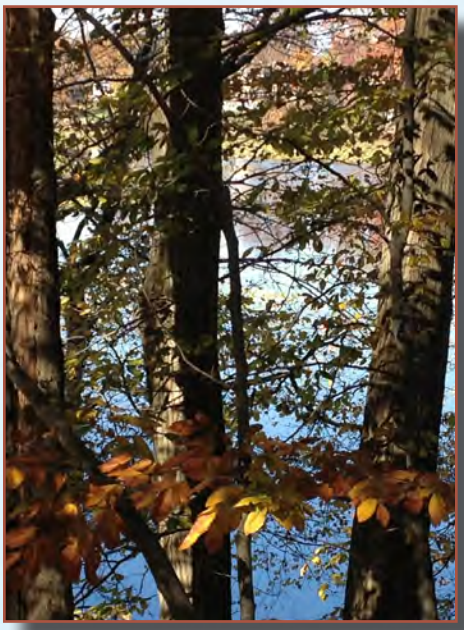


Criterion 4: Conservation and Maintenance of Soil and Water Resources

Soil and water underpin forest ecosystem productivity and functions. Forest Ecosystems play an important role in the regulation of surface and groundwater flow and, together with associated aquatic ecosystems and clean water, they are essential to the quality of human life.

The interactions of soil, water, climate, topography, and biological activities influence the character and health of streams and rivers flowing through and from forests. Forest management activities can significantly alter forest soils, water quality and quantity, and associated aquatic habitats. Appropriate forest management can protect and conserve the soil and water values of a forest and of downstream land uses. Inappropriate management may result in soil compaction, erosion, loss of riparian buffering capacity, increased sediment loads in streams, degradation and destruction of riparian and aquatic habitats, and altered flow regimes. Change in water flow can lead to an increased risk of flooding or to a reduction in the quantity and flow of water in streams that affect other land-use activities downstream. This can have detrimental implications for human safety, property, and economics.

Figure 31. Physiographic provinces of Delaware.

Source: United States Geological Survey

INDICATOR 8

Soil quality on forestland

Forest soils support forest productivity and other ecological and hydrological functions through their ability to cycle, hold, and supply water and nutrients, store organic matter and provide habitats for plant roots and for a wide range of soil organisms. Soil quality influences the type of vegetation that will grow at a particular site, as well as the rate of growth of that vegetation. Soils are generally of adequate quality in Delaware to support forest growth—native vegetation on all but the wettest sites was historically forest. Today, soil drainage is one of the primary factors determining forest cover type, growth rate, and operational limitations.

Physiographic provinces of Delaware

Most of Delaware's forests occur on three broad soil types: Piedmont soils, Coastal Plain well-drained soils, and Coastal Plain poorly-drained soils. While all soil types are capable of producing good growth, native cover types and equipment limitations differ.

The Piedmont physiographic province (Figure 31) accounts for about 5% of the land area in Delaware. It is roughly delineated as the portion of the state lying north of Interstate 95. Piedmont soils tend to have a clay component and may be well drained or poorly drained, depending on topography and specific soil properties. Native cover is a hardwood mix containing red and white oaks (*Quercus* spp.), American beech (*Fagus grandifolia*), hickory (*Carya* spp.), and yellow-poplar (*Liriodendron tulipifera*).

The Coastal Plain physiographic province accounts for the southern 95% of Delaware. Topography is generally flat and low lying and most of these soils have a large sand component.

Well-drained soils on the Coastal Plain benefit from at least minimal elevation above low lying areas. The native cover type on these soils is mixed hardwoods and, in the southern part of the state, loblolly pine (*Pinus taeda*). A standard measure of wood volume is the board foot, which is defined as a 12-inch by 12-inch board that is one inch thick. Loblolly pine stands on well drained Coastal Plain soils typically yield 11,500 board feet/acre at age 50 according to USDA NRCS Soil Survey publications.

The other predominant Coastal Plain soil type occurs in areas with poor drainage and/or a high water table. Native forest cover usually includes red maple (*Acer rubrum*), blackgum (*Nyssa sylvatica*), American holly (*Ilex opaca*), sweetgum (*Liquidambar styraciflua*), and water-tolerant oaks (*Quercus* spp.), with some loblolly pine in the southern half of Delaware. While loblolly pine stands on these soils may yield over 16,000 board feet/acre at age 50, seasonal wetness often restricts access for timber harvest.

Soil quality is relatively good throughout Delaware. While nearly all of Delaware's land was farmed at one time since European settlement—except the very wettest sites—these activities resulted in minimal soil degradation. Unlike other areas of the country that experienced significant soil erosion during the clearing of forests for agriculture, Delaware's relatively flat terrain did not produce such dramatic erosion.

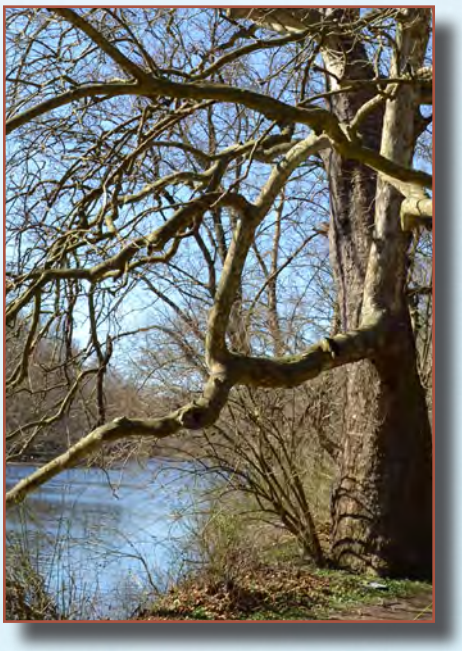
The primary influence of humans on soils is the extensive network of ditches that were dug in Coastal Plain areas, particularly in the latter half of the 20th century. Many streams were straightened and/or channelized, and an extensive network of connected ditches was completed in the headwaters of numerous watersheds to improve drainage for agricultural use. These ditches are usually referred to as tax ditches because landowners are taxed for the installation and maintenance of the ditch system. There are approximately 2,022 miles of tax ditches in Delaware that drain 359,518 acres. This increased drainage often resulted in not only the conversion of forestland to agriculture but also a change in forest type. For instance, the occurrence of species that require very wet or saturated soils, such as baldcypress (*Taxodium distichum*) and Atlantic white-cedar (*Chamaecyparis thyoides*), was drastically reduced as their habitat was altered. There are opportunities on some tax ditch systems to alter drainage patterns to re-establish the original hydrology within neighboring forested areas.

Conclusions

Most of Delaware is situated within the Coastal Plain physiographic province, although approximately 5% of Delaware is part of the Piedmont. Forest soils are generally productive for tree growth throughout Delaware. The primary impact of humans upon Delaware's soils is the extensive ditch system installed in the latter half of the 20th century. This not only resulted in the clearing of larger areas of forests but also produced different forest types in some cases because of hydrological changes. With minimal deviations in elevation, equipment limitations on wetter soils represent the only major soil-related operational constraint on forest management activities.

Delaware Piedmont in New Castle County

Tax ditch in Sussex County



INDICATOR 9

Area of forestland adjacent to surface water and forestland by watershed

Forested areas are important to water quality. Within forests, rainwater percolates into the ground and recharges the aquifers that provide people with drinking water. Forests typically do not act as sources of pollutants, so, other things being equal, watersheds with more forest cover tend to have cleaner water. Along streams, forest cover provides shade to regulate water temperature and roots reduce soil erosion. Trees absorb nitrogen and phosphorous, which in high amounts can cause water pollution. Forested buffers along waterways also increase the distance between sources of pollution and the waters they could pollute.

Major watersheds in Delaware

The U.S. Geological Survey utilizes an 8-digit Hydrological Unit Code (HUC) to identify major watersheds. Under this system, Delaware contains all or part of nine HUC watersheds (Figure 32). A watershed is an area of land that drains all the streams, ditches, and rainfall to a common outlet such as the mouth of a bay or any point along a stream or river channel.

The Chester-Sassafras, Choptank, Nanticoke, Blackwater-Wicomico, and Pocomoke watersheds are part of the larger Chesapeake Bay watershed. Approximately 35% of Delaware is located within the Chesapeake Bay watershed but this only represents 1% of the entire watershed. The Chesapeake has been recognized for decades as one of the most important estuaries within the United States and numerous efforts are underway to improve its water quality. These efforts were highlighted by White House Executive Order 13508: Chesapeake Bay Protection and Restoration (May 12, 2009). Delaware is also a Headwater State Partner within the Chesapeake Bay Program, a unique regional watershed partnership working to improve the bay's water quality since 1983.

The remaining areas of the state drain into the Delaware River and Bay (Lower Delaware, Brandywine-Christiana, and Broadkill-Smyrna watersheds) and the Atlantic Ocean (Chincoteague watershed—also known as the Inland Bays watershed in Delaware).

Overall, Delaware is about 29% forested. Forest cover varies by watershed from a low of 15% (Lower Delaware) to a high of 52% (Pocomoke) (Table 9). The Pocomoke, Nanticoke, and Choptank watersheds (all part of the Chesapeake Bay watershed) in the southwestern portion of the state contain the highest proportion of forest.

Geographic Information System (GIS) technology allows sophisticated analyses of geographic data on standard desktop computers. A GIS proximity study identified all forestland in the state that lies within 100 feet of surface waters. These "buffer" areas are important for water quality because they can trap sediment and other pollutants before they reach streams. Buffers also serve as wildlife corridors and provide aesthetic benefits in many cases.

Figure 32. Major watersheds in Delaware.

Source: United States Geological Survey

Table 9. Forestland in Delaware by watershed, 2014.

Watershed	*% Forest*	*Total Acres*	*Forest Acres*	*Forest Acreage Change 2007–2014*
Pocomoke*	52	22,646	11,840	-3,615
Choptank*	44	64,777	28,398	3,021
Nanticoke*	41	318,323	130,151	8,678
Chester-Sassafras*	38	49,227	18,846	2,081
Blackwater-Wicomico*	34	1,389	478	115
Chincoteague	34	187,898	64,732	7,880
Broadkill-Smyrna	23	399,190	91,389	907
Brandywine-Christina	22	215,517	47,779	3,347
Lower Delaware	15	4,718	693	unknown

* Part of the Chesapeake Bay watershed

Watershed	*Total Acres*	*Forest Acres*	*% Forest*	*Forest Acreage Change 2007–2014*
Delaware Bay and Estuary	504,135	113,209	22	-19,035
Chesapeake Bay	456,361	189,713	42	13,881
Inland Bays	187,046	64,732	35	1,562
Piedmont Basin	115,286	26,651	23	N/A

Source: United States Geological Survey

In all, approximately 34,800 acres of forest are acting as buffers using the 100-foot criterion. This acreage represents about 9% of Delaware's forestland. Delaware has approximately 3,100 miles of rivers and streams. About 40% of these stream miles are currently buffered by at least 100 feet of forest on both sides. The other 60% contain reduced or no buffers and are located primarily in agricultural and urban areas where pollution may occur at higher rates.

Conclusions

The percentage of forest cover varies significantly by watershed, with the densest cover in the southwest quadrant of the state. However, only one of Delaware's watersheds is over 50% forested. Roughly one-tenth of the forestland in Delaware is in riparian buffers, so forest management activities should be tailored to reduce sedimentation of waterways. Because more than half of Delaware's stream miles do not have 100-foot riparian buffers, opportunities are available to establish buffers on agricultural lands and in urban areas to protect and improve water quality.

INDICATOR 10

Water quality in forested areas

Clean and abundant water is necessary for all species. Clean water is also important for fishing, swimming, and other forms of recreation. Forests play an important role in protecting and improving water quality—both surface and groundwater. Forested wetlands serve as sinks to slow runoff, filter water, and release clean water into waterways and underground aquifers. The use of Best Management Practices (BMPs) when harvesting timber helps maintain water quality in forested areas.

Delaware faces considerable water quality challenges. Most of the streams and lakes in Delaware are listed as impaired by the EPA.

Surface water

Delaware faces considerable water quality challenges. The Environmental Protection Agency (EPA) publishes a list of water bodies in each state that fail to meet water quality standards. Most of the streams and lakes in Delaware are listed as impaired by the EPA. In 2012, the Delaware Department of Natural Resources and Environmental Control (DNREC) found that 85% of Delaware's rivers and streams did not fully support swimming use and 94% did not support fish and wildlife use. This is a 3% improvement in both categories over the 2008 data. Additionally, DNREC found that 41% (3% improvement) of Delaware's freshwater ponds and lakes did not fully support swimming use and 74% (15% improvement) did not fully support fish and wildlife use. The cause of impairment in most cases is excesses of nitrogen and phosphorus. These nutrients cause excessive algal growth, which in turn leads to algal blooms and oxygen-starved water conditions that can kill fish. Nitrates are also a known carcinogen. Nitrogen and phosphorus pollution come from many sources, including fertilizer applied by farmers and homeowners, domestic and wild animals, and septic systems.

To meet the EPA's requirements, Delaware must develop plans to reduce pollution to acceptable levels. The Total Maximum Daily Load (TMDL) approach, required by EPA, quantifies current levels of each pollutant as well as the maximum allowable level. Teams are assembled on a watershed-by-watershed basis to develop strategies to reduce pollution to TMDL levels. These strategies are known as "Pollution Control Strategies" and can incorporate new regulations, education, and specific clean-up efforts.

The multiple programs addressing nutrient problems generally credit forests as the most beneficial land use in terms of nitrogen and phosphorus pollution rates. Creating forestland (e.g., afforestation) by converting other land uses reduces the amounts of nitrogen and phosphorus that reach streams and groundwater. These reductions are incorporated into the model used to demonstrate that pollution is being reduced to acceptable levels. Delaware participates in the Conservation Reserve Enhancement Program (CREP) that provides cost shares and annual rental payments to landowners who plant trees to improve water quality. Over 1,750 acres have been enrolled in CREP in the last ten years with an additional 57 acres of riparian forests. More information about CREP is included in the discussion of Indicator 14, "Investments in forest health, management research, and wood processing." Targeted planting of trees in urban areas around catch basins and along drainage areas can also reduce the velocity and impact of stormwater runoff.

Wetlands provide a wide range of valuable natural benefits and forested wetlands are widely recognized as the premier wetland type.

When trees are harvested for commercial use, operators must obtain a permit from the Delaware Forest Service. Forest Service personnel ensure that Best Management Practices (BMPs) are used to prevent unnecessary pollution of waterways by sediment and other pollutants. Timber harvest BMPs are discussed in more detail under Indicator 17, "Forest management standards/ guidelines."

While most of Delaware's drinking water is supplied through groundwater, there are two cities—Newark and Wilmington—that rely on surface water for a portion of their drinking water supply. The Hoopes Reservoir holds two billion gallons of water and provides a reserve supply for the City of Wilmington when the water level of the Brandywine River becomes too low. Water is pumped into the reservoir from the Brandywine River when necessary and when water levels permit. Water also enters the Hoopes from a relatively small watershed—about 1,250 acres of which approximately 486 are forested. The Newark reservoir contains approximately 318 million gallons and is supplied by pumping water from the nearby White Clay Creek. Maintaining as much forestland as possible within the Brandywine and White Clay Creek watersheds (both of which extend well into Pennsylvania) as well as the small watershed that directly feeds the Hoopes Reservoir is vital to water quality.

Groundwater

Forests also play a critical role in Delaware's groundwater recharge. DNREC's Division of Water has identified approximately 119,000 acres of excellent groundwater recharge area—approximately 10% of Delaware's land base. For Delaware, groundwater recharge potential maps show land areas characterized by their abilities to transmit water from land surface to a depth of 20 feet. Excellent recharge areas allow precipitation to rapidly infiltrate to the underlying aquifer and are typically areas with natural vegetative cover, flat topography, permeable soils, a deep water table, and the absence of confining beds. These areas provide much of the groundwater to recharge Delaware's underground aquifers—the state's primary water supply for all purposes (drinking water, irrigation, etc.). Of the 119,000 acres, almost one-third are forested (36,350 acres). Keeping these areas forested will not only help maintain Delaware's groundwater supply but also help filter and clean this water.

Forested wetlands

Wetlands provide a wide range of valuable natural benefits, including slowing water runoff, trapping sedimentation and filtering pollutants before they reach streams and other waterways, valuable habitat for many species of wildlife and plants, and recreational opportunities. Forested wetlands are widely recognized as the premier wetland type. Delaware has lost a significant portion of its forested wetlands through drainage and clearing for other land uses. Additional wetlands have been degraded by a variety of impacts including invasive species, fragmentation, improper timber harvests, sediment and chemical runoff from adjoining land uses, and drainage. Forested wetland losses have slowed dramatically in recent decades with new laws, regulations, and a greater public awareness and appreciation of the importance of wetlands.

The most recent estimates of forest wetlands, based on an analysis of 2017 land cover by the DNREC (known as the State Wetland Mapping Project or SWMP), was 145,308 total acres. Palustrine wetlands (Table 10) make up virtually all (145,193 acres) of the forested wetlands in the state. These wetlands include any non-tidal inland wetland that lacks flowing water and contains ocean-derived salts in concentrations of less than 0.5 parts/ thousand.

Table 10. Palustrine forested wetlands, 2017.

County	*Acres*	*% of Delaware's Forested Wetlands*
New Castle	15,111	10
Kent	55,155	38
Sussex	74,927	52

Source: DNREC Division of Watershed Stewardship.

The remaining acres are classified as estuarine forested wetlands, where a river current meets a tidal area. Estuarine forested wetland acres for each county are as follows: New Castle – 6, Kent – 13, and Sussex – 96.

The *2010 Delaware Forest Resource Assessment* reported over 205,000 acres of forested wetlands in the state based on a 2007 DNREC land cover analysis. Compared to the 2017 data, this is an apparent 43% decrease in wetland acreage. However, the 2017 wetland data was created using the new National Wetland Inventory 2.0 mapping standards. These standards are different than all prior wetland standards used in Delaware (including 2007) resulting in measurements that cannot reliably be compared to earlier analyses. It should be noted that although comparisons of acreage are not equivalent because of the standards employed, the percentage of Delaware's wetland forests in each county has remained virtually unchanged over that ten-year period.

As discussed in more detail under Criterion 1, Coastal Plain seasonal ponds are a very important component of forested wetlands. In addition to the habitat function they serve for salamanders and other biota, forests help maintain water quality of seasonal ponds by filtering nutrients and other pollutants, preventing invasive species from readily establishing in the ponds, and also serving as groundwater recharge areas. Rainwater slowly percolates through forest soils, and over time, this groundwater flows into seasonal ponds flooding them in the winter and spring.

Clean and abundant water is a byproduct of healthy forests. Therefore, it is important that forest management activities protect water quality. The Delaware Forest Service recently participated in a joint Maryland/ Delaware BMP effectiveness study and the results revealed a very high compliance rate (>90%) when BMPs were involved with water quality (stream or ditch crossings). Only one minor and easily fixed issue was discovered during the study.

Conserving forests that are critical to water quality and quantity, such as forested wetlands and riparian forests, is vital to Delaware's environment and economy.

Conclusions

Delaware faces important water quality challenges and most streams and ditches in all watersheds are impaired or are under a TMDL reduction. Protecting and maintaining excellent groundwater recharge areas is vital to the state's primary water resource. Additionally, while surface water is not a primary source of drinking water in Delaware, it is a source for two of Delaware's largest cities. Forests play, and will continue to play, an important role in protecting and enhancing water quality and quantity. Conserving forests that are critical to water quality and quantity, such as forested wetlands and riparian forests, is vital to Delaware's environment and economy.