Community Assessment program (Walsh et al. 2007) recently employed multivariate analysis methods to classify the watershed quality of streams throughout Pennsylvania, utilizing site-specific physical, chemical, and biological (fish, mussels, macroinvertebrates) data. The analysis defined the best 20 percent of the state's watersheds as "Conservation Watersheds," the worst 20 percent as "Restoration Watersheds," and the middle 60 percent as "Enhancement Watersheds." Enhancement Watersheds were further subdivided into two tiers, with "Tier 1" representing better water quality and watershed condition than "Tier 2." The Conneaut Creek watershed was classified as a Watershed Enhancement Area, with the entire main stem portion classified as Tier 1 (Figure 4.9), meaning it is likely in good condition, but with some threats that should be addressed. The East Branch and West Branch subwatersheds of Conneaut Creek were classified as Tier 2 (see Figure 4.9), meaning they are likely to have significant water quality and watershed condition issues and could greatly benefit from restoration activities.

These classifications were used as an organizing framework for general planning actions defined in the final chapter of this report. Specifically, the main stem subwatersheds (Tier 1) will be considered higher priority areas for future land protection actions, such as property acquisitions and conservation easements; and the East and West Branch subwatersheds (Tier 2) will be considered higher priority for general prescriptions of restorative actions, such as BMP installations.

Environmental Threats and Concerns

Perhaps the greatest threat to the water and natural resources of the Conneaut Creek watershed is climate change and consequent habitat degradation, including strain on populations of special concern species due to encroachment by invasive and pest organisms, such as the hemlock wooly adelgid (aphid) and Asian clam. The woolly adelgid is one of several biological threats to forest health in Pennsylvania (PADCNR 2009). Since first being identified in the southeast corner of the state in 1967, this insect has caused widespread mortality of hemlock


Conneaut Creek
Watershed
WEA Tier
Tier 1
Tier 2
3
1.5
0
3
Miles

trees, and has spread two-thirds of the way across the state toward Erie (PADCNR 2009). The pest is likely to advance across the entire northeast with climate warming in the future (Paradis et al. 2007). In the Conneaut Creek watershed, loss of protective cover and shade currently provided by eastern hemlock could exacerbate the elevation of stream temperatures associated with climate change, and challenge the persistence of temperature-sensitive fish and amphibians inhabiting riparian habitats. Fish species of special concern in the Conneaut Creek watershed that might be affected include the Northern brook lamprey, American brook lamprey, and Brook stickleback (see Table 4.2). The economically important steelhead fishery in Conneaut Creek could also be adversely affected by stream temperature increases due to climate change and hemlock decline due to wooly adelgid.

Populations of interior forest bird species have declined in other places where the wooly adelgid reduced hemlock cover; among the birds that have been negatively affected elsewhere in Pennsylvania is the Acadian flycatcher (Allen et al. 2009), an interior forest species common in the Conneaut Creek watershed (see Table 4.2). Hemlocks help keep streams cooler in summer, and prevent small ones from drying up (Ward et al. 2004). Since hemlock is the main conifer of mixed forests in the Conneaut Creek watershed, loss of this tree could adversely affect physical qualities of riparian and bottomland habitats supporting the special concern plant species of the Conneaut Creek watershed (see Table 4.2), such as Pineland pimpernel, Harbinger of spring, and Shumard's oak.

The Asian clam (*Corbicula fluminea*) is another invasive species that may present a greater threat to heritage resources of Conneaut Creek as a consequence of climate warming in the future. This non-native clam has been spreading through river systems in more southern portions of the United States for several decades, and is already established in the main stem portion of Conneaut Creek between the Pennsylvania–Ohio line and Albion (personal observations of J.M. Campbell). The potential negative effect of increasing populations of this clam on native freshwater mussel communities has been documented (Neves et al. 1997). Milder spring climate in northwestern Pennsylvania in the future could allow increased population growth of the Asian clam and present a serious threat to the survivorship of native freshwater mussels, which are known to be sensitive to ammonia released following Asian clam summer dieoffs (Scheller 1997, Weitere 2009).

Zebra mussels (*Dreissena polymorpha*) introduced to the Great Lakes have already contributed to a "catastrophic" decline of native mussels in the Great Lakes, and degradation of streams by pollution and destruction of riparian buffers have contributed to mussel declines in Great Lakes tributaries (Metcalfe-Smith et al. 1998). The *Corbicula fluminea*-climate change combination may exacerbate native mussel species losses in Conneaut Creek and other Great Lakes tributary streams in the near future. An apparent decline in native freshwater mussel community species richness in Conneaut Creek has been indicated by comparative analyses of modern field surveys and historical museum records (Weber and Campbell 2005, Krebs et al. 2010). These findings, coupled with the solid representation of Pennsylvania special concern freshwater mussel species in the northern main stem area of Conneaut Creek (see Table 4.2) underscore the importance of advancing immediate protective and restorative actions to try to maintain remaining populations.

Another concern in the Conneaut Creek watershed related to the invasive species issue is adverse effects of periodic applications by the U.S. Fish and Wildlife Service of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM), as part of the Great Lakes Fisheries Commission program for controlling populations of the invasive Sea lamprey. Since Conneaut Creek is a major spawning habitat for Sea lamprey in Lake Erie, TFM is periodically applied to the stream to kill the larval stage of the lamprey (PAFBC 2009), and die-offs of native fish and amphibians (especially mudpuppies) have occurred during these treatments (Grasman et al. 2000, Kuehner 2006). TFM also poses a potential threat to heritage resources of Conneaut Creek, since it has been determined that the chemical is toxic to freshwater mussels in tests using species that occur in Conneaut Creek (Boogaard et al. 2004).

Several other invasive animal species, besides the examples mentioned above, may also potentially threaten heritage resources of the Conneaut Creek watershed, independent of climate change influence. An excellent summary of potential invasive animal threats is found in the Crawford County Natural Heritage Inventory (PNHP 2008). For example, an invasive beetle named the Emerald ash borer, that attacks the various species of ash in Pennsylvania, has been detected in 17 different Pennsylvania counties (including Mercer County); and as of July 30, 2010, both Erie and Crawford Counties are under quarantine to restrict movement of potentially contaminated ash wood material (Pennsylvania Department of Agriculture 2010). This insect presents a distinct threat to Pumpkin ash, one of the plant species of special concern in the Conneaut Creek watershed (see Table 4.2).

Another major concern is water quality problems in Conneaut Creek due to non-point source pollution, especially nitrogen, phosphorus, pesticides, and mercury. The extensive area of the Conneaut Creek watershed still under active agricultural use indicates the possibility that nutrients and pesticides may enter the watershed's surface and ground waters , necessitating continued efforts by Conservation District and NRCS personnel to actively promote their educational and incentive programs to install BMPs and restore riparian areas and wetlands in the watershed.

Finally, pollutant releases from NPDES permitted discharges should be carefully monitored, especially if dry-weather base flow discharges of Conneaut Creek and its tributaries decrease in the future, consequent to climate change phenomena. In particular, the wastewater treatment plant (WTP) in Albion, Pennsylvania has a documented record of violations involving releases of ammonia, which is toxic to freshwater mussels. The WTP's location on the East Branch of Conneaut Creek, just above its confluence with the main stem section known to harbor native freshwater mussel species of special concern, indicates that corrective actions should be enacted with expedience.

5. Recreational Resources

Recreational opportunities exist throughout the Conneaut Creek watershed, and most of these opportunities highlight the natural resources in the basin. As the human population continues to expand, demands for recreational opportunities will increase. Opportunities must be developed that satisfy these demands at the same time providing protection for the natural resources that outdoor recreationalists potentially threaten. The quality of recreational opportunities in the Conneaut Creek watershed, as elsewhere, is inextricably linked to water quality, wildlife and plant quality, and overall environmental quality. The conservation of natural resources is therefore necessary to ensure quality recreational opportunities exist in the future.

As part of a Lake Erie Watershed Conservation Plan funded by the Pennsylvania Department of Conservation and Natural Resources (DCNR) in 2005, the Lake Erie Region Conservancy (LERC) conducted a survey of area residents that indicated a general satisfaction with the region's many and varied recreational opportunities. This speaks well of the accessibility and quality of the watershed's water and related land-based resources, but also underscores the importance that these natural resources be protected from unsustainable development and the pollution that accompanies it. Responses made by study area residents surveyed regarding outdoor recreational interests indicated the following as having the highest satisfaction ratings among those surveyed: picnicking (92%), motor boating (88%), swimming (87%), and fishing (86%). These were closely followed by non-motor boating, hunting, bicycling, and hiking in equal percentages (85%).

Activities showing somewhat lower but still favorable satisfaction ratings include wildlife viewing (81%) and bird watching (76%). The survey's favorable satisfaction ratings show a clear preference for water-based activities. This suggests that facilities for land-based recreation activities within the study area are considered at least somewhat inadequate.

The high satisfaction score recorded for fishing in the Lake Erie watershed is not exclusively lake-based and bears some relation to the study area's many excellent opportunities for stream fishing and its very successful Lake Erie tributary steehead fishery. The first and second largest sub-watersheds in the Pennsylvania Lake Erie watershed, Conneaut Creek and Elk Creek, respectively, also display an exceptional availability and diversity of recreational resources. While this may be an artifact of their exceptional size, their biotic diversity, and value, as well as the number and diversity of access points, nonetheless rank these sub-watersheds among the region's most valuable recreational resources. Of particular note is the very large number and total length of unpaved road surface in both sub-watersheds, as well as the extraordinary presence of two potential pedestrian and/or bicycle access routes that extend throughout the entire north-south extent of the Conneaut Creek watershed. These unpaved roads

and potential non-motorized thoroughfares offer excellent potential for low risk recreational access to some of region's most scenic and naturally rich areas.

Demand

Often, forms of outdoor recreation are not compatible with sustainability of the natural resources they utilize. It is the responsibility of planners, municipal leaders, and recreational organizations to ensure that activities in the Conneaut Creek watershed do not negatively impact the rich diversity and natural resources that draw tourism dollars into the region. Currently there is no promotion of the watershed as a tourism destination and it is difficult to predict any future promotion of the watershed. There is an abundance of recreational opportunities within the Conneaut Creek watershed that increase the quality of life for residents in the area. Should the population of Erie County continues to grow westward toward the Conneaut Creek watershed, demand for recreational opportunities will increase. If the natural resources that these recreational opportunities are centered around are not protected, recreational opportunities will decrease and quality of life will suffer.

There has been some interest in linking Conneaut Creek with other watersheds such as French Creek into a Water Trails Project under the Pennsylvania Fish and Boat Commission and the Pennsylvania DCNR. Under this program, minimal amenities would be provided at various locations throughout the watersheds for canoe and kayakers. An educational program would be part of this project. Paddlers would have the opportunity to learn about the resources of the watersheds and some of the threats to these resources through signage. Some examples of this educational signage have already been erected at various access points in the French Creek watershed through a cooperative project between the Western Pennsylvania Conservancy, the The Pennsylvania Environmental Council's French Creek Project, the U.S. Fish and Wildlife Service, and the Pennsylvania Department of Environmental Protection. This project has raised some concerns over the impacts to freshwater mussel habitat and other aquatic life if access points are located in sensitive areas or if boating traffic increases significantly on either creek.

Today, more and more people are turning to alternative forms of transportation for travel, recreation, and fitness. Specifically, walking and bicycling have grown in popularity throughout the region. This resurgence has led to increased interest in pedestrian and bicycle trails as well as greenways. These projects can benefit the individuals using them, the communities in which they are located or link together, and the environment through protection of open space and natural resource buffering. In response to this demand, several groups have begun planning trail and greenway development throughout the watershed. These projects range from preserved green space and walking trails to rail trails and designated on-road bicycle routes. Other forms of recreational transportation include all terrain vehicles (ATV) and snowmobiles. Presently, snowmobiling and ATV riding occurs on a few select public lands but largely both forms of recreational transportation are limited to private property. In particular, these motorized forms of off-road transportation can negatively the natural resources of the region when done irresponsibly. Statewide, efforts are being made to include designated areas where ATV riding and snowmobiling can occur with minimal environmental impact.

The biggest demand for recreational activities in the Conneaut Creek watershed have been and remain hunting and fishing, canoeing and kayaking.

Supply

The Conneaut Creek watershed offers outdoor enthusiasts a good supply of outdoor recreational amenities, although many activities are limited by the relative lack of public lands in the watershed. Water based outdoor recreational activities are restricted by the lack of access due to the overwhelming amount of privately owned land. There are however, some public amenities that offer access to Conneaut Creek, natural areas, wildlife refuges and hunting land (Figure 5.1).

Water-Based Recreation

The main stem of Conneaut Creek is navigable by canoe and kayak for most of its entire length from Conneauville, Pennsylvania, to its confluence with Lake Erie at Conneaut, Ohio, primarily when water levels are the highest. This is usually in spring, early summer, or late fall/early winter. Small boats have also been known to fish certain areas of the creek where several fish species are known to be such as bass, walleye, muskie and steelhead. Most fish have been stocked by local residents and members of fishing and sportsmen clubs and organization. Public access is however, very limited and not marked as such. This requires water recreationalists to explore on their own and risk trespassing on private land. Most access requires a fairly physical experience portaging up and down steep banks and parking difficulties along highway or requesting use of private lands.

Land-Based Recreation

Land-based recreation opportunities are very limited in the Conneaut Creek watershed due to the lack of public land. Pennsylvania State Game Land 101 is the only public land in the watershed and offers hunting for deer and small game. There has been recent interest in forming trails and greenways in the region linking to trails outside the watershed. One such trail in the Erie County portion would be along the Bessemer and Lake Erie Railroad from the Albion/Cranesville area to the Ohio State line Springfield, Pennsylvania, as suggested in the Erie County Department of Planning Trails and Greenway Plan.

Recreational and Scenic Ecotourism

Although there are many excellent opportunities to develop new recreation/ecotourism activities with stream associated educational/scenic tours within the Conneaut Creek watershed, it is evident from all of our interaction with residents in the basin that this would not be welcomed by most. There is a very strong sentiment for privacy and private-property rights. Most who recreate in the area live in the area, are relatives and/or friends of those who live in the area, or have received special permission from land owners to carry out their activities such as canoeing, kayaking, or fishing. It should be noted that over the past several years the presence of bald eagles has increased significantly after being extinct in the region and several nests are

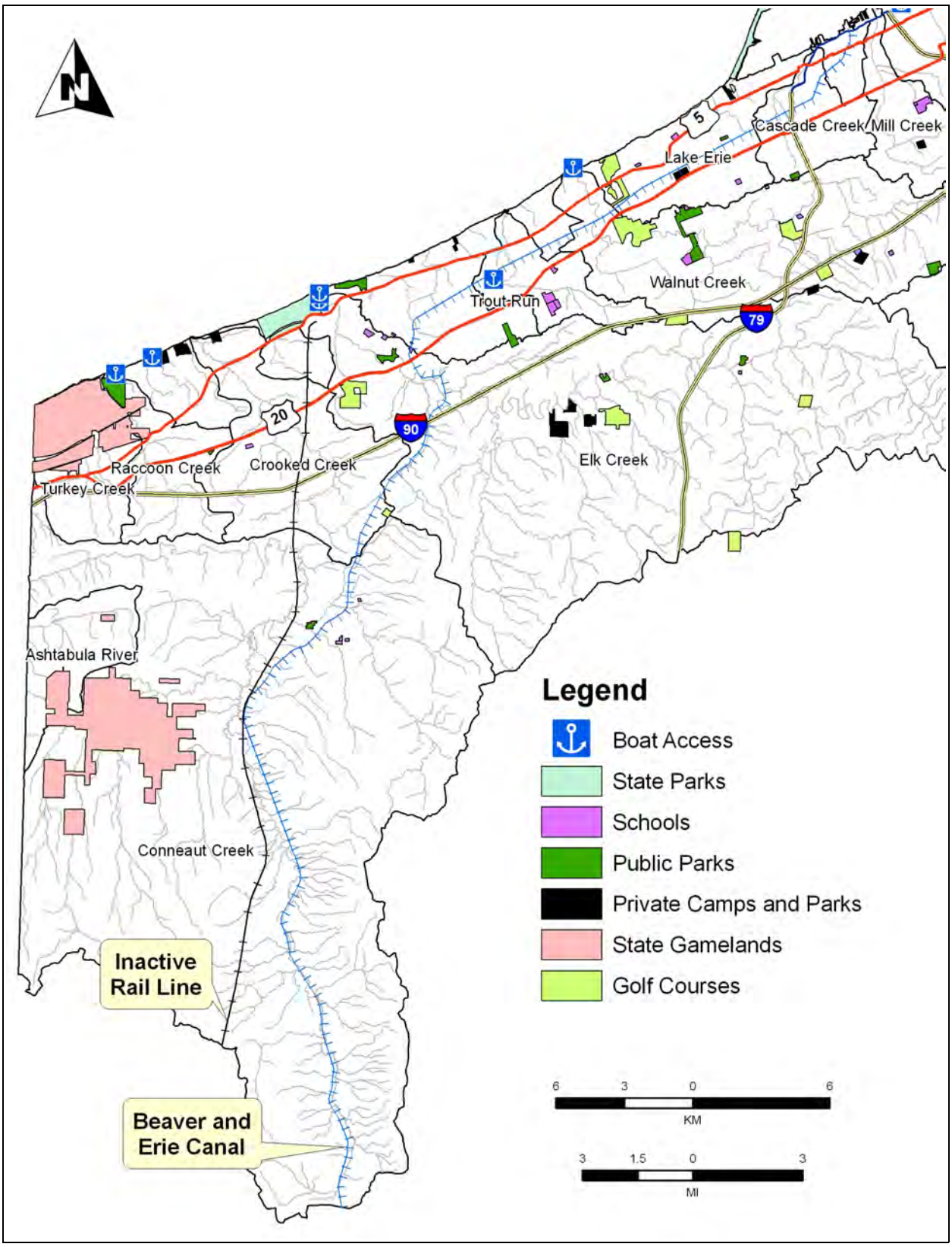


Figure 5.1 Recreational opportunities in the greater Conneaut Creek watershed.

located within a few mile from the Conneaut Creek watershed. Sightings are frequent in the watershed and birding enthusiasts are becoming more aware of the presence of the eagles.

In the early stages of this Conneaut Creek Watershed Plan, we were able to contact stakeholders that we knew and worked with in the past. This enabled us to get a sense of place, interests, and emotions of those that have lived there in some cases for several generations. But it also gave us an inside look at properties that local residents did not own but would like to see protected. This has led to several discussions about conservation easements and other land protection techniques with several land owners. It has also led to some very meaningful negotiations about purchases with large property owners such as the railroads. One such property is a 1,200 acre tract of open space on the north side of Interstate 90 in Ohio and Pennsylvania that is owned by the Canadian National Railroad. Although only a portion of this property is located in the Conneaut Creek watershed, discussions are taking place with several major conservation organizations about this acquisition being the lynchpin for connecting existing public lands, such as Game Land 101, Game Land 314, and Erie Bluffs State Park. Such acquisitions would satisfy growing recreational needs while protecting the most pristine and abundant natural areas in northwestern Pennsylvania and northeastern Ohio.

6. Conservation Action Plan

For purposes of defining the final recommendations of this conservation plan, the Pennsylvania portion of the Conneaut Creek watershed has been divided into four planning areas (Figure 6.1), conforming to the subdivision recommended by the Pennsylvania Aquatic Community Classification program (Walsh et al. 2007) and the shared resource characteristics indicated by the distribution of natural heritage resources, as summarized in Table 4.2. Priority projects and recommendations for implementation will be briefly described herein for each planning area, followed by general prescriptions.

Recommendations and Implementation Schedule for Planning Areas

Northern Main Stem Planning Area

The Northern Main Stem area contained the richest diversity of special concern species, known cultural resources, and already realized recreational opportunities. Its position immediately adjacent to the designated Wild and Scenic River segment in Ohio makes this area a lynchpin for conservation actions to enhance watershed protection restoration activities already underway immediately downstream. This area also merits special consideration because of its strategic location relative to large forested tracts near the Pennsylvania-Ohio boundary (Game

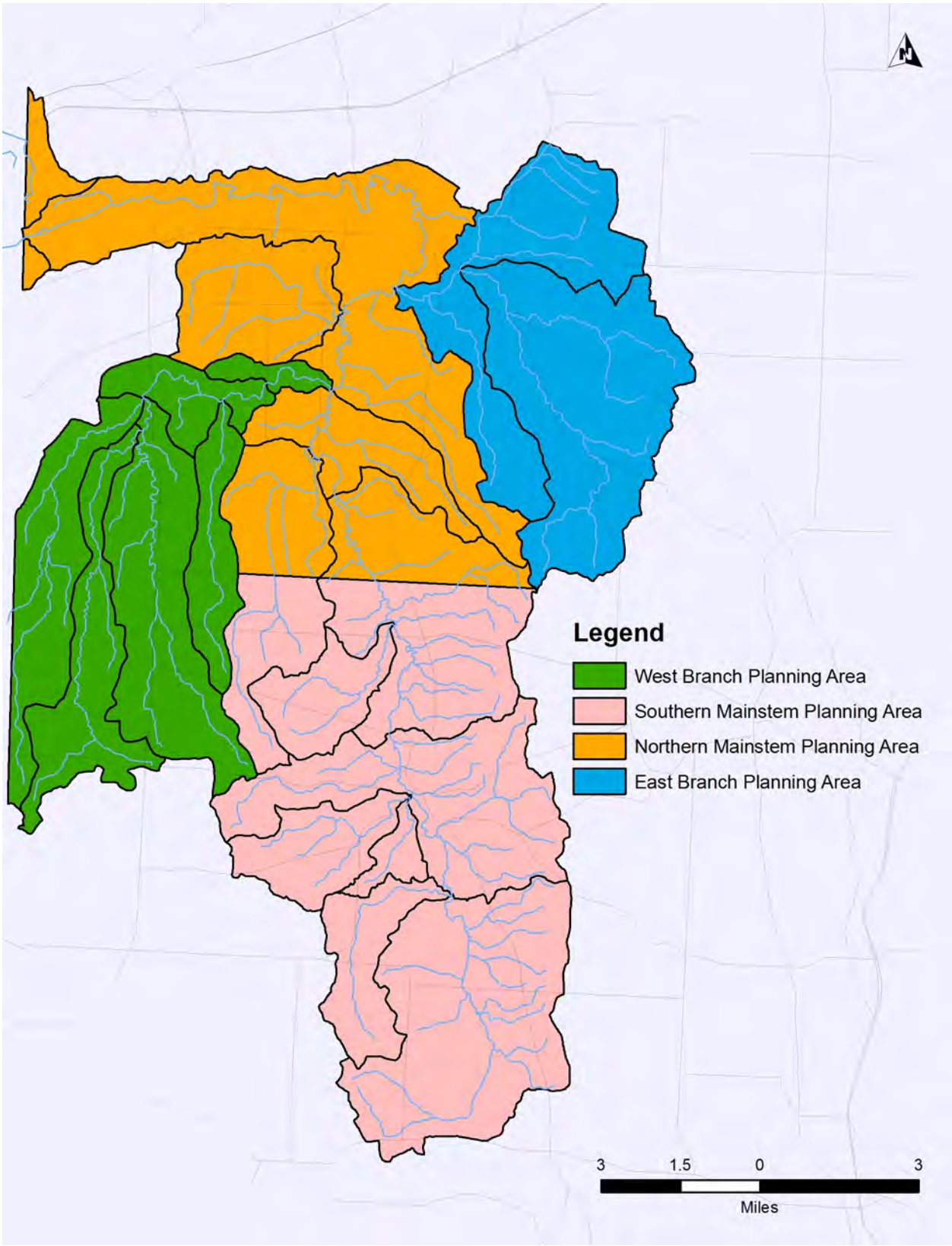


Figure 6.1. The Conneaut Creek watershed planning areas.

Lands 101 and 314), defining the northern and southern ends of a potential core forest corridor (see Figure 4.7), that would be a unique resource of significance in the larger Lake Erie basin.

A three-phased approach to identifying and prioritizing candidate conservation project sites was utilized within this area. In Phase 1, digitized records of properties and shape files obtained from Erie County were used to map parcels >50 acres in relation to stream channels within the Northern Main Stem area. The subset of >50 acre parcels closely associated with stream channels were then further screened using aerial photography and additional GIS-mappable natural resource data, including major plant community types (Myers and Bishop 1999) and wetlands (digitized NWI data: US- FWS 1981). The initial pool was narrowed to sites found to be closely associated with: (1) core forest at least 300 acres in size, (2) forested wetlands, (3) emergent wetlands and channel marsh habitats, (4) wetland complexes associated with open water and core forest, and (5) riparian and upland forests with significant natural conifer elements. The Rivers Conservation Plan (LERC 2008) had identified these specific habitats as having critical importance for federal and state "species of special concern" known to occur within the Pennsylvania Lake Erie watershed, and for serving other important ecosystem functions related to water resource protection.

In Phase 2 of project site identification, address and owner information obtained from county assessment records for the narrowed pool of parcels was used to attempt to contact property owners and determine their willingness to participate in future conservation and restoration activities in the watershed. Due to generally poor accessibility of candidate sites discovered during the "owner contact" process, additional candidate properties were also identified during Phase 2 by an informal process involving conversations with a diverse selection of stakeholders knowledgeable about the watershed and its people (including, but not limited to, private property owners in the Northern Main Stem area and personnel of state, county, and federal agencies. This "informal" phase 2 methodology was found to be more practical and effective than the systematic methodology originally proposed. Phase 3 consisted of on-site examination of candidate sites, where feasible, and re-evaluation of sites by project archaeologists and biologists, the findings of natural heritage, cultural, and recreational resource information detailed in Chapters 3, 4, and 5 of this report. Criteria used to prioritize candidate properties for final recommendations included the amount of "frontage" along the main stem of the stream, potential for site to have recreational value or cultural resources, whether the site would provide access to the stream from public roads, potential for the site to contribute to "interior forest" restoration, and type of resources on adjoining property. A number of actions were also taken during Phase 3 to begin the process of securing protection for one particularly important site discovered during Phase 2 in the Northern Main Stem area (i.e., the Canadian National Railroad property).

Figure 6.2 shows the locations of properties finally selected for advancing conservation and protection actions during the Phase 3 analysis, and selected details about the sites are found in Table 6.1. The 1200-acre Canadian Railroad property is included among the properties identified as "high" priority for future conservation actions, based upon its key location between Game Lands 314 and 101 in the proposed core forest restoration corridor. Some progress has already been made in forming a partnership among the conservation organizations identified in

Table 6.1. Summary of projects proposed for advancement within the Northern Main Stem planning area of the Conneaut Creek watershed.

Description	Natural Resources	Actions	Possible Partners
Canadian Railroad Property	Large tract with rich diversity of forests and wetlands at key location to restore interior forest	Protection via acquisition and restoration of forests and degraded areas	The Nature Conservancy, Western Pennsylvania Conservancy, Pennsylvania Game Commission, LERC
Main Stem Access and Core Forest Corridor Parcels: 1, 4, and 12, and 13	Properties in or near proposed core forest corridor and possibly providing fishing access to stream	High priority for protection actions (acquisition or easements)	PFBC, DCNR, LERC
Marsh Run and Ashtabula Creek Headwaters Forest and Wetland Restoration Area: Parcels 6 and 7	Properties adjacent to already protected area (isolated section of Game Land 101)	Restoration actions to restore forests and wetlands, BMPs	Pennsylvania Game Commission, Erie County Conservation District, NRCS
Main Stem Big Bend Wetland Complex Cluster: Parcels 19-22	Properties under single ownership with extensive wetlands associated with stream	Protection and/or restoration actions	Pennsylvania Game Commission, PFBC, DCNR, LERC
West Albion Restoration Cluster: Parcels 15, 16, 17, 25, and 26	Properties with opportunities to protect and restore forests and riparian areas of headwaters and main stem	Protection via easements (parcels 17 and 26), and restoration of forests and riparian areas, BMPs	PFBC, Erie County Conservation District, NRCS

Table 6.1 to advance this project, and talks with the property owner have been promising. The Lake Erie Region Conservancy's initial exploration of the Canadian Railroad lands during the summer of 2008 also lead to a new record of a Pennsylvania Special Concern plant (i.e., Pumpkin ash) in the Pennsylvania Natural Heritage database.

Other high priority sites for protection actions within the Northern Main Stem area included parcels (numbered 1, 4, and 12 in Figure 6.2) adjoining the main stem within the core forest restoration corridor south of the Canadian Railroad property; these parcels also merited higher priority because they could provide access to the creek, and fit the profile of sites likely to contain cultural resources. The other high priority project sites identified in Table 6.1 for the Northern Main Stem planning area would advance conservation actions that highlight wetland

resources (parcel cluster 19-22 in Figure 6.2). If all of the "high priority" projects suggested here for the Northern Main Stem area can be carried out, the collective conservation impact would exceed 2,000 acres of land and approximately 5 mi of stream. The actions will also benefit over a dozen different Special Concern species, including several Pennsylvania Endangered fish, mussels, and plants known to occur in the Northern Main Stem area. The Lake Erie Region Conservancy has set a goal to work with partners to advance discussions with all of the "high priority" site owners during 2011, and establish firm action plans for these properties by the end of 2012.

Southern Main Stem Planning Area

The guidance for suggesting specific project sites for conservation actions in this area was obtained from the recently completed Crawford County Natural Heritage Inventory (PNHP 2008). The recent and thorough completion of this document, which included detailed, site-specific examination of the Crawford County portions of the Conneaut Creek watershed, constitute a basis for decision-making superior to what we would have been able to accomplish. Table 6.2 identifies the priority actions recommended for this portion of the watershed. These projects would enact conservation measures on approximately 4 mi of stream and will help maintain and improve unique habitats containing three Pennsylvania Special Concern species (one plant and two fish). Detailed conservation prescriptions for these sites are available in the inventory document (PNHP 2008), and will not be duplicated here. The Lake Erie Region Conservancy plans to initiate discussions with conservation partners identified in Table 6.2 regarding these projects in 2011, following dissemination of this plan.

Table 6.2. Summary of projects proposed for advancement within the Southern Main Stem planning area of the Conneaut Creek watershed.

Description	Natural Resources	Actions	Possible Partners
Springboro South BDA	Floodplain forest with PA Special Concern wildflower (PNHP 2008:191)	Property owner education, BMPs, possible easement protection	The Nature Conservancy, Western Pennsylvania Conservancy, Pennsylvania Game Commission, LERC, Crawford County Conservation District, NRCS, WPC, LERC
Dicksonburg BDA	Stream and adjoining riparian areas with two PA Special Concern fishes (PNHP 2008:203)	BMPs, preserve and restore forested riparian buffers, possible easement protection	Crawford County Conservation District, NRCS, WPC, LERC

East Branch Planning Area

The conservation projects identified in Table 6.3 for the East Branch planning area focus generally on restoration activities, consistent with the recommendations of the Pennsylvania Aquatic Community Assessment program (Walsh et al. 2007). The key starting point for conservation actions in the East Branch subwatershed of Conneaut Creek will be the removal of the old Erie-Bessemer Railroad dam on Temple Creek in Albion, at a "steelhead fishing hotspot." Removing the dam will facilitate fish passage to upstream reaches of Temple Creek. The Pennsylvania Fish and Boat Commission, in partnership with the Albion Sportsmens' Club, has already advanced planning on this project with a funding request to the U.S. Army Corps of Engineers Great Lakes Fishery and Ecosystem Restoration Program (GLFER). The dam removal project is scheduled for 2013.

Most of the other projects suggested for the East Branch planning area (Table 6.3) were prompted by the opportunity affording by improved fishing resources that will follow dam removal. The riparian restoration work along Temple Creek above the dam would affect over three miles of stream, and would improve access for fishermen. LERC will discuss these projects with the partners identified in Table 6.3 following dissemination of this plan, and facilitate establishment of a timetable for carrying out these projects, to commence following dam removal in 2013.

The Temple Creek Headwaters Riparian Forest and Wetlands Restoration project identified in Table 6.3 was prompted by the Crawford County Natural Heritage Inventory (PNHP 2008) "Pont Road Wetlands BDA" (PNHP 2008:192). This project, located at the boundary between the Conneaut and French Creek watersheds, would benefit a single Pennsylvania Special Concern plant species. The inventory document contains a detailed conservation prescription for this site.

West Branch Planning Area

Like the East Branch, conservation projects identified in Table 6.4 for the West Branch planning area focus generally on restoration activities, consistent with the recommendations of the Pennsylvania Aquatic Community Assessment program. All of the projects suggested for the West Branch subwatershed are based on the Crawford County Natural Heritage Inventory (PNHP 2008). Detailed conservation prescriptions for each of these sites are available in the inventory document (PNHP 2008), and will not be duplicated herein. If enacted, these projects would impact several thousand acres of land, including major portions of Game Land 101, about 5 mi of West Branch tributary streams, and benefit a total of 7 Pennsylvania Special Concern plant and fish species. The conservation work in the West Branch also enhances the proposed "core forest" restoration effort being advanced in the Northern Main Stem planning area. LERC will suggest to planning partners listed in Table 6.4 that steps be taken to initiate these projects in 2011-2012.

Table 6.3. Summary of projects proposed for advancement within the East Branch planning area of the Conneaut Creek watershed.

Description	Natural Resources	Actions	Possible Partners
Bessemer Dam Removal	Remove old railroad dam to restore fish passage to Temple Creek	Funding assistance pending from US Army Corps of Engineers GLFER program	PFBC, Albion Sportsmens Club
Temple Creek Access	Riparian areas adjacent to stream and associated habitats	High priority for protection actions (acquisition or easements) Restoration of eroded areas, development of trails and parking areas, fishing access easements	PFBC, Albion Sportsmens Club, Erie County Conservation District, LERC
Pont Road Temple Creek Riparian Restoration Corridor	Riparian areas adjacent to stream and associated habitats	Restoration actions to restore forests and wetlands, BMPs, Restoration of forested buffers, possible fishing access easements	PFBC, Albion Sportsmens Club, Erie County Conservation District, NRCS, LERC
Reservoir Road Old Growth Hemlock Ravine Restoration Corridor	Old growth hemlock-beech forest surrounding stream along Reservoir Road	Trash removal, planning to manage hemlock wooly adelgid, educational program	Northwestern School District, Albion Borough, Mercyhurst College, LERC
Temple Creek Headwaters Riparian Forest and Wetlands Restoration Area	Properties with opportunities to protect and restore forests and riparian areas of headwaters and main stem habitats adjacent to Temple Creek headwater stream and wetland with PA Special Concern plant (PNHP 2008:192)	Restore wetlands and forests in agricultural areas, BMPs	Crawford County Conservation District, NRCS, LERC

Table 6.4. Summary of projects proposed for advancement within the West Branch planning area of the Conneaut Creek watershed.

Description	Natural Resources	Actions	Possible Partners
West Branch BDA	Rich diversity of forested, wetland, and stream riparian habitats with four PA Special Concern Plants and one Special Concern fish (PNHP 2008:69-71)	Restore forests and wetlands to expand interior forest already protected by Gameland 101, possible easement and acquisition protection, BMPs	Erie and Crawford County Conservation Districts, NRCS, PA Game Commission, PFBC, The Nature Conservancy, WPC, LERC, DCNR
Mud Run Wetland BDA	Wetlands in successional woodland and shrublands within valley of Mud Run and partly within Gameland 101, with one PA Special Concern plant species (PNHP 2008:68)	Restore altered hydrology and forests, manage invasive plant species, BMPs	Crawford County Conservation District, PA Game Commission, NRCS, WPC
East Branch of West Branch Headwaters BDA	Forested headwaters and wetlands of East Branch of West Branch of Conneaut Creek, with one PA Special Concern plant species (PNHP 2008:67)	Maintain and restore forest in areas surrounding wetlands, BMPs, avoid disturbances that would create edge habitat or create opportunities for invasive plants	Crawford County Conservation District, NRCS, WPC

Cultural Resource Recommendations

Prehistoric sites are most commonly located near more or less permanent sources of water (e.g.,. streams, springs, marshes, etc.), while later historic sites can be expected to be found along (or in close proximity to) historic roads, trails, and paths. Archaeological sites from all time periods tend to be located on level or low-slope settings (especially higher floodplain terraces) characterized by well-drained soils. The Conneaut Creek watershed is remarkable for its decided dearth of registered archaeological localities; however, interviews with the region's avocational archaeologists and artifact collectors have revealed a rich archaeological heritage for the watershed. Educational outreach is recommended, as it would doubtlessly benefit the

archaeological understanding of the region for professional, avocationalist, and resident alike. The avocational archaeologists operating in the watershed, for example, have a very strong interest in site associated with the earliest prehistoric culture groups of the Paleoindian period. Such Paleoindian sites *are* represented and recorded in the adjacent French Creek drainage—especially around Conneaut Lake and the Pymantuning Reservoir—and are most frequently associated with glacial features such as Pleistocene lakes, strandlines, wetlands, outwash plains, moraines, and kame terraces. An investigation for such sites within similar topographic and geologic settings in the Conneaut Creek watershed would probably serve as an excellent educational outreach theme.

Aside from—or, perhaps, in tandem with—such efforts, the tangible first step in protecting the watershed's cultural resources would be the development an archaeological predictive model to better understand and refine where potentially significant archaeological localities might be found. Although the development of such a model is well beyond the scope of this document, the archaeological and historical background provided in the document provides an excellent culture-historical context for the formulation of such a model. The only sure way to obtain information on the distribution of cultural resources within the watershed would be to have professional archaeologists develop a model and survey/sample the area.

Recreational Resource Recommendations

In order to protect the natural integrity of the Conneaut Creek watershed it is recommended that little if any promotion of the area's recreational opportunities take place. This recommendation is based on the remoteness of the creeks and lack of public access to Conneaut Creek and its tributaries. It is also based on the wishes of most property owners along the streams and their rights as property owners. The increasing activity of the steelhead fishery has already increased the human pressure on the watershed and this phenomenon is expected to have a steady growth as word of mouth alone will fuel this activity.

It is recommended, however, that the interests and discussions mentioned in the Chapter 5 of this plan under Demand be pursued; a cooperative project with watershed stakeholders that would provide minimal amenities and contain a strong educational component. Currently, only the local residents and the hardy and ardent outdoor enthusiasts of the region know of the watersheds abundant natural resources and the longer this awareness can be maintained the longer they can be preserved.

It is further recommended that some effort be put forth to contact a few property owner's about possible use of their land to facilitate parking for stream activities. This would only be for one or two vehicles near stream access points that already exist, mostly near bridges. The purpose would be as much for access as for safety concerns connected to parking along roads.

Headwaters Protection

Besides continuing the advancement of BMPs (e.g., PADEP 2000) as part of restoration efforts proposed in Tables 6.1-6.4, under the leadership of Conservation Districts and NRCS, additional planning efforts are recommended to protect the headwaters of Conneaut Creek and its tributaries. Campbell's (2005) extensive study of streams in the Pennsylvania Lake Erie watershed, including Conneaut Creek (summarized in LERC [2008]), highlighted the functional importance of headwaters tributaries for maintaining water quality. Campbell (2005) had demonstrated that: (1) small streams may collectively hold greater ecosystem diversity than the larger channel systems that they "feed," (2) small tributaries produce biologically diverse invertebrate communities that rival large streams, and (3) small streams contain some unique species of invertebrates not found in larger channels. Aquatic ecologists have known for more than two decades that headwaters streams are critical "primary functional units" of the larger systems they connect to, having major roles in organic matter (food) processing (Merritt and Cummins 1996; Vannote et al. 1980) and nutrient cycling. A nationwide study by Peterson et al. (2001) reported that small streams are more effective than larger ones in removing excess nitrogen (originating in fertilizer runoff and atmosphere) from receiving waters. Small streams have recently been found to serve important groundwater recharge functions (Conrad et al. 2004; Goodrich et al. 2003; Izbicki 2007; Meyer et al. 2007). Scientists and various agencies are now advocating that more vigorous protection of these habitats is critical for securing water supplies (Cohen 1997a, 1997b; Lowe and Likens 2005; Meyer et al. 2007; Sierra Club 2006).

Appropriate actions to protect the headwaters of Conneaut Creek could include a concerted effort to encourage farmers to install or enlarge forested buffers in small drainage-ways currently subject to livestock grazing or cultivation. Careful management of timber removal operations in areas containing small streams should also be promoted. Properties containing streams passing through hilly terrain where erosion problems occur should be identified so landowners may be provided information about funding and technical assistance available through a variety of state and federal programs..

Conservation Actions to Contend with Climate Change and Invasive Species

Maintaining and increasing the amount of intact forests in the Conneaut Creek watershed is a prudent action to counter the impending effects of climate change on our cold water fisheries (Johnson et al. 2003). In particular, forested tracts which contain significant stands of evergreen (coniferous) and mixed (evergreen and deciduous) forest adjacent to wetlands and streams should be very carefully managed to minimize loss of protective shade, which helps maintain cool temperatures necessary to support cold water fishes. The Pennsylvania Game Commission had identified protection and conservation of coniferous forests as a top priority in its Comprehensive Wildlife Conservation Strategy (PGC 2005). It is strongly recommended that conservation partners in northwestern Pennsylvania and Ohio consider developing action plans to deal pre-emptively with the hemlock wooly adelgid threat approaching from the east (exemplary measures identified in PADCNR 2009 and Ward et al. 2004).

The immediate threat to native mussels of Conneaut Creek posed by the presence of the Asian clam (see details in "Environmental Threats and Concerns" in Chapter 5), likely to be

exacerbated by climate change, suggests another item for interstate and private/public agency partnered planning—perhaps to initiate a monitoring program aimed at determining locations where invasive clam and freshwater mussel communities are likely to interact. That same partnership should simultaneously address the serious questions and issues regarding the use of TFM to control Sea lamprey populations in Conneaut Creek. A coordinated effort to address managing all three of these invasive species issues would seem to be supportable by grant funds that are now becoming available for conservation planning and actions that address climate change and invasive species issues

Dissemination Plan

Electronic copies of the final document will be sent to *all* of the "stakeholders" and hard copies will be delivered to the "key" future planning partners for implementation (WPC, TNC, Pennsylvania SeaGrant, DCNR, PFBC, and PGC). LERC is already engaged in discussions with several of these organizations, regarding the Canadian Railroad property project, and those discussions will continue.

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