

Land & Biological Resources

The Brodhead watershed consists primarily of small communities, rural areas, farmland, and forests, with pockets of urbanization found mostly in the southern part of the watershed, in Stroudsburg and East Stroudsburg Boroughs and Smithfield and Stroud Townships. The dominant land cover in the watershed is forest, at 84 percent. Deciduous forest is the most common type, at 67 percent, or 122,384 acres. Mixed forest covers over 10 percent of the watershed, or 18,982 acres. Evergreen forest covers nearly 7 percent of the watershed, or about 12,355 acres. Residential use accounts for 3.7 percent of the land use in the watershed, or 6,771 acres.

Soil Characteristics

Soils Types

Like geology, soils play an important role in determining stream chemistry, and are also important for development and land planning purposes. Properties such as thickness, texture, and moisture capacity make some soil associations better suited to certain uses, such as agriculture or development, than others. The Brodhead Creek and its tributaries flow through eight major soil associations. These include the Lackawanna-Wellsboro-Oquaga, Wurtsboro-Swartswood-Volusia, Clymer-Buchanan, Wellsboro-Morris-Lackawanna, Lordstown-Oquaga, Mardin-Bath-Volusia, Benson-Rock outcrop, and the Wyoming-Chenango-Pope.

The northwest portion of the watershed consists almost entirely of deep soils formed in glacial till, such as the Lackawanna-Wellsboro-Oquaga, Wurtsboro-Swartswood-Volusia, Clymer-Buchanan, and Wellsboro-Morris-Lackawanna Associations. It also contains pockets of moderately deep soils formed in glacial till: the Lordstown-Oquaga Association. An area extending from Stroudsburg west to the Brodheadsville area also consists of moderately deep soils formed in glacial till; the Mardin-Bath-Volusia Association.

Across the southern boundary of the watershed lies the steep, shallow, well-drained soils and areas of rock outcrop underlain by shale, slate, sandstone and quartzite of the Benson-Rock outcrop. Lastly, in a dendritic pattern throughout the watershed, mostly following the low-lying stream corridors, is the Wyoming-Chenango-Pope Association.

Limitations

Lackawanna-Wellsboro-Oquaga Association – This soil association is the most common association in the watershed and is found in the central to northwest part of the watershed. The soils are mainly level to sloping, but some moderately steep slope soils are found on knolls and in stream valleys. Lackawanna soils are well drained but have a slowly permeable fragipan. (A fragipan is a brittle subsurface layer that appears cemented and restricts roots.) Wellsboro soils are moderately well drained and have a

seasonal high water table during wet periods. Oquaga soils are moderately deep and well drained. Except where cleared, these soils are too stony for cultivation and are better suited to woodland, wildlife habitat, and recreation. The major limitations in addition to stoniness are the slow permeability, the seasonal high water table, and the moderate depth to bedrock.

Wurtsboro-Swartswood-Volusia Association – This soil association is also found throughout the northwest portion of the watershed, and is similar to the Lackawanna-Wellsboro-Oquaga Association. Wurtsboro soils are moderately well drained and have a seasonal high water table during wet periods. Swartswood soils are well drained but have a slowly permeable fragipan. Volusia soils are somewhat poorly drained and have a seasonal high water table during wet periods. The major limitations in addition to stoniness are the slow permeability and the seasonal high water table.

Clymer-Buchanan Association – This soil association is found in a limited area to the west of Pocono Creek, south of Tannersville. Clymer soils are well drained, while Buchanan soils are moderately well drained or somewhat poorly drained and have a seasonal high water table during wet periods. The major limitations in addition to stoniness are the seasonal high water table in the Buchanan soils.

Wellsboro-Morris-Lackawanna Association – This soil association is also found in a limited area, straddling the border of Pocono and Stroud Townships. Wellsboro soils are moderately well drained and have a seasonal high water table. Morris soils are somewhat poorly drained and have a seasonal high water table during wet periods. Lackawanna soils are well drained and have a slowly permeable fragipan. The major limitations in addition to stoniness are the slow permeability and the seasonal high water table.

Lordstown-Oquaga Association – This soil association is found throughout the upper watershed on ridges and uplands of the plateau. The soils are mainly sloping to very steep, but some soils on the ridgetops are nearly level. Lordstown soils are yellowish brown, are moderately deep to bedrock, and are well drained. Oquaga soils are reddish brown, are moderately deep to bedrock, and are also well drained. These soils have low to moderate available water capacity and crop yields decrease during dry periods. The major limitations in addition to stoniness are the moderate depth to bedrock and the slope.

Mardin-Bath-Volusia Association – This soil association extends in a broad swath from Stroudsburg east to near Brodheadsville. Mardin soils are moderately well drained and have a seasonal high water table. Bath soils are well drained but have a slowly permeable fragipan. Volusia soils are somewhat poorly drained and have a seasonal high water table. The major limitations in addition to stoniness are the slow permeability and the seasonal high water table.

Benson-Rock outcrop Association – This soil unit extends along the southern edge of the watershed; its steep slopes form the watershed boundary to the south. It consists of moderately steep to very steep bedrock ridges. The soils are mainly steep and hilly, but

some rolling and nearly level soils can be found on ridgetops. Benson soils are shallow and well drained. This association is poorly suited to most crops grown in the region because of surface stones, rock ledges, and shallow depth to bedrock. Slope is also a major limitation.

Wyoming-Chenango-Pope Association – This soil association can be found along valley bottoms in the watershed. All of these soils are deep and well drained. Most of this unit has been cleared and is used for agriculture. The major limitations for these soils are the rapid permeability and flooding.

Of particular concern for this watershed plan is the fact that most of the watershed has severe limitations for conventional, in-ground septic tank absorption fields. (See the map of *Septic Tank Absorption Limitations*¹⁷.) Only a small percentage of the soils in the watershed are classified as having moderate or slight limitations for septic tank absorption capacities. Thus, many homes in the rural areas of the watershed use alternative systems such as sand mounds for wastewater treatment. Given these limitations and the widespread use of sand mound systems throughout the watershed, it is critical that these systems are monitored and maintained in proper working order. To that end, the Action Plan recommends that municipalities establish sewage management programs to assure that on-lot systems are properly monitored and maintained.

This plan also encourages the exploration of other alternative systems for wastewater treatment which would offer improvements over the prevalent methodology. One such alternative system is land application of treated sewage and industrial wastewater. The map of *Soil Suitability for Land Application of Treated Wastewater*¹⁸ shows where in the watershed soils that are suitable for land application are located. Suitable soils were chosen according to their ranking in a table of suitable soils found in the *Manual for Land Application of Treated Sewage and Industrial Wastewater*, PA DEP, 1981. Soils are represented on the map in three categories:

- “Most Suitable” soils are those with a maximum application rate of 1.5”-2.0” per week. These soils are well drained (wooded or open). Their irrigation season is approximately March to December.
- “Suitable” soils are those with a maximum application rate of 1”-1.5” per week. These soils are shallow well drained to moderately well drained (wooded or open). Their irrigation season is approximately March to December.
- “Less Suitable” soils are those with a maximum application rate of 0.5” per week. They are somewhat poorly drained and have an irrigation season of approximately May to September.

¹⁷ Map was produced using readily available information for Monroe County. Additional information is required to complete this map for the portion of the watershed falling within Greene Township, Pike County.

¹⁸ Ibid.

“Not Suitable” soils are those that are poorly drained or slopes in excess of 15 percent.

Little use has been made of these systems in the Brodhead watershed to date. However, one notable example of a spray irrigation system in the watershed is that operated by Spruce Lake Retreat, in Barrett Township, at the headwaters of the Brodhead Creek.

This spray irrigation wastewater system sprays into three forested zones comprising a total of five acres. The permitted volume for 2001 was 494,000 gallons per month for the months of March through November. However, the actual volume sprayed during the 2001 nine-month permitted period was 228,000 gallons per month, on average.

Another system, located on the watershed boundary, is operated by Pleasant Valley School District at their Middle School in Brodheadsville.

An interesting nearby project is that of the Pike County Business Center, located in Blooming Grove Township, a 615-acre business park with a projected sewage flow of 10,000 gallons per day. Sewage will be collected from each site, treated, and returned to be recycled as flush water for toilets and urinals. The remaining 20% will be discharged to a spray irrigation field.

Land Ownership

About 16,100 acres of land, or 8.7% of the Brodhead watershed, are publicly owned, including state lands, county lands, and municipal lands. Private protected lands, including private conservation lands, homeowners' association lands, and purchased agricultural easements, total about 3,375 acres, or about 1.8% of the watershed. Quasi-protected lands, or lands indicating a conservation interest, include agricultural security areas and Pennsylvania Act 319 lands. These lands total about 99,300 acres, or 54% of the watershed.

State Lands

There are about 15,000 acres of state-owned land in the watershed, including state forests, gamelands, and Big Pocono State Park.

- *Delaware State Forest* – 8,638 acres of this 80,000-acre state forest are in Monroe County; about 6,630 acres fall within the Brodhead watershed.
- *State Gamelands* – About 6,000 acres of land in the Brodhead Watershed is owned by the Pennsylvania Game Commission. State Gamelands # 38 and State Game Lands #182 are both found in Pocono Township.
- *Big Pocono State Park/Camelback Mountain* – This park consists of 1,306 acres of rugged terrain on the summit and the ski slopes of Camelback Mountain.

County Lands

There are about 400 acres of county-owned land in the watershed.

- *Kettle Creek Wildlife Sanctuary* - Owned by Monroe County and located in Hamilton and Jackson townships, this 120-acre site contains the offices of the Monroe County Conservation District and the District's Environmental Education Center and grounds dedicated to environmental study and the enjoyment of nature.
- *Meesing Nature Center* – This 130-acre site is located in Middle Smithfield Township. The Meesing Nature Center is in the Delaware State Forest on ground owned by PA DCNR and leased by Monroe County. The Monroe County Conservation District operates a maple sugar demonstration site there.
- *Monroe County Park* - The County Recreation and Park Commission headquarters is located in Snydersville. The site features an administration building and an 11-acre park with ballfields, trail and restroom. It is the county's only active recreation site.
- *Burnley Workshop* - The Burnley Workshop leases land from Monroe County. The Workshop allows Monroe County to use the land for athletic fields.
- *J.A. Karmilowicz, Inc. Tract* – Monroe County recently purchased this 100-acre tract with open space bond monies for permanent preservation and as a crucial connection for the planned Brodhead greenway and development of the Godfrey Ridge trail. The tract, which is adjacent to

the Brodhead Creek in Stroud and Smithfield Townships, will protect nearly a mile of riparian woodland.

Municipal Lands

There are about 700 acres of municipal-owned protected lands and parkland in the watershed.

- High Acres – Barrett Twp, 21.68 acres
- Chestnuthill Township Park – Chestnuthill Twp, 37 acres
- Dansbury Park – East Stroudsburg Borough, 15.7 acres
- Zacharius Pond – East Stroudsburg Borough, 25.1 acres
- Gregory’s Pond – East Stroudsburg Borough, 10 acres
- Miller Park – East Stroudsburg Borough, 2 acres
- Schimpf – Hamilton Twp, 21 acres
- FSR Homestead – Hamilton Twp, 5 acres
- Open Space – Hamilton Twp, 2 acres
- Jackson Memorial – Jackson Twp, 4.9 acres
- Resica – Middle Smithfield, 37 acres
- Unnamed – Middle Smithfield, 17 acres
- Open Space Natural Area – Middle Smithfield, 5 acres
- Mt. Pocono Borough Park – Mt. Pocono Borough, 2 acres
- Deerfield Oak Street Park – Mt Pocono Borough, 15 acres
- Paradise Twp Park – Paradise Twp, 10 acres
- Mountain View Park – Pocono Twp, 81 acres
- Saylorsburg Playground – Ross Twp, 14.09 acres
- Waterfront Park – Smithfield Twp, 53.3 acres
- Minisink – Smithfield Twp, 25 acres
- Little League Field – Smithfield, 11 acres
- Big Pines – Stroud Twp, 25 acres
- Jay Albertson – Stroud Twp, 5.37 acres
- Katz Park at Wedgewood Lake – Stroud Twp, 7.2 acres
- Kovarick Lands – Stroud Twp, 13 acres
- Michael Moore – Stroud Twp, 0.51 acres
- Daily Property – Stroud Twp, 1.91 acres
- Laurel Street Pond – Stroud Twp, 1.58 acres
- McMichael Creek Conservation Lands – Stroud Twp, 107 acres
- Yetter – Stroud Twp, 15 acres
- Carl Dennis – Stroud Twp, 31.19 acres
- Pinebrook – Stroud Twp, 60 acres
- Third Street Park – Stroudsburg Borough, 3 acres
- McMichaels/Rotary – Stroudsburg Borough, 5 acres
- Glen Park – Stroudsburg Borough, 10 acres
- Stroudsburg Park – Stroudsburg Borough, 5 acres

Other Protected and Quasi-Protected Lands

Other protected lands in the watershed include private conservation lands – including those protected by conservation easement, homeowners’ association lands, and purchased

agricultural easements. Quasi-protected lands include agricultural security areas, Pennsylvania Act 319 lands, and hunting & fishing club lands.

- Private conservation lands are those protected by private land trusts and conservancies, such as the Nature Conservancy and the Pocono Heritage Land Trust. Private conservation lands total about 2,400 acres in the watershed. These include the Tannersville Cranberry Bog, owned by the Nature Conservancy. Lands protected by easement include those along Buck Hill Creek, including Jenkins Woods.
- Homeowners association lands (HOA) protect about 515 acres of land in the watershed through their commons. Homeowners associations in the county range from small developments of 25 houses to large communities such as Penn Estates. Public access is often restricted from these lands.
- Purchased Agricultural Easements permanently protect about 460 acres of agricultural land in the watershed.
- Agricultural Security Areas are not protected but are areas deemed suitable for protection by purchased agricultural easements. There are about 3,800 acres of Agricultural Security Areas in the watershed.
- Pennsylvania Act 319 lands are those protected under the “Clean and Green” program, which provides property tax breaks to owners. These lands are *not* permanently protected – a landowner can simply pay the back-taxes in order to develop the site (examples of this have already occurred in Monroe County). Act 319 lands in the watershed total approximately 95,500 acres and include both agricultural and forested lands.
- Hunting and fishing club lands include those owned by the Pohoqualine Fishing Club, Henryville Conservation Club, Brodhead Forest & Stream, Brodhead Hunting & Fishing, Parkside, and others. While the nature of their ownership provides a measure of protection, these lands are not permanently protected.

Critical Land Areas

Natural Areas Inventory Sites

Important natural features of the Brodhead watershed were first identified in 1991 with the completion of the *Monroe County Natural Areas Inventory*. This inventory was the result of a combined effort between the Department of Community Affairs, The Nature Conservancy, and Monroe County. An update of this report was conducted in 1999 in conjunction with the development of the Monroe County Open Space Plan, adopted in June 2001.

The emphasis of the *Monroe County Natural Areas Inventory* is upon locations for species listed as rare, threatened, or endangered in Pennsylvania and exemplary natural communities. A few of these species are listed by The Nature Conservancy as globally imperiled Exemplary Natural Communities. NAI sites are shown on the map of *Critical Land Areas*.

Natural Treasures Registry Sites

The Monroe County Open Space “Natural Treasures Registry” (NTR) project was initiated during preparation of the County Open Space Plan to allow County citizens and other interested individuals to suggest or identify areas of special interest or unique natural features that could be considered for eventual protection. Using a *Natural Treasures Registry* referral form, individuals and organizations were asked to identify and register “lost” natural areas that may not be included in existing County or state natural areas inventories. This effort is ongoing.

Nominated sites include many scenic and cultural sites, as well as habitat sites. Included in the habitat sites initially nominated were vernal pools, headwaters areas, wetlands, swamps, and riparian areas. Sites nominated for their cultural or scenic quality included views of woodlands, farms, and waterfalls.

This community-generated natural treasures information will help identify and protect significant and important sites of local interest and is meant to be an ongoing process. It also should be noted that some of the nominations received identified resources which might be better viewed as relating to the County’s cultural heritage, such as small eighteenth century cemeteries and important scenic sites. Natural Treasures Registry sites of the watershed are shown on the map of *Critical Land Areas*.

Important Bird Areas

IBA is a bird habitat conservation project administered by the National Audubon Society. The IBA program is a global effort to identify the areas that are most important for maintaining bird populations, and focus conservation efforts at protecting these sites. IBA is cited by DCNR as important to consider during the development of a Pennsylvania Watershed Conservation Plan.

Audubon Pennsylvania’s Important Bird Areas Program was the first to develop a state IBA program in the United States. Based on strict scientific criteria, a group of scientific

advisors (known as the Ornithological Technical Committee) selected 73 Important Bird Areas encompassing over one million acres of public and private lands. These sites include migratory staging areas, winter feeding and roost areas, and prime breeding areas for songbirds, wading birds and other species. They also include critical habitats, such as spruce-fir bogs, tidal saltmarsh, bottomland hardwood swamps, and open grasslands. IBA sites in Pennsylvania are selected by the technical committee on an ongoing basis.

Important Bird Areas are sites that provide essential habitat for one or more species of bird. IBAs include sites for breeding, wintering, and/or migrating birds. IBAs may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape. IBAs may include public or private lands, or both, and they may be protected or unprotected.

To qualify as an IBA, sites must satisfy at least one of the following criteria. The site must support:

- Species of conservation concern (e.g. threatened and endangered species);
- Restricted-ranges species (species vulnerable because they are not widely distributed);
- Species that are vulnerable because their populations are concentrated in one general habitat type or biome; or
- Species, or groups of similar species (such as waterfowl or shorebirds), that are vulnerable because they occur at high densities due to their congregatory behavior.

There are three Important Bird Areas in Monroe County, including Pocono Lake Preserve (# 63 in Pennsylvania IBA book) and Long Pond Preserve (# 64). In addition, the entire Kittatinny Ridge (#51) is considered an Important Bird Area, encompassing 280 square miles of forested ridge. This ridge forms the southern boundary of Monroe County, and falls just outside the Brodhead watershed. The Kittatinny Ridge is the premier raptor migration corridor in the northeastern United States.

Biological Resources

The biologic quality of Monroe County and the Brodhead watershed is recognized not only by the county itself, but also by the Commonwealth of Pennsylvania, the U.S. Environmental Protection Agency, and the Nature Conservancy. In a preliminary evaluation, the U.S. Environmental Protection Agency has identified Monroe County as an area of high biodiversity within the Middle Atlantic Region of the United States. Biodiversity is defined by the EPA as “the variety and variability among living organisms and the ecological complexes in which they occur”.

Wildlife

Terrestrial Wildlife

The landscape of the Brodhead watershed, with its forests and numerous streams, ponds, and bogs, provides valuable habitat for wildlife. The most well-known mammal species are game animals, including black bear and white tailed deer. Squirrel, raccoon, woodchuck, skunk, and opossum are found in the more developed areas of the watershed. Common furbearers include mink, muskrat, beaver, and otter, all of which are associated with and depend upon clean water. A 1995 study of Monroe County found a total of 231 species in the county: 40 species of herpetofauna, 147 species of birds, and 44 species of mammals. However, by some estimates, the watershed may support as many as 56 species of mammals. The following is a list of mammals known to inhabit the watershed, their occurrence (common or uncommon) and their habitats:

- Black Bear – Wetland areas and upland areas
- White-Tailed Deer – Common throughout, found in both remote and populated areas
- Coyote – Throughout, more common in upper watershed
- Red Fox – Lower areas of watershed
- Gray Fox – Found in upper, more wooded areas
- Bobcat – Upper watershed, found in more remote areas
- Beaver – Small feeder streams and lakes in upper watershed
- Otter – Along streams through much of watershed, very mobile
- Mink – Common along waterways
- Fisher (recently reintroduced in north-central Pennsylvania)
- Raccoon – Common along waterways
- Weasel, striped skunk, opossum – Common throughout in a variety of habitats, including the Short-tailed weasel (rare).
- Muskrat – Common in smaller streams and wetlands
- Woodchuck – Common in lower watershed in open areas
- Squirrels & Chipmunks – Common, found in forested areas throughout. These include: Gary squirrel (common), Red squirrel (common), Chipmunk (common), and Northern flying squirrel (rare).
- Cottontail Rabbit – Open areas in lower watershed

- Snowshoe Hare – Uncommon, found in upper watershed mostly associated with wetland areas
- New England cottontail (rare)
- Porcupine – Becoming more common in upper watershed areas that are predominantly forested
- Mice, Voles, Shrews, Moles – Common throughout watershed in preferred habitat for each species. These include: Woodland jumping mouse (rare), Meadow jumping mouse, White-foot mouse (common), Deer mouse (common), House mouse, Star-nose mole, Hairy-tailed mole, Short-tailed shrew, Masked shrew, Water shrew, Red-backed vole, Meadow vole, Rock vole (rare), Pine vole (woodland vole), Norway rat, and Eastern woodrat.
- Bats include the Little brown bat and the Big brown bat.

Reptiles and Amphibians

A wide variety of amphibians and reptiles inhabit the woods, meadows, wetlands, and waters of the Brodhead watershed. Amphibians evolved from fishes about 350 million years ago to become earth's first terrestrial vertebrates and are still dependent upon clean water in one important way – for reproduction. Jelly-like eggs are laid in water, hatch into gilled larvae or tadpoles, and later metamorphose into air-breathing amphibians. These adults are still dependent upon water for their survival – they need to maintain moist skins even in their terrestrial lives. Amphibians are often dependent upon “vernal pools” for their reproduction. Formed by spring runoff in wooded depressions, these pools lack predatory fish and turtles and provide a safe area for breeding before drying up in mid-summer. The following is a list of amphibians known to inhabit the watershed, their occurrence (common or uncommon) and their habitats:

- Fowler's Toad – Uncommon, found in sandy areas near the Delaware River
- American Toad – Common throughout, found in variety of habitats
- Gray Treefrog – Common in woodlands throughout, especially near wetlands
- Spring Peeper – Common near most aquatic habitats
- Pickerel Frog – Common throughout in variety of habitats
- Wood Frog – Common in woodlands throughout
- Bullfrog – Common throughout in many aquatic habitats
- Green Frog – Common throughout in many aquatic habitats
- Slimy Salamander – Common in woodlands throughout
- Four-Toed Salamander – Uncommon, found in woodlands especially near sphagnum wetlands
- Northern Spring Salamander – Uncommon, found in springs & small streams
- Northern Red Salamander – Uncommon, found in woodlands near springs and small streams
- Long-Tailed Salamander – Uncommon, found in woodland seeps

- Northern Two-Lined Salamander – Common, found in small streams and seeps throughout
- Marbled Salamander – Uncommon, localized in woodlands
- Jefferson Salamander – Uncommon, localized in woodlands
- Spotted Salamander – Common in woodlands throughout
- Red-Spotted Newt – Common in standing water habitats (adults) & woodlands (immature stage) throughout
- Northern Dusky Salamander – Common in small streams, brooks, and seeps
- Mountain Dusky Salamander – Uncommon, found in woodlands near small streams
- Red-Backed Salamander – Common in woodlands throughout

Reptiles evolved about 300 million years ago from amphibians. They are completely terrestrial in their breeding and inhabit both terrestrial and aquatic habitats. The following is a list of reptiles known to inhabit the watershed, their occurrence (common or uncommon) and their habitats:

- Northern Water Snake – Common in variety of water habitats
- Northern Brown Snake – Uncommon and localized in a variety of habitats
- Northern Red-Bellied Snake – Common in wooded areas of upper watershed
- Eastern Ribbon Snake – Uncommon, found in or near a variety of aquatic habitats
- Eastern Garter Snake – Common throughout in a variety of habitats
- Eastern Hognose Snake – Uncommon, found in dry, sandy soil habitats
- Northern Ringneck Snake – Common in rocky, upland areas
- Eastern Worm Snake – Uncommon, found in woodlands, sandy bottomlands
- Northern Black Racer – Common in many upland habitats
- Eastern Smooth Green Snake – Common, but localized in grassy, weedy habitats of upper watershed
- Black Rat Snake – Common in rocky habitats, especially in lower watershed
- Eastern Milk Snake – Common in variety of habitats throughout
- Northern Copperhead – Uncommon, found in rocky upland areas
- Timber Rattlesnake – Uncommon, found in rocky woodlands of upper watershed
- Snapping Turtle – Common throughout in a variety of aquatic habitats
- Spotted Turtle – Uncommon, found in marshes, swamps, and small streams
- Wood Turtle – Uncommon, found in woodlands near water
- Box Turtle – Uncommon, found in upland habitats
- Painted Turtle – Common in a variety of aquatic habitats
- Bog Turtle – Uncommon; occurs on PNDI species listing.

The biggest problem facing reptiles and amphibians in the watershed is loss of habitat. Countless acres of wetlands and woodlands have been replaced by housing developments, lawns, shopping malls, and parking lots. A large number of amphibians and reptiles are also killed by cars as they cross roads.

Aquatic Wildlife

The Brodhead watershed supports coldwater fishes throughout its entire length. Most of the headwater streams and small tributaries are the remaining refuges of the brook trout, the salmonid native to the drainage. Brook trout once thrived in much of the drainage but have been relegated to the headwater areas due to environmental degradation and competition with exotic species. Introduced brown trout have become naturalized through much of the watershed. In a few limited areas of the Swiftwater and upper McMichael Creeks, there is some natural reproduction of introduced rainbow trout. Some headwater streams have fish populations limited to trout alone or trout and sculpins. Fish diversity increases in a downstream progression to include dace, darters, fallfish, suckers, American eels, and other species including the endangered bridled and ironcolor shiners in the Marshalls Creek. From the vicinity of Stroudsburg to its confluence with the Delaware River, the Brodhead includes some cool and warmwater species, along with the typical trout stream species. Rock bass, smallmouth bass, and bluegills inhabit the lower reaches. Migratory species include the American eels mentioned previously, along with the occasional American shad or striped bass from the Delaware. Sea Lampreys spawn in the lower Brodhead and Marshalls Creeks. The entire Brodhead drainage is an important recreational fishery heavily utilized in private and public areas by anglers fishing for wild and stocked trout and for other species in the lower drainage.

The Brodhead drainage also hosts very diverse aquatic invertebrate populations. There are numerous taxa of mayflies, stoneflies, and caddisflies, along with true flies, aquatic beetles and their larvae, and hellgramites. In addition to the aquatic insects, there are crustaceans - crayfish, sowbugs, and shrimp. Freshwater clams, snails, and worms are included in the invertebrate populations. As in any complex drainage, there is a great deal of longitudinal succession of invertebrate species in the Brodhead. In most of the headwater tributaries, species predominate that are limited to pristine conditions because of low pollution tolerance. Intolerant species continue to predominate through most of the drainage with the exception of certain degraded areas.

Birds of the Brodhead Watershed

The Brodhead watershed is home to a rich and varied avifauna. The dramatic rise in elevation from the watershed's confluence with the Delaware River to the top of the Pocono Plateau where the headwater streams rise is the reason for the diversity in habitats that support such diverse bird life.

The altitude and latitude of the Pocono Plateau create climatic conditions that support several boreal species. Northern birds finding the southern limits of their breeding range include the Magnolia and Blackburnian warblers, Red-breasted Nuthatch and the Golden-crowned Kinglet. The cliffs on the southern face of Spruce Mountain are home to the only nesting pair of Common Ravens in the entire region. The watershed's swift flowing

streams are home to the Louisiana Waterthrush, one of the species on the National Audubon Society's "Watch List" for Pennsylvania. Several other species on the "Watch List" found in the watershed include the Wood Thrush, Black-throated Blue, Cerulean, Worm-eating Warbler, and Prairie Warbler. The Golden-winged warbler is the subject of a national effort by the Cornell Laboratory of Ornithology to study its decline as well as being on the "Watch List." This bird can be found nesting at the Meesing Nature Center as well as the Tannersville Cranberry Bog. At the lowest elevations of the watershed at least one southern species finds the northern limits of its range, the Yellow-throated Warbler. In between are a dazzling array of neotropical migrants and residents alike.

Bald Eagles and Osprey have made an incredible recovery in northeastern Pennsylvania and are often seen in the Brodhead watershed. Although not yet listed as breeders in the watershed it is just a matter of time before the nest of one or both of these species is found. Red-tailed hawks are the most common diurnal raptor in the watershed but Broad-winged, Red-shouldered, Sharp-shinned and Cooper's hawks are all recognized as breeders in the region. The most common of the nocturnal raptors is the Barred Owl, which is associated with swamps and bottomland forests. In the dryer forests and in more developed areas the Great-horned Owl and Screech Owl are found. There is some evidence that the smallest of our nocturnal raptors, the Northern Saw-whet Owl, uses the valleys of the Brodhead Watershed as migration corridors. In an effort to learn more about this secretive bird, the Pocono Avian Research Center conducted a mist netting effort on the property of Skytop Lodge in the fall of 2000. Even though there had been no previous records of these diminutive owls on the 5,000-acre property, PARC banded sixty owls in late October and early November, with a high of thirty individual birds banded on the night of October 22. The nocturnal bird of concern now is the Whip-poor-will, which seems to be disappearing from the forests of the watershed and the entire region at an alarming rate.

Christmas Bird Counts conducted by the Pocono Audubon Society have discovered some interesting wintering birds in the watershed including Yellow-rumped Warbler, Bluebird, Northern Shrike and, depending on conditions, several species of northern finches. During these years the watershed supports wintering populations of grosbeaks, siskins, redpolls and crossbills. In all seasons it is possible to see chickadees, titmice, cardinals and blue jays. The heavily forested nature of the watershed makes it prime habitat for woodpeckers and several of the more rare species are found here including the Red-bellied woodpecker, the Pileated woodpecker and the Yellow-bellied Sapsucker.

Game bird populations are very high. The Ruffed Grouse can be heard drumming throughout the watershed in the spring. Woodcock fill the late winter twilight with their incredible courtship flights but neither of these birds can compare in stature with the wild turkey that is undergoing a population explosion. These large birds are taking advantage of banner crops of nuts provided by the beech and hickory trees over the last few years.

There is a growing problem in the watershed with non-migratory Canada Geese. Over the last ten years they have become more hated than Starlings. Starlings and House Sparrows are not the problem in the Brodhead watershed that they are in more urban and agrarian

communities but they are still causing problems for other cavity nesting birds. The Brown-headed Cowbird is found in the watershed but the severity of its impact on the overall bird populations in the watershed is not yet known.

Due to its clean flowing streams and intact habitats, the Brodhead watershed is home to one of the richest avifauna in the state. Besides the natural threats to the watershed's birds there is the growing problem of habitat manipulation as either fragmentation or outright loss. Continued research by the Audubon Society and Pocono Avian Research Center will be invaluable resources in recording the changing dynamics of avian populations in the watershed and monitoring the effectiveness of resource management on a habitat scale.

PNDI Species

The Pennsylvania Natural Diversity Inventory (PNDI) database was established in 1982 as a joint effort of the Pennsylvania Science Office of the Nature Conservancy, the Pennsylvania Department of Environmental Resources (now the Department of Conservation and Natural Resources), and the Western Pennsylvania Conservancy. Since its development, the PNDI database has become Pennsylvania's chief storehouse of information on outstanding natural habitat types (natural communities). Its focus is on species rarity and areas of highest natural integrity in order to protect the full range of biological diversity in Monroe County.

The Pennsylvania Natural Diversity Inventory has identified many species of special concern that exist within the Brodhead watershed. These are:

- Roadside skipper (*amblyscirtes vialis*)
- Bog rosemary (*andromeda polifolia*)
- Dusted skipper (*atrytonopsis hianna*)
- Brown sedge (*carex buxbaumii*)
- Collin's sedge (*carex collinsii*)
- Cloud Sedge (*carex haydensii*)
- Slender sedge (*carex lasiocarpa*)
- Mud sedge (*carex limosa*)
- A sedge (*carex tetanica*)
- Bog turtle (*Clemmys Muhlenbergii*)
- Timber rattlesnake (*Crotalus horridus*)
- Elegant skimmer (*dorocordulia lepidia*)
- Small waterwort (*elatine minima*)
- Boreal bluet (*enallagma boreale*)
- Persius duskywing (*erynnis persius persius*)
- Bobcat (*felis rufus*)
- Small floating manna grass (*glyceria borealis*)
- Barrens buckmoth (*hemileuca maia*)

- Cobweb skipper (*Hesperia metea*)
- Henry's elfin (*incisalia henrici*)
- Frosted elfin (*incisalia irus*)
- Common juniper (*juniperus communis*)
- American brook lamprey (*lampetra appendix*)
- Bog copper (*lycaena epixanthe*)
- Appalachian sandwort (*minuartia glabra*)
- Northern Myotis (*myotis septentrionalis*)
- Bridle Shiner (*notropis bifrenatus*)
- Ironcolor shiner (*notropis chalybaeus*)
- White fringed orchid (*platanthera blephariglottis*)
- Mulberry wing (*poanes massasoit*)
- Racemed milkwort (*polygala polygama*)
- Bushy knotweed (*polygonum ramosissimum*)
- Three-toothed cinquefoil (*potentilla tridentata*)
- Pink sallow (*psectraglaea carnosa*)
- Tufted buttercup (*ranunculus fascicularis*)
- Smith's bullrush (*schoenoplectus smithii*)
- Torrey's bullrush (*schoenoplectus torreyi*)
- Northeastern bullrush (*scirpus ancistrochaetus*)
- Bur-reed (*sparganium angustifolium*)
- White twisted-stalk (*streptopus amplexifolius*)
- Allegheny cave amphipod (*stygobromus allegheniensis*)
- Spreading globe flower (*trollius laxus*)
- Eastern mudminnow (*umbra pygmaea*)

For a complete list of PNDI species in the Brodhead watershed and their state and federal status, see *Appendix E, List of PNDI species and Ecological Communities*.

Important Habitats

The emphasis of both the Pennsylvania Natural Diversity Inventory (PNDI) database and the *Monroe County Natural Areas Inventory* is upon locations for outstanding natural habitat types and exemplary natural communities. Many nominated Natural Treasures Registry sites also represent important habitat areas. NAI sites, Natural Treasures Registry Sites, and wetlands are shown on the map of *Critical Land Areas*.

The Pennsylvania Natural Diversity Inventory has identified several natural community types and geologic features that exist within the Brodhead watershed. These are:

- Acidic broadleaf swamp
- Acidic shrub swamp
- Boreal conifer swamp
- Broadleaf-conifer swamp
- Erosional remnants

- Invertebrate fossil animals
- Mesic central forest
- Northern conifer forest
- Northern conifer swamp
- Glacial bog
- Ridgetop dwarf-tree forest

For a complete list of PNDI natural community types in the Brodhead watershed and their state and federal status, see *Appendix E, List of PNDI species and Ecological Communities*.

Vegetation

Land Cover Types

Forest types in the watershed include deciduous forest (67 percent), mixed forest (10 percent), and evergreen forest (7 percent). Mixed forest refers to those areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the tree cover present. All together, eighty-four percent of the watershed is covered by deciduous, mixed, and evergreen forests. Shrubland types in the watershed include deciduous shrubland, evergreen shrubland, and mixed shrubland. About 6 percent of the watershed is covered by pasture or hay. Woody wetlands are more common than emergent herbaceous wetlands, covering about 2.5 percent of the watershed. The following describes some of the major vegetative community types in the watershed.

Forest Community Types

The following summarizes the major forest cover classes in the watershed:

- Northern Hardwood Forest – Common in the upper watershed on the Pocono Plateau, dominated by northern hardwoods such as American beech, red maple, yellow birch, white ash, and eastern hemlock. Common understory trees and shrubs include maple-leaf viburnum, spice bush, mountain laurel, and rhododendron.
- Northern Conifer Forest – Characterized by northern evergreens, predominately the eastern hemlock in the canopy and rhododendron in the understory and shrub layers. Groundcover supports a wide variety of ferns, mosses and liverworts. Commonly found in deep cool ravines on steep slopes, especially north-facing ones.
- Northern Hardwood - Northern Conifer – Mix of hardwoods and conifers with no clear dominance by either.
- Mixed Oak – Common in the lower watershed, supports high diversity. Black, red, and white oak are the dominant species. Associated species include tulip poplar, basswood, American beech, and white ash.
- Shrub/Scrub Oak Barrens – Dominated by scrub oak, pitch pine, and dense heath shrubs. Found scattered on the Pocono Plateau on dry sites exposed to wind and subject to repeated burns by wildfires.

Wetland/Aquatic Community Types

The following summarizes the major wetland cover classes in the watershed:

- Northern Conifer Swamp – Forested wetland dominated by coniferous species such as white pine and eastern hemlock, influenced primarily by acidic water. Other indicator species include yellow birch, speckled alder, and high bush blueberry
- Boreal Conifer Swamp – Forested wetland dominated by boreal coniferous trees such as black spruce, balsam fir, and tamarack. Often contains small open bog areas.
- Broadleaf-Conifer Swamp – Forested wetland co-dominated by both coniferous and broadleaf trees.
- Hardwood Swamp – Forested wetland dominated by broadleaf deciduous trees such as red maple, black gum, and yellow birch.
- Acidic Shrub Swamp – A shrub-dominated wetland with at least 50 percent shrub cover and less than 20 percent trees. Indicator species include speckled alder, high bush blueberry, and smooth alder.

Invasive Species

Exotic plants are a serious threat to the watershed. These species grow aggressively, spread, and displace native plants that have more value as forage and habitat for indigenous animal species. In addition, invasive species can disturb or alter natural communities within an ecosystem, often upsetting the natural balances required to keep these systems functioning properly. Endangered, rare, and threatened native species are especially at risk because they occur in small populations, which makes them particularly vulnerable.

Invasive plants are generally undesirable because they are difficult to control. Most invasive plants arrived from other continents and as such are often referred to as “exotic,” “alien,” “introduced,” or “non-native.” Invasive plants are noted for their ability to grow and spread aggressively. They can be trees, shrubs, vines, grasses, or flowers. Invasive plants have the ability to reproduce rapidly by roots, seeds, shoots, or by a combination of all three. They also have the ability to adapt to a diverse range of growing conditions and once established, exploit or colonize these areas. Second to habitat loss from development, invasive plants are the next major factor contributing to the decline of native plants in the watershed.

Recognition of invasive plants, understanding the potential damage they can cause, managed control, and most importantly, avoiding the use of them in plantings, is essential to stopping their spread and protecting native vegetation.

The following species have been documented by DCNR Bureau of Forestry as serious threats in Northeastern Pennsylvania and are present in the Brodhead watershed:

Amur Honeysuckle	<i>Lonicera maackii</i>	Shrub - seeds spread by birds
Autumn Olive	<i>Elaeagnus umbellata</i>	Shrub - seeds spread by birds

Bull Thistle	<i>Cirsium vulgare</i>	Noxious Weed – seed in open fields
Canada Thistle	<i>Cirsium arvense</i>	Noxious Weed – seed in open fields
Garlic Mustard	<i>Alliaria petiolata</i>	Noxious Weed – seed in woodland understory
Jap. Honeysuckle	<i>Lonicera japonica</i>	Vine – seed spread by birds
Multiflora Rose	<i>Rosa multiflora</i>	Shrub – seed spread by birds
Norway Maple	<i>Acer platanoides</i>	Tree – straight species spread by seed
Oriental Bittersweet	<i>Celastrus orbiculatus</i>	Vine – spread by seed
Purple Loosestrife	<i>Lythrum salicaria</i>	Wetland Flower - root or seed in waterways
Reed Grass	<i>Phragmites australis</i>	Wetland grass - forms huge colonies
Tatarian honeysuckle	<i>Lonicera tatarica</i>	Vine- seed spread by birds
Tree of Heaven	<i>Alianthus altissima</i>	Tree – spread by seed
Jap. Knotweed	<i>Polygonum cuspidatum</i>	Noxious Weed - dense stands in wet areas

Hazard Areas

Superfund Sites

Superfund is a program administered by the EPA to locate, investigate, and clean up the worst hazardous waste sites throughout the United States. Citizen concern about the prevalence of highly contaminated sites – including abandoned warehouses, manufacturing facilities, processing plants, and landfills – prompted Congress in 1980 to establish the Superfund Program to address the health and environmental threats posed by hazardous waste sites. Five Superfund sites are found within the Brodhead watershed. These include:

- Brodhead Creek, located south of the Main Street bridge, Stroudsburg
- Butz Landfill, located on township route 601, Stroudsburg
- Snyder Site, located on Shinehill Road, Scotrun
- Truck Stop Asbestos Site, located on Route 611, Bartonsville
- Village of Reeder's GW, located on Route 715, Jackson Township

An additional two sites are located just outside the watershed boundary. Surface drainage from these sites does not flow to the Brodhead Creek.

- Route 940 Drum Dump, located off route 940, Pocono Summit
- Tobyhanna Army Depot, located in Tobyhanna

Description of the Brodhead Creek Superfund Site. From 1981 through 1984, several investigations and emergency response measures were initiated when coal tar was observed seeping into the Brodhead Creek. Measures to mitigate the problem included installation of temporary filter fences and underflow dams to intercept coal tar seepage, installation of a temporary coal tar recovery pit on the bank of the creek, construction of a slurry wall, excavation of a backwater channel area, and installation of recovery wells in the main coal tar pool, with the subsequent recovery of approximately 8,000 gallons of coal tar. The site was placed on the National Priorities List (NPL) in December 1982.

Cleanup information and site status for the sites listed above can be obtained through the EPA's website, by querying Monroe County Superfund sites through the "Envirofacts Warehouse".

Landfills / Waste Sites

Landfill sites in the watershed include one located on Dry Sawmill Run, Pocono Township; and one located near Pocono Creek in Stroud Township – both located in the Pocono Creek subwatershed. Also, on the main stem of the Brodhead is a landfill site in East Stroudsburg Borough; this is the current site of the Twin Boroughs Recycling Center. The Stroud Township and East Stroudsburg landfills are routinely monitored. Monitoring has indicated the presence of contaminants at concentrations that were generally low, but in some cases exceeded regulatory limits. These landfills discharge leachate to the Pocono and Brodhead Creeks, respectively.

Butz Landfill, a closed landfill and Superfund site, is also located in the Pocono Creek subwatershed, at the base of Camelback Mountain. A closed municipal landfill is located in Barrett Township in the headwaters of Cranberry Creek off of Sand Spring Road.

Mines / Quarries

A total of seven major mining operations have been identified within the Brodhead watershed. These include the following:

Upper Brodhead Creek watershed:

- Bill Barry Excavating – Barrett Township, Lower Seese Hill Road

Paradise Creek watershed:

- Bill Barry Excavating – Barrett Township, Cranberry Creek headwaters

McMichael Creek watershed:

- Eureka Stone – Snydersville, east of Rte 33
- Eureka Stone – Saylorsburg sandpit, west of Rte 33
- Hanson Aggregates – Bossardville
- Pocono Industries (Lesoine's) – Hamilton Township, Rte 209, north of Rte 33

Marshalls Creek watershed:

- Middle Smithfield Materials – west of Rte 209, one mile before Fernwood

In addition, numerous operations hold mining permits for sites under five acres:

Small permits (under five acres):

- Harry Ahnert – Paradise Township, Rte 611 south of Mt. Pocono
- Russell Nauman – Paradise Township, Devils Hole
- Harry Howard – Barrett Township, Cranberry Creek headwaters
- Birchwood/Worthington – Pocono Township

- Floyd DeHaven – Pocono Township
- Russel Dyson – Pocono Township, Rte 314, west of Rte 611
- Sheldon Kopelson – Pocono Township
- Pocono Manor – Pocono Township, north of Brookdale
- Pocono Manor – Tobyhanna Township, east of Rte 380
- Michael Brocko – Hamilton Township, Rte 209
- G&R Materials Recycling – Hamilton Township, Rte 33, north of Snydersville
- Izzy Industries – Hamilton Township, east of Rte 33, Snydersville
- Possinger (3 permits) – Hamilton Township, Snydersville
- Charles Hoffman, McIlhaney – Chestnuthill Township
- Richard Ianuale – Jackson Township, Sciota
- Louis Manzie – Stroud Township, Hamilton Road
- Marion Serfass – Stroud Township, Hamilton Road
- Louis Manzie – Stroud Township, Rte 191, north of Stroudsburg
- Papillon Contracting – Stroud Township Rte 191, north of Stroudsburg
- Penn Hills Enterprises – Stroud Township Rte 191, north of Stroudsburg
- Robert Felins – Stroud Township, Rte 80

Hazardous Materials

Hazardous materials information is contained in the Resource Conservation and Recovery Act Information (RCRAInfo), a national program management and inventory system about hazardous materials handlers. In general all generators, transporters, treaters, storers, and disposers of hazardous materials are required to provide information about their activities to state environmental agencies. These agencies, in turn, pass on the information to regional and national EPA offices. This regulation is governed by the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. A hazardous materials query of Monroe County found 184 facilities known to handle hazardous materials. These included industrial facilities, air-conditioning and heating equipment, dry cleaning, upholstery repair shops, paint shops, and automotive services, among others.

Underground Storage Tanks (UST) Sites

According to recent data, there are 97 underground storage tank locations in the Brodhead watershed. Not surprisingly, the majority of these are found in the Stroudsburg/East Stroudsburg Borough area. Many others are found along major road corridors. These underground storage tanks contain leaded and unleaded gasoline, diesel fuel, heating oil, kerosene, BTEX, and other fuel oils. Site locations include automobile gas stations and service centers, convenience stores, car and truck washing stations, apartment buildings, department and chain stores, the Monroe County Courthouse, borough maintenance buildings, resort facilities, and schools.