

DELAWARE

FOREST RESOURCE ASSESSMENT



REPORT TO THE U.S. FOREST SERVICE

October 2020



Table of Contents

I.	Introduction	p. 1
II.	The 2010 Delaware Forest Action Plan in Retrospect	p. 2
III.	Forest Conditions and Trends	p. 3
	Criterion 1: Conservation and Biological Diversity	p. 3
	Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems	p. 28
	Criterion 3: Maintenance of Forest Ecosystem Health and Vitality	p. 32
	Criterion 4: Conservation and Maintenance of Soil and Water Resources	p. 42
	Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles	p. 49
	Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits to Meet the Needs of Societies	p. 54
	Criterion 7: Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management	p. 71
IV.	Existing and Emerging Benefits and Services	p. 81
V.	Issues, Threats, and Opportunities	p. 85
VI.	Rural Priority Landscape Area	p. 98
VII.	Urban Priority Landscape Areas	p. 115
VIII.	Multi-State Regional Priority Landscape Areas	p. 120
IX.	Forest Resource Assessment Summary	p. 127
X.	Appendices	p. 128





DELAWARE FOREST RESOURCE ASSESSMENT

I. Introduction

Forests are an essential part of Delaware's green infrastructure. What remains today deserves protection and conservation whenever possible. The countless natural benefits forests provide should never be underestimated, especially those related to clean air and clean water. The health of our environment in many cases is a reflection of the health of our forests. Imagine for a moment, Delaware without any trees or forests. Such a scenario might seem inconceivable but if it did come true, the unfortunate consequences—ecologically, socially, and economically—would be catastrophic.

The Delaware Forest Service (DFS) strives to conserve, protect, and enhance Delaware's forest resources for current and future generations. Without a doubt, forests have played a key role in the state's history—from pre-European settlement to the founding of our nation to the present day. It is our fundamental responsibility to help ensure that forests persist so they continue playing a critical role in the lives of all Delawareans. To that end, this statewide forest resource assessment presents an overview of the current status of Delaware's forests—both rural and urban, public and private—as well as the numerous ecological benefits they provide.

Included in the assessment are the following:

- Conditions and trends affecting Delaware forests,
- Benefits and services provided by Delaware forests,
- Issues, threats, and opportunities facing Delaware forests, and
- Priority forest landscape areas identified through the assessment process.

The information presented here is a 10-year update of the *2010 Delaware Forest Resource Assessment* and follows the same seven criteria and eighteen indicators as outlined in the Montréal Process and adopted by the Northeast-Midwest State Foresters Alliance. All aspects, both biological and social, of forests and their sound management are addressed. These include biological diversity, productive capacity, forest health, soil and water resources, carbon cycles, social aspects, and legal and economic issues. Each criterion is supported by at least one corresponding indicator.

A variety of sources were used to compile the data in this assessment. Where possible, the most recent data was compared to historical data including a decade ago when the first assessment was published. Data from multiple sampling periods were used to detect and show trends. Furthermore, all forests in Delaware were considered as this was necessary to present a thorough assessment of the resource. Included are rural and urban forests as well as forests owned publicly and privately.

This *2020 Delaware Forest Resource Assessment* was compiled and written by DFS staff members in consultation with a variety of stakeholders and guidance from the Forest Stewardship Committee (see [Appendix 1, Stakeholder Involvement](#)). Additionally, every attempt was made to capture and include input and recommendations from all of our stakeholders and other interested individuals from the general public.



II. The 2010 Delaware Forest Action Plan in Retrospect

The Delaware Forest Service (DFS) submitted two key documents to the U.S. Forest Service in 2010 that together made up the state's Forest Action Plan: *Delaware Forest Resource Assessment* and *Delaware Statewide Forest Strategy*. The assessment summarized the state of forest resources in Delaware up to 2010. Detailed information contained therein served as a guide in developing a strategy for the subsequent ten years with an overarching goal of protecting Delaware forests and all the natural benefits they provide.

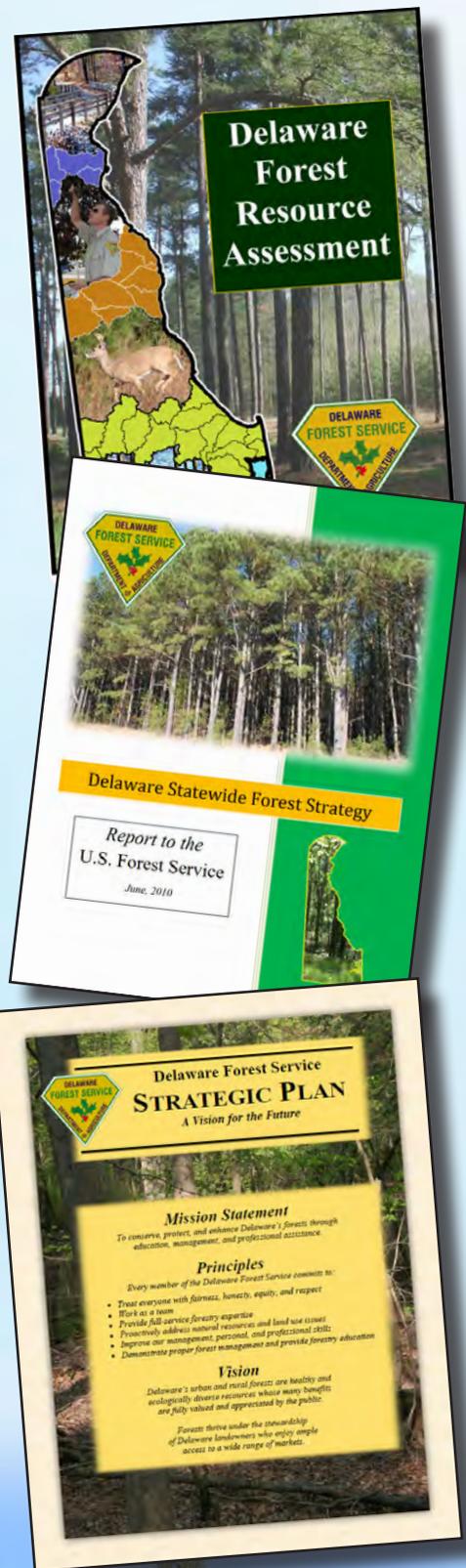
The *2010 Forest Action Plan* addressed four priority issues: *Forest Health and Functionality*, *Forest Markets*, *Sustainable Forest Management*, and *Public Awareness and Appreciation of Forests*. Within these four broad priority issues, 19 specific strategies were developed and within the strategies, 78 specific performance goals/measures of success were identified.

As of 2020, the DFS and associated partners have completed 54 (69%), partially completed 21 (27%), and were unable to address just 3 (4%) goals. This is an improvement over the five-year interim reporting for 2015. One partially complete and two uncompleted goals moved up to the completed category. Of our 78 state goals, 24 were directly related to U.S. Forest Service National Priorities—16 (67%) were completed and 8 (33%) were partially completed. There are ongoing efforts to address all the unfinished goals and add to the success of the goals fully completed.

Of particular note is the Delaware Forestland Preservation Program having a source of funding through the Aglands Preservation Program budget for the last two years. But this is a very significant change because for the prior ten years there was zero funding for this program that was initially funded at the \$1 million level only in 2009.

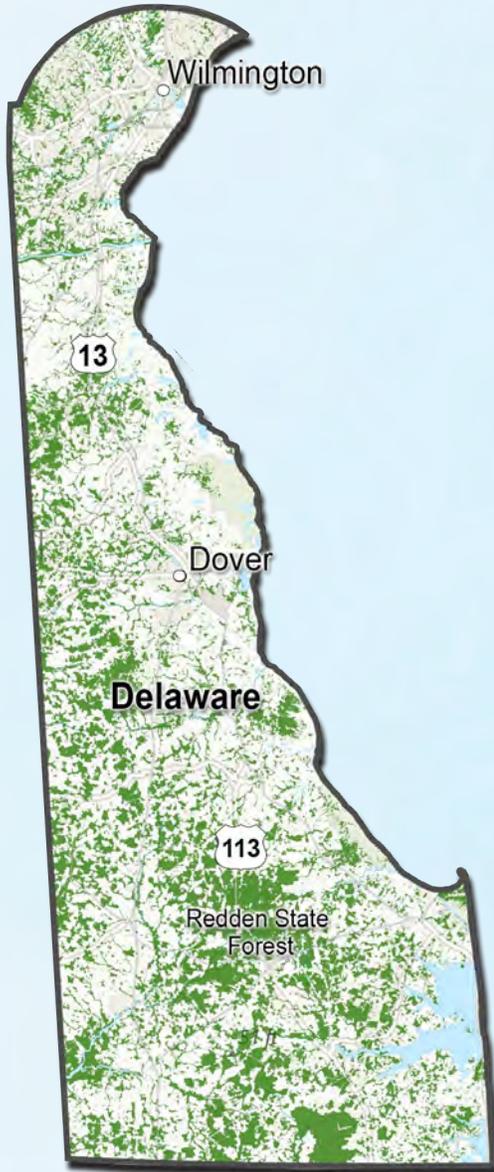
Additionally, through a competitive U.S. Forest Service Landscape Scale Restoration grant, Delaware is part of a regional economic impact study of forests and the forest industry. This study will be published in 2020 and Delaware is to receive state-level economic information that can be used to bolster the local forest products industry in the future.

The *2010 Delaware Forest Action Plan* resulted in DFS staff members concentrating their efforts on attaining the 78 strategic goals. Nearly all were completed or partially completed with ongoing efforts to further advance the goals. After ten years of dedicated and targeted work, now it is time to reassess the forest resources of Delaware as many changes have occurred in that time frame. An updated forest resource assessment is essential for the development of a revised strategy containing new attainable goals. In the pages that follow, you will find detailed information describing the changes that have occurred since 2010.



III. Forest Conditions and Trends

Figure 1. Forests of Delaware.



Source: Delaware Dept. of Agriculture

The Montréal Process criteria listed below provide broad categories or goals for sustainable forest management and are used at national and international levels. The Northeast-Midwest State Foresters Alliance and Eastern Region State and Private Forestry indicators and metrics were developed for use in region-wide and state-level forest resource assessments to measure the criteria.

Criterion 1: Conservation and Biological Diversity

Forests, and particularly native forests, support a substantial proportion of the planet’s biological diversity and terrestrial species. Biological diversity enables an ecosystem to respond to external influences, to recover after disturbance, and to maintain essential ecological processes.

Human activities and natural processes can impact adversely on biological diversity by altering and fragmenting habitats, introducing invasive species, or reducing the population or ranges of species. Conserving the diversity of organisms and their habitats supports forest ecosystems and their ability to function, reproduce, and remain productive.

INDICATOR 1

Area of total land, forestland, and reserved forestland

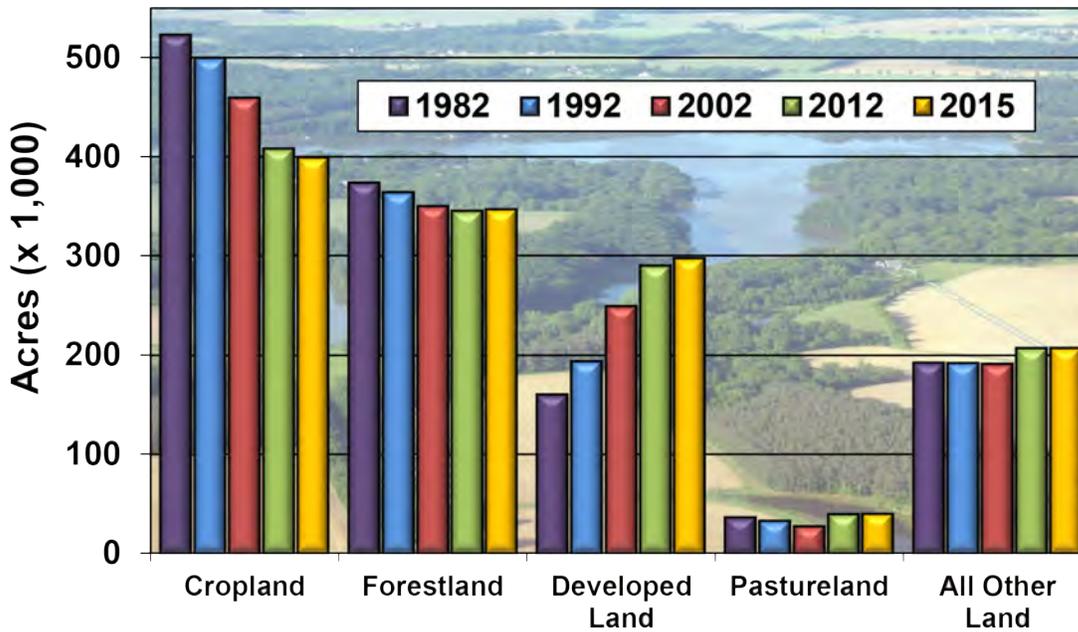
This indicator assesses the percentage of the state that is forested and the percentage of the forested area that is protected from development. The amount of forestland relative to other cover types provides an initial impression of the importance of the resource. The amount of protected forestland indicates the degree to which the resource is sheltered from mismanagement or clearing for some other non-forest use.

Total land and forestland in Delaware

Total land area of Delaware is estimated to be about 1.25 million acres, of which approximately 359,000 acres are currently forested (Figure 1). Forestland includes forested areas that are undeveloped or not developed for non-forest land users, are at least one acre in size and 120 feet wide, and contain a canopy cover of at least 10%. This is the definition used by the U.S. Forest Service for their national Forest Inventory and Analysis (FIA) program from which much of the data in this assessment originates.

Cropland occupies approximately 400,000 acres in Delaware (Figure 2). There has been a steady decrease in cropland and forestland since 1982. Most of this land-use loss is attributable to development (137,000 acres) over the last 35 years or so—an average of about 3,900 acres of forestland lost per year in Delaware.

Figure 2. Acres by land cover type in Delaware, 1982–2015.



Source: USDA NRCS 2015 National Resources Inventory Summary Report

Delaware is typical of the states in the Eastern U.S. with forested areas having declined significantly since European colonization in the 1600s. During pre-colonial times the forests of Delaware covered about 90% or 1.1 million acres of the state’s total land area. Virtually the entire state was covered in forest except for the wettest sites, particularly marshlands along the coast. Large areas of forestland were subsequently cleared for agricultural use.

Forestland coverage was at its minimum in Delaware around the turn of the 19th century with an estimated low of 350,000 acres (Table 1). Over the next 120 years, forest acreage has fluctuated due to patterns in cultivation and abandonment of agricultural fields. Presently, forestland acreage in Delaware stands at approximately 359,000 acres, just slightly more than what occurred here about a century ago.

Not surprisingly, nearly all the losses in forestland since 1986 have occurred in Sussex County, Delaware’s most rural county and home to an ever-increasing demand for coastal community development (Figure 3). New Castle and Kent Counties have experienced slight gains over this time period whereas Sussex County has experienced a loss of over 36,000 acres of forestland. The net annual loss of forestland since 1986 is 957 acres.

Change in Delaware population 2010–2019

In 2010, the population of Delaware was 879,934. Nine years later in 2019 that population had increased by 10% to 989,803 with projections to exceed 1,000,000 by the year 2020. Most of this population growth, as expected, is in Sussex County along the coastal area. This population increase is spurred on by widespread development which in turn decreases the amount of forestland in the county. This trend is expected to continue over the next decade.

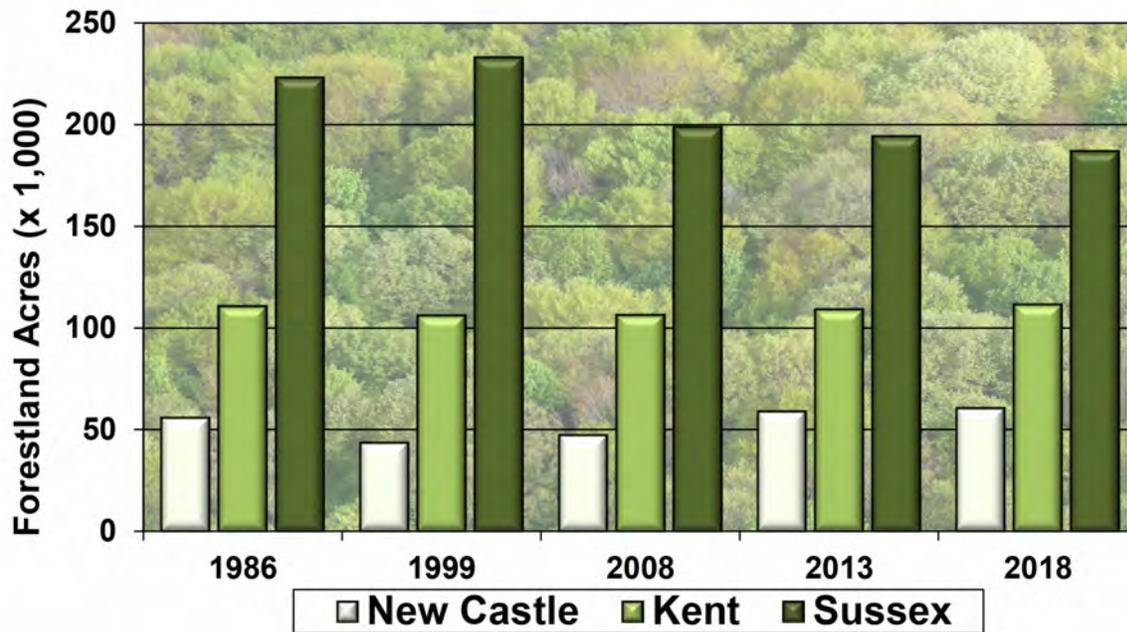
Table 1. Delaware forest acres.

Year	Acres (x 1,000)
1907	350
1920	351
1938	423
1953	454
1963	392
1977	392
1986	389
1999	382
2008	352
2012	348
2016	355
2018	359

Source: Oswalt et al. 2019. Forest Resources of the United States, 2017

Gen. Tech. Rep WO-97 U.S. Forest Service Forest Inventory and Analysis and Delaware Forest Service data

Figure 3. Delaware forest acres by county, 1986–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Protected forestland

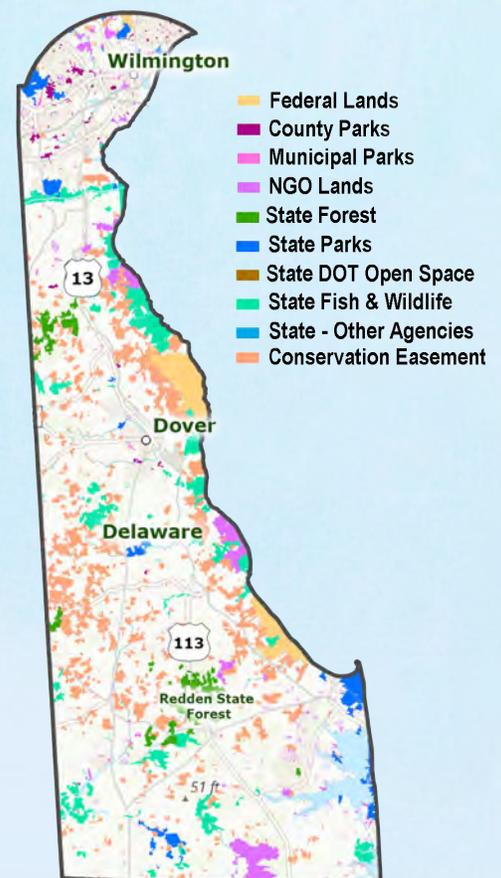
Currently, approximately one-third of all Delaware forestland is protected from development. This includes government-owned and non-governmental organization-owned (NGO) tracts of forestland and areas protected by permanent conservation easement—notably the 36,537 acres protected through easements purchased by the Delaware Aglands and Forestland Preservation Programs (Figure 4). The Forestland Preservation Program has recently received funding that will help protect additional forested acres in Delaware.

From 2002 until 2010, the Delaware Forest Service (DFS) had a string of successes in procuring six Forest Legacy Program (FLP) acquisition grants totaling \$14.925 million. Through the multi-phased Green Horizons project, the DFS purchased and protected 2,845 acres of former industrial forestland that is now part of Redden State Forest and open to the public for a variety of uses. Delaware’s Open Space program was instrumental in the success of the FLP purchases by providing required matching funds. Delaware counties and NGOs also provided significant financial assistance in protecting forestlands over the last two decades.

Protected forestland in Delaware has increased significantly since 1960 (Figure 5). A large portion of this increase resulted from the passage of Delaware’s Land Protection Act in 1990, which established the state’s Open Space program and a permanent funding source for state land acquisitions. Since its inception in 1990, Delaware’s Open Space program has protected over 62,700 acres of land at a total cost of \$174,244,321 (\$104,663,343 in state funds).

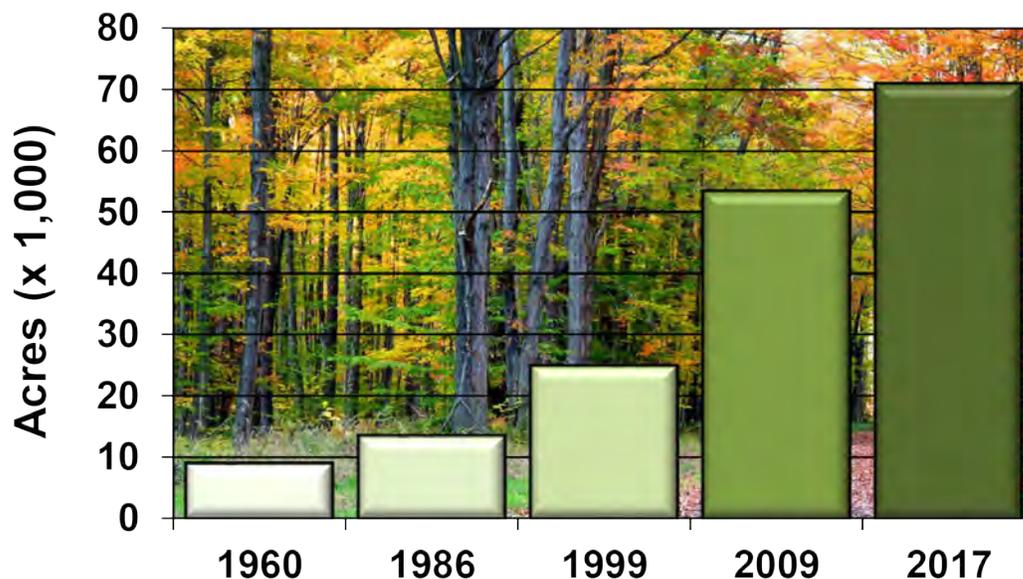
Delaware currently has no forested areas that are specifically designated as “reserved,” where no timber harvesting is allowed by statute. However, roughly 30,000 acres are owned and managed by NGOs and the Delaware Division of Parks & Recreation where silvicultural activities generally are not practiced or if so, at a minimum.

Figure 4. State, Federal and NGO Lands, 2017.



Source: State of Delaware

Figure 5. Protected forestland in Delaware.



Source: U.S. Forest Service Forest Inventory and Analysis

Urban forests

Urban forest (canopy) cover varies greatly within Delaware. The DFS completed a GIS analysis in 2019 of urban forest canopy in Delaware's 57 incorporated municipalities. Of the 89,746 acres located within municipal boundaries, 22,551 acres (25.1%) have urban tree cover. Urban tree cover varies significantly among communities, ranging from 10 to 85%. When one includes not only the incorporated municipalities, but also other urbanized areas designated by the 2010 Census (such as the area of Bear in New Castle County), the total land area within all urbanized areas totals 262,244 acres of which approximately 81,126 acres have urban forest cover, thus Delaware's total urban forest canopy coverage is approximately 31%.

Conclusions

Delaware has lost two-thirds of its forests since European settlement. This loss stabilized around 1900 with notable increases occurring in the mid-20th century. A subsequent steady decline took place until the early 21st century when remaining forest acreage leveled off around 360,000 acres—the most recent declines can be attributed to development. Forests in Delaware offer the path of least resistance when constructing massive infrastructure projects like State Route 1 or expansive housing developments. Although currently at about only 29% of the total land mass, Delaware forests are still a significant part of the landscape and a critical part of the ecological infrastructure. Currently only about one-third of Delaware forests are safeguarded against development. What remains is worth protecting either through conservation easements or fee simple acquisition. Delaware established the first state-funded program in the nation specifically designed to purchase conservation easements on working forestlands. Efforts should be made by the DFS and all concerned partners to ensure enough forestland is protected to maintain all the vital functions and natural benefits that forests provide.



Delaware established the first state-funded program in the nation specifically designed to purchase conservation easements on working forestlands.



INDICATOR 2

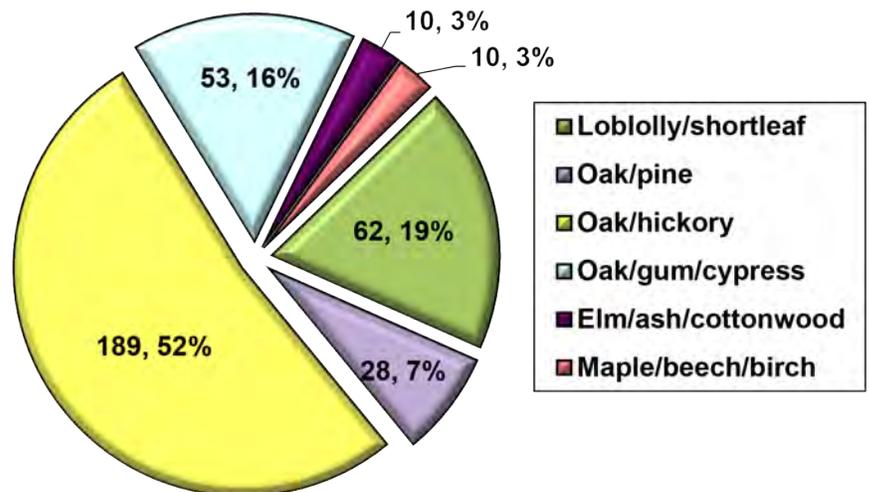
Forest type, size class, age class, and successional stage

This indicator provides a view of the overall forest resource in the state. Periodic forest inventories are used to develop reports that describe the basic biological characteristics of our forests and trees contained therein. Ideally, the state's forest resource will contain a mixture of native forest types and, within each type, there exists a mosaic of tree size and age classes.

Forest types in Delaware

Forests are often classified by type—that is, the common dominant tree species or combination of tree species found in those forests. Forest types found in Delaware are based on periodic inventories conducted by the U.S. Forest Service through its Forest Inventory and Analysis (FIA) program. Just over half of the forested area in Delaware currently consists of an oak/hickory species complex (Figure 6). Pine and pine/oak types make up about one fourth of the total area. Minor hardwood components such as gum, maple, and beech, inhabit the remaining forested acreage.

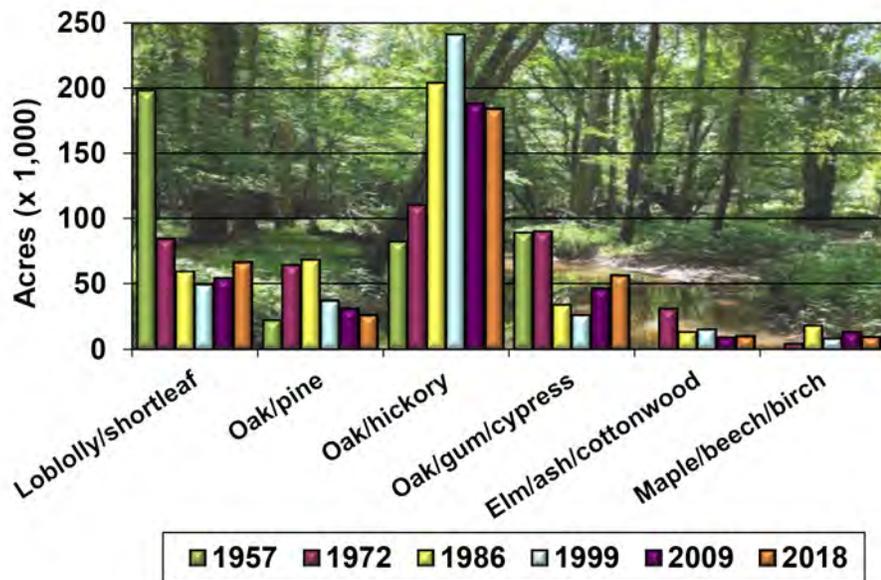
Figure 6. Acres (x 1,000) by forest type in Delaware, 2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Although the total area of forestland has remained relatively stable over the last 60 years, significant changes have occurred within Delaware's forests (Figure 7). Notably, loblolly pine (*Pinus taeda*) acreage steadily decreased from nearly 200,000 acres in 1957 to less than 50,000 in 1999 (a 75% decline). However, in the last 20 years, pine acreage has increased to 67,000 acres. A dramatic decline occurred between 1957 and 1972 when large areas of woodland were cleared for agricultural use and before Delaware's *Seed Tree Law* was enacted. This steep decline is significant because loblolly pine is one of Delaware's most valuable commercial timber species and historically has contributed significantly to Delaware's economy.

Figure 7. Forest types of Delaware, 1957–2018.

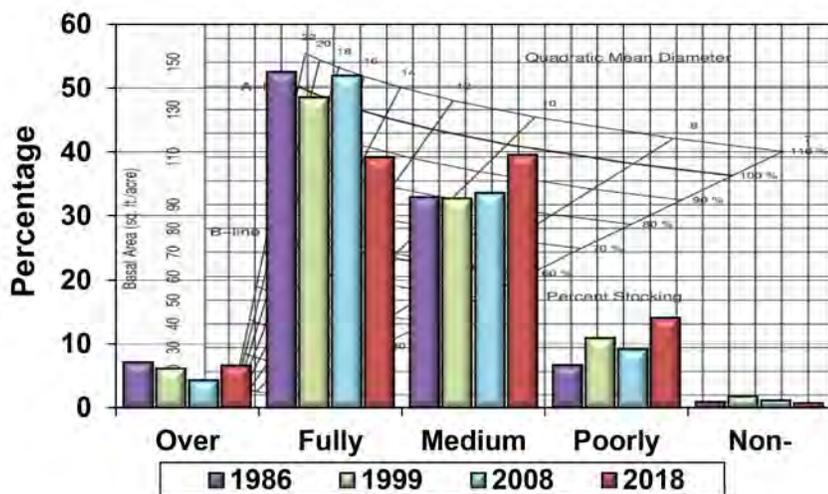


Source: U.S. Forest Service Forest Inventory and Analysis

The passage of Delaware’s *Seed Tree Law* in 1989 was prompted by the precipitous loss of loblolly pine forests. The law requires forest landowners to ensure sufficient regeneration after a harvest. Loblolly pine and yellow-poplar (*Liriodendron tulipifera*) are covered under this law that only applies to forests greater than 10 acres. This law only applies to parcels that will remain in forestland and it does not apply to land-use changes such as development.

The decline of loblolly pine acreage is due, to a large extent, to trends in growth and removals (see Criterion 6, page 56). From 1959 to 1999, removals of softwood growing-stock consistently exceeded growth. During that same time period (and continuing today) hardwood growth far-exceeded removal of hardwood growing-stock. In many cases, natural regeneration by hardwoods (particularly oaks and hickories) after a loblolly pine clearcut harvest results in a hardwood stand replacing a former pine stand.

Figure 8. Stocking classes in Delaware forests, 1986–2018.



Source: U.S. Forest Service Forest Inventory and Analysis



Nearly 80% of Delaware’s forests are currently either medium- or fully-stocked, indicating near optimum growth based on scientific growth curves.



Table 2. Growing-stock wood volume by tree species groups, 2009–2018.

Species Group	Wood Volume (1,000 cubic feet)		
	2009	2016	2018
Loblolly and shortleaf pine	98,294	117,253	146,359
Other yellow pines	24,841	15,772	16,577
Other eastern softwoods	1,592	582	3,626
All softwoods	124,727	133,607	166,562
Select white oaks	70,760	83,248	98,490
Other white oaks	1,246	1,944	2,876
Select red oaks	10,435	3,895	2,990
Other red oaks	114,656	141,089	142,730
Hickory	6,010	6,934	7,452
Soft maple	189,720	197,964	231,836
Beech	12,266	12,786	16,034
Sweetgum	114,517	113,236	123,207
Tupelo and blackgum	33,821	37,959	43,147
Ash	18,923	20,711	24,966
Cottonwood and Aspen	1,436	1,019	2,540
Yellow-poplar	94,652	137,733	161,811
Black walnut	5,355	6,188	9,838
Other eastern soft hardwoods	38,763	30,435	36,262
Other eastern hard hardwoods	23,321	19,815	23,397
Eastern non-commercial hardwoods	1,945	886	1,010
All hardwoods	737,826	815,842	928,587
Total	862,553	949,449	1,095,149

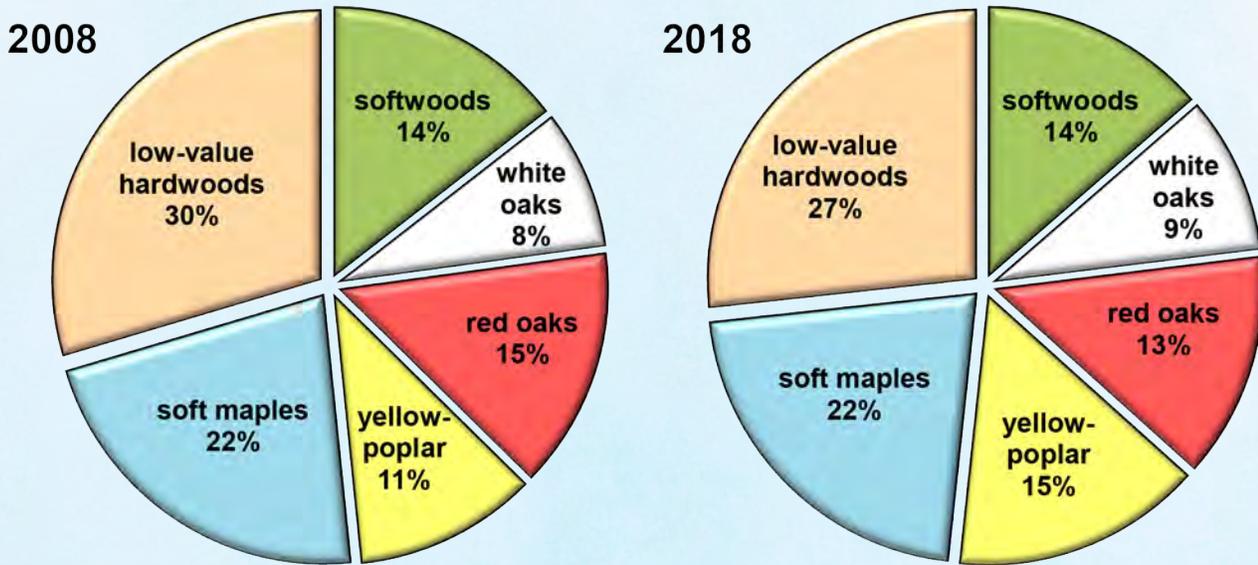
Source: U.S. Forest Service Forest Inventory and Analysis

Between 1959 and 1999, the oak-hickory forest type nearly tripled from 82,000 to 241,000 acres. In the last 20 years loblolly pine has reclaimed significant acreage at the expense of the oak-hickory forest type that is currently at 184,000 acres.

There were more than 240 million trees (≥ 1 inch in diameter) in 2018, an 8% drop since 1999, which reflects the corresponding loss of forest acreage. Tree stocking is a measure of the number and size of trees on an acre of forest. Since 1986 the percentage of forested acres fully-stocked decreased by 13% but the medium-stocked acreage increased by 7% (Figure 8). There was also a 7% increase in poorly-stocked acres. Nearly 80% of Delaware's forests are currently either medium- or fully-stocked, indicating near optimum growth based on scientific growth curves.

Total growing-stock volume of all species was 862 million cubic feet in 2009 (Table 2). But in the last ten years, there has been a significant increase (27%) in volume to the current level of 1,095 million cubic feet. Growing-stock, by definition, does not include non-merchantable species or trees that are unmarketable due to defects. Approximately 95% of total volume is marketable and considered growing-stock volume. Note the large volume increases for loblolly pine (+49%), white oak (*Quercus alba*) (+39%), and yellow-poplar (+71%), the most valuable commercial tree species growing in Delaware. Also note the rapid decline in northern red oak (*Quercus rubra*) (-71%), the most commercially valuable of all species in the red oak group.

Figure 9. Total volume by species in 2008 and 2018.



Source: U.S. Forest Service Forest Inventory and Analysis

The breakdown of growing-stock volume by major species group over the last ten years is shown in Figure 9. Hardwoods still account for 86% of the total volume. Low-value hardwoods and red oaks (primarily northern red oak) decreased slightly whereas the more valuable white oaks and yellow-poplar increased. Softwoods, primarily loblolly pine, stayed constant over this time period.

Nearly one-half of all growing-stock volume consists of red maple (*Acer rubrum*) and other low-value hardwoods. This abundance is due to a combination of factors including oak decline and mortality from widespread gypsy moth infestations in the 1980s and 1990s, damage from the 1994 ice storm (particularly pine forests), and improper timber harvests. Past poor timber harvests resulted in pine forests regenerating to low quality hardwood forests and the common practice of high-grading (removing only the best species and specimens) that results in an increase of poorly-stocked forests.

A primary reason why poor hardwood management is so common is the lack of markets for small-diameter and low-quality hardwood. Better and sustainable management of such stands and a greatly improved market for low-value hardwood in the future could help shift species composition back to favor oak, yellow-poplar, loblolly pine, and other valuable species. The development of new markets for low-value hardwood products would help improve the health and sustainability of many hardwood forests.

Conifers (softwoods) account for 14% of all live growing-stock tree volume in Delaware. Loblolly pine accounts for about 90% of the entire conifer volume. Virginia pine (*Pinus virginiana*), baldcypress (*Taxodium distichum*), and Atlantic white-cedar (*Chamaecyparis thyoides*) account for most of the remaining conifer volume. The amount of baldcypress and Atlantic white-cedar has declined due to past timber harvesting and the historical practices of draining wetlands and channelizing streams.

A primary reason why poor hardwood management is so common is the lack of markets for small-diameter and low-quality hardwood.



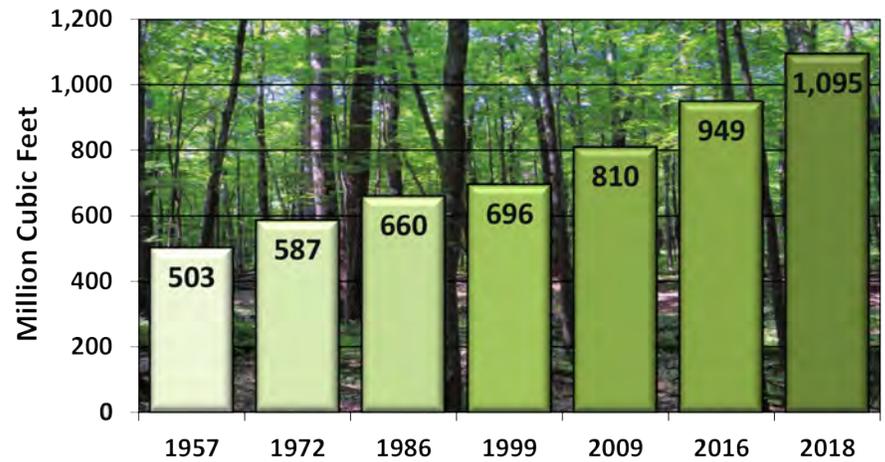


Without a thriving timber industry in Delaware, the trend toward larger diameter trees will continue and eventually create an imbalance in forest age structure.

Forest age and size classes

Total growing-stock volume has more than doubled since 1957 (Figure 10). However, softwood and hardwood totals have not changed equally over this 60-year period as one might expect. Softwood volume had declined by half in 1999 and hardwood volume more than doubled (Table 3). Over the next two decades, softwood rebounded and regained half of that 50% volume loss since 1957. And hardwoods continued to increase in volume another 60%. These changes over the last 20 years indicate Delaware forests are moving in a positive direction in terms of health and viability.

Figure 10. Net volume of trees in Delaware for all diameter classes, 1957–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Table 3. Growing-stock volume, 1957–2018.

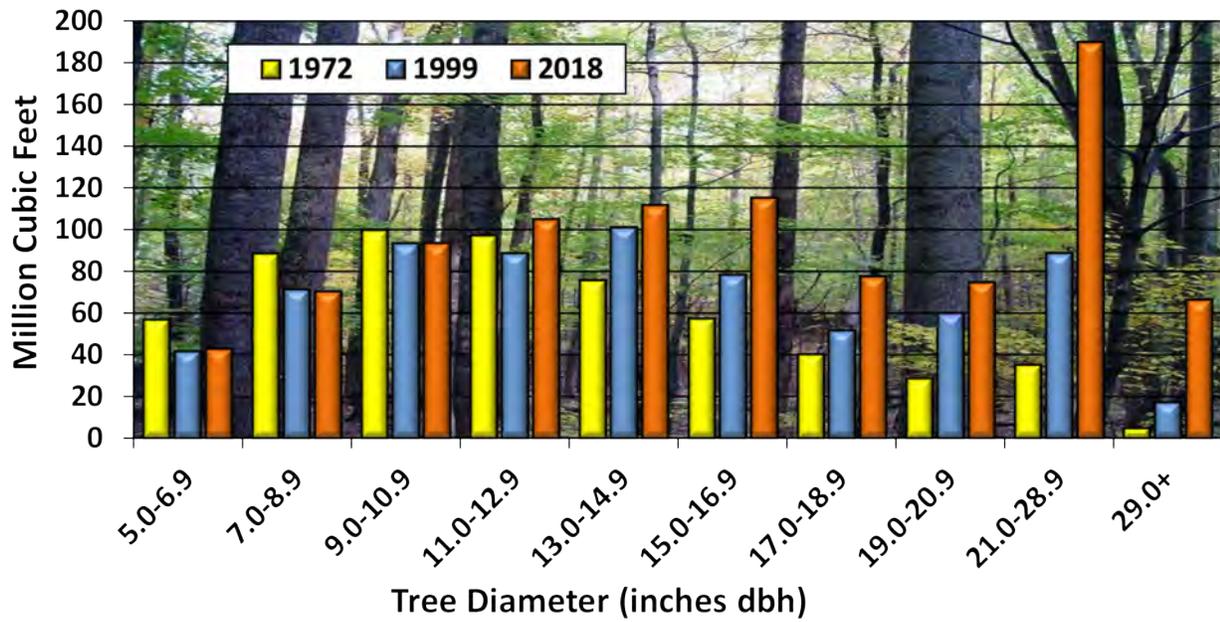
	Wood Volume (million cubic feet)						
	1957	1972	1986	1999	2009	2016	2018
Softwoods	230	184	164	115	120	134	167
Hardwoods	273	403	496	581	690	816	929
Total	503	587	660	696	810	949	1,095

Sources: U.S. Forest Service Forest Inventory and Analysis and USFS Resource Bulletins NE-109 and NE-151

Along with this dramatic increase in growing-stock volume, there has been a corresponding shift in this volume from smaller diameter classes to the more commercially valuable larger diameter classes (≥ 13 inches in diameter).

Figure 11 clearly shows that shift over the last 46 years. Note the dramatic increase in trees ≥ 21 inches in diameter. Many of these older trees are too large for conventional sawmills and have become unmerchantable. Without a thriving timber industry in Delaware, this trend toward larger diameter trees will continue and eventually create an imbalance in forest age structure.

Figure 11. Net volume of trees in Delaware in 1972, 1999, and 2018, grouped by diameter class.

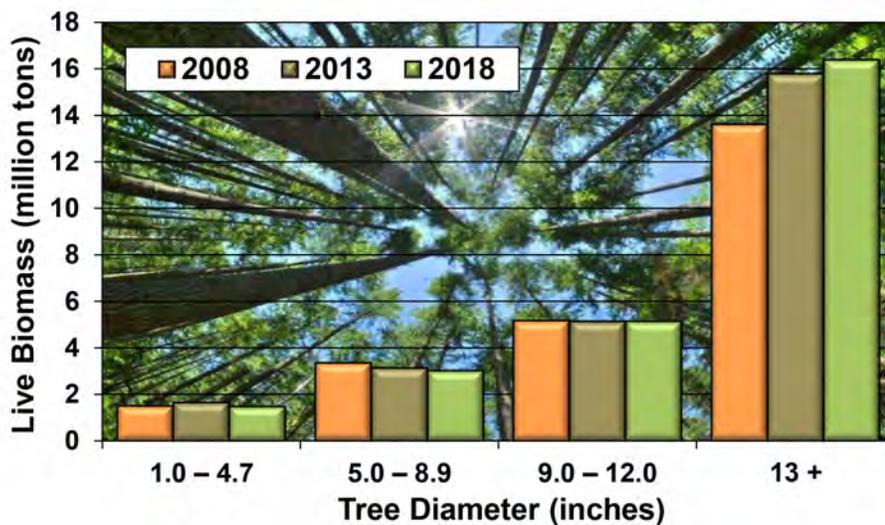


Source: U.S. Forest Service Forest Inventory and Analysis

To further illustrate this shift, FIA measurements of live biomass are heavily skewed toward the 13+ inch diameter classes (Figure 12). Nearly two-thirds of all live-tree biomass is held in these larger diameter classes. Since 2008, 2.77 million tons of biomass have been added to Delaware forests. Biomass is defined as the quantity of wood fiber, for trees 1.0-inch dbh and larger, expressed in terms of oven-dry weight. This includes above-ground portions of the tree—bole/stem (trunk), bark, and branches.



Figure 12. Live-tree biomass (trees at least 1 inch dbh) on forestland by diameter class, 2008–2018.



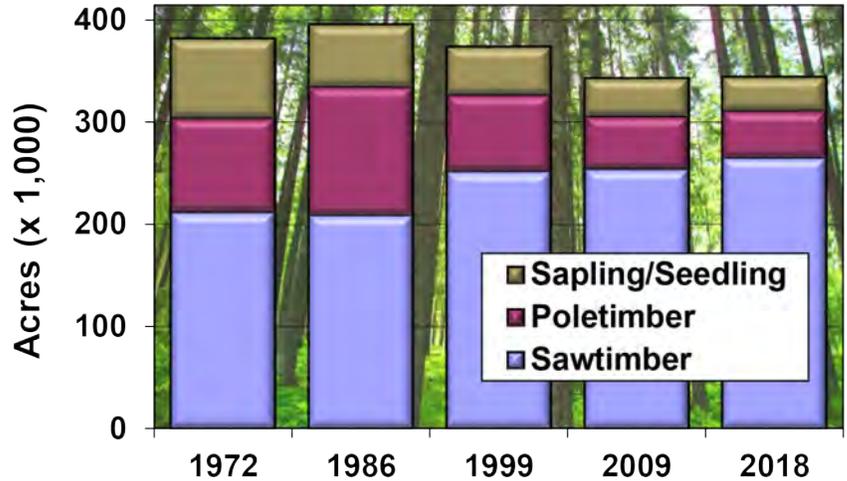
Source: U.S. Forest Service Forest Inventory and Analysis



The results show an aging of Delaware's forests that now contain a greater proportion of older, larger size classes.



Figure 13. Stand size classes, 1972–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Another way to view trends in tree size is to analyze the inventory data by size classes (Figure 13). Sawtimber accounts for the majority (77%) of the forested acreage in Delaware in 2018. In 1972 sawtimber only accounted for 55% of Delaware's forests. Poletimber and sapling/seedling acreage has decreased significantly, from 45% in 1972 to just 25% in 2018. As average diameter has increased, more stands moved into the sawtimber size class. The results show an aging of Delaware's forests that now contain a greater proportion of older, larger size classes. These changes are likely due to changing dynamics of forestland ownership, a dwindling of forest industry forestland holdings, more owners with smaller tracts of forestland who do not harvest timber, an increased acreage of publicly-owned forests, and a decreased demand from a shrinking forest industry.

U.S. Forest Service FIA Tree-Size Classes

A classification of trees based on diameter measurement.

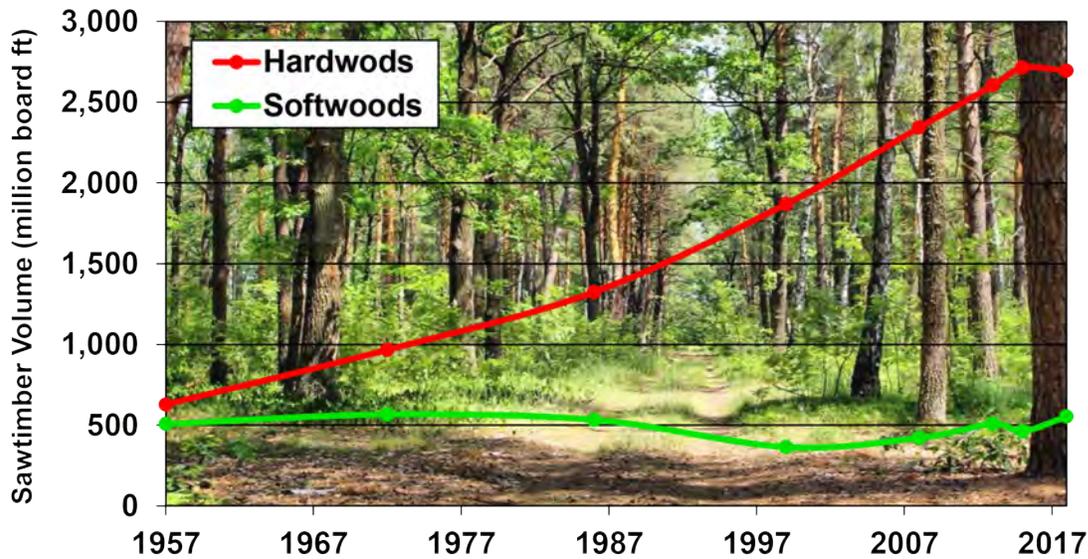
Seedling – An established tree smaller than 1.0-inch dbh (diameter at breast height [4.5 ft above the ground]) for timber species or 1.0-inch drc (diameter at root collar) for woodland trees.

Sapling – A timber species 1.0- to 4.9-inches dbh; also, a single-stemmed woodland tree 1.0- to 4.9-inches drc, or a multistemmed woodland tree with a cumulative drc of 1.0- to 4.9-inches.

Poletimber-size tree or medium tree – A timber species at least 5.0-inches dbh, but smaller than 9.0-inches dbh for a softwood, and smaller than 11.0-inches dbh for a hardwood. A woodland tree 5.0- to 8.9-inches drc (single stem measurement or computed multistem measurement) is also included in this category.

Sawtimber-size tree or large tree – A timber species that is at least 9.0-inches dbh for a softwood, and at least 11.0-inches dbh for a hardwood. A woodland tree 9.0-inches drc and larger (single stem measurement or computed multistem measurement) is also included in this category.

Figure 14. Sawtimber volume in board feet (1/4-inch rule), 1957–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Figure 14 shows the trends in sawtimber volume over the last six decades for both hardwoods and softwoods (mostly loblolly pine). Although overall pine volume has declined by nearly 30% since 1957, the amount of sawtimber volume has actually increased slightly after a dip in the 1990s and early 2000s. Conversely, hardwood sawtimber has seen a steady and dramatic increase in that same time period but appears to be leveling. The increases in sawtimber acreage can be directly attributed to increases in hardwood volume.

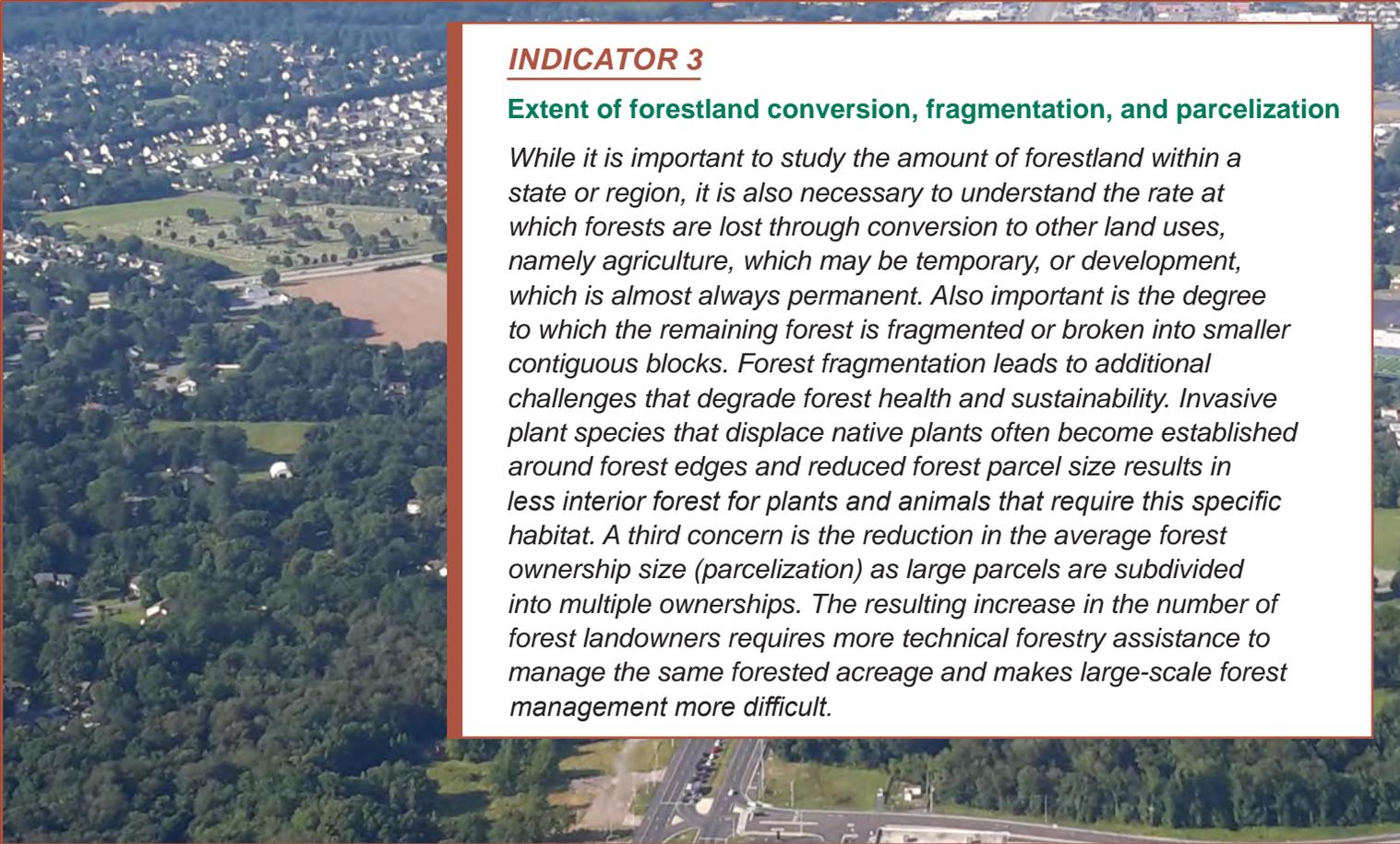
Ideally, Delaware forests should contain a balanced mixture of species and ages. Older timber may be appealing to those who envision this age class as a typical healthy forest, but having an imbalance of age classes, especially tipping toward older growth, is of great concern to a forest manager. Younger forests are needed to replace older forests that are lost to harvesting, natural mortality, or catastrophic events (hurricanes, ice storms, etc.). These forests are also filled with seedlings and saplings providing vital habitat to a variety of wildlife species. A mosaic of stand sizes, ages (including older-growth), and species composition will ensure future sustainability of the many natural benefits that come from forests.

Conclusions

Delaware's forestland base has remained relatively constant over the past century, but significant changes have occurred in forest composition. The oak-hickory forest type now covers more acreage than all the other types combined. In 1957, loblolly pine forests dominated with just over 50% of the total forest acreage—now loblolly pine accounts for less than 20% of that acreage. And today, half of all growing-stock volume consists of red maple and other low-value hardwood timber species, which are minor components of all forest types. This is a dramatic change since 1957 when half of all growing-stock was loblolly pine and other softwoods. Additionally, Delaware forests are aging and increasing in size to a significant degree. Three-quarters of Delaware's forests are now classified as sawtimber and less than 10% are seedlings and saplings. These trends are a great concern. It is imperative to maintain a balance of forest types and tree sizes and ages within each forest type, otherwise there will be a corresponding imbalance in other critical ecosystem functions forests perform, particularly wildlife habitat.

In 1957, loblolly pine forests dominated with just over 50% of the total forest acreage. Now, loblolly pine accounts for less than 20% of that acreage.

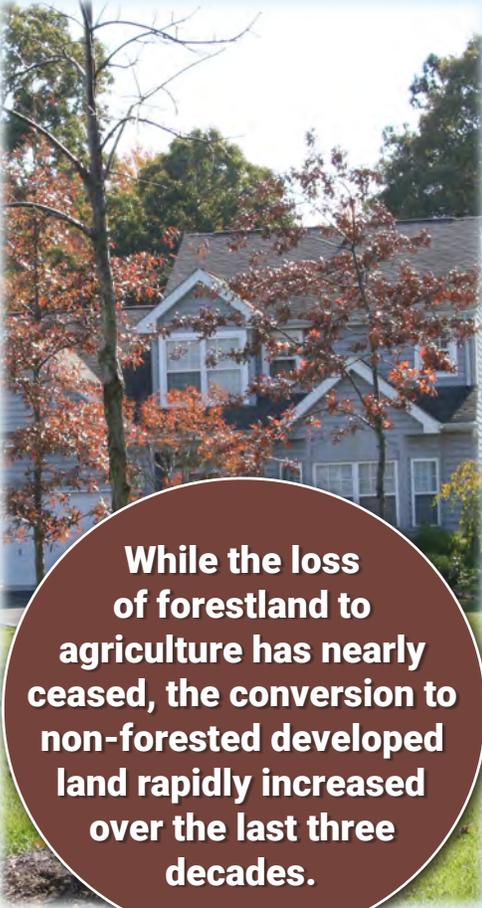




INDICATOR 3

Extent of forestland conversion, fragmentation, and parcelization

While it is important to study the amount of forestland within a state or region, it is also necessary to understand the rate at which forests are lost through conversion to other land uses, namely agriculture, which may be temporary, or development, which is almost always permanent. Also important is the degree to which the remaining forest is fragmented or broken into smaller contiguous blocks. Forest fragmentation leads to additional challenges that degrade forest health and sustainability. Invasive plant species that displace native plants often become established around forest edges and reduced forest parcel size results in less interior forest for plants and animals that require this specific habitat. A third concern is the reduction in the average forest ownership size (parcelization) as large parcels are subdivided into multiple ownerships. The resulting increase in the number of forest landowners requires more technical forestry assistance to manage the same forested acreage and makes large-scale forest management more difficult.



Forest conversion

Delaware's forestland acreage has remained relatively constant over the last century. And although the current acreage is slightly higher than in 1907, there has been a steady decline since the 1950s peak of 454,000 acres. Conversion of forestland to agricultural land in the 1960s and 1970s was the primary reason for this decline. But this conversion rate slowed dramatically with the advent of the Conservation Reserve Enhancement Program (CREP). The loss of forestland through the conversion of cropland has virtually stopped with the planting of nearly 3,000 acres of cropland to trees through CREP. However, while the loss of forestland to agriculture has nearly ceased, the conversion to non-forested developed land rapidly increased over the last three decades.

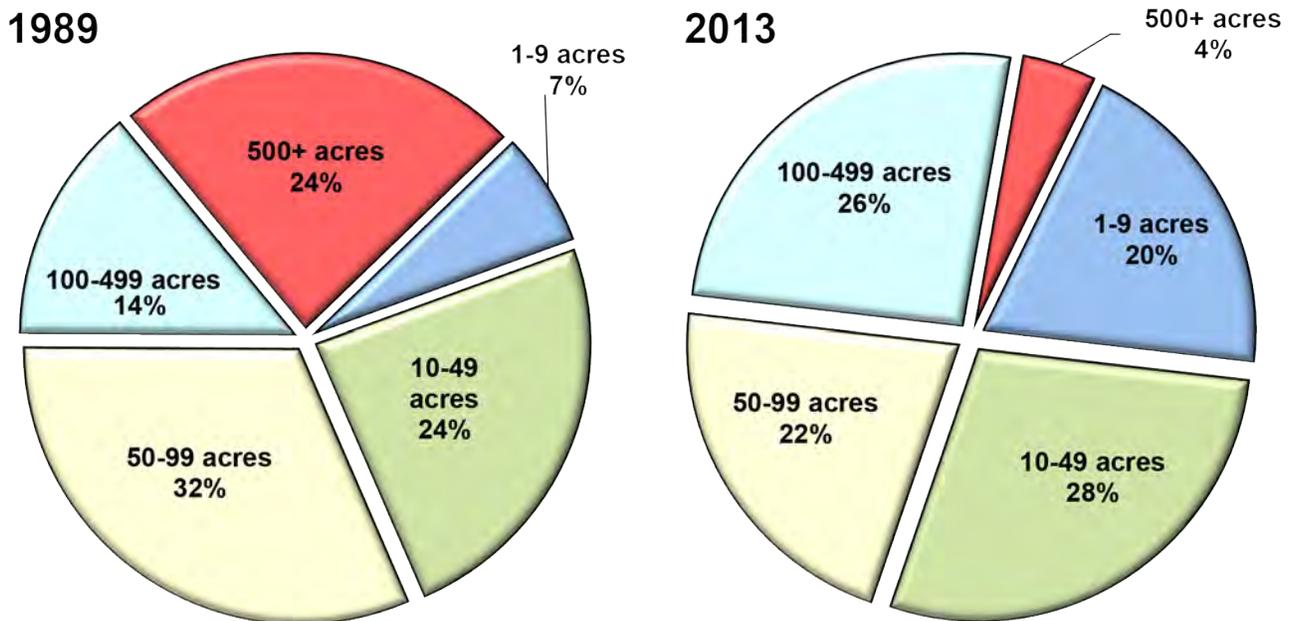
Land values in Delaware have increased significantly since the late 1980s and in some cases this increase has been 20- to 30-fold. The development boom that began around 2000 and peaked in 2007 was driven by the housing market. And although the following ten years saw a sharp decline in this market, development has increased again in recent years. If the next housing expansion mirrors the last, the expectation is a loss of another 10,000+ acres to development. The DFS completed a study that revealed nearly 16,000 acres of forestland were contained in areas approved for development between 2002 and 2009, which equaled 7.3% of the remaining unprotected forestland (217,000 acres)—privately-owned land without a permanent conservation easement. It only seems inevitable that similar future losses will occur as Delaware's population grows and this is a concern. Unlike a change from forest to agriculture where the area may return to forest in the future, development represents a permanent reduction in the forestland base.

While the loss of forestland to agriculture has nearly ceased, the conversion to non-forested developed land rapidly increased over the last three decades.

Forest fragmentation

Over the last 70 years as the amount of forestland has decreased, there has been a corresponding increase in forest fragmentation (smaller areas of contiguous forests). In 2009, the DFS identified 343 contiguous forest blocks larger than 250 acres. The mean size was 515 acres and the total area within contiguous blocks summed to 176,711 acres. An analysis based on 2017 aerial imagery revealed that 112 of those forest blocks had been reduced in size. Of those, 14 were removed because they fell below the 250-acre threshold. In a single case, a block was split, but both halves remained over 250 acres (resulting in one new block). The final result is 330 large forest blocks over 250 acres (14 blocks from 2009 lost) and the total forest within contiguous blocks is 170,105 acres (a loss of 6,600 acres). The primary observed causes reducing the size of forest blocks was development and conversion to agriculture.

Figure 15. Privately owned forest parcel acreage in Delaware in 1989 and 2013.



Source: U.S. Forest Service Forest Inventory and Analysis, National Woodland Owners Survey

Forest parcelization

Privately-owned forest parcel acreage has changed dramatically (Figure 15). Based on FIA data of the National Woodlands Owners Survey, in 1989 nearly three-quarters of private forestland was held in parcels greater than 50 acres. By 2013 that percentage dropped to about half. Forest parcels less than 50 acres increased from 31% to 48% during that same time period. Much of this increase can be attributed to the decrease in very large parcels (≥ 500 acres) that are privately-owned. Some of these parcels were developed, others were purchased by the state and added to the land holding inventories of the DFS and DNREC's Divisions of Fish & Wildlife and Parks & Recreation.

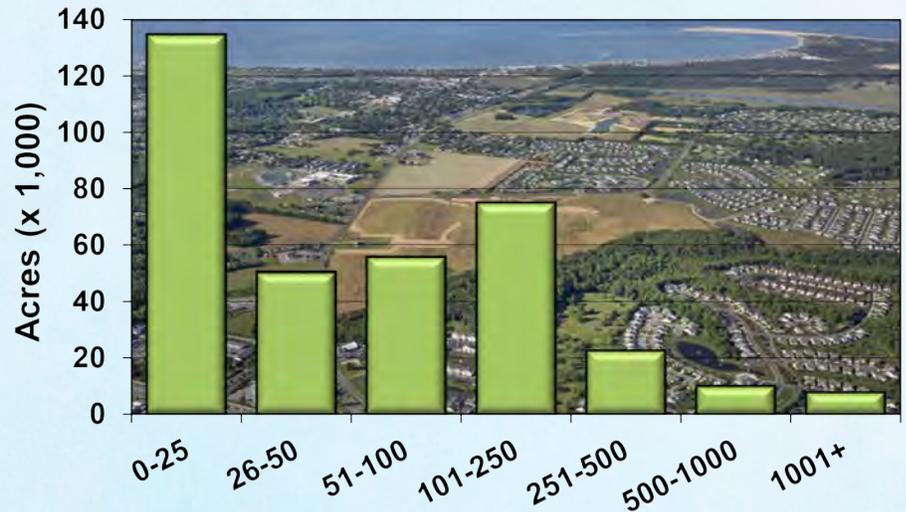
Two-thirds of Delaware forests are located in areas with population densities between zero and 100 people/square mile and nearly 90% are located in areas of less than 250/square mile (Figure 16). Delaware's population continues growing with a 10% increase over the last nine years. The current total population of 989,803 equates to an average of 507 people/square mile. In 2000, that average was under 400. Not only is the population increasing, but it is also becoming less concentrated within municipalities and spreading across the landscape. In 1920, about half of the state's population lived in Wilmington, Delaware's largest city, however, today less than 8% lives there.

Between 1950 and 2005, Delaware lost 384,000 acres of farmland, an average of nearly 7,000 acres/year (and a simultaneous average yearly loss of about 1,700 acres of forestland). The American Farmland Trust (AFT) published a study that found that between 1984 and 2002, 118,000 acres of farms and forests were consumed by 96,000 residential housing units (1.23 acres/house). This total is nearly equal to all the acres consumed in the previous 300 years. Prior to 1984, 260,000 housing units consumed 125,000 acres of land (0.48 acres/house). Delaware's population is not only increasing, but that population is also using more land for each new home. If this unsustainable trend continues, even more farmland and forestland will be lost to housing development.



The loss of forestland has increased significantly in the past 30 years. This can be attributed primarily to development.

Figure 16. Forestland by population density (people/sq. mile) in 2017.



Source: U.S. Forest Service Forest Inventory and Analysis

Urban areas have displaced about 15% of Delaware’s forests. A 2010 U.S. Forest Service study (General Technical Report NRS-62) estimated that by 2050, 32.5% of Delaware’s forestland will have been subsumed by urban growth. This means that by 2050 almost one-third of Delaware’s former forests will lie within the limits of new urban areas. Only four other states are expected to experience a greater degree of absorption of forests into expanding urban areas: Connecticut (36%), Massachusetts (37%), New Jersey (40%) and Rhode Island (48%).

Urban forests

As the amount of rural forestland decreases and fragments, and as urban areas expand, it is expected that Delaware’s forested urban areas will increase. A 2010 GIS analysis of aerial photographs indicated that nearly 40,000 acres of urban forests were located within Delaware’s 57 incorporated municipalities and other urbanized areas designated by the 2000 Census. The total land area within these urbanized areas totaled approximately 234,000 acres, thus Delaware’s urban forest canopy coverage was just under 17% ten years ago. In 2019, an analysis using LIDAR-derived canopy data revealed 81,126 acres of urban forests in a total urbanized area of 262,244 acres which translates into 31% of forest canopy coverage currently. At first glance this appears to be a large increase (a doubling of acreage), but the methodologies used are different, so it is not practical to make direct comparisons. A LIDAR analysis in 2010 may very well have resulted in more than 40,000 acres of urban forests. Nevertheless, the new measurement using the latest technology is reliable and above the national average of 27%.

Conclusions

Delaware has more forested acres now than it did more than a century ago. However, the loss of forestland has increased significantly in the past 30 years and this change is due primarily to development. Along with outright loss of forestland, there is an accompanying increase in fragmentation and an increase in the urban forest component. New houses are using an increasing amount of land and we are on the cusp of another housing boom in Delaware. All indications are that the real estate market is improving again. The trends in population increase and loss of forestland present both environmental and economic challenges to all future Delawareans.

INDICATOR 4

Status of forest/woodland communities and associated species of concern

Forests provide habitat (shelter, food, nesting sites, etc.) for numerous animal species and are home to a wide variety of plant species. Some rare plants are found only in specific types of forest and some rare animals require certain forest habitat for their survival. Protecting and conserving the wide range of forests native to Delaware is critical to the survival of many plant and animal species—both rare and common. Recognizing and understanding the rare, threatened, and endangered species of plants and animals found in our forests is the first step in their conservation.

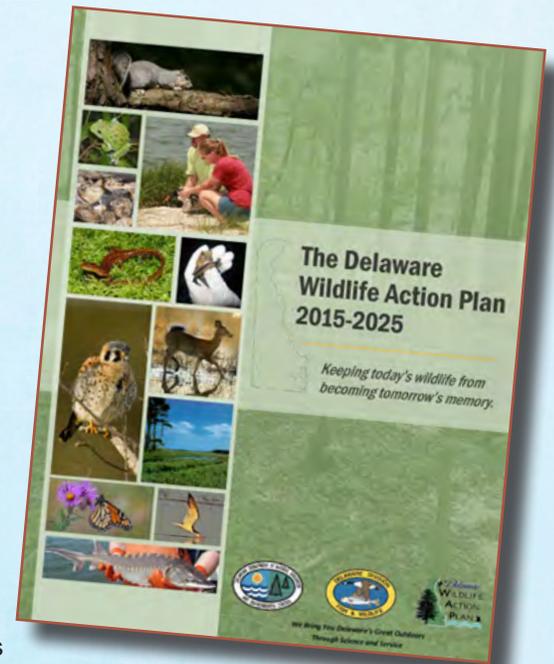
Delaware Wildlife Action Plan

The Delaware Wildlife Action Plan (DEWAP) 2015-2025 is the state's updated version of a comprehensive strategy for conserving the full array of native wildlife and habitats—common and uncommon—as vital components of the state's natural resources. The first DEWAP was completed in 2006. The updated DEWAP not only considers species and habitats, but it is also comprehensive in terms of those responsible for its implementation. Though DNREC's Division of Fish & Wildlife (F&W) is the lead agency that is coordinating implementation, the DEWAP is intended for all agencies, nonprofits, and individuals who are actively engaged in conservation efforts, including the Delaware Forest Service. Together with all conservation partners, the aim is to maintain existing populations and prevent species from becoming threatened or endangered.

Delaware is the second smallest state in the U.S. and yet it harbors a surprising diversity of wildlife species and habitats within its borders. Over 2,800 species are documented to occur in the state and more than 125 specific types of habitat are found in the state including coastal marine waters and brackish marshes, tidal and non-tidal freshwater streams and wetlands, and upland forests and meadows. Of these, the DEWAP identifies 688 Species of Greatest Conservation Need (SGCN) and nearly all of Delaware's habitats are used to some extent by at least one SGCN. Because the DEWAP is a comprehensive plan for all species, large blocks of forest and wetland habitats (≥ 250 acres) that support many common species are also identified. Maps depicting habitat for a full array of wildlife species were created to show areas of the state to focus conservation efforts. The maps are also intended to help guide more site-specific conservation planning efforts. One successful example cited as a site-specific community-based planning effort was the Blackbird-Millington Corridor Conservation Area Plan where F&W partnered with The Nature Conservancy.

Recognizing all possible issues that affect habitats and species of conservation concern, whether the impacts are fully understood or not, is an important step in building a comprehensive plan. For 12 habitat groups (including forested non-tidal wetlands and natural forested uplands), 289 issues were identified along with 755 corresponding actions. For five taxa groups (birds, fish, herpetofauna, invertebrates, and mammals), 419 issues and 651 actions were identified. From this extensive list of issues and actions, a clear picture of priorities emerged. Among these were addressing habitat loss and degradation, including loss and conversion of forest habitat to other non-ecological land uses.

Delaware is the second smallest state in the United States and yet harbors a surprising diversity of wildlife species and habitats within its borders.





Forest communities

Delaware is in a floral transition zone between northern and southern forest types, which creates a diverse group of forest communities in a relatively small geographic area. Thirty-one forest communities (with tree canopy $\geq 60\%$) and nine woodlands (tree canopy $< 60\%$) are listed in the 2009 *Guide to Delaware Vegetation Communities*, which follows the National Vegetation Classification System (NVCS). The NVCS classifies vegetation on a national scale for the United States and is linked to the international vegetation classification. It provides a uniform name and description of vegetation communities found throughout the country and helps determine the relative rarity of different community types.

Delaware rare forest communities include the Inland Dune Ridge Forest found in the Nanticoke River area; Southern New England Red Maple Seepage Swamp found in the Piedmont; North Atlantic Coastal Oak-Holly Forest found in the Nanticoke and Choptank River watersheds; Northern Coastal Plain-Piedmont Basic Mesic Hardwood Forest found scattered throughout the state; and the Chesapeake Bay River Bluff Chestnut Oak Forest found in the Appoquinimink River watershed.

Delaware rare woodlands include Central Appalachian/Piedmont Bedrock Floodplain Woodland found in one location in the Piedmont; several woodlands found in the southern portion of the state including Red Maple-Tussock Sedge Wooded Marsh near Millsboro, the Inland Dune and Ridge Woodland/Forest found in the Indian River and Nanticoke river watersheds, and coastal woodland communities like the maritime Red Cedar Woodland, Loblolly Pine Dune Woodland, and Loblolly Pine-Wax-myrtle-Salt Meadow Cordgrass Woodland. The Pitch Pine Dune Woodland is only found at Cape Henlopen State Park and the Pond Pine Woodland is found at Prime Hook NWR and at a site near Millsboro.

Loblolly pine forest acreage decreased significantly from 1957 to 1999 (149,000 acres) but this trend has since reversed with an increase of 18,000 acres since 1999. Part of this reversal can be attributed to passage of the *Seed Tree Law* and the availability of publicly-funded cost-share programs to assist landowners with reforestation and other forest management expenses. Many of Delaware's bottomland tree species have also experienced substantial declines over the last 50 years due to logging and wide-scale drainage by ditching and stream channelization. Atlantic white-cedar and baldcypress, in particular, experienced significant declines. This loss is evident by the reduction in acres of the oak/gum/cypress forest type where these two species are commonly found. Acreage for this type dropped from 90,000 acres in 1972 to 26,000 in 1999 (see Figure 7). The actual acreage of Atlantic white-cedar and baldcypress is much lower than this total. However, like loblolly pine, the oak/gum/cypress forest type has rebounded and in 2018 the acreage had climbed back up to 56,000 acres. Vegetation communities in which these bottomland species are commonly found include Coastal Plain Atlantic White Cedar-Red Maple Swamp that occurs throughout the Coastal Plain, Atlantic White Cedar/Seaside Alder Woodland found in the Cedar Creek and Prime Hook Creek watersheds, Chesapeake Bay Cypress-Gum Swamp found in the Nanticoke River, Deep Creek, and Pocomoke River watersheds, and Wind-tidal Cypress-Gum Swamp found in the Broad Creek watershed. As a further example, in 2010 the 10,600-acre Great Cypress Swamp in southern Delaware had virtually no Atlantic white-cedar or baldcypress remaining due to historic logging and ditching. However, recent forest management projects by Delaware Wild Lands, Inc., to recover Atlantic white-cedar and baldcypress have been positive and encouraging. Approximately 400 acres have been recovered so far through planting and selective harvesting of competing species. This contiguous swamp is thought to have encompassed over 50,000 acres before European settlers arrived.

Recent forest management projects by Delaware Wild Lands, Inc., to recover Atlantic white-cedar and baldcypress have been positive and encouraging.



Atlantic white-cedar

Coastal Plain seasonal ponds

Coastal Plain seasonal ponds, or Delmarva Bays, are an important part of Delaware's forest landscape. This unique non-tidal freshwater wetland supports a wide variety of state and globally rare plant and animal species. Seasonal ponds are found on the landscape within forested areas and appear as open canopy depressions that are usually elliptical and up to two acres (sometimes larger). Hundreds of these ponds are scattered throughout the state but they most frequently occur in southwestern New Castle County and northwestern Kent County. The geologic origins of Coastal Plain seasonal ponds are still not well understood. The most plausible theory supposes that Delmarva Peninsula ponds were formed between 15,000 and 20,000 years ago when the climate was much colder and drier. The theory suggests that strong winds created blow-outs or depressions in unvegetated sandy areas and deposited the sand around pond perimeters that often appear as elevated rims. Seasonal ponds are strongly influenced ecologically by fluctuating groundwater levels that rise and fall with the seasons. By definition, seasonal pools have no permanent surface water connection to other water bodies. They typically fill in winter and spring when groundwater levels are high and begin to recede during summer months, when precipitation is typically low and evapotranspiration is high. By late summer/early fall, these shallow ponds are usually dry. This is significant for many uncommon animal species that breed in these ponds as they are void of predatory fish.

Seasonal ponds support a distinctive community of vertebrates and invertebrates due to this regime of flooding and drying. Some animals and plants have adapted to life within seasonal ponds and many are very rare in Delaware. The absence of predatory fish permits successful breeding of state-rare amphibians such as the marbled (*Ambystoma opacum*), spotted (*A. maculatum*), and tiger (*A. tigrinum*) salamanders that require seasonal pools to produce offspring. Also included in this list of rare amphibians are Cope's gray treefrog (*Hyla chrysoscelis*), barking treefrog (*H. gratiosa*), and carpenter frog (*Lithobates virgatipes*). They too use fish-free seasonal pools for reproduction. The ambystomid or mole salamanders listed actually spend the majority of their lives underground in forests and woodlands surrounding seasonal ponds. Though the ponds themselves are critical for sustaining salamander populations, the adjacent forests are just as vital to these amphibians, providing critical habitat during most of their annual life cycle.

There are also several state and globally rare plants found in Coastal Plain seasonal ponds. Of nearly 80 native plant species primarily found growing in Delaware seasonal ponds, 40 are state rare and six are globally rare. The feather foil (*Hottonia inflata*) and water crowfoot (*Ranunculus flabellaris*) are examples of state-rare plants that are entirely dependent on the fluctuating groundwater levels of seasonal ponds for the completion of their life cycles. These species flower at the water's surface when the seasonal ponds are filled in the spring and seeds germinate in late summer when ponds recede. Without this regime of flooding and drying, these species would not persist. An example of a globally rare plant found in Delaware seasonal ponds is the dwarf fimbry (*Fimbristylis perpusilla*). This sedge is known from several ponds at Blackbird State Forest in southwestern New Castle County.

Forests encircling seasonal ponds maintain the ecological integrity of these critical habitats in many ways. Coastal Plain seasonal ponds represent about 30% of the approximately 18,760 acres of Category 1 Wetlands in Delaware—rare freshwater wetland communities that are considered ecologically unique. These irreplaceable wetlands provide habitat for many state and globally rare animal and plant species that depend on them for their very survival.



Blackbird State Forest



Spotted turtle



Marbled salamander

Species of conservation concern

More than 2,500 animal species (vertebrates and invertebrates) are native to Delaware and of those, 584 are listed as Species of Greatest Conservation Need (SGCN) or more data is required for further determination or they are extirpated from Delaware (Table 4). Tier 1 SGCN (165 total) are in the highest need of conservation action. These include the rarest species in the state, species that are highly globally imperiled, and species with regionally important Delaware populations that are also under high threat from a changing climate. Tier 2 SGCN are of moderate conservation concern in Delaware. These include species that have rare to uncommon breeding populations in the state, species with broad distributions that are threatened by changes in climate, and species for which Delaware has high responsibility within the northeast region. Tier 3 SGCN are for the most part still relatively common in Delaware, but are listed as SGCN for various reasons, including documented population declines, high responsibility of the northeast region for the global population, or continued need for monitoring and/or management. This tier also includes non-breeding species that are uncommon in Delaware. Extirpated species once occurred in Delaware but have been determined through extensive survey effort to no longer occur in the state. The extirpated species included as SGCN have some possibility of reintroduction (i.e., suitable habitat may occur in the state and potential source populations may exist).

Table 4. Status of native animals in Delaware, 2018.*

Taxonomic Group	Estimated Total Number of DE Species	Species of Greatest Conservation Need (SGCN)					
		Total	Tier 1	Tier 2	Tier 3	Data Needs	Extirpated
Mammals	60	16	4	3	5	3	1
Birds	410	173	48	68	53	3	1
Amphibians	28	18	5	7	6	0	0
Snakes and Lizards	24	14	3	9	1	1	0
Turtles	16	5	3	2	0	0	0
Fishes	177	32	10	12	10	0	0
Mussels	14	11	6	4	0	0	1
Invertebrates	1,700+	289	82	96	27	80	4
Snails	96+	26	4	20	2	0	0
Total	2,525+	584	165	221	104	87	7

* Only animals found when terrestrial, freshwater, and brackish habitats are included. The total number of species is a conservative estimate given that many more invertebrae species likely occur in the state.

Source: The Delaware Wildlife Action Plan 2015-2025

Forest-dependent state endangered species

Delaware is home to 538 different species of mammals, birds, reptiles, and amphibians. Of these, 13 species are listed as endangered in the state and are forest-dependent (Table 5). For these species, healthy and contiguous forests are essential for their well-being. Continuing efforts should be made to protect critical forested habitat where these species occur. This could include actively managing the forest to prevent the ecological value to these species from degradation. Forest management and wildlife management activities that have common goals and objectives are mutually compatible. Efforts should consider active forest management as a viable method of protecting and enhancing forest habitat for all wildlife species both common and endangered.

13 species are listed as endangered in the state that are forest-dependent. Healthy and contiguous forests are essential for their well-being.

Forest-dependent birds

Avian diversity in Delaware forests depends on the geographic location, forest type, structure, and age. Of the more than 100 native bird species that are dependent on forests for breeding, migration, or overwintering, four are considered state-endangered (Table 5). Distributed widely throughout the state, some bird species depend on forest block size, tree size, plant community composition, forest and understory structure, and forest condition and growth stage (age). This further highlights the importance of maintaining a mosaic of forest types and age classes to maintain the diversity and health of all forest-related ecosystems.



Hooded warbler

Table 5. State of Delaware endangered forest-dependent species, 2015.

Scientific Name	Common Name	Federal Status	Global Rank	State Rank	DEWAP Tier	
					2007	2015
Birds						
<i>Buteo platypterus</i>	Broad-winged Hawk	NL	G5	S1B, S1N	1	1
<i>Setophaga cerulea</i>	Cerulean Warbler	NL	G4	S1B	1	1
<i>Setophaga citrina</i>	Hooded Warbler	NL	G5	S1B	1	1
<i>Limnothlypis swainsonii</i>	Swainson's Warbler	NL	G4	SHB	1	1
Reptiles						
<i>Pantherophis guttatus</i>	Red Cornsnake	NL	G5	S1	1	1
<i>Cemophora coccinea</i>	Scarletsnake	NL	G5	SH	1	1
<i>Nerodia erythrogaster</i>	Plain-bellied Watersnake	NL	G5	S1	1	1
Amphibians						
<i>Pseudotriton montanus</i>	Mud Salamander	NL	G5	S1	1	1
<i>Ambystoma tigrinum</i>	Eastern Tiger Salamander	NL	G5	S1	1	1
<i>Hyla gratiosa</i>	Barking Treefrog	NL	G5	S1	1	1
Mammals						
<i>Myotis lucifugus</i>	Little Brown Bat	NL	G5	S1	1	1
<i>Myotis septentrionalis</i>	Northern Long-eared Bat	LT	G4	S1	1	1
<i>Sciurus niger cinereus</i>	Delmarva Fox Squirrel	LE, XN	G5T3	S1	1	1

Source: The Delaware Wildlife Action Plan 2015-2025

- NL Not listed
- LT Listed as Threatened
- LE Not evaluated
- XN Delisted
- G3 Vulnerable – At moderate risk of extinction due to restricted range, relatively few populations (≤ 80), recent and widespread declines, or other factors.
- G4 Apparently Secure – Uncommon but not rare; some cause for long-term concern due to declines or other factors.
- G5 Secure – Common; widespread and abundant.
- T3 Subspecies ranking (see G3 above).
- S1 Extremely rare within the state (typically 5 or fewer occurrences).
- SH Historically known to occur in the state.
- B Breeding population.
- N Non-breeding population.



Ten years ago, Delaware listed eight bird species as endangered. Since then, five were removed and one was added. The bald eagle (*Haliaeetus leucocephalus*) moved from Tier 1 to Tier 3 because it is now relatively common throughout the state. Cooper's hawk (*Accipiter cooperii*) was removed from the SGCN altogether. And the red-headed woodpecker (*Melanerpes erythrocephalus*), brown creeper (*Certhia americana*), and northern parula (*Parula americana*) were moved from Tier 1 to Tier 2. The new addition is the broad-winged hawk (*Buteo platypterus*) that is a raptor of extensively forested areas and very few nest in Delaware due to the extent of forest fragmentation. However, during migration, thousands pass through the northern Delaware Piedmont on their way to South America for the winter.

Table 6. Forest-dependent bird species of greatest conservation need (SGCN).

Scientific Name	Common Name	DEWAP Tier
Forest Birds		
<i>Vireo gilvus</i>	Warbling Vireo	2
<i>Colaptes auratus</i>	Northern Flicker	3
<i>Haliaeetus leucocephalus</i>	Bald Eagle	3
<i>Icterus galbula</i>	Baltimore Oriole	3
<i>Myiarchus crinitus</i>	Great Crested Flycatcher	3
<i>Tyrannus tyrannus</i>	Eastern Kingbird	3
Forest Interior Birds		
<i>Buteo platypterus</i>	Broad-winged Hawk	1
<i>Setophaga cerulea</i>	Cerulean Warbler	1
<i>Certhia americana</i>	Brown Creeper	2
<i>Pheucticus ludovicianus</i>	Rose-breasted Grosbeak	2
<i>Piranga olivacea</i>	Scarlet Tanager	2
<i>Setophaga dominica</i>	Yellow-throated Warbler	2
<i>Buteo lineatus</i>	Red-shouldered Hawk	3
<i>Piranga rubra</i>	Summer Tanager	3
<i>Vireo flavifrons</i>	Yellow-throated Vireo	3
Forest Interior Understory Birds		
<i>Setophaga citrina</i>	Hooded Warbler	1
<i>Catharus fuscescens</i>	Veery	2
<i>Hylocichla mustelina</i>	Wood Thrush	2
<i>Setophaga ruticilla</i>	American Redstart	2
<i>Empidonax vireescens</i>	Acadian Flycatcher	3
<i>Geothlypis formosa</i>	Kentucky Warbler	3
<i>Helmitheros vermivorum</i>	Worm-eating Warbler	3
<i>Mniotilta varia</i>	Black-and-white Warbler	3
<i>Parkesia motacilla</i>	Louisiana Waterthrush	3
<i>Bonasa umbellus</i>	Ruffed Grouse	extirpated
Forest Interior Wetlands Birds		
<i>Limnithlypis swainsonii</i>	Swainson's Warbler	1
<i>Setophaga americana</i>	Northern Parula	2
<i>Protonotaria citrea</i>	Prothonotary Warbler	3
Pine Specialist Birds		
<i>Melanerpes erythrocephalus</i>	Red-headed Woodpecker	2
<i>Sitta pusilla</i>	Brown-headed Nuthatch	2

Source: The Delaware Wildlife Action Plan 2015-2025



The other three Delaware endangered forest-dependent bird species are all warblers—small neotropical migrants that require forest habitat for breeding. The cerulean warbler (*Setophaga cerulea*) uses mature floodplain forest for nesting in Delaware typically in semi-open canopy well above the forest floor. This species is restricted to the Piedmont region of Delaware within the northern reaches of the White Clay Creek watershed. Sharply contrasting with the cerulean warbler, the Swainson's warbler (*Limnothlypis swainsonii*) and hooded warbler (*Setophaga citrina*) nest much closer to the ground. For these two species, the forest structure (particularly the understory) is far more important than the other forest components. Hooded warbler breeding records are widely distributed across Delaware but are rare. This species requires rich, moist upland forest with a very dense understory. Swainson's warbler also requires a very dense understory, but this species prefers mature forested swamps and bogs and is restricted to Sussex County (Pocomoke and Nanticoke watersheds). Both species are quite rare, and there have been no confirmed reports of Swainson's warbler breeding in Delaware since the 1970s, most likely due to decreased habitat suitability and outright habitat loss.

Although three of the four Delaware endangered birds rely on forest interior, there are many other SGCN in the Tier 2 and Tier 3 categories that also utilize this particular forested habitat (Table 6). The red-shouldered hawk (*Buteo lineatus*), for example, is very sensitive to disturbance of any kind. Nesting within the interior of a forest block reduces the potential for disturbance that would otherwise cause this bird to abandon its nesting attempts. Other species, including many forest-dependent songbirds, require forest interior habitat to reduce the predation and parasitism pressure on their respective populations. Associated with forest edge are greater densities of predators such as foxes, raccoons, and even other avian predators such as blue jays (*Cyanocitta cristata*) and crows (*Corvus brachyrhynchos*). Parasitism by the brown-headed cowbird (*Molothrus ater*) also occurs more frequently along forest edges where the species can easily detect host nests.

The many bird SGCN that depend on interior forests are faced with shrinking forest patches and higher levels of inter- and intra-specific competition for food and nesting resources. As Delaware's forests become more fragmented, this creates more edge and an advantage for the parasitic cowbird. Large blocks of contiguous forest provide greater interior habitat that benefits non-breeding bird species that may use these large forested areas as migratory stop-over sites or for overwintering. Losses of forest interior habitat not only negatively affect many local breeding bird populations, but also places additional stress on those birds that spend a short period in Delaware during spring and fall migration.

Delmarva fox squirrel

Ten years ago, the Delmarva fox squirrel (*Sciurus niger cinereus*), a subspecies of fox squirrel found only on the Delmarva Peninsula, was the only terrestrial mammal in Delaware listed under the Federal Endangered Species Act as an endangered species. This species' population had been reduced to a small portion (<10%) of its original native range due to habitat loss and hunting (Figure 17). The process to develop a Habitat Conservation Plan (HCP) for the squirrel was initiated in 2003 and included an HCP advisory team and science team. The HCP was not completed until 2014 due to disagreements among landowners and government officials concerning permissible land uses. Then in November 2015, the Delmarva fox squirrel was delisted as a federally endangered species by the U.S. Fish & Wildlife Service.

The many SGCN birds that depend on interior forests are faced with shrinking forest patches and higher levels of competition for food and nesting resources.



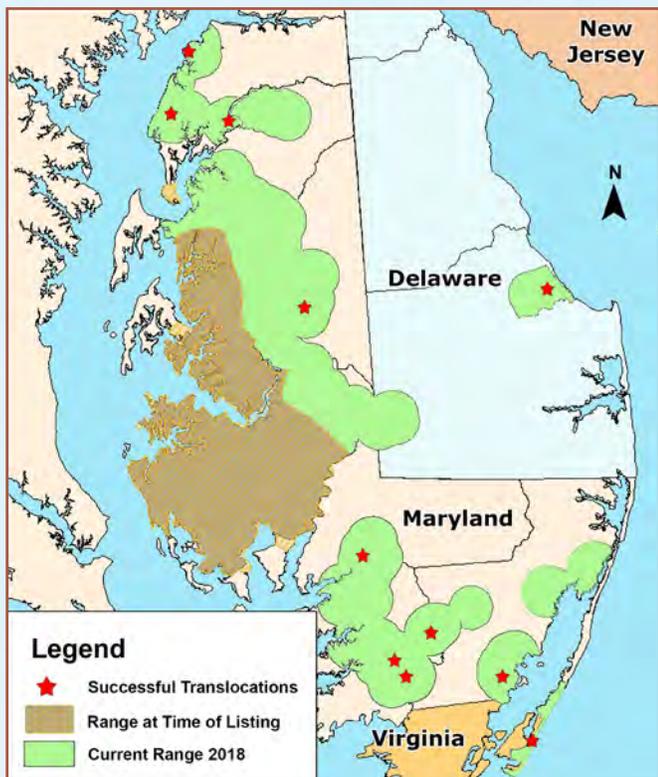
Cerulean warbler



Delmarva fox squirrel

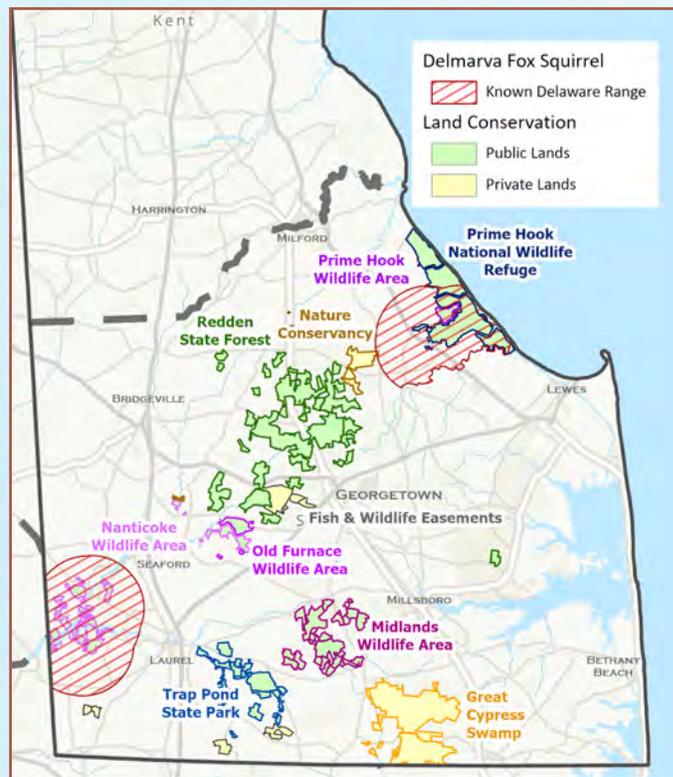
Although still listed as endangered by the State of Delaware because of its rarity locally (only two confirmed locations), the federal delisting has paved the way for cooperative efforts with private and public forest landowners to expand existing populations. There are no longer any federal restrictions on forest management activities that may or may not directly affect the fox squirrel. Additionally, the state's Division of Fish & Wildlife drafted a conservation plan for the species in 2014. Connectivity between Prime Hook and Nanticoke Wildlife Area populations may be possible through translocation of individuals from existing populations to suitable forested habitat in and around Redden State Forest (Figure 18). Without any restrictive federal mandates on forestland use with respect to this rare Delaware species, neighboring forest landowners might be more likely to help build the Delmarva fox squirrel population to its historically widespread level.

Figure 17. Current distribution of the Delmarva fox squirrel, *Sciurus niger cinereus*.



Source: U.S. Fish & Wildlife Service

Figure 18. Current distribution of the Delmarva fox squirrel, *Sciurus niger cinereus*, in Delaware.



Source: State of Delaware

Forest-dependent bats

Forests offer many essential resources to bats including a diverse assemblage of prey insects, trees for maternity colony and individual roosts, overwintering locations, and ponds. Some bats use buildings in the summer to raise their young while others use caves, mines, or other structures for winter hibernation. However, all Delaware bat species use forests for some aspect of their life history requirements. Therefore, forest management is crucial to maintaining high-quality habitat and healthy bat populations.

Threats to bats include habitat loss, pollution, climate change, direct persecution, wind turbines, and disease. Tragically, several species experienced precipitous population declines in eastern North America as a result of white-nose syndrome (WNS). This exotic fungal disease invades the bats' skin tissue during hibernation disrupting physiological processes and causing them to awaken and expend energy needed to survive the winter. The disease has killed millions of bats and continues to spread throughout North America at an unprecedented rate.



Little brown bat

Of particular concern in Delaware are the forest-dependent little brown bat (*Myotis lucifugus*) and northern long-eared bat (*M. septentrionalis*), both Tier 1 SGCN with the latter also listed as federally threatened. Also affected by WNS are the eastern small-footed bat (*M. leibii*), big brown bat (*Eptesicus fuscus*), and tri-colored bat (*Perimyotis subflavous*).

To ease population decline, resource managers can take actions that benefit bats during the spring, summer, and fall. Securing habitats and providing roosting, food, and watering sites may help both the survivors of WNS and bats not affected by WNS. Accommodating the needs of the various species requires a mosaic of forest types and ages as well as non-forest habitats (e.g., grasslands, wetlands, scrub-shrub, etc.). The size and juxtaposition of patches are also critical to meeting life history requirements of many bats. At a local scale, the presence of high-quality maternity habitat near quality foraging and water localities can be key to maintaining population levels.

Delaware forests play an essential role in bat ecology by providing breeding habitat in summer months, roosting sites for local and migratory species in the spring and fall, and hibernation sites for some species during winter. The silver-haired bat (*Lasionycteris noctivagans*), red bat (*Lasiurus borealis*), and big brown bat hibernate in the tree hollows, under bark, in wood piles, and in leaf litter. While specific roost tree and landscape types vary among species, most bats prefer to roost in large-diameter trees and snags, which generally persist longer than smaller snags and can support more roosting bats.

Forest plants

Because of its latitude, Delaware is in a transition zone for northern and southern plant species. For example, Delaware is the northern extreme limit of certain southern tree species such as loblolly pine and baldcypress. Conversely, some northern species are not found south of Delaware, except primarily at higher elevations (e.g., sugar maple [*Acer saccharum*], basswood [*Tilia americana*], and eastern hemlock [*Tsuga canadensis*]). Wetland and upland forest interior habitats in Delaware support a greater diversity of native vascular plants than any other specific habitat type in the state, with upland forest types as the most species-rich. Specifically, 450 taxa (species and varieties) are considered forest interior species in Delaware and 260 of these are considered upland species. No tree species known to have occurred in Delaware at the time of European settlement are extirpated and none are listed as federally threatened or endangered.

Two forest interior plant species are federally listed as threatened by the U.S. Fish & Wildlife Service: swamp pink (*Helonias bullata*) and small whorled pagonia (*Isotria medeoloides*). Although Delaware's state endangered species law does not include plants, the state's Wildlife Species Conservation & Research Program maintains a list of rare Delaware plant species. Approximately 36% (163 species) of all native forest interior plants within the state are rare with the greatest number (57%) of these occurring in upland forests. The primary cause of decline is loss of habitat including wetlands and upland forests.



Northern long-eared bat



Basswood



Swamp pink



Conclusions

Although no Delaware tree species are federally threatened or endangered, significant changes have occurred in Delaware's forest types. In addition to the outright loss of loblolly pine forests, there has been a significant loss of baldcypress and Atlantic white-cedar, two species that once dominated the landscape in their respective habitats. Though only two plant and one animal species that are forest dependent are federally listed as threatened, there are many other state SGCN that require forested habitats. Further loss of forests in Delaware will most certainly place many other species at risk. Forest management practices that can enhance and protect critical wildlife habitat should be encouraged and those practices that cause harm should be avoided.

Summary – Criterion 1

While Delaware has more forested acres now than a century ago, forest acreage is currently declining. There has been a net annual loss of just under 1,000 acres since 1986. This loss is due to Delaware's ever-increasing human population and the demand for housing. Recent growth patterns in land development create even more forest fragmentation and parcelization. Delaware has taken active steps to protect the remaining forestland—approximately 30% (107,000 acres) of its 359,000 acres of forestland are now protected through either public ownership or permanent conservation easements. This is an improvement over ten years ago of approximately 7,000 acres. However, substantially more acres need protection from conversion to non-forest uses for future generations to ensure that there is a sufficient forest base to sustain many of the natural benefits and services Delawareans currently enjoy.

Likewise, we must ensure an adequate mixture of forest types for the future from both an ecologic and economic point of view. Delaware experienced a dramatic decline in loblolly pine in the late 20th century and a slow but very steady increase in the volume of older and larger timber. These trends are not catastrophic but require our attention so that a balance is maintained for species composition as well as age and size composition. This balance is necessary to ensure that sufficient habitat is available for the animal and plant species that require a wide diversity of forest habitat and cover, particularly threatened species and species of greatest conservation concern. Approximately one-third of forest dependent plants and animals are included on the state's list of species of concern.

Maintaining a critical mass of forestland and a wide range of forest types in Delaware ties directly into two of the U.S. Forest Service's Eastern Region State and Private Forestry (S&PF) national priorities—*Conserve and manage working forest landscapes for multiple values and uses* and *Enhance public benefits from trees and forests*.



Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

Many communities depend on forests directly or indirectly for a wide range of forest-based goods and benefits. The sustainable provision of these benefits is clearly linked to the productive capacity of the forest. If this capacity is exceeded there is the risk of ecosystem decline and collapse.

For forests to be sustainable, it is necessary to understand the levels at which goods and benefits may be extracted or used without undermining the functioning of forest ecosystems or processes. The nature of forest goods and benefits changes over time due to social and economic trends and technological developments. Change in the productive capacity of forests may be a signal of unsound forest management practices or other agents that are affecting forest ecosystems in some way.

INDICATOR 5

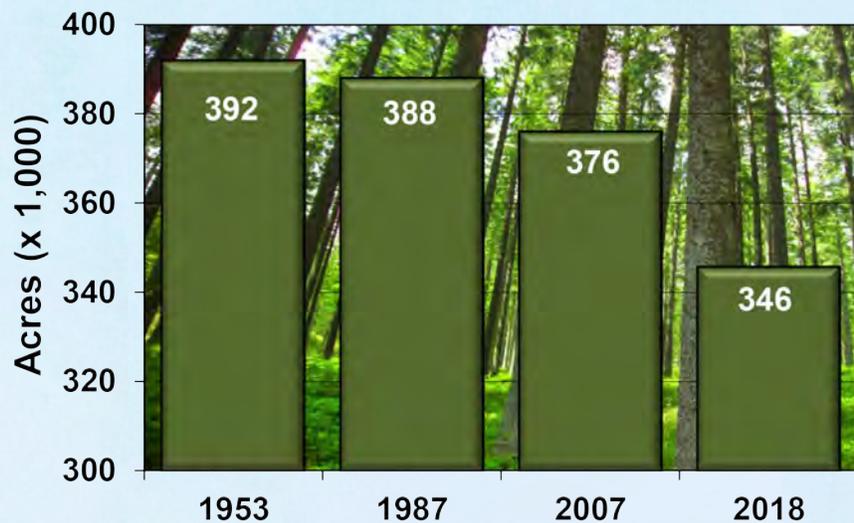
Area of timberland

Timberland is defined as any forestland capable of producing trees that may be profitably and legally harvested. The amount of timberland in the state defines the total forest land base available to produce goods and services for the benefit of society.

Amount of timberland

Of the state's 359,000 forested acres in 2018, more than 96% were classified as timberland. The remaining 4% of forestland is located in areas where regulations prohibit timber harvest, or, in very few cases, the soil is not capable of producing a viable timber crop, such as pockets of upland forests within tidal marshes. Timberland acreage has declined by about 12% since 1953 (Figure 19), development and changing landowner goals is largely to blame for this drop in timberland acreage.

Figure 19. Acres of timberland in 1953–2018.



Source: U.S. Forest Service Forest Inventory and Analysis



Conclusions

Delaware's timberland acreage has remained constant relative to total forest acreage over the last 65 years. The increase in the rate of development in Delaware has impacted the forest land base and as a result, total acreage of timberland has declined somewhat.

INDICATOR 6

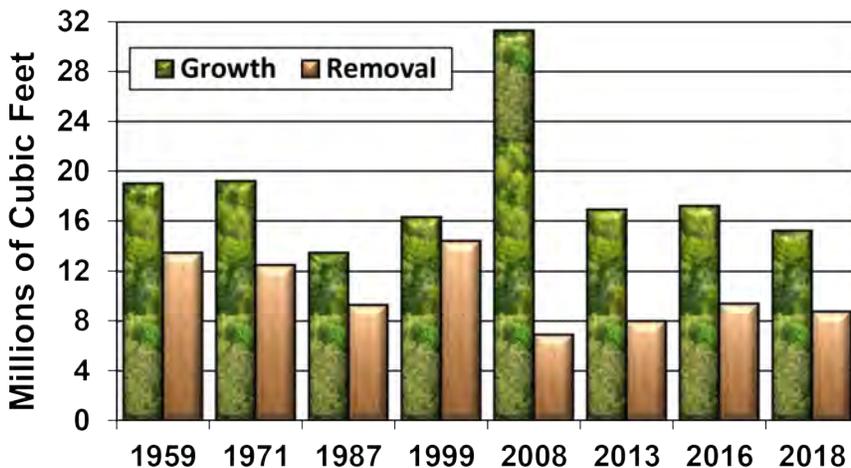
Annual removal of merchantable wood volume compared with net growth

Forests provide valuable products that can be periodically harvested. Forests are also composed of living trees with quantifiable rates of growth. To a large extent, the difference between rate of growth and rate of removal determines whether the resource base is being used in a sustainable manner. It is very important to know whether forests are harvested beyond their ability to renew themselves or are under-utilized for wood products.

Net growth and removals

Growth of all tree species in Delaware has exceeded removal for nearly 60 years based on long-term FIA data (Figure 20). Beginning around 2008, growth began to far exceed removals by more than 4½ times in 2008 and double or nearly double for the 2013, 2016, and 2018 sampling periods. This result is a direct reflection of a decrease in the housing market and a steady decline in the timber industry in Delaware and throughout the entire Delmarva Peninsula that includes the Eastern Shores of Maryland and Virginia.

Figure 20. Total annual growth and removals of all tree species, 1959–2018.



Source: U.S. Forest Service Forest Inventory and Analysis



Table 7. Growing-stock growth and removals, 1959–2018.

Year	Million Cubic Feet		
	Growth	Removal	Net
Softwoods			
1959	6.5	9.0	-2.5
1971	4.6	8.1	-3.5
1987	4.1	4.6	-0.5
1999	4.2	6.7	-2.5
2008	7.1	4.1	3.0
2013	4.0	2.1	1.9
2016	5.1	2.4	2.7
2018	5.5	1.3	4.2
Hardwoods			
1959	12.5	4.5	8.0
1971	14.6	4.4	10.2
1987	9.4	4.7	4.7
1999	12.1	7.7	4.4
2008	24.2	2.8	21.4
2013	12.9	5.9	7.0
2016	12.1	7.0	5.1
2018	9.7	7.5	2.2

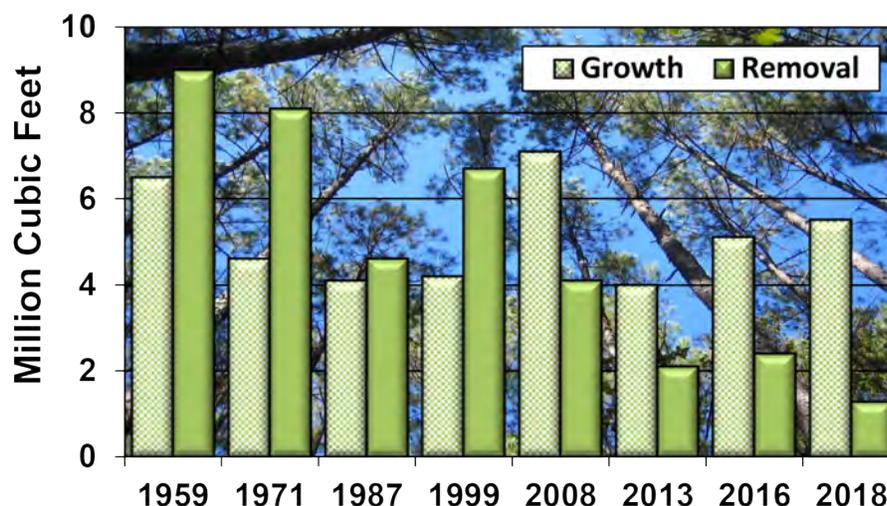
Source: U.S. Forest Service Forest Inventory and Analysis

Since 2008, growth has far exceeded removals for softwood. Pine acreage has increased a bit, and this is reflected in the recent increase in softwood growth.

Type of removals

Up until 1999, removal of softwood growing-stock had consistently exceeded growth (Table 7). Softwood (mostly loblolly pine) removals exceeded growth from 1959 to 1999 (Figure 21). However, after 1999 there was a reversal in this trend and at least since 2008, growth has far exceeded removals for softwood. Pine acreage has increased a bit, and this is reflected in the recent increase in softwood growth. This trend will continue if the resource is managed sustainably.

Figure 21. Annual softwood growth and removals, 1959–2018.



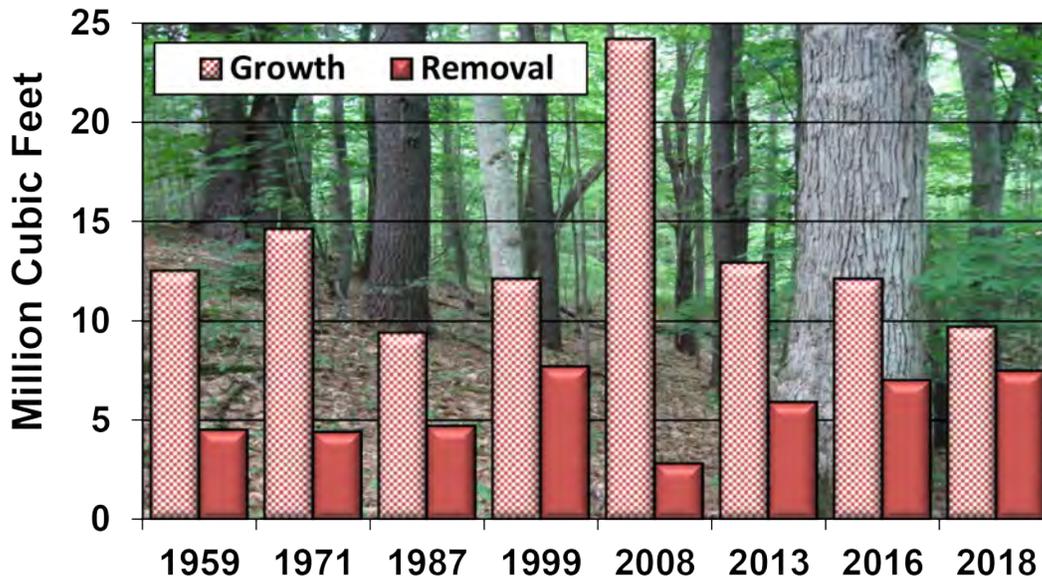
Source: U.S. Forest Service Forest Inventory and Analysis

For hardwoods, growth has consistently exceeded removals since 1959 (Figure 22). However, that gap has steadily closed from 2008 when growth exceeded removals by 764% to 2018 where the difference was just 30%. But the fact remains that over the years, this consistency of growth exceeding removals has resulted in the steady increase in hardwood volume from 628 million board feet in 1957 to 2,695 million in 2018. Also note that over the last ten years there has been an increase in hardwood removals reflecting new and expanded markets for this resource.

The surplus growth of hardwood species presents an industry opportunity. Current forestry practices strive for sustainability and there is growing demand for energy sources from renewable resources. Much of Delaware’s hardwood growth is concentrated in low-value timber species such as red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), and blackgum (*Nyssa sylvatica*) (see Table 2 and Figure 9 in Criterion 1 text). While Delaware or the entire Delmarva Peninsula does not have enough forestland to support a major energy plan, there is sufficient low-value hardwood volume to support regional or local operations such as a heat/energy system for schools or small industry.

The Maryland state prison in Princess Anne currently uses wood chips for heat and electricity, but unfortunately will switch to natural gas in 2021. This market had provided an opportunity for local forest landowners to conduct revenue-producing thinning operations for low-value trees (especially hardwoods) that greatly increase the future value of the remaining crop trees. Delaware could support similar wood chip operations with the current amount of available wood volume.

Figure 22. Annual hardwood growth and removals, 1959–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Conclusions

Overall tree growth exceeds total wood removed by timber harvesting. In particular, over the last ten years softwood growth has outpaced removals—a reversal from the previous 50 years. This has resulted in a slight increase in loblolly pine acreage and, for now at least, a stable resource. If the outright loss of pine acreage is curtailed, and the resource managed sustainably, there appears to be an ample supply to support a thriving pine timber industry in Delaware. Additionally, there is great potential for new and expanded markets for hardwood products.

Summary – Criterion 2

Delaware’s timberland area—forestland capable of producing trees that may be profitably and legally harvested—has remained relatively constant over the past century, although it has decreased in response to the recent increases in residential development. Forest growth continues to exceed removals and over the last decade there has been a welcome reversal of softwood removals exceeding softwood growth. If managed sustainably, both hardwoods and softwoods can continue providing a multitude of natural benefits including timber products without returning to downward trends in resource availability. Addressing this criterion directly relates to two of the U.S. Forest Service’s Eastern Region S&PF national priorities—*Conserve and manage working forest landscapes for multiple values and uses* and *Enhance public benefits from trees and forests*.

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

The maintenance of forest health and vitality is dependent upon the ability of the ecosystem's functions and processes to recover from or adapt to disturbances. While many disturbances and stress events are natural components of forest ecosystems, some may overwhelm ecosystem functions, fundamentally altering their patterns and processes and reducing ecological function.

Decline in forest ecosystem health and vitality may have significant economic and ecological consequences for society including a loss of forest benefits and the degradation of environmental quality. Information gained on the impacts of biotic and abiotic processes and agents may inform management strategies to minimize and mitigate risk. The maintenance of forest ecosystem health and vitality is the foundation of sustainable forest management.

INDICATOR 7

Area of forestland affected by potentially damaging agents

Damaging agents include insects, diseases, and invasive species that have a significant impact on forests as well as wildfires, drought, ice storms, and other natural forces. Damaging agents can alter species composition, reduce growth rates, and disrupt normal forest management activities. While many forces of nature cannot be prevented, it is important to anticipate problems whenever possible and to develop vigilant early detection programs when new insect and disease threats become apparent.

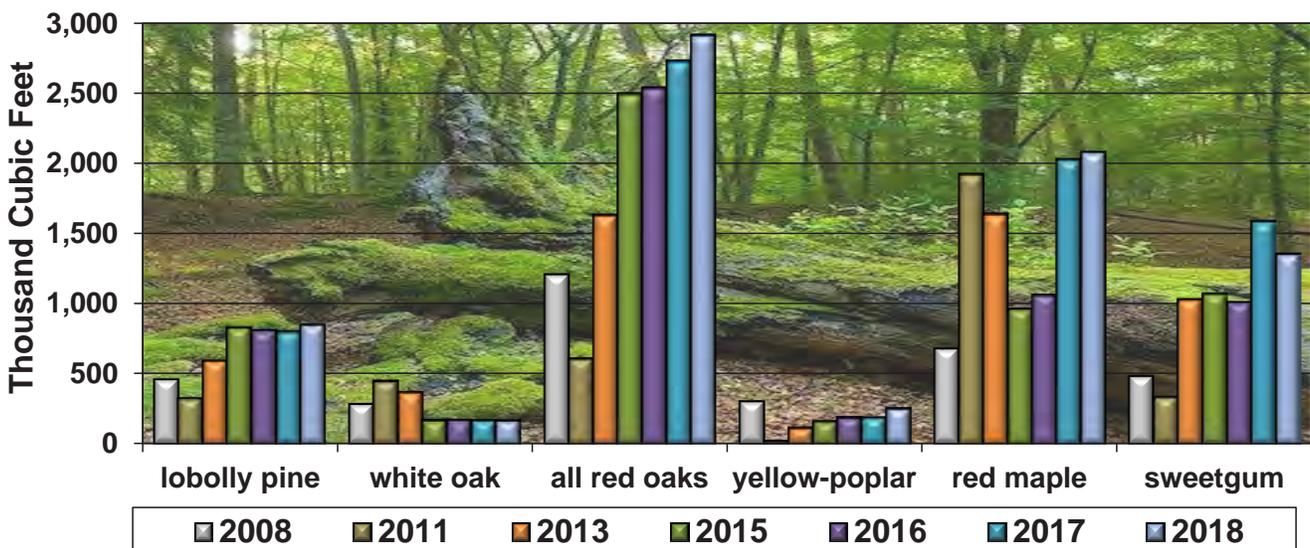


Emerald ash borer

Tree mortality

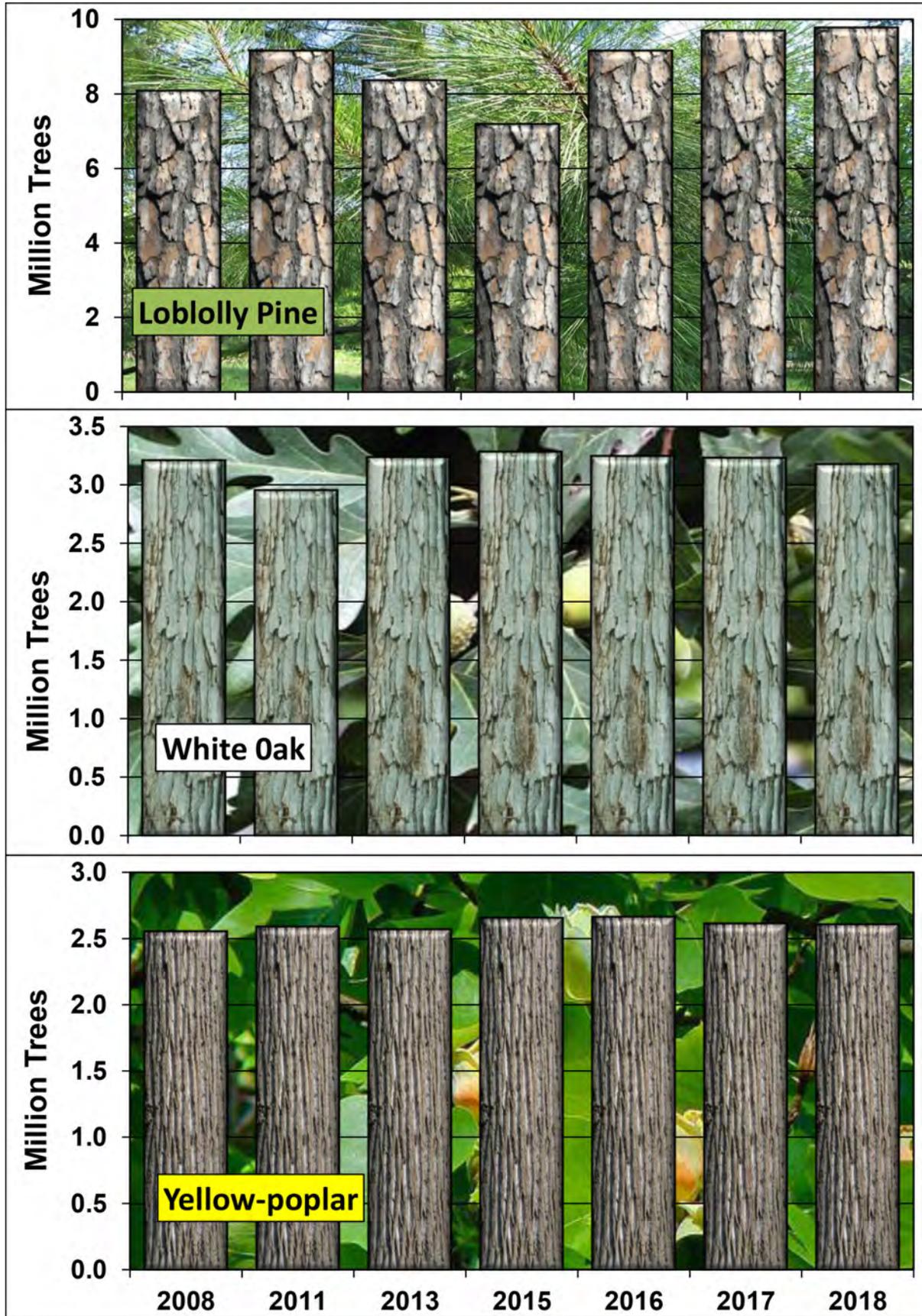
Over the last ten years, tree mortality rates have been low and relatively consistent for the three most valuable commercial tree species in Delaware: loblolly pine (*Pinus taeda*), white oak (*Quercus alba*), and yellow-poplar (*Liriodendron tulipifera*) (Figure 23). The higher loblolly pine mortality rate is mostly due to natural thinning as a pine forest matures. This natural process is not of much concern because pine acreage has increased during this time period and volume increased too, especially in the diameter classes 13 inches and greater. This point is further supported by growing-stock tree numbers—loblolly pine trees have actually increased by 1.7 million since 2008. During that same time period, white oak and yellow-poplar numbers have remained virtually constant (Figure 24).

Figure 23. Annual mortality of growing-stock trees (at least 5 inches dbh), 2008–2018.



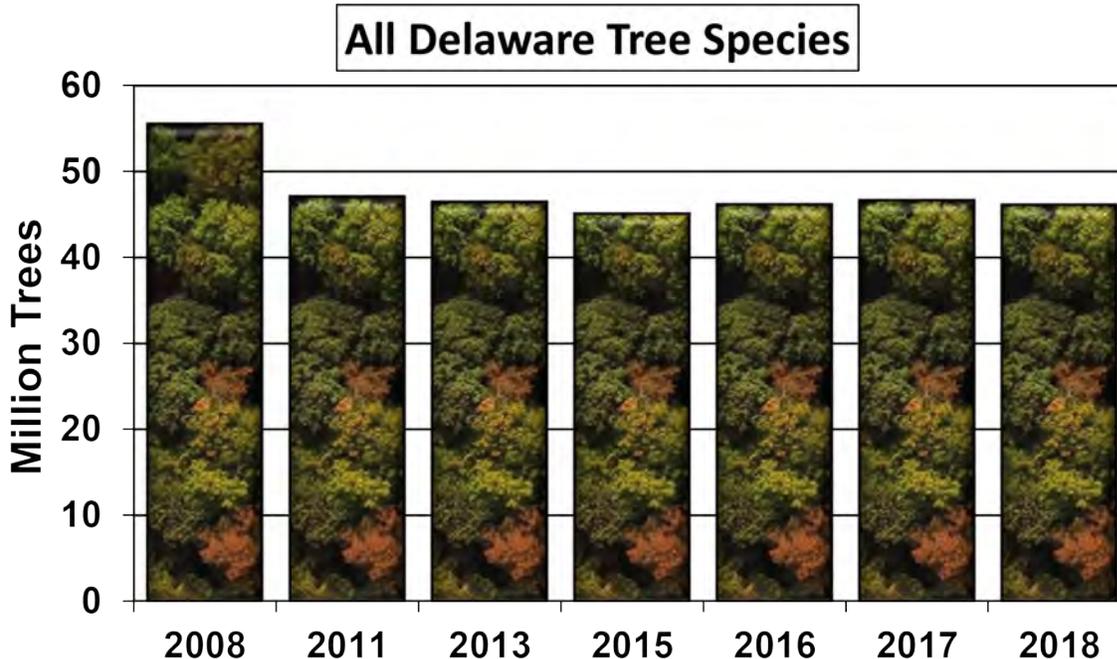
Source: U.S. Forest Service Forest Inventory and Analysis

Figure 24. Number of high-value growing-stock trees (at least 5 inches dbh), 2008–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Figure 25. Estimated total number of growing-stock trees (at least 5 inches dbh), 2008–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Looking at the total number of growing-stock trees over the last decade, there was a precipitous drop between 2008 and 2018 of 8.5 million trees (Figure 25). But since 2008, the total number of growing-stock trees in Delaware has remained constant. About half of the decrease (3.9 million) can be directly attributed to the decline in the number of red oaks (*Quercus* spp.), red maple (*Acer rubrum*), and sweetgum (*Liquidambar styraciflua*) trees (Figure 26). The other half is mainly due to the loss of forested acres and the fact that there are more larger trees now than ten years ago. Red oaks (all species) declined by 10% (0.54 million trees) but nearly two-thirds of this decline was due to northern red oak (*Quercus rubra*) mortality (0.34 million trees). Red maple, although still the most common tree species in Delaware, declined by 26.5% (3.37 million trees). Likewise, sweetgum declined by 12.5% (0.92 million trees). The cause(s) of red maple and sweetgum mortality are not well understood. Both of these common species are considered low-value, but they can be used for making paper and pellets for heating and large-diameter sweetgums are frequently used to build crane mats in Delaware.

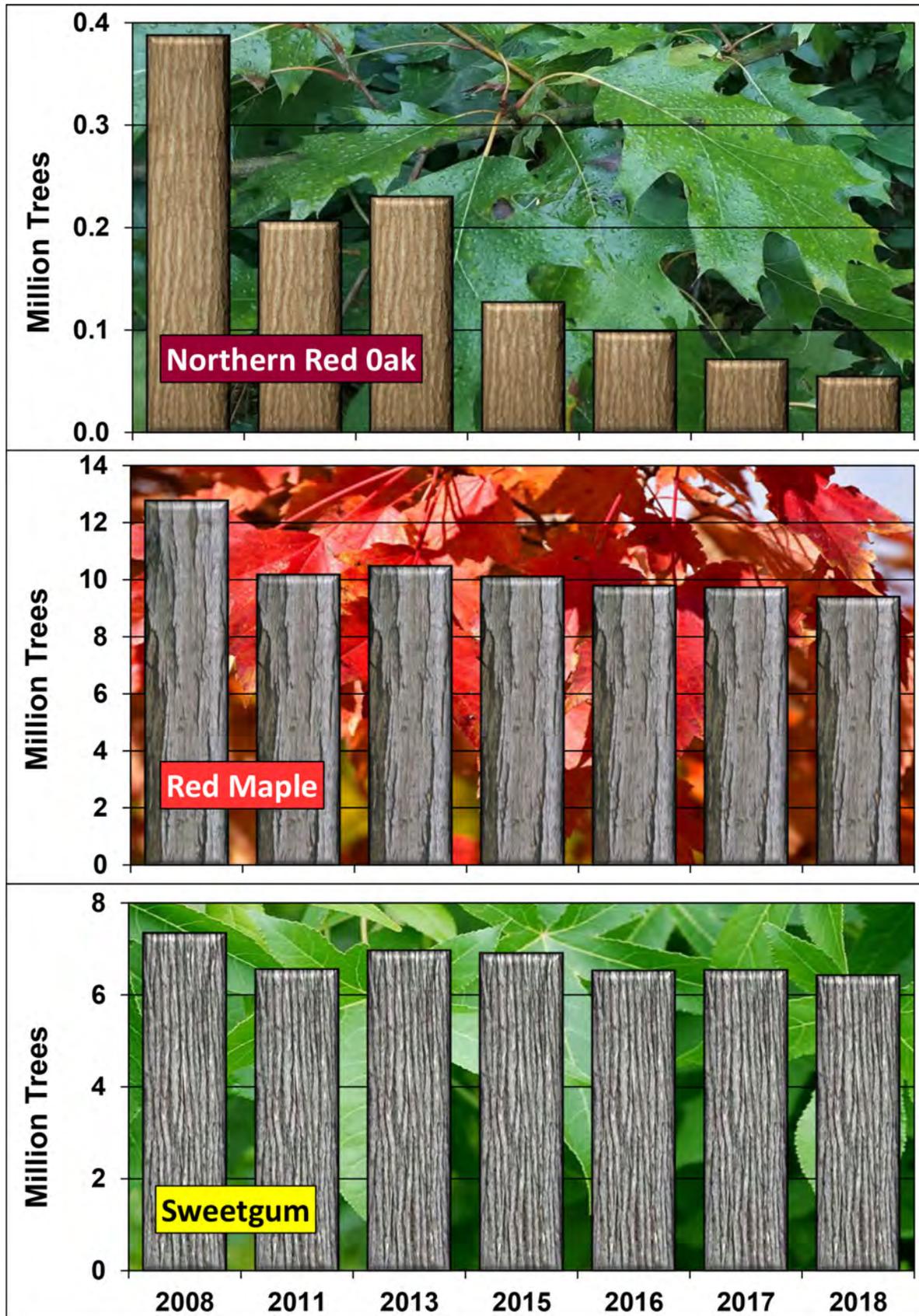
Wildfire

Overall, wildland fire is not a significant threat to Delaware's forests. In recent history, most of the largest wildfires occurred in marshes along the state's coastline. Occasionally, a wildfire within a forest will exceed 100 acres—typically in a young loblolly pine plantation—but these are rare and usually occur during a drought. Delaware's 60 volunteer fire companies (VFC) are nearly always the first responders to wildland fires and are very well equipped to control and contain them. Virtually every Delaware VFC operates a fully-equipped wildland fire brush truck.

The occurrences of wildland fires in Delaware was greatly reduced by the formation of the Delaware Forest Service in 1927. Fire towers were installed in strategic locations throughout the state to catch wildfires early, before they had a chance to spread over wide areas. This new feature in the fire prevention arsenal, along with quick responses from VFCs, greatly improved response times. Delaware also has relatively flat terrain interspersed with numerous ditches, other waterways, roads, and crop fields making it much less likely for a fire to spread and damage extensive acreage.

However, young loblolly pine stands are particularly vulnerable to fire damage but only on rare occasions when a combination of specific environmental conditions coincide. This was the case for the 2005 Cross Keys fire in Millsboro, which burned 168 acres and turned into a plume-dominated fire for several hours. The mid-April fire was caused by a careless smoker throwing a lit cigarette out of a car window. Temperatures at the time were in the high 80s and relative humidity was 11% (almost unheard of in Delaware). Drought conditions persisted that week and gusty winds pushed the road-side ignition into a young (<10 years old) loblolly pine plantation. The fire then spread into the tree crowns and ran through the plantation that afternoon. The fire settled down in the early evening when winds calmed, relative humidity rose, and temperatures dropped.

Figure 26. Number of growing-stock trees (at least 5 inches dbh) for declining species, 2008–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Drought

Historically, Delaware has experienced about two months of drought per year since 1895. A drought month is defined as a month in which the Palmer Drought Severity Index indicates moderate, severe, or extreme drought conditions (NOAA National Climatic Data Center). In 2000, NOAA started the U.S. Drought Monitor (USDM) to show the location and intensity of drought across the country. The USDM uses a five-category system labeled from abnormally dry to exceptional drought. Since 2000, the longest duration of drought in Delaware lasted 55 weeks beginning in late October 2001 and ending in mid-November 2002—the most intense period of this drought occurred in August where exceptional drought affected 74% of all of Delaware. However, since the end of 2013, Delaware has only experienced brief periods of abnormally dry or moderate drought conditions.

Extended periods of extreme drought can kill trees outright but is of more concern as an inducer of stress in trees. Stress predisposes trees to insect and disease problems, which do not normally affect healthy trees. In 2009, tree mortality resulted in an estimated loss of 5.0 million cubic feet of growing-stock. In 2018 losses were estimated at 9.1 million cubic feet. This equates to just less than 1% of all growing-stock in Delaware. Such a low rate is a completely acceptable level of mortality in a healthy forest. Every year some trees in any given forest die as a result of competition for light and other resources, as well as events such as severe drought, wind damage, lightning, and insect and disease attacks.

Other climatic events (hurricanes, ice storms, etc.)

Hurricanes occasionally occur in Delaware, although forests have not experienced significant damage since Hurricane Hazel in 1954. Delaware is typically impacted by tropical storms every few years, but these events do not cause substantial forest damage. However, a large portion (30%) of Delaware's forests were significantly impacted by an ice storm in February 1994 (Figure 27). The 117,047 acres of damaged forest were contained in a swath of land in southern Kent and northern Sussex Counties. While 26 years have passed since this rare Delaware event, its long-term effects on forest health continues. Trees severely and even moderately damaged (97,980 acres or 84% of the total damaged area) incurred significant amounts of breakage and twisting thus downgrading their health in the long run and exposing them to attacks by secondary stress agents, mainly insects and diseases.

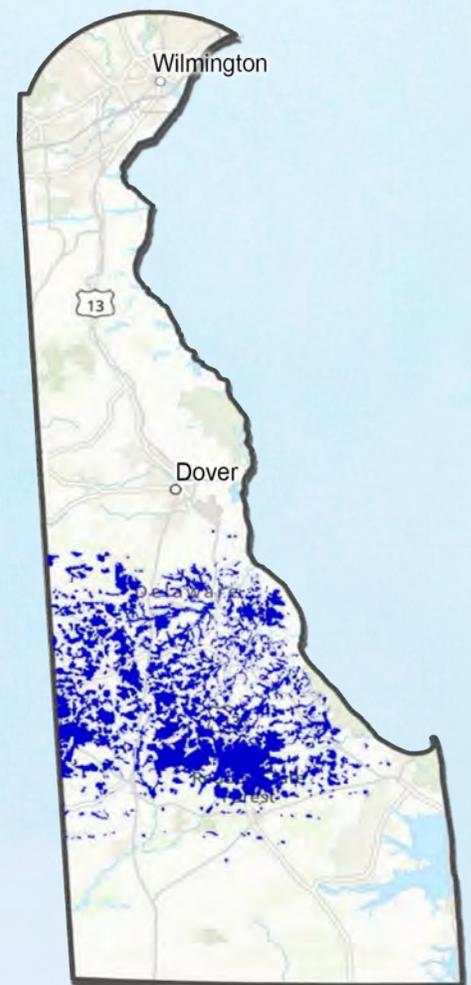
Climate change and sea level rise

There is growing concern among forestland managers about the potential impacts of climate change in Delaware, particularly sea level rise. Delaware's entire eastern border (and its longest border) is the Atlantic Ocean and Delaware River and Bay and 95% of the state lies within the Coastal Plain. While considerable research is still needed, several potential issues relating to forests and forested habitat include:

- Migration of maritime forests/riparian areas inland,
- Shifts in species range (migration),
- Changes in species composition or disappearance of species, and
- Increases in invasive/nuisance species and diseases.

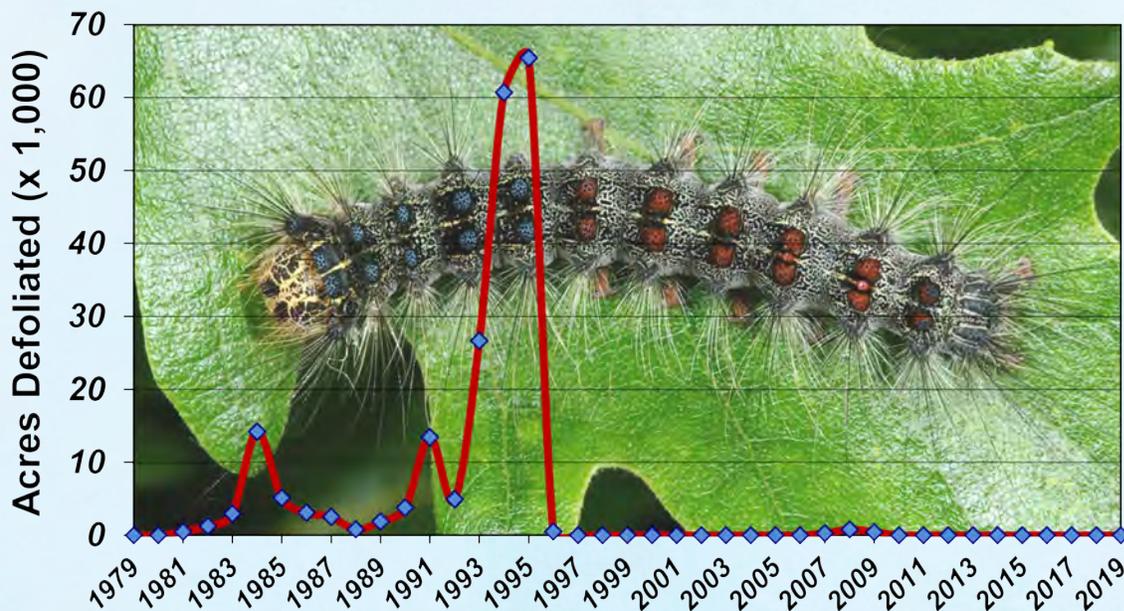
Additionally, there is a need to establish baseline risk assessment for species and habitats. Consideration can then be given to methods to move low-lying riparian forest buffers inland as sea level slowly rises to ensure these buffers are not lost. It is important that assessments also account for possible rate changes in the future. However, nearly 100 years of data from the Lewes, Delaware, tidal gauge show a trending (linear) annual increase of 3.53 mm (=1.39 inches/decade)—about half of this rise is due to land subsidence, the other half to actual sea level rise.

Figure 27. Ice storm damage in 1994.



Source: Delaware Forest Service

Figure 28. Gypsy moth defoliation in Delaware, 1979–2019.



Sources: Delaware Forest Service and U.S. Forest Service, Forest Health Protection, Gypsy Moth Digest

Forest pests (insects, diseases, deer browse)

One native and three exotic pests have historically affected Delaware's rural and urban forests to varying degrees. Two tree species—American chestnut (*Castanea dentata*) and American elm (*Ulmus americana*)—are now reduced to very low population levels because of exotic disease. Chestnut trees once dominated the eastern forests of Appalachia including Delaware's Piedmont region, but now are reduced to stump sprouts that eventually succumb to the chestnut blight (*Cryphonectria parasitica*) and die, never reaching significant size (>8 inches dbh). This tree species is still found throughout Delaware hardwood forests.

American elms were virtually eliminated by the Dutch elm disease (*Ophiostoma novo-ulmi*) and at one time were quite abundant in Delaware, especially along tree-lined streets as their umbrella-shaped crowns and height (>100 feet) provided shade and beauty to communities. With aggressive protection measures, some mature trees still exist in Delaware. Smaller elm trees are still found in the natural environment, but their once significant ecological role in the forest has been dramatically reduced.

The southern pine beetle (*Dendroctonus frontalis*) is a native insect that can cause localized mortality in loblolly pine stands. An outbreak occurred in 1994 in the Great Cypress Swamp affecting nearly 1,500 acres of loblolly pine stands causing extensive pine mortality. If detected early, small outbreaks can be controlled by the complete elimination of the beetle population through clearcutting and removal of the brood-infested trees.

The gypsy moth (*Lymantria dispar*) is a European species whose caterpillars feed on an extremely wide range (>500 species) of hosts but mostly favor hardwood species such as oak. First detected in Delaware in 1979, gypsy moth populations peaked in the mid-1990s with over 60,000 acres of forests defoliated in 1994 and 1995 (Figure 28). The precipitous drop in population numbers resulted from mortality due to a naturally-occurring virus and a newly introduced fungus (*Entomophaga maimaiga*) from Japan. For nearly 25 years Delaware has not had any significant gypsy moth defoliation although residual populations still exist, especially in southern Sussex County.

There are five relatively new pest species that have the potential to seriously impact Delaware forests, both urban and rural: sirex woodwasp (*Sirex noctilio*), Asian longhorned beetle (*Anoplophora glabripennis*), emerald ash borer (*Agrilus planipennis*), sudden oak death (*Phytophthora ramorum*), and thousand cankers disease.

Sirex woodwasp was first detected in northern Pennsylvania and New York but now is found in Vermont, Connecticut, Ohio, and Michigan. In these states the wasp causes considerable damage to red pine (*Pinus resinosa*) stands. Loblolly pine is a mainstay of Delaware's forest industry but has never been infested in its natural setting. Since 2006, the Delaware Forest Service has conducted annual surveys for this potentially deadly pest by using traps baited with a special chemical formulation and trap trees deliberately stressed to attract sirex adults in the area. To date, no sirex woodwasps have been detected in Delaware through these monitoring surveys.

An established population of the exotic Asian longhorned beetle (ALB) was first detected in New York City in 1996. It spread quickly to neighboring New Jersey and isolated populations can now be found in Massachusetts, Ohio, and Illinois. ALB feeds on a variety of tree species but prefers maples (*Acer* spp.). Red maple is still the most abundant tree species in Delaware and is susceptible to an ALB infestation. The Delaware Forest Services monitors for the presence of this tree pest through trapping and it has not been found in the state as of early 2020.

Emerald ash borer (EAB) is an exotic pest imported from China that feeds nearly exclusively on ash, *Fraxinus* spp. (it also feeds on fringetrees, *Chionanthus* spp.). Ten years ago, populations of EAB were only known to be found in areas 100 miles away from Delaware. However, in 2016 a single specimen was collected on a purple sticky trap in northern New Castle County and in 2018 infested trees were detected in the Seaford area. In 2019 more specimens were trapped along the western edge of New Castle County and through a biomonitoring technique using a wasp (*Cerceris fumipennis*), it was positively detected in Stanton. While ash represents only about 1% of Delaware's rural forests, it has been planted widely in urban areas and some communities have nearly a 100% ash street-tree component. Now that this pest is established in Delaware, it is only a matter of time before virtually all ash trees are attacked. EAB is established in 35 states now and to date has killed tens of millions of ash trees.

Sudden oak death (SOD) represents a significant threat to Delaware's oak trees, prized for both wildlife and commercial value. SOD has caused widespread destruction of tanoaks and other species in coastal California and southwestern Oregon. Landscape plants infected with spores of this virulent pathogen have been shipped from western nurseries to the mid-Atlantic region and not all infected plants were located. SOD surveys were conducted in Delaware from 2004 to 2008 but evidence of the disease was not found. SOD is still not known to occur in the natural environment outside of its present known western distribution.

Three of the four relatively new pests have not yet been detected in Delaware through survey efforts. Monitoring surveys will continue in the future and as new threats emerge, forest health staff will continue to respond with appropriate surveying and outreach efforts.

Mortality has risen significantly for red oak species, red maple, and sweetgum recently. About two-thirds of the mortality for the red oaks is related to one particular commercially valuable species—northern red oak (*Quercus rubra*). Red oaks are very susceptible to a disease called bacterial leaf scorch (*Xylella fastidiosa*), which was first detected in an urban setting in northern Delaware in the mid-1990s. This virulent disease has since spread throughout the entire state and is now common in the natural environment and there are no known cures for this disease. To make matters worse, once a red oak is weakened by this pathogen, a second disease, hypoxylon canker (*Hypoxylon atopunctatum*) attacks the tree. This secondary pathogen does not normally attack and kill healthy red oak trees. The combined attack by these two diseases has had a devastating effect on Delaware's red oak resource, particularly northern red oak.

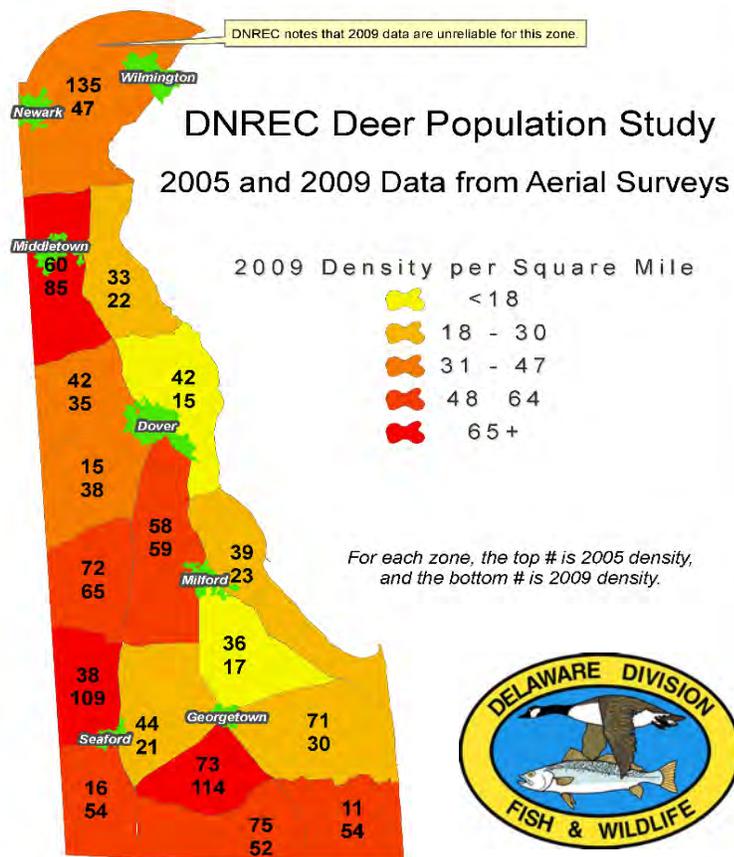
White-tailed deer (*Odocoileus virginianus*) are extremely common in Delaware due to optimal habitat that occurs throughout the state. As a result, in some areas overall deer populations reached densities exceeding 100/square mile in 2009 (Figure 29). Delaware's Department of Natural Resources and Environmental Control (DNREC), Division of Fish & Wildlife has not performed additional deer density estimates since the 2009 study, but updated population surveys are slated for the spring of 2020. Field observations and reports of fairly widespread, and sometimes extreme, crop damage by deer indicates that populations in many areas of the state are still very high. DNREC biologists compared harvests between the five-year average of 2011–2015 and the three-year average of 2016–2018. Only two zones (1A – extreme northern Delaware and 5 – eastern portion of Dover to the Delaware Bay) showed a harvest decline, each around 10%.

All other zones showed an increase in harvest numbers with 12 zones above 5%. The three highest increases were in zones 1B (+24.4%) in northern Delaware, 8 (+26.9%) in the central part of the state south of Dover, and 13 (+19.4%) in the southwest corner of the state. Harvest number changes often reflect total population numbers, assuming that hunter numbers and effort remain relatively constant.

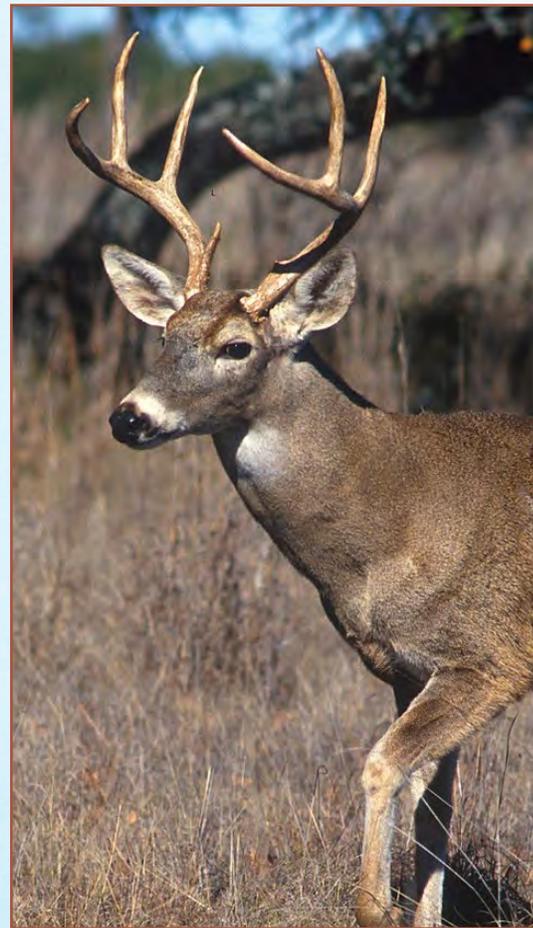
Over the last 20 years, Delaware hunting regulations have been adjusted to allow the harvesting of more deer by encouraging the taking of does. This is the most efficient means at reducing deer densities. Since 1988 the annual statewide deer harvest has more than tripled (Figure 30). The harvest on State Forest lands averaged just over 400 deer over the last ten years. This is almost double for the average of the prior ten years (231 deer/year between 1999–2009). According to the Quality Deer Management Association's (QDMA) Whitetail Report 2019, Delaware had the highest antlerless deer per antlered buck harvested ratio in 2017 (2.0) among the lower 48 states. Additionally, Delaware ranked second in antlerless harvest/square mile (5.2), with Maryland having the top spot at 5.7. But the fact still remains that deer populations in the state remain high.



Figure 29. Delaware deer population estimates, 2005 and 2009.

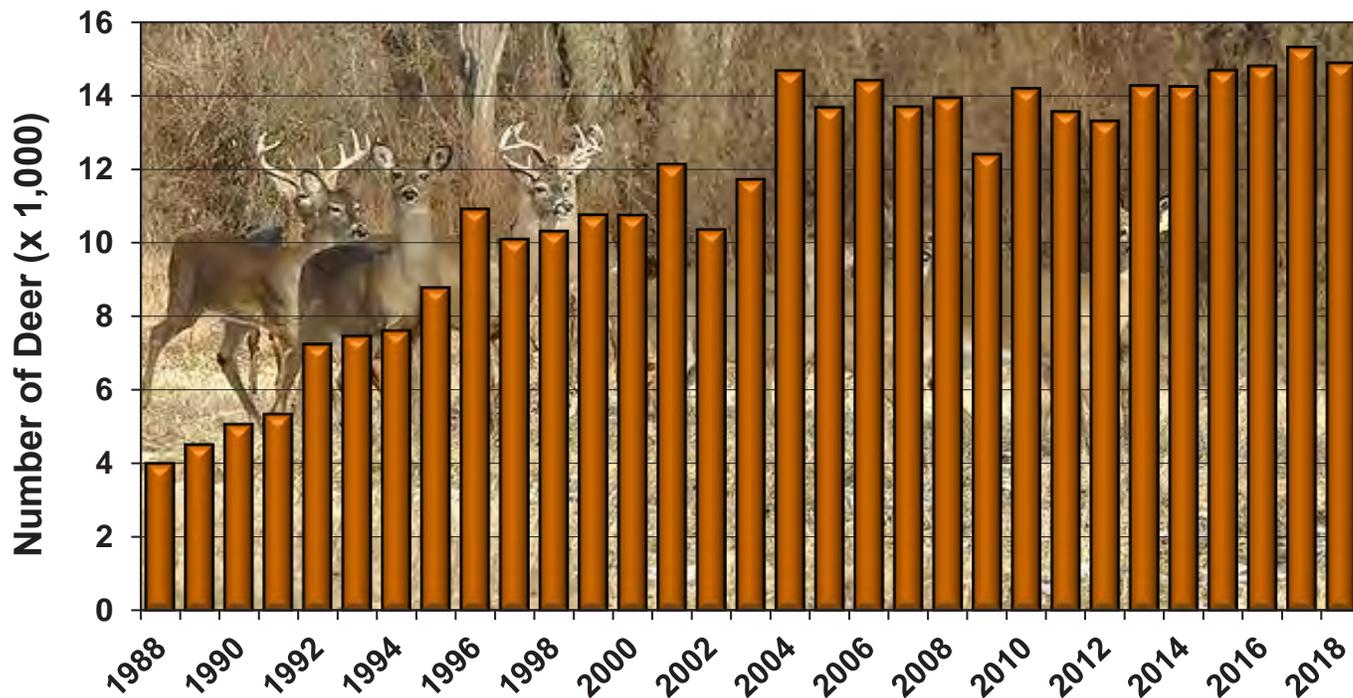


Source: DNREC Division of Fish & Wildlife



White-tailed deer

Figure 30. Delaware white-tailed deer harvest, 1988–2018.



Source: DNREC Division of Fish & Wildlife

Table 8. Delaware interior forest invasive plant species.



Oriental bittersweet



Japanese stiltgrass



Norway maple

Scientific Name	Common Name	Life Form
<i>Acer palmatum</i>	Japanese maple	deciduous tree
<i>Acer platanoides</i>	Norway maple	deciduous tree
<i>Ailanthus altissima</i>	tree-of-heaven	deciduous tree
<i>Akebia quinata</i>	five-leaf akebia	woody vine
<i>Alliaria petiolata</i>	garlic mustard	herb
<i>Allium vineale</i>	field garlic	herb
<i>Ampelopsis glandulosa</i>	porcelain-berry	woody vine
<i>Aralia elata</i>	Japanese angelica-tree	deciduous tree
<i>Berberis thunbergii</i>	Japanese barberry	deciduous shrub
<i>Cardamine impatiens</i>	touch-me-not bittercress	herb
<i>Celastrus orbiculatus</i>	Oriental bittersweet	woody vine
<i>Elaeagnus umbellata</i>	autumn olive	deciduous shrub
<i>Euonymus alatus</i>	winged euonymus	deciduous shrub
<i>Euonymus fortunei</i>	winter creeper	woody vine
<i>Ficaria verna</i>	lesser celandine	herb
<i>Galanthus nivalis</i>	snowdrops	herb
<i>Glechoma hederacea</i>	ground-ivy	herb
<i>Hedera helix</i>	English ivy	woody vine
<i>Hedera hibernica</i>	Atlantic ivy	woody vine
<i>Hemerocallis fulva</i>	orange daylily	herb
<i>Hosta ventricosa</i>	blue plantain-lily	herb
<i>Ilex crenata</i>	Japanese holly	evergreen shrub
<i>Leucojum aestivum</i>	summer snowflake	herb
<i>Ligustrum sinense</i>	Chinese privet	deciduous shrub
<i>Ligustrum vulgare</i>	European privet	deciduous shrub
<i>Lonicera japonica</i>	Japanese honeysuckle	woody vine
<i>Lonicera maackii</i>	Amur honeysuckle	deciduous shrub
<i>Lonicera morrowii</i>	Morrow's honeysuckle	deciduous shrub
<i>Lonicera standishii</i>	Standish's honeysuckle	deciduous shrub
<i>Lonicera tatarica</i>	Tartarian honeysuckle	deciduous shrub
<i>Lysimachia nummularia</i>	creeping Jenny	herb
<i>Magnolia kobus</i>	Kobus magnolia	deciduous tree
<i>Magnolia tripetala</i>	umbrella tree	deciduous tree
<i>Mahonia bealei</i>	leatherleaf mahonia	evergreen shrub
<i>Mahonia repens</i>	creeping hollygrape	evergreen shrub
<i>Malus baccata</i>	Siberian crabapple	deciduous tree
<i>Microstegium vimineum</i>	Japanese stilt grass	grass
<i>Morus alba</i>	white mulberry	deciduous tree
<i>Narcissus pseudonarcissus</i>	daffodil	herb
<i>Oplismenus undulatifolius</i>	wavyleaf basketgrass	grass
<i>Pachysandra terminalis</i>	pachysandra	herb
<i>Paulownia tomentosa</i>	royal paulownia	deciduous tree
<i>Perilla frutescens</i>	beefsteak plant	herb
<i>Persicaria longiseta</i>	longbristle smartweed	herb
<i>Persicaria perfoliata</i>	mile-a-minute	herb
<i>Poa compressa</i>	Canada bluegrass	grass
<i>Poa trivialis</i>	rough bluegrass	grass
<i>Prunus avium</i>	sweet cherry	deciduous tree
<i>Prunus subhirtella</i>	weeping Higan cherry	deciduous tree
<i>Rhodotypos scandens</i>	jetbead	deciduous shrub
<i>Rosa multiflora</i>	multiflora rose	deciduous shrub
<i>Rubus laciniatus</i>	evergreen blackberry	deciduous shrub
<i>Rubus parvifolius</i>	three-leaf blackberry	deciduous shrub
<i>Rubus phoenicolasius</i>	wineberry	deciduous shrub
<i>Urtica dioica</i>	stinging nettle	herb
<i>Viburnum dilatatum</i>	exotic arrow-wood	deciduous shrub
<i>Viburnum plicatum</i>	Japanese snowball	deciduous shrub
<i>Viburnum setigerum</i>	tea viburnum	deciduous shrub
<i>Viburnum sieboldii</i>	Siebold's viburnum	deciduous shrub
<i>Vinca minor</i>	lesser periwinkle	herb

Source: DNREC Wildlife Conservation & Research Program

Elevated deer densities often result in browse damage to understory plants in the forest, especially seedlings of favored tree species such as oak. Studies in other states have shown that deer populations of more than 20 or 25/square mile can significantly impair seedling growth and negatively influence species composition in a developing stand. Understory nesting habitat for some birds, particularly neotropical migratory species, can also be reduced dramatically. A deer exclosure study initiated by the Delaware Forest Service showed conclusively that areas with high deer densities suffer substantial damage to the forest understory.

Invasive plants

Non-native, invasive plants often go unnoticed to the untrained eye. However, their presence continues to grow, negatively impacting Delaware forests particularly in highly fragmented areas such as urban settings and the edges of expanding suburbs. While there is no estimate of the number of native plants displaced by invasive species, DNREC's Wildlife Species Conservation & Research Program identifies 60 species of non-native, invasive plants that are detrimental to forest interior habitat (Table 8). Many of them are out-competing native trees in urban forests and open areas reverting to forestland.

Conclusions

Certain living (biotic) and non-living (abiotic) agents damage forests in Delaware. Abiotic stressors are uncontrollable (e.g., drought, storms, sea level rise) but can be mitigated to a degree. Many biotic stressors also fall into this category of uncontrollable. Once established in the environment free from their natural regulating forces, invasive exotic organisms spread rapidly and have the potential to decimate a host species (e.g., Dutch elm disease, chestnut blight, emerald ash borer). Some forest pests can be controlled through silvicultural prescriptions (e.g., southern pine beetle). And many invasive exotic plant species simply out-compete native vegetation putting those more desirable species at a disadvantage. Steps should be taken wherever and whenever possible to reduce the impact of all forest-damaging agents.

Summary – Criterion 3

Delaware's forests face a variety of health concerns—including threats that are present and threats that could potentially arrive in the near or distant future. Weather events, such as the 1994 ice storm, pose sporadic threats to forest health and can significantly impact the long-term well-being of our forests. Neither the normal "background" tree mortality rate nor the occurrence of wildfires present a major threat to Delaware's forest resources. Constant browse damage to seedlings by a large deer herd has likely begun altering species composition in hardwood forests throughout the state. Non-native, invasive plants also negatively and significantly impact Delaware's forests, particularly in the northern part of the state and within urban/suburban areas. Several exotic insects and diseases present potential threats to rural and urban forests as well. Therefore, surveys to assess current threats and detect new pests are essential for continued forest health. Addressing all of these concerns is important to ensure that Delaware maintains healthy forest ecosystems. Thankfully, none of these threats are considered a current forest health catastrophe. However, each has the potential to produce substantial impact, and in combination over time, could be devastating. The emerald ash borer seems likely to fall into this category in the near future. Taking steps to minimize damaging threats and developing plans to respond to their future occurrences is vital and ties directly into one of the U.S. Forest Service's Eastern Region S&PF national priorities—*Protect forests from threats.*



Several exotic insects and diseases present potential threats. Therefore, surveys to assess current threats and detect new pests are essential for forest health.



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.



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.

Source: United States Geological Survey

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.

Figure 32. Major watersheds in Delaware.



Source: United States Geological Survey

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.

Table 9. Forestland in Delaware by watershed, 2014.

<i>Watershed</i>	<i>% Forest</i>	<i>Total Acres</i>	<i>Forest Acres</i>	<i>Forest Acreage Change 2007–2014</i>
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

<i>Watershed</i>	<i>Total Acres</i>	<i>Forest Acres</i>	<i>% Forest</i>	<i>Forest Acreage Change 2007–2014</i>
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.

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.



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.



Summary – Criterion 4

Forests play a vital role in conserving and enhancing soil and water quality and quantity. While nearly all of Delaware’s watersheds are under 50% forested and most of Delaware is located in the Coastal Plain with little topography, our forests nonetheless provide excellent buffers and protect groundwater recharge areas. Forests also help protect water quality for Delaware’s two large cities that utilize surface water for drinking water supplies. Approximately one-third of Delaware is located within the Chesapeake Bay watershed and protecting and expanding forested areas and buffers in this area as well as throughout all of Delaware is important. There could also be opportunities to restore the hydrology of bottomland forests by working with Delaware’s tax ditch system. Regardless, maintaining and expanding forest buffers and forested areas critical to water quality protection is directly related to one of the Eastern Region S&PF national priorities—*Enhance public benefits from trees and forests.*



Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

Forests are renewable and one of the largest terrestrial reservoirs of biomass and soil carbon. They have an important role in global carbon cycles as sinks and sources of carbon. Carbon stocks in forests include aboveground biomass, belowground biomass, dead and decaying organic matter and soil carbon. Carbon is also stored in wood products.

The biosphere has a significant influence on the chemical composition of the atmosphere. Vegetation draws CO₂ from the atmosphere through photosynthesis and returns it through respiration and the decay of organic matter. The interchange between the biosphere and atmosphere is large—approximately one-seventh of total atmospheric CO₂ passes into vegetation each year.

Global climate change could have significant impacts on the structure, distribution, productivity, and health of temperate forests as well as impacts on forest carbon stocks and fluxes.

Forest management practices also affect the carbon cycle and fluxes. Deforestation has a negative impact, but management activities that maintain and enhance the carbon stored in forests and forest products over the medium to long term can help mitigate atmospheric CO₂ levels. In addition, biomass from forests can substitute for fossil fuels thereby reducing greenhouse gas emissions.



INDICATOR 11

Forest ecosystem biomass and forest carbon pools

Trees store carbon (referred to as a carbon sink) in their xylem (wood) and other tissues. Carbon storage is important because carbon (in the form of carbon dioxide) plays a role in the greenhouse effect and the warming of the Earth. Carbon dioxide concentrations in the atmosphere have risen every year since the industrial revolution. Forests “lock up” some of the carbon emissions produced each year and reduce the rate of increase of atmospheric carbon dioxide. Forest inventory data can be used to quantify carbon storage in Delaware’s forests.





Carbon is also stored in harvested wood, such as durable wood products (e.g., lumber for housing) that can last for a century or longer.

Forest ecosystem biomass

Forest biomass is closely related to forest carbon stocks—conditions that increase rates of tree growth will also increase rates of carbon storage within forests. The conditions that influence growth can include environmental conditions such as patterns of temperature and rainfall, atmospheric CO₂, and nitrogen deposition. Forest management practices, such as invasive plant control and forest thinning, also influence tree growth. FIA data for Delaware from 2017 shows that live aboveground forest biomass was an estimated 25.7 million tons, an increase of 9% since 2011 (Table 11).

Table 11. Delaware forest characteristics, 2011 and 2017.

<i>Characteristic</i>	<i>2011</i>	<i>2017</i>
Area (thousands of acres)	340	356
Aboveground biomass of live trees (dry weight, thousand tons)	23,570	25,711
Net volume of live trees (million cubic feet)	861	947

Source: U.S. Forest Service Forest Inventory and Analysis

Forest carbon pools

In forest ecosystems, carbon is stored in different pools or stocks: aboveground live biomass, belowground live biomass, dead wood, litter, and forest understory (Table 12). Carbon fluxes are the amount of carbon moving from one stock to another over a specified period of time. Carbon is also stored in harvested wood, such as durable wood products (e.g., lumber for housing) that can last for a century or longer. Data from the 2017 growing season estimate the aboveground live tree carbon storage in Delaware's forests at 12.86 million U.S. tons (up from 12.60 in 1999). Dead, understory, litter, and belowground components account for an additional 6.59 million U.S. tons for a total forest carbon pool of 19.45 million tons in 2017.

Carbon may be a consideration in forest management activities even if it is not the primary objective. Carbon management often focuses on the amount of carbon stored in biomass and soil, as well as the rate new carbon is absorbed (sequestered) from the atmosphere to support tree growth.

Table 12. Total forest component carbon pool, 2017.

<i>Component</i>	<i>U.S. Tons (millions)</i>
Aboveground live tree	12.86
Standing dead	0.61
Understory	0.32
Down dead wood	1.35
Litter	1.76
Belowground live roots	2.55
Total	19.45

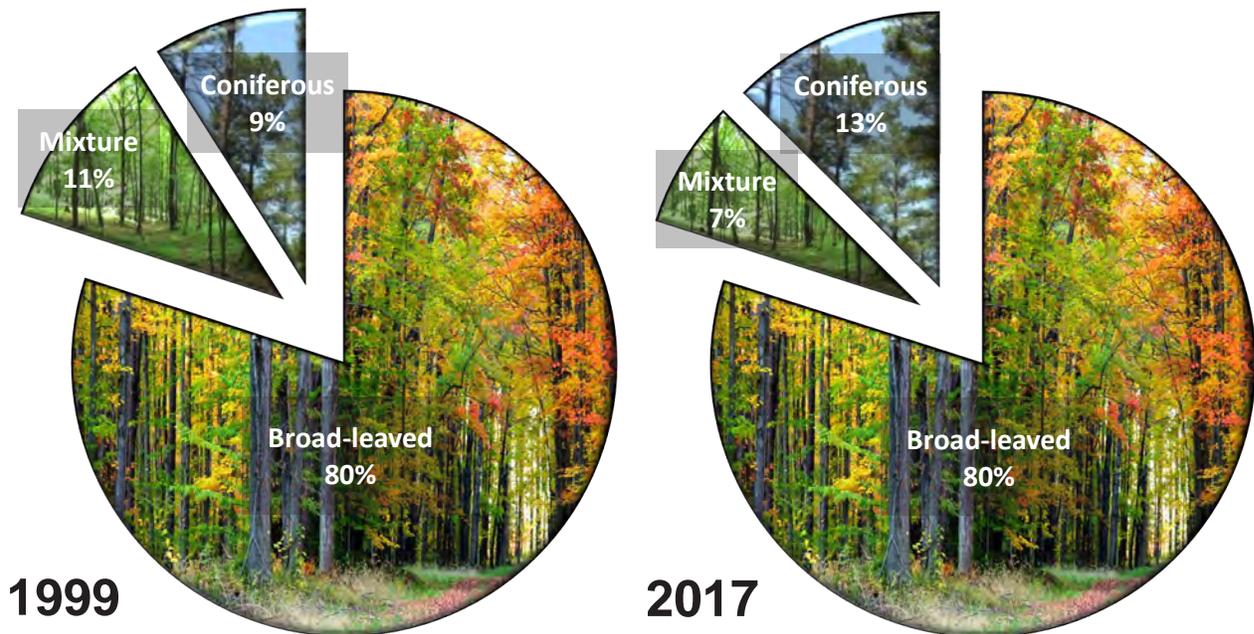
Source: U.S. Forest Service Forest Inventory and Analysis

Forest carbon by forest type

Four-fifths of the aboveground carbon is found in broad-leaved stands (Figure 33). These are forests dominated by deciduous trees such as red and white oaks (*Quercus* spp.), maples (*Acer* spp.), sweetgum (*Liquidambar styraciflua*), and yellow-poplar (*Liriodendron tulipifera*). This percentage is the same as it was in 1999, however there is a noticeable shift in aboveground carbon (4%) away from mixed to coniferous forests. Most of this increase is attributable to the increases in loblolly pine acreage and volume. Both forest types sequester and store carbon at various rates depending on age, condition of trees, and other factors.



Figure 33. Aboveground live tree carbon by forest type in 1999 and 2017.



Source: U.S. Forest Service Forest Inventory and Analysis and DNREC Division of Climate, Coastal, & Energy

Urban and community forests

Urban and community forests play an important role in carbon sequestration and storage. Trees in urban and community environments may have higher rates of carbon sequestration as a result of lower tree densities, greater foliar biomass, irrigation, and fertilization (from stormwater runoff and/or landscape management). Proper siting and maintenance are important for maximizing the carbon benefit of urban forests. Trees that are well-adapted to their site have higher growth rates and lower mortality rates, thus providing more long-term carbon storage.

Trees in both forest and urban and community settings absorb atmospheric carbon through photosynthesis. This ongoing process of carbon sequestration adds to the amount of carbon storage as trees accumulate more biomass. The annual rates of carbon sequestration by urban and community forests continue to grow as tree canopy cover in urbanized areas expands.



The U.S. Forest Service has conducted research on urban and community forest carbon sequestration and storage (Nowak, et al. 2008, Nowak and Greenfield 2012, 2018). Carbon sequestration and storage estimates were updated in 2018 using urban land estimates from the 2010 U.S. Census, with tree cover estimates and carbon values based on earlier published methods. Some of the estimated benefits for Delaware are:

- Carbon storage: 3.1 million U.S. tons
- Carbon sequestration: 136,300 U.S. tons annually
- Air pollution removal: 2.7 U.S. tons annually
- Number of trees per capita: 25.3 trees

Trees in urban and community settings provide other environmental benefits. Trees remove air pollutants by filtering particulate matter on plant surfaces and absorb some pollutants through respiration— these values vary under local conditions based on the amount of tree canopy cover, pollution concentrations, and other factors. The estimates shown above are a first-order approximation of a statewide total. It should be noted, however, that local-scale design of trees and forests can affect local-scale pollutant concentrations.

Urban trees and forests also shade buildings and act as wind buffers, thus reducing energy demand for cooling and heating. Reducing building energy use results in avoided emissions of greenhouse gases and other pollutants that would have been generated through fossil-fuel combustion from heating and electricity production.

Change in forest carbon

The amount of carbon absorbed and stored within a forest ecosystem is affected by land-use change, management activities, disturbance, and climate. Disturbances—both natural and human-induced— influence the composition, structure, and function of forests. Natural disturbances include insect pests, disease, fire, and wind. Climate change will affect forests by altering the frequency and severity of disturbance.

Avoiding forest losses resulting from deforestation and conversion to non-forest uses helps maintain both the carbon already stored in the forest system and the capacity of the forest to continue absorbing (sequestering) additional carbon.

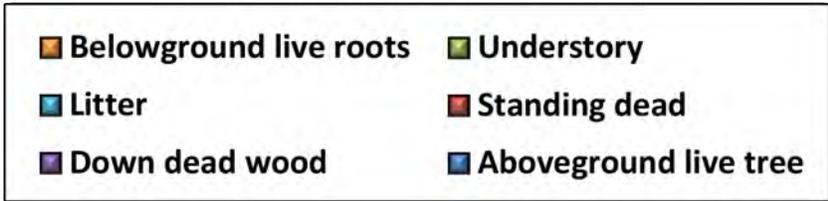
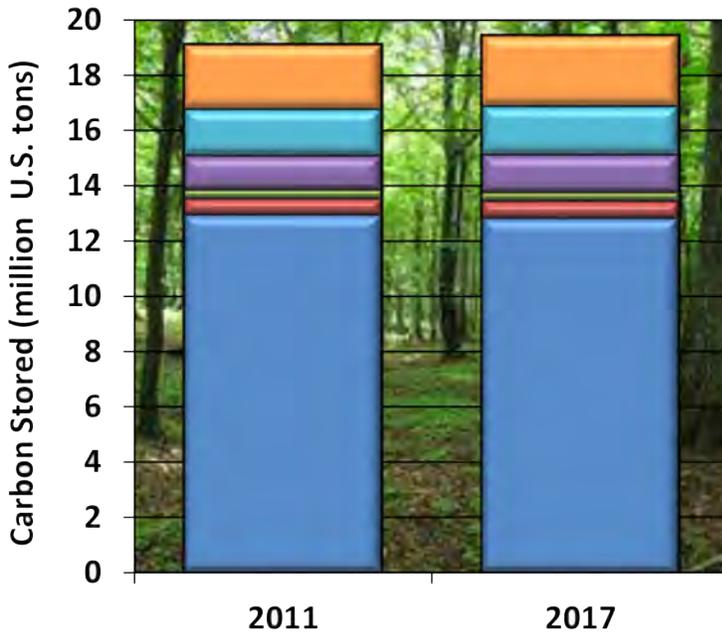
In the past decade, forestland acreage in Delaware has not changed significantly. However, forest growth has increased the total amount of biomass in forest ecosystems. Annual net growth of forest trees has outpaced annual harvest removals and annual mortality.

Figure 34 shows the change in carbon storage in different pools from 2011 to 2017. Total carbon storage increased by 1.7% from 19.13 to 19.45 million tons. The increase since 1986 is 8.1%. These increases are expected because trees in Delaware's forests are growing larger (see Figure 11). While larger trees can store more carbon in living biomass and the trend of increasing carbon storage is desirable, it is important to remember that as forests continue aging, their ability to sequester additional carbon decreases. Therefore, maintaining a balanced mixture of young through mature forests is important not only for wildlife habitat, sustainable forest management, and other purposes, but also for carbon sequestration.

Avoiding forest losses from deforestation and conversion to non-forest uses helps maintain carbon already stored in the forest system and the capacity of the forest to continue absorbing additional carbon.



Figure 34. Carbon pools of Delaware forests in 2011 and 2017.



Source: U.S. Forest Service Forest Inventory and Analysis and DNREC Division of Climate, Coastal, & Energy

Conclusions

Delaware's forests are excellent carbon sinks. Furthermore, research has shown that forest management activities can increase the amount of carbon stored by forests. Preserving forests during periods of increased development is also important for carbon storage because affected forests are usually not replaced or, at best, only partially replaced so this carbon storage source is eliminated or greatly reduced. Voluntary carbon markets still exist within the United States and Delaware is a member of the Regional Greenhouse Gas Initiative (RGGI), which includes ten northeastern and mid-Atlantic states. All except New Hampshire have formally committed to advance the goals of the Paris Agreement and reduce their emissions 26–28% below 2005 levels by 2025. Currently, forestry practices approved by RGGI for carbon credit are afforestation (planting open land with trees), improved forest management (to increase carbon stocks), and avoided conversion (of privately-owned forestland). Conserving our existing forests, expanding forestland where possible (including urban forest areas and community open spaces), and including carbon storage in forest management plans will help maintain and increase the role of Delaware's forests in the global carbon cycle.

Preserving forests during periods of increased development is important for carbon storage because affected forests are usually not replaced or, at best, only partially replaced.





Forests in Delaware contain nearly twenty million tons of carbon and this amount has increased with maturation of the forests.

Summary – Criterion 5

Forests in Delaware currently contain nearly twenty million tons of carbon and this amount has increased with maturation of the forests. Urban forests, in addition to removing pollutants, also reduce energy consumption by cooling urban areas in the summer and warming them during the winter. This helps mitigate the effects of global climate change, which is directly related to the Eastern Region S&PF national priority to *Enhance public benefits from trees and forests*. Forest management activities can lead to increased growth rates and increased uptake of carbon in vigorously growing stands. Expanding forested areas in both rural and urban areas—and reducing their permanent loss to development and other land uses—increases carbon sequestration and storage. Maintaining and managing our rural and urban forest resources provides a wide variety of benefits, including carbon sequestration and storage.

Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits to Meet the Needs of Societies

Forests provide a wide variety of social, cultural, and economic goods, services, and other benefits that contribute to meeting the needs of society. Many people and communities are dependent on forest for their livelihood and well-being. Information on the production and consumption of forest products, investment and employment in the forest sector, forest-based recreation and tourism, and other social and cultural forest values illustrate the many benefits forests provide. The markets for forest products are a significant sector of our state's economy. Maintaining and growing these markets is vital not only to Delaware's economy but also sustaining the forest land base—owners need to generate sufficient income from their forests to retain their forests. Furthermore, it is important to develop new markets, such as wood energy, to maintain a robust and diverse forest products economy so it is not overly dependent on a single market. Public investment in forests, forest markets, and forest research is also necessary to ensure a sustainable land base and the best information is available to landowners and decision-makers. Addressing all of these issues is necessary to help ensure that Delaware's forests will continue to meet society's needs in the future.

INDICATOR 12

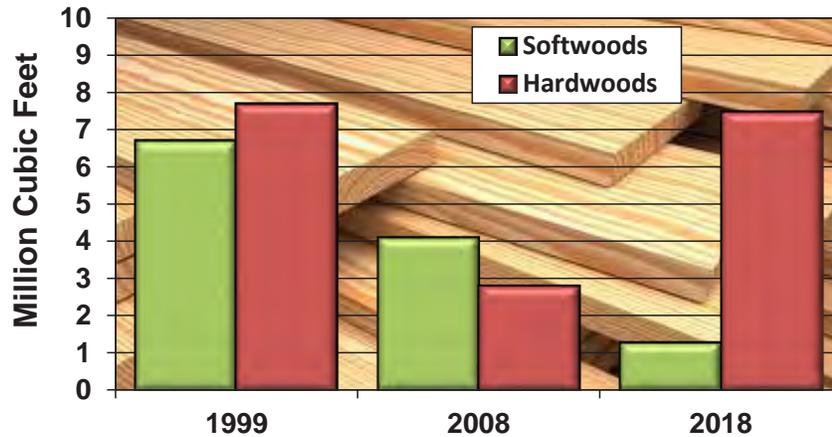
Wood and wood products production, consumption, and trade

Wood products have always been a critical component of Delaware's economy. Lumber remains the primary building material for new houses. Pulp, paper, and other forest products provide many of the household goods often taken for granted. In 1965, the total consumption in the United States of solid wood products, paper, and pulp was 13.3 billion cubic feet. By 2005, consumption of these products had grown to 20.0 billion cubic feet, an increase of 50%. This total dropped to 13.1 by 2009 but recovered somewhat by 2017 to 17.1 billion cubic feet (USFS Res. Pap FPL-RP-701). Delawarean's appetite for wood and wood products continues to grow—it is important that our state maintain a sufficient forest base and the technology to help meet this demand.

Wood removals and product class

In 1999, approximately 14.4 million cubic feet of growing-stock were removed through timber harvests in Delaware. In 2008 that number dropped to 6.9 million cubic feet and in 2018 removals totaled 8.8 million cubic feet. Volumes of softwoods and hardwoods were nearly equal in 1999, but by 2008 both declined significantly but with softwood removals greater than that of hardwoods (Figure 35). By 2018 hardwood removals returned to the 1999 level but softwoods removals continued to decline.

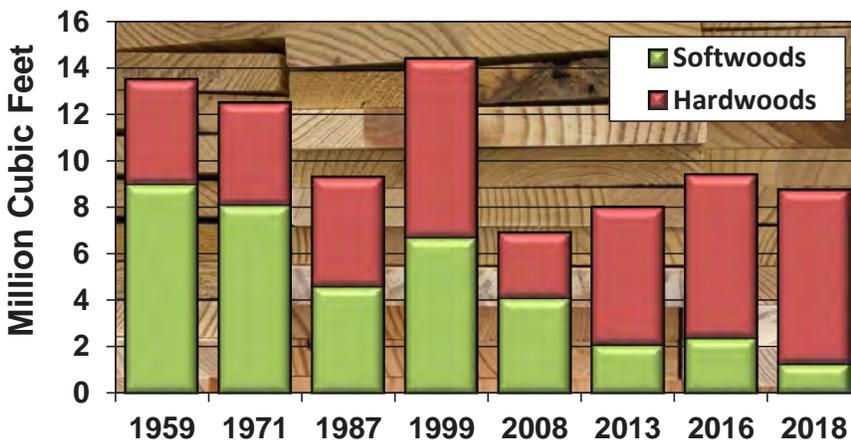
Figure 35. Wood removals in Delaware, 1999, 2008 and 2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Historic removals from 1959 to 1999 did not fluctuate greatly—annual removals ranged from approximately 10 to 14 million cubic feet (Figure 36). This relatively consistent harvest reflects the fact that Delaware’s forested acreage remained fairly constant during that time period. The proportion of hardwood to softwood volume has since increased considerably, however, due to the replacement of loblolly pine stands by hardwood stands as well as reduced demand due to the loss of several pine sawmills on the Delmarva Peninsula. Additionally, markets for small and poor-quality hardwood timber, primarily pulpwood and wood chips for the prison in Princess Anne, Maryland, increased over the last two decades.

Figure 36. Annual growing-stock removals, 1959–2018.



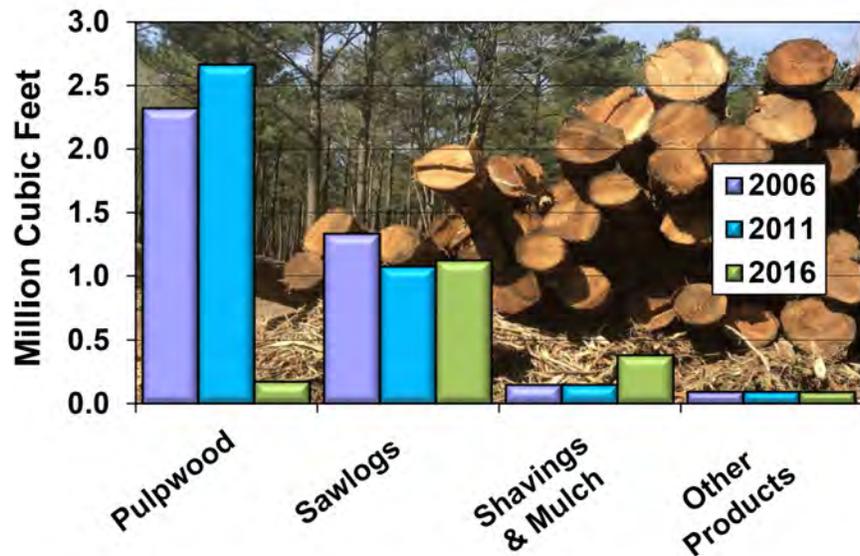
Source: U.S. Forest Service Forest Inventory and Analysis





Pulpwood and sawlogs accounted for more than 90% of the total volume harvested in 2006 and 2011, but only amounted to 74% in 2016 (Figure 37). Shavings and mulch, which only accounted for 4% of the harvested volume in 2006 and 2011, increased to 22% in 2016. The remaining volume consisted of posts, poles, firewood, and industrial fuelwood. Note the collapse in the demand for pulpwood, once the mainstay of Delaware's timber industry, from 2011 to 2016. Nearly all of these harvests occur on privately-owned forestland—State Forests and a portion of State Wildlife Areas are the only publicly-owned forests that are actively managed for timber production.

Figure 37. Timber harvest by product class, 2006, 2011, and 2016.



Source: U.S. Forest Service Forest Inventory and Analysis

A unique and important market for byproducts from sawmills in Delaware and the Delmarva Peninsula is bedding for the poultry industry.



The Delaware Forest Service (DFS) tracks most of the state's timber harvesting through its notification system required by the state's *Erosion and Sedimentation Law* (Title 3, Chapter 10, Subchapter VI) for all harvests exceeding one acre. In the period (2010–2019) since our last assessment, on average, approximately 2,683 acres of timber are harvested annually—down from 4,567 acres, on average, from 2000 to 2009.

Approximately 37% of this most recent total (974 acres [2,467 prior to 2010—54%]) were clearcut harvests, 33% were selection harvests (867 acres [1,461 prior to 2010—32%]), and the remainder were pine thinning harvests (797 acres [638 prior to 2010]). While the size, quality, and species of trees vary greatly by harvest, and thus the timber harvest revenue varies depending on these factors, the DFS estimates that these harvests return at least \$2.5 million each year to landowners. While still significant, the overall timber income has decreased markedly (estimates are at least 33%) because the dramatic decrease in timber prices caused, in large part, by the precipitous drop in lumber prices following the collapse of the real estate market and housing industry and the resulting closure of sawmills.

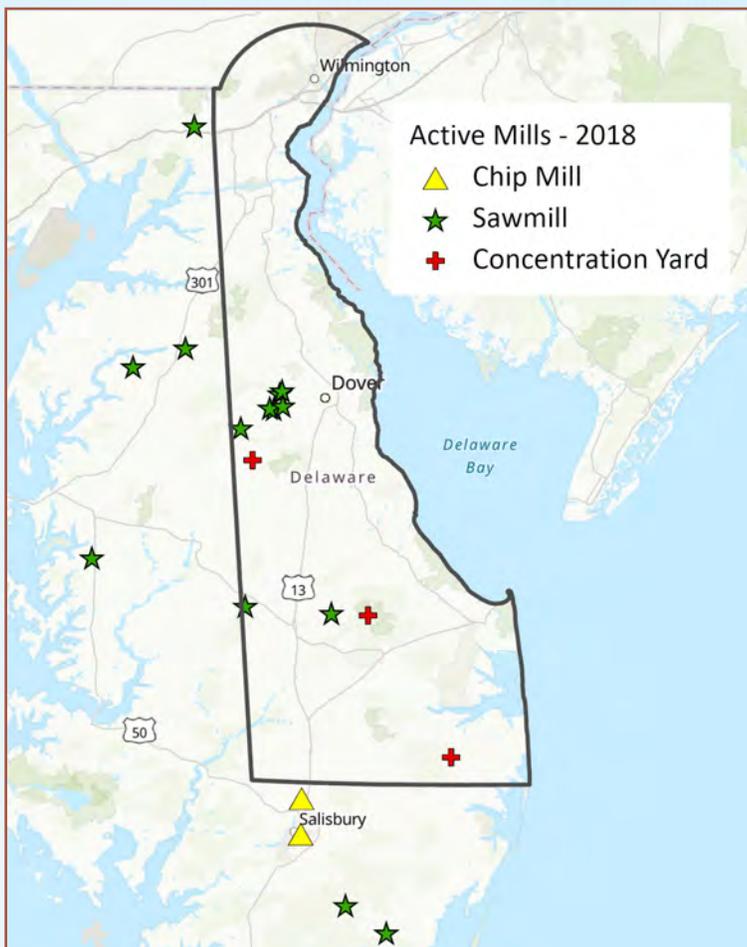
A somewhat unique, and important, market for byproducts from sawmills in Delaware and the entire Delmarva Peninsula is bedding for the poultry industry. Sussex County Delaware produces more chickens (broilers) than any county in the nation. This requires large amounts of bedding material, much of which is supplied as shavings and sawdust (pine is preferred but hardwood sawdust is also used) from the mills.

Mills on Delmarva

It is worth noting that the bulk of the timber harvested in Delaware is processed out-of-state. There are no major sawmills or other wood processing facilities in the state. Two sawmills process pine sawtimber from Delaware—both are located in Maryland counties adjoining Delaware. Twenty years ago, there were at least eight pine sawmills on the Delmarva Peninsula. Most of the state's hardwood sawtimber is processed by three mills—all located in Maryland—although there are nine small sawmills, including Amish-owned mills, in southern and central Delaware. These nine sawmills specialize in hardwood sawtimber.

There are also two small concentration yards in southern Delaware that purchase some pine and hardwood timber. Pine and hardwood pulpwood is supplied to a single mill in Spring Grove, Pennsylvania, and a pulp/chip products producer located in Maryland. The paper mill has a satellite chip mill located on Maryland's Eastern Shore, and the pulpwood company operates one of the previously mentioned concentration yards in Delaware. **Figure 38** shows the locations of these mills and concentration yards.

Figure 38. Delmarva Peninsula mills, 2018.



Source: Delaware Forest Service and Maryland Forest Service

Although difficult to quantify, there is a slow increase in the number of portable sawmills in the area, including small, often solar-powered lumber dry kilns. The impact of these niche operations may grow in coming years and the technical assistance needed by these operators is often quite different from that of traditional larger sawmills.

The bulk of the timber harvested in Delaware is processed out-of-state. There are no major sawmills or other wood processing facilities in the state.





Conclusions

Over the last 20 years, annual softwood removals have decreased from 6.7 to 1.3 million cubic feet, while annual growth averaged 5.2 million cubic feet. This is encouraging because for the forty years prior to 2000, removals far exceeded growth and this, in the long run, is unsustainable. Annual hardwood harvests rose significantly by 1999 (to 7.7 million cubic feet) and then the following ten years bottomed out at 2.8. However, the last ten years has seen a steady increase in annual hardwood removals. The majority of wood volume harvested in Delaware falls into pulpwood and sawlog product classes and virtually all of this timber is processed out-of-state.

INDICATOR 13

Outdoor recreational participation and facilities

In addition to forest products such as lumber and paper, forests provide many non-extractive benefits. Public recreation is one such benefit. The recreational infrastructure and the degree to which people are using forests for recreation help us understand the importance of recreational opportunities in our forests.



Outdoor recreation

Forests offer a wide variety of outdoor recreational opportunities. Table 13 details public participation in ten outdoor activities. Most of these activities occur in part or entirely within forested areas. Estimates were based on a survey of Delaware households, and the number of participants was calculated using Delaware Population Consortium figures for the number of Delaware households and the average household size (2.61 people/household).



Table 13. Participating individuals in outdoor recreation, 2018.

Activity	Participation %	10 Year Change	Number	10 Year Change
Walking or jogging	82	-3	754,100	+13,100
Picnicking	66	+3	607,000	+60,000
Swimming	62	-3	570,200	+3,200
Bicycling	59	-1	542,600	+19,500
Fishing	56	+9	515,000	+105,000
Hiking	55	+9	505,800	+104,800
Camping	44	+13	404,600	+134,600
Canoeing/Kayaking	41	+14	377,100	+142,100
Hunting	28	+13	257,500	+126,500
Horseback riding	22	+5	754,100	+54,300

Source: Statewide Comprehensive Outdoor Recreation Plan, 2018-2023

DE population 2009	884,124
DE population 2019	976,972
10-year increase:	92,848

Currently, there are more than 567 miles of trails open to the public, a slight increase compared to 2010. In addition, approximately 155 of these trail miles are open to horseback riding and 483 miles to mountain biking.

Delawareans often use public lands for recreation and many of these activities occur within forested areas. Publicly protected lands have grown from about 125,000 total acres in 2002 to over 140,000 acres in 2019. The majority of these lands are within State Parks, State Wildlife Areas, State Forests, and Delaware's two National Wildlife Refuges. Forest covers approximately 45% of these State and Federal lands, all of which are open for public recreation. Maintenance and enhancement of these facilities is necessary to accommodate Delaware's growing population.

Conclusions

Data indicate that recreation in forests is a widely enjoyed activity in Delaware. A well-developed recreational infrastructure, including campsites, trails, and more than 55,000 acres of forest on state and federal lands, is available to the public.

INDICATOR 14

Investments in forest health, management, research, and wood processing

Maintenance of healthy forests requires funding. Surveys for insects and diseases, monitoring of forest conditions, tree planting, and research in forestry all require time and money. Furthermore, landowners and communities require technical forestry assistance to maintain and manage their forest resources. Likewise, forest industries must invest in their operations if they are to remain competitive and continue to provide employment opportunities. Tracking the public and private funds invested in these various operations (forest health, management, research, and wood processing) is a good indicator of the likely success and long-term sustainability of forests and forestry in the state.

U.S. Forest Service Eastern Region S&PF Funding

The Delaware Forest Service (DFS) receives core program funding each year from the U.S. Forest Service Eastern Region State and Private Forestry (S&PF) program budget. The four core program areas are forest health, forest stewardship, fire, and urban and community forestry. Over the past three fiscal years, total federal funding has averaged about \$480,000/year (Table 14). These essential funds help the DFS provide forest health monitoring and pest diagnosis, forest landowner assistance, wildfire mitigation and suppression, and community forestry assistance. Funding for three positions and related operating expenses is included in these annual core grants. The DFS has also received Eastern Region S&PF funding in the past for land acquisition through the U.S. Forest Service Forest Legacy Program (FLP). Through a series of six acquisition grants from 2004 to 2010, Delaware received \$14,950,000 for legacy projects in the state. Additionally, Chesapeake Bay watershed funding is often available to Delaware in an effort to increase tree canopy coverage in Delaware communities within this priority watershed.

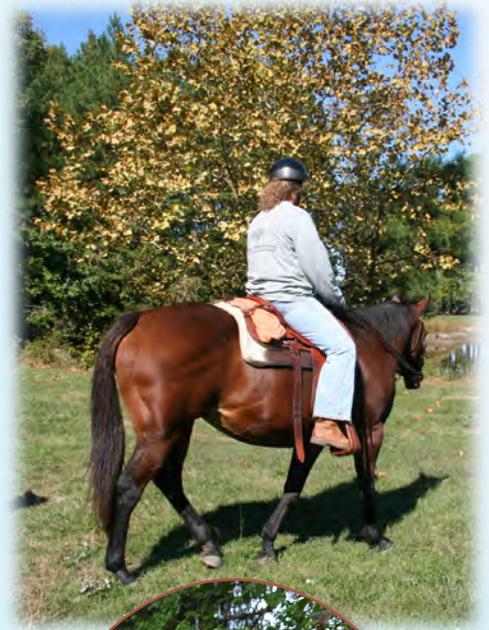


Table 14. Core forestry funding by U.S. Forest Service Eastern Region State and Private Forestry.

<i>Program</i>	<i>FY17</i>	<i>FY18</i>	<i>FY19</i>
Forest Health	73,000	73,000	73,000
Forest Stewardship	71,200	62,782	61,520
State Fire Assistance	108,676	113,277	113,277
Volunteer Fire Assistance	33,773	27,928	28,963
Urban & Community Forestry	200,000	200,000	200,000
Total	486,649	476,987	476,760

Source: Delaware Forest Service

State funding

The majority of public funds invested in forest health and management is provided through the DFS within the Delaware Department of Agriculture (DDA). Each year, the DFS receives approximately \$1,210,000 in state (general) funds—most (95%) of these funds support 16.5 staff positions within the DFS (Table 15). These positions include foresters who provide technical forestry assistance to landowners and communities, assist with wildfire suppression, and manage and maintain the three State Forests. These funds have remained fairly stable throughout the past decade, with a slight increase, although a past economic downturn resulted in the loss of three positions and some operational funds.

Table 15. Delaware Forest Service positions and budget.

<i>Fiscal Year</i>	<i>Total Positions</i>	<i>General Fund Positions</i>	<i>Budget (\$ thousands)</i>	
			<i>Total</i>	<i>General Fund</i>
2009	25	17.5	2,578	1,213
2010	24	17.5	2,155	1,082
2011	23	16.5	2,008	1,067
2012	23	16.5	2,170	1,168
2013	23	16.5	2,053	1,157
2014	23	16.5	2,043	1,155
2015	23	16.5	2,079	1,135
2016	23	16.5	2,002	1,125
2017	23	16.5	2,135	1,217
2018	22	16.5	2,126	1,245
2019	22	16.5	2,209	1,213
2020	22	16.5	2,203	1,246

Source: Delaware Forest Service



The DFS also generates income from its three State Forests, primarily through timber sales and cropland leases. These appropriated special funds (ASF) allow annual spending authority of \$660,500 and support 2.5 staff positions within the DFS. However, over the last ten years, the average revenue generated was only \$386,000. This revenue reduction is primarily due to the drop in timber value over that time period. Starting in FY20 all cropland leases were restructured and rebid resulting in a 30% increase in projected revenue. This will help replace the lost revenue in timber sales.

Delaware provides funds each year to landowners to cost share forest management expenses (tree planting, timber stand improvement, etc.) and to communities for tree planting and tree management (pruning, hazard tree removal, etc.) on publicly-owned lands. Available funds for both landowner and urban forestry projects total \$75,000. The state of Delaware provides \$37,500 for each program through proceeds from State Forest timber sales and cropland leases (ASF funds), while approximately \$40,000 is available through federal grants. The federal funds for urban forestry projects are provided through the Urban and Community Forestry (U&CF) program within the Eastern Region S&PF budget.

Since its inception in 1991, the U&CF grant program has provided over \$1.75 million through 568 grants to over 200 organizations for tree planting and tree management projects on publicly-owned land throughout Delaware. These grants, matched by communities with either nonfederal funds or in-kind services, have resulted in the planting of over 13,000 trees. Funds are also used to complete street-tree inventories and community forest management plans. These activities help to sustain our state's urban forest resource.

Nearly all of the forest health investments within Delaware are included in the state and federal funds previously discussed. For the last ten years, the DFS has consistently received \$73,000 of base S&PF funding for forest health—much of this funding supports one-half of a senior forester position dedicated to forest health issues (state funds support the remaining half of the position). The DFS annually monitors for various forest pests and has established multiple, long-term forest health monitoring projects, such as annual sampling for southern pine beetles as part of a southern regional effort to detect population trends. The forest health specialist also completes an annual aerial defoliation survey to monitor for any significant damage from forest insects. The DFS often receives additional federal funds (typically \$5,000 to \$10,000) for specific forest health projects—such as monitoring for thousand cankers disease, emerald ash borer, sirex woodwasp, and Asian longhorned beetle. The base forest health funding has remained stable over the past decade while the availability of federal funds for monitoring for specific forest pests has actually increased.

The DFS works in partnership with the DDA Plant Industries section which handles forest pest issues related to the horticultural and agricultural industries and has the authority to impose quarantines within the state for various agricultural and forest pests. The Plant Industries section is also responsible for monitoring the state's gypsy moth population and inspecting the state's horticultural industry for any quarantined forest pests.



The urban and community forestry grant program has provided over \$1.75 million through 568 grants to over 200 organizations for tree planting and tree management projects.



Forest research

Forestry research opportunities are limited in Delaware because no university offers an accredited forestry program and there are no National Forests or U.S. Forest Service Research Stations in the state. Furthermore, with its small staff (22 positions including only 10 forester positions), the DFS does not have sufficient capacity to implement significant forestry research. The DFS conducts small scale research projects, but they are limited in scope and budget. This situation is unlikely to change with current state budgets.

There is limited federal funding provided for forestry research at Delaware's two land grant universities—Delaware State University (DSU) and the University of Delaware (UD). From 1995 to 2008, Delaware received between \$60,000 and \$92,000 annually for forestry research through the McIntire-Stennis budget, and all of these funds were awarded to UD. However, the McIntire-Stennis law was changed in 2008 such that 1890 Land Grant colleges became eligible for this forestry funding. Therefore, beginning in FY10, DSU began receiving a portion (10%) of the funds (Table 16). This amount was increased by an additional 10% for each of the following three years to 40% of the total amount. The split in funds currently remains at 60% for UD and 40% for DSU.



Table 16. McIntire-Stennis funding (dollars) for Delaware.

<i>Fiscal Year</i>	<i>University of Delaware</i>	<i>Delaware State University</i>	<i>Total Funding</i>
2009	92,876	0	92,876
2010	100,923	11,214	112,137
2011	99,038	24,709	123,747
2012	114,712	49,162	163,874
2013	113,883	75,922	189,805
2014	113,502	75,668	189,170
2015	102,411	68,274	170,685
2016	113,162	75,441	188,603
2017	137,345	91,564	228,909
2018	137,666	91,777	229,443
2019	133,095	88,730	221,825

Source: Delaware Forest Service

Wood processing

There is virtually no new investment in (primary) wood processing industries in Delaware as there are only a handful of small sawmills with no paper mills or other solid wood product industries. The existing sawmills are small, use primarily low-grade hardwood logs, and are family-operated. The largest hardwood sawmill in Delaware closed more than ten years ago. With the current depressed lumber market, additional investment in either the existing sawmills or new ones is unlikely unless markets improve. Furthermore, the number of sawmills in surrounding states that purchase Delaware timber continues to shrink, particularly pine sawmills. In the last ten years, another two pine sawmills closed on the Delmarva Peninsula making that six closures in 20 years. This, combined with the recently depressed economy and real estate market, produced a dramatic decrease in timber demand in Delaware.

Recently, however, the national and local economies have improved, and housing starts are increasing again, thus creating an opportunity for a new pine sawmill in Delaware (or elsewhere on the Peninsula). FIA data clearly show there is an ample supply of pine timber available for a revitalization of the timber industry in Delaware.

Additionally, while this is not considered wood processing, there are potential new markets for forest products on the horizon. Delaware is a member of the Regional Greenhouse Gas Initiative (RGGI) and forest management, urban forestry, and avoided deforestation are now approved forestry offsets for RGGI. Furthermore, markets for other non-wood services, such as wetland mitigation banking and endangered species banks—collectively referred to as ecosystem services—have potential to expand in Delaware.

Conclusions

Delaware does not have a forest research station or any universities that have an accredited forestry program. Nonetheless, the state receives significant state and federal funding for forest health and forest management. These funds have remained relatively stable over the past decade. Delaware also provides funding to communities and landowners for tree planting and other forestry activities, and these funds have also remained relatively constant. There is little investment or research in wood processing industries, primarily because Delaware has few primary wood processors (sawmills) and no papermills. There may be an opportunity to site a sawmill in Delaware in the future, but this will not occur until lumber prices substantially improve.

INDICATOR 15

Forest ownership, land use, and specially designated areas

The percentages of public and private sector forestland ownership give an indication of the amount of forestland that is protected from conversion to other uses. Further analysis of private forests, such as the amounts under conservation easements and property tax reduction programs, provides a further understanding of the long-term sustainability of a state's forest resources.

Forestland ownership

Since the 2010 forest resource assessment, publicly-owned forestland in Delaware has increased by about 2% (from 20% to 22% or about 7,000 acres). Most of this gain can be attributed to fee simple purchases of land made through the federal Forest Legacy Program and the state's Open Space Program. Public land is mostly state owned (18%) with some county/municipality (2%) and federal (2%) ownership, but the majority of forestland in the state is still privately owned (Figure 39). Of the nearly 282,000 acres of private forest, individuals and families own more than two-thirds. Family corporations account for about one-quarter and the remainder is held by private conservation groups such as The Nature Conservancy. Glatfelter Pulp Wood Company is Delaware's sole remaining industrial forest landowner and they have divested well over half of their holdings since 1999. Their remaining lands are for sale on the open market and will likely be sold within the next decade. The only timber management organization (TIMO) that owns forestland in Delaware is the Forestland Group that purchased 1,358 acres of former Glatfelter properties. All of these lands have a permanent conservation easement held by the Delaware Forest Service (DFS).

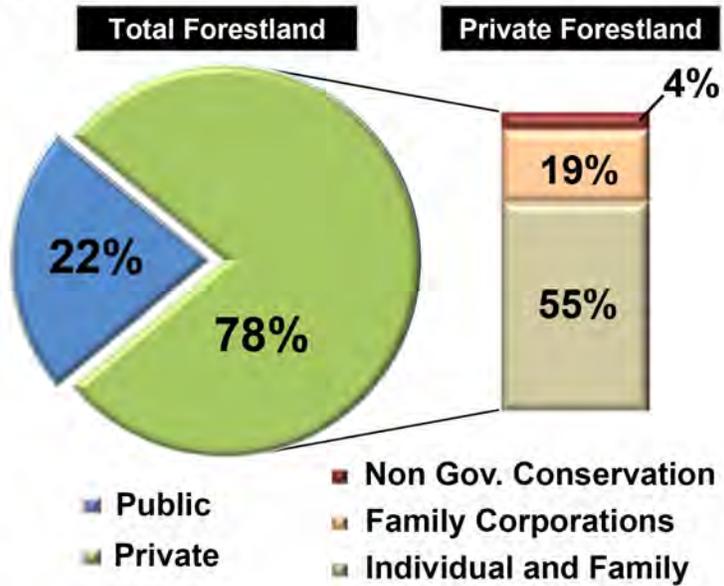


FIA data clearly show there is an ample supply of pine timber available for a revitalization of the timber industry in Delaware.



Since 1995, State Forest acreage has more than doubled from 9,100 acres to 21,126 acres—including 2,428 acres through the Forest Legacy Program.

Figure 39. Delaware forestland ownership, 2018.



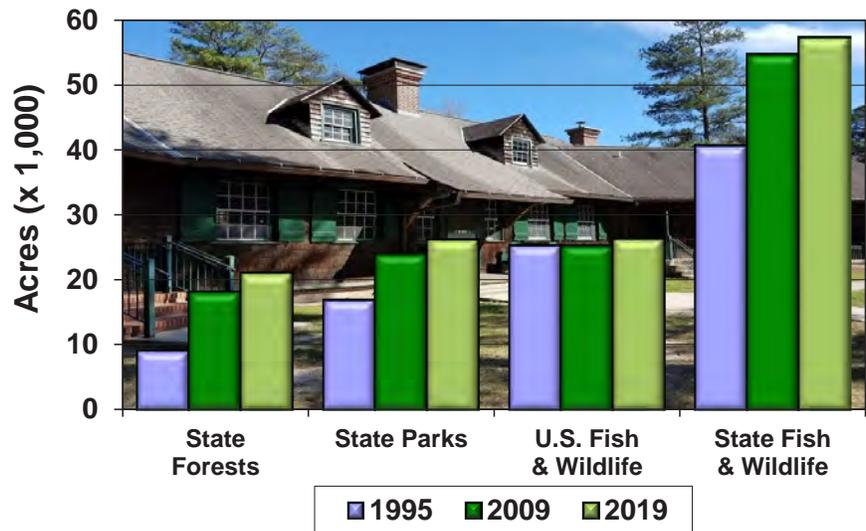
Source: U.S. Forest Service Forest Inventory and Analysis

State lands

State ownership has increased considerably (57% overall) in the last 24 years as private lands have been purchased or donated to the State Forest system, State Parks, and Fish & Wildlife (Figure 40). Many of these purchases were made possible through Delaware’s Open Space Program. Additional purchases of forestland by the DFS since 2004 included 2,428 acres through the Forest Legacy Program. Since 1995, State Forest acreage has more than doubled from 9,100 acres to 21,126 acres. This equates to a 132% increase in land holdings that are managed for multiple public uses and for timber production.



Figure 40. Public land ownership in 1995, 2009, and 2019.

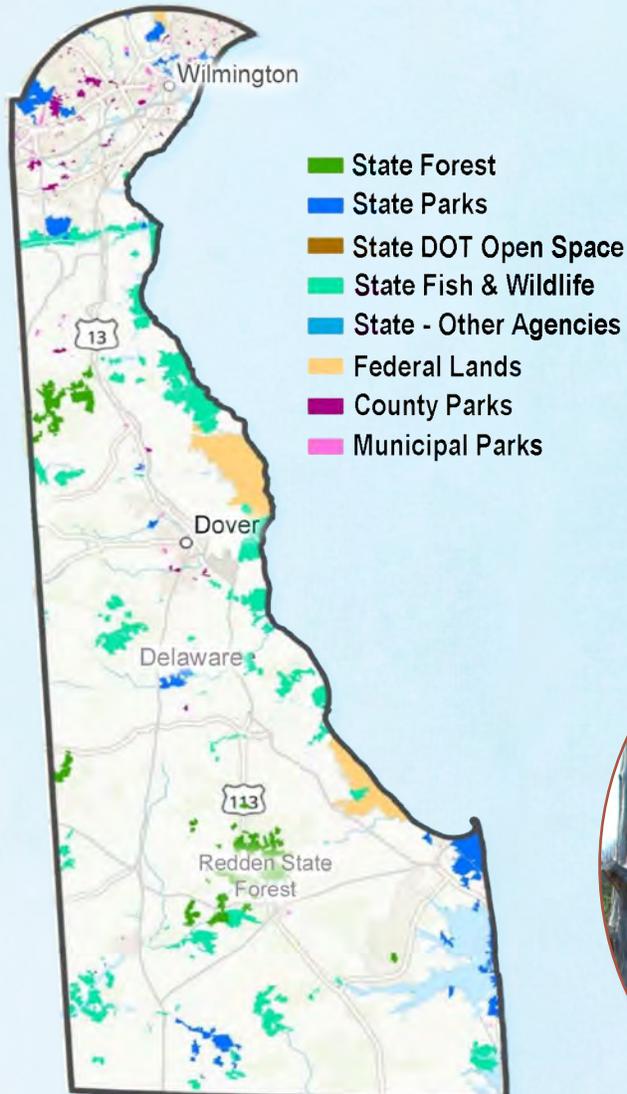


Sources: Delaware Forest Service, Delaware Department of Natural Resources and Environmental Control, and U.S. Fish & Wildlife Service

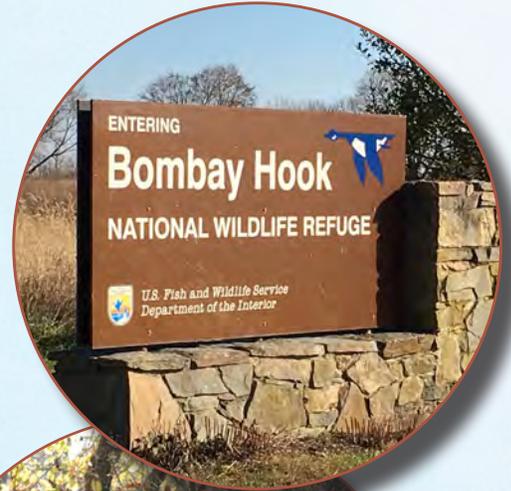
Protected land

Public ownership includes federal lands managed by the U.S. Fish & Wildlife Service (Bombay Hook and Prime Hook National Wildlife Refuges) and state lands managed by several agencies, primarily State Forests, State Parks, and State Wildlife Areas (Figure 41). Additional public lands are owned by other state agencies, counties, and municipalities. Portions of these protected land holdings include forestland and marshland.

Figure 41. Public ownership (all lands), 2017.



Source: Delaware State Agency reporting



Private land with public conservation easements

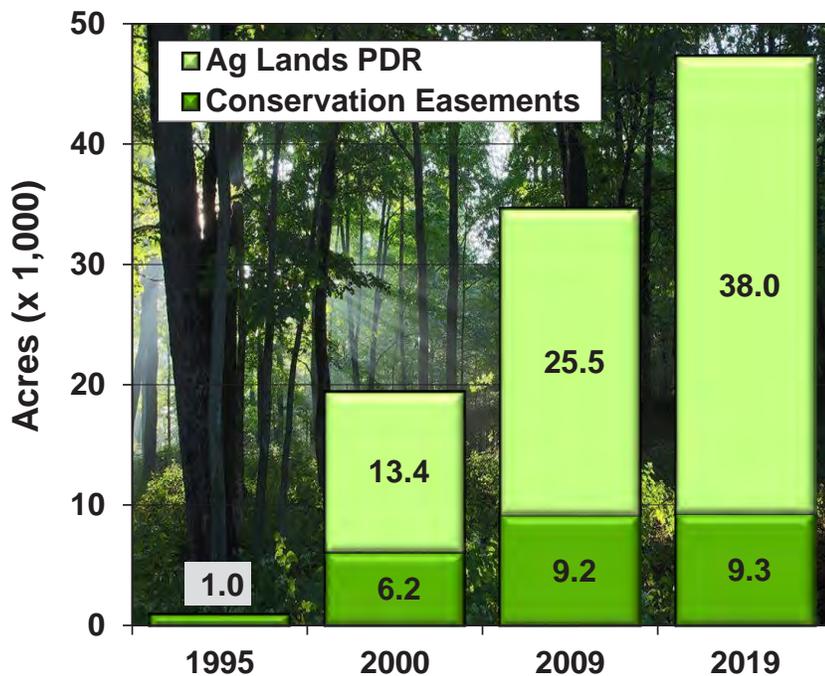
The State of Delaware holds conservation easements on private lands through a variety of programs. The Delaware Agricultural Lands Preservation Foundation (DALPF) has the most easements with over 139,000 acres in permanent protection (a 42% increase in the last ten years). Of this total, approximately 38,000 acres are forested. While these easements are permanent, they do not prohibit the future conversion of forestland to cropland (as long as all federal and state laws are satisfied). However, most of these areas are wetland forests unsuitable for agricultural uses. An additional 1,200 acres of forestland easements are held by the DALPF through a separate Forestland Preservation Program in which it is prohibited to convert the protected forestland to non-forest uses.

The DFS holds permanent easements on nearly 8,000 acres of forestland—a 14% increase in the last ten years. These easements require owners to maintain the land as forests and follow a forest stewardship (management) plan. Most of these easements are located on working forestlands (loblolly pine plantations) formerly owned by the Chesapeake Forest Products Company. Another easement totaling 908 acres was purchased through the Forest Legacy Program. The remaining easements, 1,200 acres, were purchased through Delaware’s Forestland Preservation Program. The Department of Natural Resources and Environmental Control, Division of Parks & Recreation, also holds conservation easements on forestland totaling over 1,000 acres. Most of these easements are designed to protect biodiversity and unique habitat. Total acreage of conservation easements on forestlands held by the state has increased nearly ten-fold since 1995. And since 2000, the number of forestland acres under easement with DALPF has nearly tripled (Figure 42).

The DFS holds permanent easements on nearly 8,000 acres of forestland—a 14% increase in the last ten years.



Figure 42. State-owned forested conservation easements, 1995–2019.



Source: Delaware State Agency reporting

The Forest Legacy Program (FLP) provides U.S. Forest Service funding for protection of working forestlands through outright purchase or through the creation of conservation easements. Funds may only be used in certain geographic areas known as Forest Legacy Areas (FLAs) (Figure 43). As of 2019, 3,336 acres of forests are protected under the Forest Legacy Program. This is an increase of 1,304 acres over the last ten years. Fifteen parcels totaling 2,428 acres were purchased for Redden State Forest, and one 908-acre conservation easement was established. (These totals were included in the discussion above.)

The Delaware FLP is implemented according to the Delaware FLP Assessment of Need (AON), which was originally approved by the Governor’s office on December 22, 1998. An updated AON is included in this assessment (see Appendix 3). The AON includes approved eligibility criteria for the FLAs, approved FLAs, specific goals and objectives to be accomplished by the Delaware FLP, and the process by which the Delaware Forest Service evaluates and prioritizes projects to be considered for inclusion in the FLP. The Redden/Ellendale FLA was approved for expansion on August 18, 2003. The Blackbird/Blackiston and Cypress Swamp FLAs were approved for expansion on June 7, 2006.

Additional forestlands are protected in Delaware through ownership by nongovernmental organizations (NGOs) with environmental protection missions. While many of these lands are not permanently restricted from land-use conversion through conservation easements, it is very likely that these forests will remain permanently protected. NGOs own over 16,000 acres of forestland. Two organizations own the bulk of these lands—Delaware Wild Lands, Inc. (over 11,000 acres) and The Nature Conservancy (over 4,000 acres).

Forestland in tax reduction programs

Much of Delaware enjoys extremely low property taxes—some of the lowest tax per assessed value in the eastern United States. Nonetheless, Delaware’s Commercial Forest Plantation Act (CFPA) offers a 30-year county tax exemption to landowners with at least 10 acres of forestland and who follow a forest stewardship plan. In 2019, 27,569 acres of private forests were enrolled in CFPA. This is a slight drop (4.9%) since 2010 but still amounts to about 10% of Delaware’s privately-owned forestland (Figure 44).

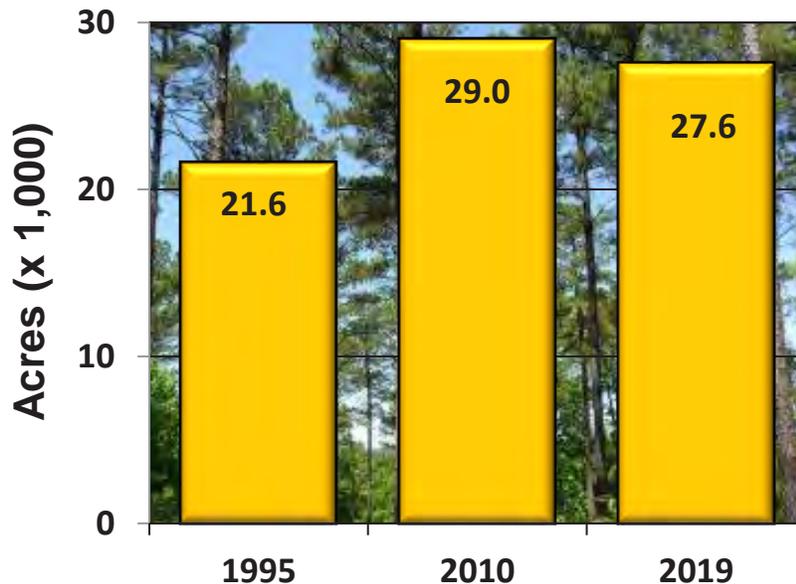
Additional forestland is enrolled in the state’s Farmland Assessment Program that provides a significant property tax reduction (often a complete exemption from property taxes) for agricultural land that generates a minimum amount of gross receipts averaged over a two-year period. Many woodlots that are associated with cropland are included in this property tax program. Currently, the DFS estimates there are approximately 63,342 acres of forestland enrolled in the Farmland Assessment Program. As of November 2019, New Castle County reported 7,242 acres and Kent County reported 21,350 acres of forestland enrolled. Sussex County only tracks total acreage (173,833); therefore, assuming 20% of these lands are forested—believed to be a reasonable estimate of the forested percentage of farms—yields an estimated 34,750 acres enrolled in Sussex County. There is no additional requirement, such as a forest management plan, for landowners with forestland within the Farmland Assessment Program.

Figure 43. Current Forest Legacy Areas.



Source: Delaware Forest Service

Figure 44. Active CFPA enrollment in 1995, 2010, and 2019.



Source: Delaware Forest Service



Forest certification

The Sustainable Forestry Initiative (SFI), a program developed by the American Forest and Paper Association, provides certification for forestlands with management plans that meet certain sustainability criteria. The Glatfelter Pulp Wood Company, a private landowner, still owns and manages over 6,000 SFI-certified acres in Delaware. Also, the 1,350 acres of forestland owned by the Forestland Group are certified through the Forest Stewardship Council (FSC). Lastly, Delaware Wild Lands, Inc., owns and manages over 21,000 acres of agricultural lands, marshlands, and forests. Their Great Cypress Swamp property in southern Sussex County consists of 10,600 acres of forestland with approximately 4,000 currently under active ecological forest management. The Delaware Forest Service considered third-party certification of State Forest forestlands, but the high cost was prohibitive and currently there is no state law requiring such certification.

Conclusions

Over 75% of Delaware's forests are privately owned. The remaining publicly-owned forests are in state ownership with some federal and county/local ownership. Therefore, programs designed for private non-industrial forest landowners will continue as the most common method to protect forests from conversion to other uses. There are a variety of conservation easement programs that have protected over 38,000 acres of forestland in Delaware. The Forestland Preservation Program has now been funded with \$1 million for each the last two years with plans to continue funding so long as the state's budget allows. Nongovernmental organizations also have protected significant forested acreage. While Delaware's county property taxes are quite low, the Commercial Forest Plantation Act and Farmland Assessment Act provide property tax exemptions for most of Delaware's forestland. One opportunity to consider is a way to work more closely with landowners with forestland in the Farmland Assessment Program.

INDICATOR 16

Employment and wages in forest-related sectors

Sustainable forest management requires an economic infrastructure for the production of end-use products from timber. While there are only a few relatively small primary wood processing facilities in the state, Delaware's working forests sustain a number of industries and employ thousands of citizens. Wages must stay competitive to ensure the long-term viability of these industries.



Wood-related products manufacturing employees

In 2018 there were approximately 1,170 people employed in the forest products manufacturing industry in Delaware. This represents about 2.25 people/1,000 between the ages of 18 and 65. This is less than half the number of people employed in this industry just 20 years ago. The average rate of pay for these individuals was about \$27/hour, and they had a total payroll of \$63.36 million. Most of these jobs are located in secondary wood processing industries. Establishments producing a variety of products including furniture, custom millwork, cabinets, and other wood products employed these citizens. Employment in wood-based industries increased from 1954, when there were 1,800 people employed in these industries, to 2000, but over the last 20 years there has been a steady decline (Table 17).

There are nine sawmills located in Delaware, excluding portable mills, and two concentration yards. The DFS also lists 14 Delaware loggers in its primary and secondary wood processors directory. Additionally, 27 Maryland (Eastern Shore) and five Pennsylvania loggers service areas in Delaware.

Table 17. Timber-related industry employment, 1954–2018.

Year	Number Employed
1954	1,800
1967	2,200
2000	2,750
2005	1,500
2010	1,200
2015	1,100
2018	1,170

Source: United States Census Bureau Economic Census

State forestry employees

Nearly all of the foresters in Delaware work for the DFS. There are a handful of individuals working as procurement foresters and there are no full-time forestry consultants in the state. This situation may be partly explained by the fact that the DFS provides most professional forestry services at no cost (although others from surrounding states work within Delaware). The DFS currently employs 10 foresters as part of its contingent of 22 full-time personnel and one seasonal position. By comparison, in 1984 the DFS employed 13 full-time, permanent staff. Staffing increased steadily over the subsequent 20 years, although the DFS lost three full-time positions since 2008.

The number of certified arborists recognized by the International Society of Arboriculture (ISA) in Delaware grew from 10 in 1995 to 81 in 2009. However, since then, that figure has dropped to a current number of 43 in 2019. The number of tree care companies also continues to grow with over 60 now located in Delaware. (Please note that not all of these companies have a certified arborist on staff.)

Additionally, the Census of Agriculture tracks farms that grow nursery stock. In 2002, 55 farms produced nursery stock on 1,190 acres. Five years later, the number of farms producing dropped to 47 on only about half the acreage in 2002. Estimated sales in 2007 totaled \$47.5 million. The downward trend in number of farms, acres, and sales continued through the most recent survey in 2017 (Table 18).

Table 18. Nursery stock crops produced on Delaware farms.

Year	Number of Farms	Acres in the Open	Sales (millions)
2002	55	1,190	NA
2007	47	541	47.5
2012	23	483	47.1
2017	16	447	13.5

Source: USDA, National Agricultural Statistics Service, Census of Agriculture

Conclusions

Forest products industries, particularly secondary wood processors, employ less than 1,200 Delawareans and constitute an important but shrinking sector of the economy. There are limited opportunities for professional foresters—most are employed with the Delaware Forest Service. Delaware has no full-time forestry consultants. The number of urban forestry jobs, such as tree care professionals, and forest nursery positions has grown, but the number of certified arborists has sharply declined in the last ten years.



Delaware has invested significant funding to purchase forestland outright and purchase conservation easements—over 55,000 acres of forestland are now publicly owned.

Summary – Criterion 6

Forests in Delaware contribute significantly not only to the state's environmental quality but also its economic viability. Despite the fact that nearly all of Delaware's timber is processed out-of-state, these harvests produce a significant return to Delaware's landowners, although the forest industry has been in decline over the last ten years. One of the consequences of this decline has been a decrease in annual harvests of hardwoods and softwoods. This has resulted in annual growth far exceeding annual removals for both groups during that time period, but hardwood growth had consistently exceeded removals at least since 1959. Hardwood harvests have increased in recent years with additional demand for low quality timber (pulp and wood energy) although ample supplies remain.

Recreational opportunities abound in Delaware and have increased with the significant additions to state-owned parks, forests, and wildlife areas—38,070 acres (+57%) since 1995 (this includes a 7,890-acre increase [8%] since 2009). A well-developed recreational infrastructure, including campsites, trails, and more than 55,000 acres of forest on state and federal lands, is available to the public.

Public investment in forest health and management has remained relatively constant with a gradual increase in some cases despite the fact that Delaware does not have a forest research station or any universities that have an accredited forestry program. The DFS offers a full range of technical forestry assistance to communities and landowners and some financial assistance for tree planting and other management activities. These funds, a mixture of state and federal sources, have also remained relatively constant although their sources have changed. Such investments help to achieve one of the national priorities of Eastern Region S&PF, namely to *Conserve and manage working forest landscapes for multiple values and uses*. There is little investment or research in wood processing industries, primarily because Delaware has very few primary wood processors (sawmills) and no papermills, but this could change in the near future because of the improvement in the national (and local) economy in the last few years.

Delaware has invested significant funding to purchase forestland outright and purchase conservation easements. Over 55,000 acres of forestland are now publicly owned (over 95% state owned) which represents approximately 15% of Delaware's forest base. An additional 45,000 acres are in permanent conservation easements. Many of these purchases have occurred in the last 20 years. Most of the privately-owned forestland is enrolled in one of two property tax reduction/exemption programs although one of the programs (Farmland Assessment) does not require any forest management by landowners.

Delaware's forest-based industry, while relatively small, significantly contributes to the economy—the secondary wood processors employ the most citizens. Opportunities for professional foresters are limited and the Delaware Forest Service is the largest employer. The number of urban forestry professionals is declining at a time when Delaware's expanding population requires additional arborists and tree nursery professionals.

All of these indicators help ensure that our citizens will continue enjoying the many natural benefits and services provided by our forests. Continuing these investments, in a cohesive and strategic manner, will help maintain and *Enhance public benefits from trees and forests*—one of the Eastern Region S&PF national priorities.



Criterion 7: Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management

A society's laws and regulations often have profound effects on the long-term sustainability of a state's forest resources. Well-designed environmental laws, regulations, standards, and ordinances can help protect and conserve forest resources, while poorly conceived policies, or the lack of policies, can result in the continuing loss and fragmentation of forests. State and local governments need to recognize the importance of forests and their associated resources and take the necessary steps to maintain and enhance them for future generations. Therefore, it is important to ensure that a state has sufficient policies and laws, as well as standards and guidelines, to address the use and long-term sustainability of its forests while not overly burdening landowners and other forest users.



INDICATOR 17

Forest management standards/guidelines

Forest management guidelines are used to ensure sustainable management of forests on private and public lands and in urban areas. The Delaware Forest Service provides forest management assistance to landowners and communities to help them manage their forest resources. Delaware actively participates in the Forest Stewardship Program, American Tree Farm System, and Tree City USA. The DFS tracks the success of these efforts through multiple performance measures; these measures indicate a steady improvement in rural and urban forest management but further outreach and assistance is still needed.



Types of forest management standards/guidelines

The Delaware Forest Service (DFS) provides a variety of technical forestry assistance to landowners including standards for forest management. One very important standard is a plan that addresses all aspects of the forest resource, including wood production, wildlife habitat, recreational opportunities, and soil and water quality protection. Forest stewardship plans incorporate all of these benefits into a long-term management plan for the forest landowner based on his/her goals for the property. By following a plan, landowners help ensure that Delaware's forests are sustainably managed.

Table 19 details forest stewardship plan activity on private lands for the years 2007 through 2019. DFS foresters offer this service free-of-charge. More Delaware forestland owners should take advantage of this opportunity and become engaged in the active management of their forests.





Table 19. New forest stewardship plans, 2007–2019.

<i>Year</i>	<i>Acres</i>	<i>Number of Plans</i>
2007	1,835	20
2008	2,722	46
2009	2,046	35
2010	3,538	45
2011	3,753	52
2012	4,435	40
2013	1,233	27
2014	1,383	15
2015	2,432	23
2016	2,311	21
2017	1,889	18
2018	1,732	17
2019	1,904	20

Source: Delaware Forest Service

The American Tree Farm System, a program operated by the American Forest Foundation, recognizes landowners who are committed to the sustainable management of their forests. Landowners must follow a forest stewardship plan for their property that is written by a certified forester and they receive professional assistance when implementing forest management activities. Wood produced from Tree Farms is now recognized by many organizations as certified. There are over 230 participating Tree Farmers in Delaware that encompass 17,299 acres of forestland. Tree Farms are inspected by a certified tree farm inspector to monitor the property and assure plan compliance.

Voluntary and mandatory standards/guidelines

The DFS continues to provide educational opportunities and technical forestry assistance to landowners and attempts to reach these landowners through the media and other avenues (direct mail, internet, workshops, etc.). One DFS performance measure is to monitor the percentage of timber harvests (on an acreage basis) that follow a forest management plan. While having a forest management plan does not guarantee that a harvest is sustainably implemented and there are certainly excellent harvests on properties that do not have a plan, this is one of the best measures to gauge success in reaching forest landowners and helping them sustainably manage their forests. [Table 20](#) summarizes this performance measure, by state fiscal year (July 1–June 30) over the past ten years. The data indicate that approximately one-third of timber harvests follow a professionally-prepared forest management plan. National estimates usually range from 10–20%, therefore Delaware's performance is above average, but much work remains.

The DFS developed best management practices (BMPs) for forest management activities in 1995, working with landowners, forest industry, nongovernmental organizations, and other public agencies. These BMPs are provided to landowners and forest operators (loggers, timber buyers, etc.) and they describe actions (buffers along waterways, proper water crossings, etc.) they must take, by law, to ensure timber harvests and other forestry activities do not degrade water quality.



Table 20. Percentage of timber harvests (acres) with a forest management plan (Non-Industrial Private Forestland). (Excludes timber harvests with land conversions.)

<i>Fiscal Year</i>	<i>% of Harvested Acres with a Stewardship Plan</i>
2010	54
2011	37
2012	30
2013	43
2014	40
2015	10
2016	39
2017	17
2018	47
2019	41

Source: Delaware Forest Service



Delaware also partners with the State of Maryland in the Maryland/Delaware Master Logger Program. The Master Logger Program is a voluntary, education and (third party) certification program for loggers. Its goal is to provide loggers with comprehensive training and education in the laws, regulations, and practices that are important to the industry. Loggers must complete a set of core courses to become certified and then complete continuing education courses to maintain current status. Core courses include sustainable forest management, timber harvesting, wildlife management, and safety techniques. Harvesters who are master loggers have a skill set that allows them to operate at the highest level of professionalism and safety. The Master Logger Program also allows landowners to select operators who are committed to professionalism and high quality, sound timber harvesting. Currently there are nine Master Loggers in Delaware and 32 on the Eastern Shore of Maryland. This is a decrease over the last ten years of one in Delaware and 12 on the Eastern Shore.

There is the potential to harvest low quality timber, primarily hardwood species, for energy production in Delaware. This could provide new markets for Delaware's forest landowners. Currently, Delaware does not have guidelines for biomass harvests. Because biomass harvests could use not only low value timber but also portions of trees that are not removed during a conventional harvest (limbs, stumps, etc.), guidelines should be developed for these harvests to ensure they do not reduce site productivity or otherwise detrimentally affect the forest.

Delaware's three State Forests are managed with the assistance of forest management plans prepared by staff foresters. All State Forest management plans were completely updated in 2006 and subsequently amended as new forested parcels were added to the inventory (31 parcels totaling 3,692 acres). The plans address not only timber production, but the entire other suite of forest resources as well (e.g., wildlife habitat, recreational opportunities, threatened and endangered species, etc.). State Parks and State Wildlife Areas are also managed with the assistance of forest management plans prepared by professional foresters. Although some of these lands are not managed for timber production, issues such as invasive species control, threatened and endangered species protection, and forest health are best approached with the help of a long-term forest management plan.





Urban forestry assistance and guidelines are provided to Delaware's communities and homeowners. Delaware participates in the Tree City USA program that recognizes communities that meet four criteria (tree board or commission, tree ordinance, spend at least \$2/capita on tree planting and management, and recognize Arbor Day). Communities achieving this status are actively managing their urban forest resources. The DFS uses the percentage of Delaware communities that have achieved Tree City USA status as a performance measure to gauge its success in helping cities and towns incorporate urban forest management into their long-term plans and thus sustainably manage their urban forests. Currently, 17 of Delaware's 57 incorporated cities and towns (30%) have achieved Tree City USA status. By comparison, in 2000 only four communities were recognized. Delaware's current Tree City USA communities are:

<u>New Castle County</u>	<u>Kent County</u>	<u>Sussex County</u>
Delaware City	Dover	Bethany Beach
Middletown	Dover Air Force Base	Bridgeville
Newark	Milford	Dagsboro
Odessa	Smyrna	Dewey Beach
Wilmington		Fenwick Island
		Lewes
		Ocean View
		Rehoboth Beach



In 2011, Delaware State University became the first (and still the only) Delaware Tree Campus USA recipient and has achieved this status for the last eight consecutive years. Efforts have been made to recruit other institutions of higher learning, but little progress has been made to date in this effort. Like Tree City USA, Tree Campus USA is sponsored by the Arbor Day Foundation.

Management of urban forest resources along public utility rights-of-way is also important to not only protect these resources but also provide for public safety. The Tree Line USA program, also administered by the National Arbor Day Foundation, recognizes utility companies that meet three criteria for proper management of trees along utility lines. Currently one Delaware company (Delmarva Power) is recognized as a Tree Line USA utility.

The three criteria for Tree Line USA are:

Quality Tree Care – The utility follows industry standards for pruning, planting, removals, and trenching and tunneling near trees.

Annual Worker Training – The utility ensures that its employees and contract workers are trained in best practices.

Tree Planting and Public Education – The utility sponsors and participates in a tree planting and public education program designed to expand canopy and educate customers about proper tree planting, placement, and pruning, including participation in community Arbor Day celebrations.



The DFS also encourages communities and homeowners to utilize International Society of Arboriculture (ISA) certified arborists for any tree care assistance. The DFS has partnered with the ISA to provide training to tree care professionals to help them better manage our urban forests. Currently there are 43 certified arborists in Delaware.

The Tree-Friendly Community program recognizes communities and homeowner associations committed to protecting and enhancing the state’s urban forest resources. This program is specific to Delaware and was developed in an effort to recognize communities for tree management, especially those located outside of municipal boundaries or homeowner groups. A community qualifies for the honor by accomplishing three of the following: 1) perform an annual ceremony to promote community forests, 2) develop a community forestry management plan, 3) complete a tree project that enhances existing urban forests, 4) adopt a community tree ordinance that protects trees, 5) form a tree commission or tree board that serves as the guiding body for tree-related decisions, and 6) have a tree budget of \$1/residential household.

Education, while not a specific forest management standard or guideline, is also an important function of the DFS. Increasing the public’s knowledge of the forest resource and its many natural benefits is vital to the long-term sustainability of our forests. Informed citizens, both children and adults, will help make wise decisions concerning forest policy. The DFS supports the internationally recognized Project Learning Tree (PLT) curriculum administered by the Sustainable Forestry Initiative, Inc. The DFS has an educator on staff who provides PLT training to teachers and other educators as well as a PLT Advisory Committee to help monitor and improve the program. Additionally, the DFS provides wildfire prevention (Smokey Bear) programs to first grade students and Arbor Day programs to elementary students to improve student understanding of forestry issues. There are also education centers and trails at Blackbird and Redden State Forests to further the public’s forestry knowledge. One of the DFS performance measures is to track the percentage (public) and number (private) of elementary schools that participate in at least one DFS educational program. For the last ten years, on average, 61% of Delaware’s 173 elementary schools participated in a DFS educational program. **Table 21** has a summary of the Smokey Bear and Arbor Day programs in Delaware since 2010.

Table 21. Elementary schools and students participating in DFS educational programs, including Smokey Bear and Arbor Day programs.

<i>Fiscal Year</i>	<i>% of Schools Participating</i>	<i>Number of Students</i>
2010	69	12,725
2011	68	14,290
2012	68	12,543
2013	61	10,670
2014	67	11,072
2015	65	13,110
2016	57	10,662
2017	62	10,679
2018	40	7,013
2019	52	9,066

Source: Delaware Forest Service





**About 30%
of Delaware's
communities
include urban forest
management in their
planning process—
an increase from
ten years ago.**

Conclusions

Delaware, through partnerships with other natural resource organizations, provides sustainable forest management standards to landowners. Tracking the percentage of timber harvests that follow a forest management plan shows that an increasing number of landowners utilize professional forestry assistance, although many landowners have yet to receive assistance. The DFS also partners with other natural resource organizations to provide urban forestry assistance and guidelines to communities, utilities, and tree care professionals. Approximately 30% of Delaware's communities include urban forest management in their planning process—an increase from ten years ago. The DFS also provides educational information and recommendations to homeowners to help them better manage their urban trees. Lastly, Delaware provides educational programs to students and adults to increase their knowledge of the importance of forest resources.

INDICATOR 18

Forest-related planning, assessment, policy, and law

Laws addressing forest management set boundaries on permissible activities to protect soil and water quality as well as the forest itself. Forest-related planning and assessment are tools through which policy recommendations are made. Solid legal and planning frameworks are necessary to ensure sustainable forest management. In addition, site-specific planning is necessary to promote proper management at the stand and parcel levels.

Forest planning and assessment

The Delaware Forest Service (DFS) has completed various forest planning documents in the last 20+ years. The *Vision for the Future of Delaware's Forests* published in 1998 provided an overview of Delaware's forest resources as well as current (at the time) and future efforts to sustain these forests. A comprehensive forest health report published in 2006 provided a status of Delaware's forests based on the seven criteria and 18 indicators for sustainable forest management used for this state assessment. Additionally, a Forest Legacy Assessment of Need (AON) was completed and accepted by the USDA Secretary in December 1998 that presented a plan and guidelines for Delaware's Forest Legacy Program including the state's four Forest Legacy Areas (see Figure 43). The DFS completed a comprehensive five-year strategic plan in 2008 with input from a variety of stakeholders including landowners, communities, nongovernmental organizations, and other public agencies. Then in 2010, a detailed forest action plan was submitted to and approved by the U.S. Forest Service. This plan consisted of two components: the *Delaware Forest Resource Assessment* and the *Delaware Statewide Forest Resource Strategy*. The progress of this 2010 plan was reviewed in 2015 and an additional update (2020) is included in Section II of this revised assessment document.

Delaware also participates in the U.S. Forest Service's Forest Inventory and Analysis (FIA) program. FIA utilizes a series of permanent plots located throughout the state to analyze the forest resources (but not urban forests) including acreage, forest types, forest volume, growth, mortality, and removals. This information is valuable not only to the DFS but also to many other parties as well including forest industry and other government agencies. In fact, much of the forest resource information in this assessment was generated through FIA data. Until 2004, the U.S. Forest Service measured the FIA plots periodically—Delaware's forests were measured in 1957, 1972, 1986, and 1999. Beginning in 2004, however, the U.S. Forest Service began measuring FIA plots on a continuous basis. Federal funding was available to measure one-seventh of the plots annually. Thus, after the first seven years, Delaware's entire data set would be available. Delaware elected to provide state funding to reduce the measurement cycle to five years because land-use changes were rapidly impacting our forestland. Additionally, due to Delaware's small size, the estimates from the FIA plots are often based on relatively few observations and thus the values have large confidence intervals. Therefore, Delaware also invested funds to double the number of permanent plots to help produce more precise estimates. 2008 was the final year of the initial five-year measurement cycle and since then, FIA has continued to visit one-fifth of Delaware's plots on an annual basis. Much of the most recent FIA data for Delaware is available through the following web site: <https://www.fia.fs.fed.us/tools-data/>.

All of these processes and supporting documents have helped inform the public about Delaware's forests and provide guidance for future activities. These efforts have helped garner support for the allocation of state and federal funds to protect strategic working forestlands and to initiate the state's Forestland Preservation Program. They have also contributed information for this statewide forest resource assessment.

Forest laws and policies

The *Delaware Seed Tree Law* (Title 3, Chapter 10, Subchapter V), enacted in 1989, applies to timber harvests of 10 acres or more where 25% of the canopy consists of pine and/or yellow-poplar, unless the forest will be converted to another land use (agriculture, development, etc.). The law requires landowners to make provisions ensuring 400 healthy pine and/or yellow-poplar seedlings/acre are established following harvest. Reforestation may be attained by planting or, where conditions permit, through natural regeneration. This law was passed due to the significant drop in loblolly pine acreage in the late 20th century and a similar, albeit smaller, decline in yellow-poplar acreage. Since 2010, an average of 24 harvest operations (down from 35 the previous ten years) averaging 1,848 total acres (1,955 acres the previous ten years) annually triggered *Seed Tree Law* reforestation requirements (Table 22). An interesting aspect of this data summary is the number of acres planted versus natural regeneration. From 2000 to 2009 an average of 939 (48%) acres were planted and 1,016 regenerated naturally. But between 2010 and 2019 only an average of 171 (9%) acres were planted while the number of naturally regenerated acres grew to 1,677. Landowners are relying more and more on the plentiful natural seed sources for reforestation.



Table 22. Number of timber harvest operations affected by the Delaware Seed Tree Law, 2010–2019.

Year	Operations	Acres	Acres Regenerated	
			Planted	Natural
2010	28	2,853	59	2,794
2011	15	529	163	366
2012	16	847	106	741
2013	20	1,637	158	1,479
2014	41	2,868	61	2,807
2015	33	1,997	242	1,755
2016	35	2,944	40	2,904
2017	10	1,155	0	1,155
2018	15	1,860	110	1,750
2019	27	1,939	0	1,787

Source: Delaware Forest Service

Erosion and Sedimentation (E&S) Law

The *Erosion and Sedimentation (E&S) Law* (Title 3, Chapter 10, Subchapter VI), passed in 1994, requires that forest management activities, including timber harvests, protect water quality by eliminating sedimentation and erosion. Operators satisfy the law by using silvicultural best management practices (BMPs) during timber harvests and other silvicultural activities. The DFS developed and published Delaware’s BMPs in 1995 through a collaborative process with forest industry, forest landowners, NGOs, and other government agencies. BMPs are designed to reduce the delivery of sediment to surface waters during harvest. Examples of timber harvest BMPs include proper placement of roads and landings, as well as retention of some trees in sensitive riparian zones. The DFS enforces the E&S Law. Enforcement options, though seldom required, include cease-and-desist orders and fines of up to \$5,000/ offense.

To monitor forest harvest operations, the *E&S Law* also requires that landowners and forest operators notify the DFS of all timber harvests totaling one acre or more. The application includes a summary and map of the harvest area, including any BMPs planned, and the intended future use of the property (remaining forest, development, agriculture, etc.). The DFS reviews the application to ensure that proposed harvests comply with the *Seed Tree Law* and E&S requirements and makes any necessary revisions to the planned BMPs before approving the permit. Foresters perform site inspections to ensure that the provisions of the harvest permits are met. Details on E&S permitting for the years 2010 through 2019 are contained in [Table 23](#). On an annual average basis over the last ten years, 98 permits were issued by DFS foresters on 4,657 acres that had a corresponding 152 inspections. For the prior time period (2000 to 2009), annual averages were 128 permits, 5,032 acres, and 266 inspections.



Table 23. E&S (timber harvest) permits, 2010–2019.

Year	Permits	Acres	Inspections
2010	115	6,735	174
2011	101	3,541	191
2012	107	4,925	211
2013	99	4,653	201
2014	126	6,230	170
2015	116	4,818	179
2016	102	4,850	141
2017	92	4,103	74
2018	61	3,277	123
2019	87	4,345	76



Source: Delaware Forest Service

In 2014, the Maryland Forest Service initiated a study funded by the U.S. Forest Service entitled *Harvesting BMPs for Working Forests in Maryland and Delaware*. The goal was to evaluate the rates at which BMPs were applied to forest harvesting operations and their effectiveness in preventing sediment from entering waterways (a goal of the Clean Water Act). Results showed that Delaware timber harvests achieved a 93% rate of compliance with BMPs designed to protect water quality and limit soil erosion.

The study concluded that average sediment delivery across all locations was just 0.3 cubic feet/site—indicating that proper use of BMPs was very successful at protecting water quality during harvest operations. Non-compliance issues were minor (e.g., one instance of an oil drip <10 square feet) and can easily be corrected by operators paying closer attention to their equipment. The study results were very encouraging, especially because between 2014 and 2016 rainfall increased 20% above the 30-year average. An increased amount of precipitation during harvesting has the potential to exacerbate sediment movement if BMPs are not followed properly.

The *Seed Tree* and *E&S Laws* are Delaware’s only two laws specific to forest management operations. Other than the *Seed Tree Law*—which only addresses pine and yellow-poplar—there are no regulations that address how landowners manage their hardwood forests for silvicultural purposes. This could partly explain the increase in low-quality hardwood species, namely gum and maple, although other events/issues have certainly contributed as well, namely extensive gypsy moth infestations, the 1994 ice storm, and the lack of markets for low quality hardwoods.

Delaware law also contains code for urban and community forestry (Title 3, Chapter 10, Subchapter III). This legislation, passed in 1998, formally established an Urban and Community Forestry Program and designated this authority to the DFS. In addition to establishing an advisory council, it also outlines actions for the DFS to expand urban forests and urban forest management, including the authority to develop guidelines for comprehensive community forestry plans, voluntary accreditation programs for tree care, and a community forestry grant program. The law does not, however, contain any specific requirements for communities to manage their urban forest resource.

A recent study on timber harvests in Maryland and Delaware concluded that proper use of BMPs was very successful at protecting water quality during operations.



Delaware law has established two advisory councils to guide the DFS: the Governor's Council on Forestry and the Delaware Community Forestry Council.

Delaware law also establishes two advisory councils to help direct and advise the DFS. Title 29 §8107A of the Delaware Code established the Governor's Council on Forestry. This seven-member board, appointed by the Governor, advises the DFS on important issues including forest health, fire prevention, forestry education, and forest management. A parallel group, the Delaware Community Forestry Council established in Title 3 §1034, performs a similar function for the DFS Urban and Community Forestry Program.

Delaware also has legislation that addresses illegal timber harvests. The *Timber Trespass Law* (Title 25, Chapter 14) establishes the penalties for the illegal removal (theft) of timber from private landowners. The court determines whether the trespass was intentional or accidental. Intentional trespass entitles the landowner to three times the value of the trees taken, or "triple stumpage." In cases of accidental trespass, the violator must pay the owner for the value of the trees removed plus court costs.

Conclusions

The DFS works to protect forest resources and water quality by enforcing existing laws and regulations. The *Seed Tree Law* was passed in 1989 to stop the loss of loblolly pine and yellow-poplar, both extremely important timber species. The *Erosion and Sedimentation Law* ensures that water quality is protected during forest management operations by utilizing best management practices. Landowners and operators file a permit for all harvests of one acre or more and the DFS monitors these harvests to ensure compliance. Additionally, two advisory councils guide the DFS on forestry issues and there is a law to protect landowners from illegal timber harvests.

Summary – Criterion 7

Forest management standards and guidelines as well as forest policies and laws are important tools used to maintain and enhance a state's forest resources. The DFS works with a variety of organizations, including the U.S. Forest Service, American Forest Foundation, and the National Arbor Day Foundation, to provide both forest management standards for rural and urban forest management and technical assistance to help landowners and communities achieve these standards. Tracking the percentage of timber harvests that follow a forest management plan and communities that have active urban forest management programs shows that an increasing amount of Delaware's rural and urban forestlands are managed with professional forestry guidance, but many have yet to receive assistance. Delaware also has various laws to help ensure the wise use and perpetuation of forest resources, including the *Seed Tree Law*, *Erosion and Sedimentation Law*, and *Timber Trespass Law*. The DFS monitors all timber harvests using a permit system to ensure these laws are followed. Two advisory councils also help guide and review forest policies. Many Delawareans, both adult and student, are exposed to forests and forestry issues through the DFS educational programs and State Forest education centers. These programs must continue and grow if future Delawareans are to make wise forest-use policy decisions. All of these efforts help address the three Eastern Region S&PF national priorities—*Conserve and manage working forest landscapes for multiple values and uses*, *Protect forests from threats*, and *Enhance public benefits from trees and forests*.

IV. Existing and Emerging Benefits and Services

In Section III of this assessment (Forest Conditions and Trends), it is quite clear that Delaware's forests provide a wide range of natural benefits and services, both those that we have traditionally recognized (wood products, wildlife habitat, recreational opportunities) as well as those that have recently begun to garner attention (carbon sequestration, water quality and quantity, etc.). The Forest Conditions and Trends section of the assessment provided an overview of these natural benefits and services. Future strategies and resources must consider and address the spectrum of all benefits provided by forests. Below is a brief summary of the existing and emerging benefits and services provided by our rural and urban forests, beginning with a summary of Delaware's forests.

Forest cover

Forests cover approximately 29% of Delaware (359,000 acres). This acreage has remained relatively constant during the last century but is beginning to decrease. Over one-quarter of Delaware's forests are protected, through public ownership, conservation easements, or nongovernmental organization (NGO) ownership.

While a significant portion of Delaware forests are protected, the remainder is becoming increasingly fragmented. A comparison between 2009 and 2017 aerial photographs found that the number of large forested blocks (250 acres or more) decreased by nearly 4% with a total loss of 6,600 acres. The majority of our state's forests are privately owned, and the average forest ownership continues to decrease, from over 30 acres/owner in 1975 to less than 10 acres today. This fragmentation and outright loss of forestland is expected to continue.

Delaware's forests are also aging, with an increasing percentage of trees in older, larger size classes. Furthermore, the species composition is also changing with more hardwoods and a recent slight increase in conifers (loblolly pine).

Delaware's urban tree canopy varies greatly among our municipalities, ranging from a low of 10% to a high of 85%. The statewide urban tree cover is 25% within municipal areas and approximately 31% when other urbanized areas (outside municipal boundaries) are included. Like rural forests, urban forests provide numerous environmental benefits including carbon sequestration, water quality enhancement, energy savings, and controlling stormwater runoff.

Biological diversity and wildlife habitat

Delaware enjoys a significant variety of tree species and forest types in a relatively small geographic area. Delaware is the northern extreme for certain southern tree species, such as loblolly pine and baldcypress, while some northern species are not found south of Delaware, except at higher elevations (e.g., sugar maple, basswood, and eastern hemlock). Delaware's forest interior habitats (both wetland and upland) support the greatest diversity of native vascular plants, more than any other specific habitat type, with upland forests representing the most species-rich forest type. There are currently 584 animal species (vertebrate and invertebrate) listed in Delaware as species of greatest conservation need (SGCN). Thirty of these are forest-dependent bird species. Furthermore, 13 vertebrate species are considered endangered in the state (SGCN Tier 1 species)—four birds, three reptiles, three amphibians, and three mammals. These animals on the state endangered list are all also forest-dependent.

Forests cover approximately 29% of Delaware (359,000 acres). This acreage has remained relatively constant during the last century but is beginning to decrease.





Small whorled pogonia

One mammal, the northern long-eared bat (*Myotis septentrionalis*), is federally listed as threatened by the U.S. Fish & Wildlife Service. And since the first Delaware forest resource assessment was completed in 2010, the Delmarva fox squirrel (*Sciurus niger cinereus*) has been delisted from its previous status as federally endangered in 1967.

Additionally, two forest interior plant species are federally listed as threatened by the U.S. Fish & Wildlife Service—swamp pink (*Helonias bullata*) and small whorled pogonia (*Isotria medeoloides*).

Some of Delaware's forest communities have, historically, experienced significant declines in acreage. Wetland forest types (baldcypress, etc.) have experienced significant acreage decreases due to harvesting and drainage. Delaware's forests are becoming older with larger trees, and thus, fewer younger stands containing saplings and seedlings. If this trend continues, it could lead to reduction in critical habitat for certain animal and plant species.

Forest products/economic contribution

A new study is planned for publication in 2020 based on statistically-valid data on the impact of the forest products industry to Delaware's economy: *Forest Products Industries' Economic Contributions: Delaware*. The contribution made by the forest industry to Delaware's economy is significant. In 2002, more than 2,600 people were employed in the forest products manufacturing industry in Delaware, representing about five people/1,000 between the ages of 18 and 65. The average rate of pay for those individuals was about \$15/hour, and they had a total payroll of \$92 million. Most of these jobs were located in secondary wood processing industries—63 establishments producing a variety of products including furniture, custom millwork, cabinets, and other wood products employed these citizens. More recent data (2018) has shown a drop in the number employed to around 1,150.

While there are very few primary wood processors in Delaware (such as sawmills), processors in adjoining states purchase a substantial amount of timber in Delaware, providing significant revenue to Delaware's forest landowners. Approximately 2,663 acres are harvested annually—991 acres by clearcut, 873 acres by selection harvests, and 799 acres of pine thinning (pulpwood). The DFS estimates that these harvests generate at least \$2.5 million of income for forest landowners.

Urban forests also contribute jobs to Delaware's economy. The number of tree care companies is growing as Delaware continues to urbanize. There are now 43 ISA-certified arborists in Delaware. Delaware farms growing nursery stock currently generate an estimated \$13.5 million in sales.

There is also an opportunity for new wood markets in Delaware, including urban wood. The growing amount of low quality (primarily hardwood) timber is a potential supply for bio-energy. Wood could help to achieve renewable energy goals and provide additional returns to landowners and timber harvesters. Additional research is needed to more accurately estimate the amount of wood that is available for this market.



Soil and water quality protection and enhancement

Delaware has significant water quality challenges. Approximately 85% of Delaware's rivers and streams do not fully support swimming use and 94% do not support fish and wildlife use. Additionally, 41% of Delaware's fresh water ponds and lakes do not fully support swimming use and 74% do not fully support fish and wildlife use. These percentages, although very high, represent an improvement over the data from ten years ago, but there is much more room for further improvement. The cause of impairment in most cases is an excess of nitrogen and phosphorus.

Forests are widely recognized as the land use that is most beneficial for water quality—they provide multiple benefits and services that improve water quality (part of the suite of non-consumptive benefits often called ecosystem services). Maintaining and expanding forest cover is a goal for many water pollution control strategies. Creating forestland (e.g., afforestation) from other land uses reduces the amounts of nitrogen and phosphorus that reach streams and groundwater. Riparian buffers help filter and clean surface waters. Forest cover also helps improve surface waters that supply municipal drinking water reservoirs. There are two drinking water reservoirs in Delaware—both in northern New Castle County.

Forests also play a critical role in Delaware's groundwater recharge by cleaning this water before it enters the aquifers. Forests comprise approximately 31% of Delaware's 119,000 acres of excellent groundwater recharge areas. These areas provide much of the groundwater to recharge Delaware's underground aquifers—the state's primary water supply for all purposes.

Wetlands provide a wide range of valuable functions, including slowing water runoff and trapping sedimentation and filtering pollutants before they reach streams and other waterways. Forested wetlands are highly valued for all of these natural benefits in addition to the valuable habitat they provide for many species of wildlife and plants. There are an estimated 145,308 acres of forested wetlands in Delaware. A particularly important forested wetland type is the Coastal Plain seasonal pond. These seasonally flooded wetlands are found throughout Delaware but particularly in southwestern New Castle County and northwestern Kent County. In addition to water quality benefits and groundwater recharge, they provide habitat to a variety of state and globally rare plants and animals.

Urban forests also provide significant water quality benefits. They filter and clean water leaving urban sites. They also help control stormwater runoff by slowing these waters and reducing their impacts on waterways. Many studies have found that well-positioned tree plantings, such as around catch basins and stormwater ponds, can reduce the water flow thereby decreasing the potential for flooding during storm events and reducing the amount of land needed for these retention ponds.



Carbon sequestration/climate moderation

The increase in carbon-containing gases in the atmosphere is widely believed to lead to increased global temperatures. Trees combat this effect because they sequester carbon and store it within their trunks, branches, roots, etc. Currently, Delaware's forests store approximately 22.5 million tons of carbon (including 3.1 million tons in urban forests). This amount is increasing because Delaware's forests are, on average, aging and thus increasing in size. While the carbon market is still emerging in the United States, prices are expected to bring at least \$4/ton. Therefore, one could argue that Delaware's forests currently store nearly \$100 million of carbon from the atmosphere.

Furthermore, forests help moderate climatic effects at the local scale. Riparian forested buffers moderate water temperatures within streams, thus protecting fish and other species that use these waters. Urban forests reduce energy consumption by cooling urban areas in the summer (shade) and providing windbreaks during the winter. A 2009 urban forest resource assessment in northern Delaware concluded that urban trees in New Castle County saved an estimated \$403,000 annually in residential building energy costs, including \$183,000 within the City of Wilmington. Forests also remove other pollutants that degrade our atmosphere. Another 2009 study estimated that Delaware's 7.1 million urban trees (at the time) removed over 1,700 metric tons/year of pollutants, including 242 tons of nitrous oxide, 221 tons of sulfur dioxide, and 744 tons of ozone. This pollution reduction was valued at \$13.5 million annually. Although these studies are slightly dated, they clearly show the importance of urban trees and the enormous energy savings they provide along with removing tons of pollutants.

Recreation

Forests offer a wide variety of opportunities for outdoor recreation. Of Delaware's top ten recreational activities, at least six occur in forested settings. Over 3.2 million people in Delaware annually participate in these six activities (walking/jogging, picnicking, hiking, camping, hunting, and horseback riding). There are 567 miles of trails open to the public in Delaware, an increase of 53% compared to 2002. In addition, approximately 155 of these trail miles are open to horseback riding and 483 miles to mountain biking. Nearly all of these trails traverse forested areas. Forests are vital to Delaware's recreation and tourism industries and to our quality of life.



Of Delaware's top ten recreational activities, at least six occur in forested settings. Over 3.2 million people in Delaware annually participate in these six activities: walking/jogging, picnicking, hiking, camping, hunting, and horseback riding.

V. Issues, Threats, and Opportunities

For the 2010 Forest Action Plan, the Delaware Forest Service (DFS) used two processes to identify the highest priority issues, threats, and opportunities for Delaware's forests. First, the DFS completed a comprehensive five-year strategic plan in 2008 through a facilitated process with forty participants representing a variety of stakeholders, including other public (state, federal, local) agencies, landowners, nongovernmental organizations, consultant foresters, forest industry, and recreationalists. Through this effort, stakeholders identified critical issues facing Delaware's forests and then defined goals and objectives for the DFS to address in the subsequent five years (2009-2013).

Second, Delaware's Forest Stewardship Committee participated in a facilitated process in 2009 to identify current issues, threats, and opportunities facing the state's forests. Beginning with the issues from the earlier strategic planning process, the committee identified additional issues, and then outlined specific threats and opportunities. The result was very similar to the outcomes of the 2008 strategic planning process.

Once the issues, threats, and opportunities were drafted, the DFS shared them with other stakeholders through presentations/site visits and electronically to determine if any changes were appropriate. The relatively few number of substantive edits were incorporated into the final list.

In 2010, four issues were identified—*Forest Health and Functionality*, *Forest Markets*, *Sustainable Forest Management*, and *Public Awareness and Appreciation of Forests*. In early 2019, in an effort to update the primary issues facing Delaware for the next ten years, an electronic survey was created and sent to hundreds of stakeholders. An overwhelming majority (92%) responded that there should be no deletions to the 2010 issues. A small percentage focused in on eliminating non-forest ecosystem services such as carbon credits because past efforts (e.g., Bay Bank) made little progress due to lack of interest. Additionally, when asked if there should be any additions to the 2010 issues, threats, or opportunities, about half of the respondents replied affirmatively and gave their suggestions.

Then in June 2019, Delaware's Forest Stewardship Committee participated in another facilitated process similar to that of 2009 to further identify current Delaware issues, threats, and opportunities facing the state's forests. The committee identified their own issues, and then outlined specific threats and opportunities. Once again, the results were very similar to the outcome of the electronic survey and, for that matter, also to the 2008 strategic planning process and subsequent 2010 Delaware forest resource assessment. Therefore, the DFS will use the same four primary issues as before but will incorporate virtually all the updated suggestions into the threats and opportunities sections. The four traditional Delaware forest resource issues will encapsulate all stakeholder concerns.





While Delaware has more forestland now than in 1900, its overall forested acreage is shrinking—primarily due to development.



ISSUE #1

Forest Health and Functionality

An adequate, healthy forestland base ensures the perpetual production of forest outputs—lumber and other wood products, wildlife habitat, recreational opportunities, water and air quality protection, carbon sequestration and storage, aesthetics, and energy savings through local climate modification.

Background

Forests provide an abundance of natural environmental and economic benefits and it is crucial that Delaware maintain a sufficient acreage of healthy forests to perpetuate these benefits. A full representation of various forest types (e.g., cypress swamps, pine forests, bottomland hardwoods, etc.) is needed to provide the habitat necessary for a diverse array of plant and animal species. Additionally, certain forests provide important environmental benefits such as improved water quality and quantity (e.g., wetlands, riparian buffers, groundwater recharge areas, Coastal Plain ponds, etc.). A sufficient base of working forests is necessary to supply the timber needed to support a viable forest industry. Furthermore, strategically located afforestation (forest expansion) can provide significant environmental benefits, such as connecting large forested blocks and creating or expanding forested corridors and buffers. Urban forests also provide numerous benefits and are important to a community's quality of life. Municipalities should include urban forestry management strategies in their long-term plans. In all cases—urban and rural—healthy forests are vital to maintain their sustainability. Landowners and foresters must work to ensure that Delaware's forests are as free from forest pests and invasive species as possible.

Future efforts must address all of these factors to help ensure the long-term health and viability of Delaware's forests and help the DFS meet one of the U.S. Forest Service Eastern Region State and Private Forestry (S&PF) national priorities—*Protect forests from threats.*

THREATS

The long-term health and sustainability of Delaware's forests are threatened on multiple fronts: outright forest loss, fragmentation, and parcelization; exotic invasive plants, insects, and diseases; uncontrolled populations of native species; loss of forest diversity; and, in certain areas, wildfires.

Forest Loss, Fragmentation, and Parcelization

Delaware's rural and urban forests face a multitude of challenges that threaten their long-term health. While Delaware has more forestland now than in 1900, its overall forested acreage is shrinking—primarily due to development. During the housing boom from 2002 and 2009, 6% of Delaware's forests (16,000 acres) were included in proposed developments. Not all of those projects occurred due to a downturn in the housing market, but it is very likely that most of those forests will either disappear or will be so fragmented that they no longer provide many of the natural benefits that all Delawareans now enjoy. Such a trend is not sustainable, and in the last several years the housing market in Delaware has improved again and even more unprotected forests are threatened with loss and fragmentation.

Furthermore, remaining forests are now in smaller blocks. The number of large, contiguous forested blocks (>250 acres) is decreasing. Many riparian forests have also disappeared or been reduced significantly such that waterways are no longer buffered. This presents challenges not only for forest management but for wildlife habitat, water quality, water retention and recharge. Fragmentation not only causes forest management challenges, it also produces other effects that are less evident. For instance, it increases the amount of forest “edge,” which often leads to the introduction of invasive plants and reduces the habitat for certain interior forest-dwelling species. In addition to a decrease in large, contiguous forested areas, there is also a loss of forested corridors (100- to 300-foot wide strips) that connect larger blocks of forestland. These areas provide protected travel routes for many wildlife species and are often located along waterways, thus also improving water quality.

Increased human population has produced more landowners and smaller forest ownerships. Today’s average forest ownership is less than 10 acres, compared to over 30 acres just four decades ago. This increasing number of forest landowners presents challenges to public agencies as they attempt to provide more assistance with fewer staff and shrinking budgets. Public managers will have to rely on new approaches and new partnerships to reach this growing landowner base. Smaller forested parcels also increase the chance for the establishment of invasive plants.

Invasive Species

While the overall impact of invasive species and non-native pests in Delaware’s forests is usually unnoticed, their cumulative effect is significant and growing.

Gypsy moth, Dutch elm disease, and chestnut blight are three examples of non-native species that have severely affected certain tree species within Delaware. Gypsy moth populations have decreased to virtually zero since 1996. However, their impact on oak forests in the late 1980s and early 1990s is still present today. The confirmed presence and establishment of the emerald ash borer (EAB) in Delaware in 2018/2019 is basically a death sentence for virtually all ash (*Fraxinus* spp.) trees in the state. This 2002 import from China has already killed more than 60 million ash trees in 35 eastern U.S. states and continues to spread wherever ash trees are found. Although ash trees comprise about only 1% of Delaware’s natural forests, EAB is of particular concern in urban areas where extensive ash trees were extensively planted along roadways. Also, the Category I wetland type composed of black ash seepage swamps is of particular risk and concern.

There are several potential threats to Delaware forests in surrounding states that could have future severe impacts. The DFS, working with the U.S. Forest Service, APHIS, and the DDA Plant Industries Section, continues to monitor for these potential threats including the Asian longhorned beetle, sirex woodwasp, sudden oak death, and the European pine shoot borer. Likewise, invasive plants continue to spread throughout Delaware forests, particularly in urban areas and those on the rural/suburban fringe. Such species include multiflora rose, Norway maple, autumn olive, mile-a-minute weed, privet, Japanese stilt grass, and phragmites.



Sirex wood wasp



Autumn olive





Destructive Native Species

In addition to invasive species, there are also native threats to Delaware forests. An overabundance of white-tailed deer has degraded many forested areas, particularly hardwood forests in northern Delaware. While DNREC's Division of Fish & Wildlife has taken steps to curb this problem, there are still portions of the state that have significant deer overpopulations. The high deer population is compounded by a decline in the number of hunters in the state. Bacterial leaf scorch (BLS), once considered a relatively minor nuisance in urban forests, has now caused widespread death and decline to several red oak species throughout Delaware. The southern pine beetle also has the potential to destroy thousands of acres of valuable loblolly pine forests.



Forest Types

In addition to the acreage of forestland, it is also important to maintain a mixture of forest types. Statewide inventories ten years ago showed that certain types of forests were increasing, such as red maple and gum, while others were decreasing significantly, particularly softwood forests (such as loblolly pine, Atlantic white-cedar, and baldcypress). In the last ten years the trend in softwood decline has reversed somewhat, especially for loblolly pine, however, low-quality hardwoods still continue to increase. These changes have repercussions not only for timber production but also wildlife habitat. Some changes in forest cover are due to timber harvesting and land clearing while others are due to changes in hydrology, such as through channelization and ditching.

Urban sprawl continues throughout much of Delaware and has resulted in a significant increase in the wildland-urban interface (WUI).

Wildfire

While wildland fire is not a substantial threat in Delaware, it is a concern in certain landscapes and forest types. Urban sprawl continues throughout much of Delaware and has resulted in a significant increase in the wildland-urban interface (WUI). The susceptibility of many of the WUI areas (particularly coastal areas) to wildland fires has increased dramatically with the presence of the invasive common reed (*Phragmites australis*). Additionally, southern Delaware has large areas of loblolly pine forests. Young stands of loblolly pine are also prone to wildland fires before they naturally prune their lower limbs.

OPPORTUNITIES

Reduce Forest Loss, Fragmentation, and Parcelization

- Protect forested areas, particularly in high priority areas, through both public funding (Forest Legacy, USDA NRCS, Delaware Aglands and Forestland Preservation and Open Space Programs, county and local governments) as well as private funding (NGOs, land trusts, etc.). Conservation easements are an economic and effective way of protecting working forests.
- Maintain existing incentives for landowners to retain their forestland (such as property tax exemptions) and explore other incentives for landowners to maintain their forestland, such as rental payments to protect the high priority forests, other tax incentives, etc.
- Encourage state, county, and local governments to incorporate forests and forest benefits into land-use planning processes to help decrease the rate of forest fragmentation in the state.



- Work with local governments to include urban tree canopy goals in municipal plans and identify priority areas for maintaining and expanding urban forests.

Improve the Diversity of Forest Types

- Establish reasonable goals for maintaining/restoring a representation of diverse and historic native forest types (species) and types of forestland (upland, floodplain/wetland, headwaters forests) while balancing the interests of landowners and society.
- Partner with other agencies and organizations (e.g., The Nature Conservancy, Delaware Division of Fish & Wildlife, Delaware Wild Lands, Inc., U.S. Fish & Wildlife Service, etc.) to restore forest types.
- Encourage active forest management on state-owned forestlands to create a mosaic of size and age classes, species compositions, and stocking levels.

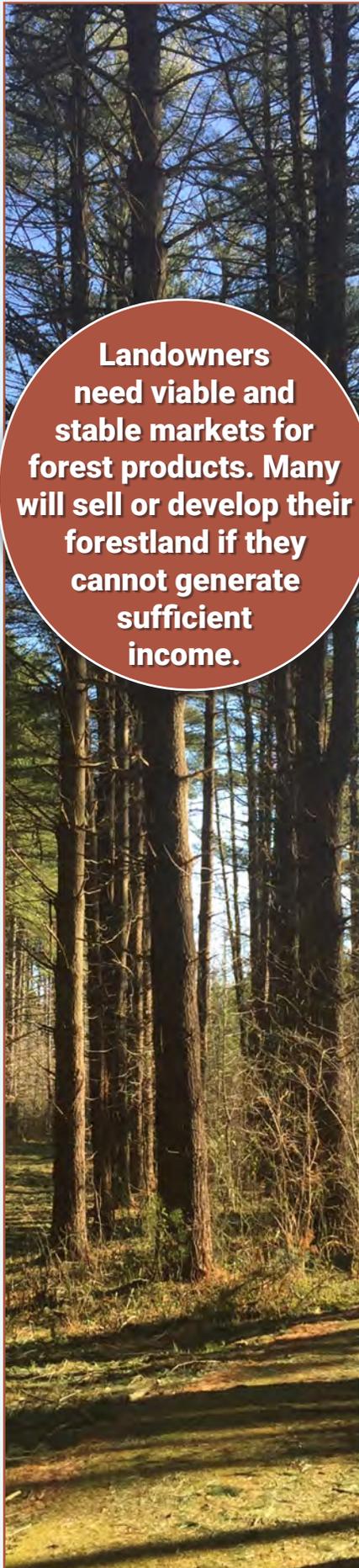
Control Native Pests and Non-native Invasive Species

- Continue monitoring for both native destructive forest pests (southern pine beetle) and non-native (such as the gypsy moth) through aerial and ground surveys and attempt to eliminate any “hot spots” before they spread and cause significant damage and loss.
- Work with state and federal partners to quarantine and eliminate, if possible, initial populations of potentially damaging forest pests.
- Address non-native and invasive species outbreaks and occurrences by working with other government agencies and nongovernment organizations, such as the Delaware Invasive Species Council (DISC).
- Support efforts to control deer populations, including Quality Deer Management and the Deer Management Advisory Committee.

Reduce Wildfire Risks

- Ensure that volunteer fire companies, the first responders to wildland fires in Delaware, are well trained and equipped to fight wildland fires.
- Utilize prescribed fire to reduce the likelihood of wildfires and to improve wildlife habitat and forest management. Create a state-wide partnership and develop cooperative agreements between agencies to efficiently and more safely expand prescribed burning opportunities on public and private lands.
- Work with at-risk communities to reduce the likelihood of catastrophic wildland fires, especially those along the coast affected by phragmites.





Landowners need viable and stable markets for forest products. Many will sell or develop their forestland if they cannot generate sufficient income.

ISSUE #2

Forest Markets

Adequate and diverse forest markets are available to landowners to satisfy their forest management goals.

Background

A stable, robust, and diverse market for forest products—not just for high-quality timber but also for poor-quality species and non-timber markets, such as carbon—contribute to Delaware’s economy and help ensure long-term sustainable forest management. Furthermore, landowners must have the ability to generate income from their forestland, otherwise they are much more likely to convert their forestland to other non-forest uses such as development. The major component of a successful mix of forest markets is a strong, stable market for traditional forest products (pulpwood, sawtimber, etc.), including markets for low-value timber. However, markets for non-wood products are important to provide a diverse suite of income opportunities for landowners. To foster these markets, it is critical that current, comprehensive inventories of the forest resource are available.

Lack of robust and diverse markets is not only a threat to forest landowners but to our forests. Policies that foster diverse and robust forest markets are necessary to retain forestland, particularly privately-owned forests, for the longterm. Without a thriving wood products market, Delaware cannot achieve one of the Eastern Region S&PF national priorities—*Conserve and manage working forest landscapes for multiple values and uses*—or the longterm, sustainable management of its forests.

THREATS

Markets for traditional forest products (pulpwood and sawtimber) have decreased dramatically in Delaware and the Delmarva Peninsula and there is a continued lack of markets for low quality hardwood timber. There is a potential for new markets for non-consumptive uses (carbon, wetland mitigation, etc.) but these have yet to develop fully.

Lack of Traditional Forest Markets

Delaware’s landowners need viable and stable markets for their forest products. Many landowners will sell or develop their forestland if they cannot generate sufficient income through forest management activities. The economic downturn ten years ago further accelerated the decline of traditional forest products markets on the Delmarva Peninsula. Combined with a national decline in lumber prices due to the collapse of the real estate market and the overall economy, timber prices in Delaware declined as much as 50%. More recently, however, the economy has improved, and housing starts are increasing again. However, the number of sawmills is less than half of the total from 25 years ago and this includes the closure of the largest pine sawmill in the region. Delaware is currently not in a good position to take advantage of a growing economy and an increased demand for wood products. A timely revival of the forest products industry is necessary to protect many of Delaware’s working forests from conversion to non-forest uses. It is important that Delaware work with surrounding states to maintain existing markets and foster new ones for traditional forest products.

Few Markets for Non-wood Forest Products

Markets for non-wood products are very important. Currently, hunting leases are the primary non-wood market for many forest landowners. However, markets continue to emerge for carbon sequestration and storage, wetlands mitigation and even endangered species mitigation and other “ecosystem services” but much work remains to bring them to fruition.

Poor Markets for Low-quality Wood

A healthy forest market should also provide demand for all types of timber—not just the high-quality species and stems—thereby helping landowners to sustainably manage their forests. Currently, there is an overabundance of low-quality hardwood in Delaware. This lack of market has contributed to the proliferation of low-valued red maple and gum forests because these species are often not removed during timber harvests. Bio-energy is a developing market that could provide new demand for low-quality hardwoods, but Delaware’s existing incinerator law severely restricts the use of wood for bio-energy purposes. Developing markets for these species would help foresters and landowners establish a better mix of tree species, both for wood production and wildlife habitat.

Periodic Forest Biomass Inventories

To maintain and expand forest markets, it is essential that a state and/or region have accurate estimates of the forest resource and the amount of wood (and other products) that the forest can produce sustainably. Encouraging new markets is only viable if there is a sufficient forest base to sustain both new and existing markets. Fortunately, the U.S. Forest Service completed a study in 2012 entitled *Greater Delaware Area Forest Biomass Resource Analysis* that showed there is an ample supply of wood in Delaware to support a thriving forest products industry. Such a study should be commissioned on a regular basis to confirm that wood resources are being managed sustainably in Delaware.

OPPORTUNITIES

Accurate Forest Biomass (Wood) Inventories

- Improve and refine the state’s forest inventory by working with the U.S. Forest Service and other partners to develop better acreage estimates of the various forest types/species (e.g., loblolly pine, baldcypress/Atlantic white-cedar, red and white oak, etc.) and the amount of wood available for various markets such as low-quality hardwoods for bio-energy.
- Work with neighboring states to consider the region’s (Delmarva Peninsula) wood supply when developing potential forest markets to ensure that any new wood markets are properly sized to the supply available and do not degrade the long-term sustainability of the forests.
- Commission periodic studies of biomass availability in Delaware and the surrounding region.

Improve Traditional Forest Markets

- Work with economic development and natural resource agencies, landowners, buyers, loggers, and wood producers and processors both in Delaware and neighboring states to maintain and support the traditional forest product markets.





- Seek to expand complementary markets, such as poultry bedding, to keep pace with the demand of expanding agricultural commodity markets.
- Tap into the expertise of the Governor's Council on Forestry to promote and attract new forest industry to Delaware in anticipation of the upcoming expansion of the Port of Wilmington that could potentially greatly expand wood product imports and exports.

Create/Expand Non-traditional Forest Markets

- Work with local artisans and entrepreneurs to develop niche markets using wood locally harvested in Delaware.
- Encourage the use of urban waste wood to take advantage of a diversity of species and large trees removed from communities due to decline, sidewalk/road conflicts, and mortality.

Develop New Bio-energy Markets

- Develop new markets for the abundance of low-valued timber in Delaware and throughout the Delmarva Peninsula.

Non-wood Ecosystem Services Markets

- Promote and facilitate non-consumptive forest markets—such as carbon credits for forest management and urban forests (not just afforestation), endangered species banks, and wetland mitigation banks—commonly referred to as ecosystem services. Support programs that help aggregate private landowners for potential ecosystem service payments.
- Support state and regional policies for ecosystem services that include forests and reward forest management, such as for carbon credits (including the Regional Greenhouse Gas Initiative [RGGI]).

ISSUE #3

Sustainable Forest Management

Delawareans must sustainably manage their rural and urban forest resources.

Background

Ultimately, we must not only maintain sufficient forest acreage but also sustainably manage those rural and urban forests if Delawareans are to enjoy all of the many natural benefits we receive from forests. Furthermore, most of these forests are, and will continue to be, privately owned (or in the case of urban forests owned by homeowners or communities). Therefore, these landowners must have the knowledge, ability, and assistance to manage their forests so that we all benefit. Furthermore, owners often need financial assistance to help them complete important management activities. Technical (foresters and arborists) and financial assistance not only benefit the forest landowner, but also help ensure that our rural and urban forests are thriving and providing the numerous benefits we all enjoy for future generations. Without sustainable management, we cannot meet the Eastern Region S&PF national priorities to *Conserve and manage working forest landscapes for multiple values and uses* and *Enhance public benefits from trees and forests*.

THREATS

Many of Delaware's urban and rural forests are not sustainably managed. Their owners either do not seek or are not aware of available professional forestry assistance. Furthermore, many owners require financial assistance to help them manage their forests. This problem not only affects the individual landowner but affects the long-term viability of Delaware's forests. Fortunately, the percentage of Delaware's forests that are not well managed is decreasing. Efforts to educate communities, landowners, and forestry operators (loggers, equipment operators, timber buyers, etc.) about forests and forest management are making an impact, however, there is room for improvement.

Lack of Technical Assistance

Many forest owners do not utilize professional forestry assistance. For instance, less than one-half of Delaware's timber harvests currently utilize a professional forester, and this is the case throughout the country. While foregoing the expertise of a professional forester does not always result in poor forest management, many times it produces poor quality forests, such as high-graded forests (only the best timber is harvested, and after repeated high-grade harvests, only poor quality specimens remain). This situation is compounded in Delaware by a lack of markets for poor-quality timber. Urban and community forests face challenges similar to rural forests. Many cities and towns do not have sufficient expertise to inventory their street trees and other publicly-owned forests or develop a management plan that outlines their long-term goals and objectives for these areas. Community leaders and citizens need access to technical assistance to help them understand the importance of forests not only aesthetically but for the numerous environmental benefits they provide (such as, improved water quality and quantity, enhanced recreational experiences, reducing energy costs, and reduced stormwater runoff). By working with professional foresters, landowners and communities can develop long-term plans for their forests, including comprehensive inventories and management plans.

Lack of Financial Assistance

Financial assistance is also necessary to help landowners and communities sustainably manage their forests. Forest landowners typically only receive revenue sporadically from timber harvests and often it is many years, if not decades, between timber harvests—particularly for landowners of small woodlots. Financial assistance, such as cost shares for forest management activities, helps ensure that landowners can and will complete non-income generating activities, such as timber stand improvement, wildlife habitat enhancement, and water quality protection activities. Furthermore, many owners acquire woodlands that have been poorly managed in the past. As these landowners begin to re-establish sound management practices in their newly acquired woodlands, they often find that the cost of these practices can be quite substantial, depending on the degree of neglect or mismanagement in the past.



Aerial herbicide applications are eligible for state forestry cost-share assistance programs.

Likewise, funding also benefits cities and towns—often providing the money needed to purchase trees for planting, complete an inventory of the community's trees, or secure an arborist for pruning and other tree care matters. Often, urban forestry budgets are the first to be cut or reduced during difficult economic times. Financial assistance combined with technical advice is a cornerstone for sound forest management. Despite uncertain budgets, it is important that Delaware work with a variety of organizations (federal, state, private) to continue providing not only technical but also financial assistance to landowners to help ensure the long-term sustainability of our rural and urban forests.

OPPORTUNITIES

Rural Forest Management and Assistance

- Continue providing technical forestry assistance to landowners for a variety of forestry issues and coordinate with other natural resource professionals (such as wildlife biologists and hydrologists) to provide comprehensive landowner assistance.
- Seek ways to reach more landowners to offer professional forestry assistance.
- Explore the possibility of providing assistance to landowners on a landscape scale, such as in a watershed, to help achieve larger-scale goals.
- Maintain and expand cost-share programs to help landowners complete forest management activities and enhance their forests (e.g., timber production, wildlife habitat enhancement, water quality protection, etc.).
- Maintain existing programs to encourage long-term forest management (e.g., property tax exemptions, etc.) and explore opportunities for new incentives.
- Consider new incentives and programs to encourage good forest stewardship among the increasing number of landowners with small woodlots (less than 10 acres).

Urban Forest Management and Assistance

- Continue providing technical forestry assistance to municipalities and civic associations to develop long term plans for their urban forests, including a comprehensive inventory, maintenance plan, and tree canopy goals.
- Seek opportunities to reach more communities and civic associations to provide professional urban forestry assistance to them.
- Maintain and expand funding to support urban forest management activities such as tree planting and tree maintenance projects.
- Consider methods to provide a certified arborist/urban forester for all municipalities.



ISSUE #4

Public Awareness and Appreciation of Forests

Delawareans must understand and appreciate the importance of forests and forest management.

Background

Everyone—landowners, homeowners, community and civic leaders, students—must appreciate and understand that forests and their proper management are necessary for our quality of life. Credible, current, easy-to-understand information and ongoing education, both student and adult, are needed for the general public to understand the broad array of natural benefits that forests provide, the intricacies of forest management, and the techniques and practices necessary to achieve the goals of management. Often, sound management techniques are not aesthetically pleasing, and this issue must be addressed in forest management education. If the public does not appreciate and understand forests and forest management, we cannot meet the Eastern Region S&PF national priorities—*Conserve and manage working forest landscapes for multiple values and uses, Protect forests from threats, and Enhance public benefits from trees and forests.*

THREATS

There is a lack of public awareness and appreciation of Delaware’s forests and forest management. While most citizens appreciate forests, many do not understand the wide range and depth of benefits our forests provide. Furthermore, many Delawareans do not understand that forest conservation and sustainable forests require public investment as well as both financial and technical assistance. Readily available information, through a variety of avenues (e.g., internet, public workshops, etc.), on a variety of topics (e.g., forest health, forest management, urban forests, etc.) and for a variety of audiences—landowners, homeowners, community leaders, legislators, students, etc.—is necessary to raise public awareness and understanding. Reaching the entire public is a difficult task, so a strategic, prioritized approach is necessary.

Student/Teacher Education

Despite ongoing efforts and recent successes, many students are not exposed to a comprehensive forestry and natural resource curriculum. Often their exposure is limited to only a few disjointed forestry issues and concepts, and many times their lessons focus on forests that are outside of Delaware or even the United States. Similarly, opportunities for teachers and other educators to learn about forests and forestry in Delaware are very limited both during their formal education and continuing education experiences. To increase student understanding of forests and forest management, teachers must first understand these issues.

Landowner/Homeowner Education

Studies continue to show that only a fraction of forest landowners (including community forest owners/managers) and homeowners participate in forestry education opportunities or are aware of the professional assistance available to them. Similarly, the DFS has found that its programs continually reach the same small minority of landowners and communities. The DFS and its partners must find new methods to reach (and interest) the vast majority of forest and tree owners who have little or no forestry knowledge.

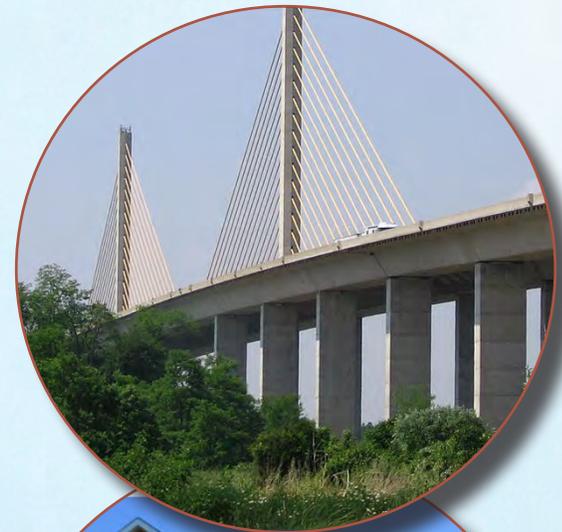


Public Understanding and Support for Forests and Forest Management

For forestry programs—state forestry agencies, forest/open space protection, landowner assistance, those offered by NGOs, etc.—to survive and thrive, the public must understand and lobby for forests and forestry. Public support leads to well-funded forestry programs and organizations. As the state and other governments face increasing budget pressures, public support for forestry is required to provide the various programs described within this assessment and corresponding strategy.

Delaware's Diversity of Land Use Ideas

Ten years ago, the Forest Stewardship Committee identified another item to consider during the assessment process, specifically Delaware's diversity or perhaps better stated, the wide diversity of strong ideas and interests regarding land and its use in this small state. While this item did not warrant stating it as a separate issue, the committee believed that it was important that the DFS and its partners were cognizant of the issue as it could impact future activities. This idea still holds true today, a decade later. There is an attitude of "downstate versus upstate" for areas south and north of the Chesapeake and Delaware (C&D) Canal. This arose from the urbanized, industrial areas in the north versus the more rural, agrarian economy in the south. This attitude has moderated with the increasing development in the southern part of the state, particularly along coastal areas. Nonetheless, there is still an urban versus rural mentality in many areas of Delaware. The dramatic increase in development has also exposed another somewhat contentious argument in the state: many Delawareans strongly endorse private property rights. However, the rapid increase in development and suburban sprawl has caused some Delawareans, particularly the newest arrivals to our state, to support tougher land use law and zoning, and this conflict is likely to continue into the future. While these opposing attitudes exist, none rise to the level of extreme. In fact, there is often an aversion by Delawareans to confrontation and "making enemies." Perhaps this is a result of Delaware's small size—everyone knows everyone else or their friend or relative, so confrontation is avoided. Nevertheless, this diversity provided the foundation for the laws and regulations that govern Delaware's forests and it will impact any future efforts to revise or develop new policies.



OPPORTUNITIES

Student Education

- Encourage a comprehensive forestry/natural resource curriculum within schools, from elementary through high school, including the possibility of required classes for students in natural resource studies.
- Offer a variety of educational opportunities for all grades—that are correlated to state educational standards—from Smokey Bear to Arbor Day to Project Learning Tree (PLT), as well as encourage outdoor classrooms at schools and assist with incorporating these classrooms into the schools' curriculum, such as tree planting projects, monitoring water quality, etc.
- Continue to support natural resource educational programs outside of traditional school programs, such as Envirothon, Science Olympiad, and forestry-related 4-H programs.



Teachers/Educators

- Continue to work with partners to integrate PLT and its related curricula (Project Wet, Project Wild) into teacher continuing education courses and into teacher curriculum at local colleges.
- Partner with other organizations to increase natural resource learning opportunities outside the classroom, including outdoor classrooms on-site and the State Forest Education Centers.
- Explore avenues to reach more teachers and educators with forestry and other natural resource educational materials.



Forest Landowners

- Provide educational opportunities for landowners, including new methods and approaches such as the electronic media and other landowners (e.g., Tree Farmers), to reach the large majority of forest landowners who have little or no forestry knowledge.
- Explore opportunities to provide forest management information to new landowners (such as when they purchase the property).



Communities and Municipalities

- Provide urban forestry education to municipal leaders and civic groups to increase their understanding of urban forests and the numerous environmental benefits they provide so they include trees and other “green infrastructure” in their planning and budgeting processes.
- Explore opportunities to provide urban forestry educational opportunities to civic associations.



General Public

- Maintain and execute a DFS marketing plan that includes forestry education and promotes successes.
- Continue providing the general public with specific, message-focused educational opportunities in forestry.
- Highlight and promote success stories for rural and urban forestry.





VI. Rural Priority Landscape Area

Overview

The Cooperative Forestry Assistance Act (CFAA) provides the authorities for a broad range of State and Private Forestry (S&PF) programs. As amended by the 2008 Farm Bill, the CFAA requires each state forestry agency to develop a Statewide Forest Resource Assessment (“State Assessment”) and Statewide Forest Resource Strategy (“Resource Strategy”), collectively referred to as a State Forest Action Plan (SFAP). Once completed, states are eligible to receive funds under the authorities of the Act. State Assessments are intended to identify key forest-related issues and priorities to support development of the long-term Resource Strategy. All states were initially required to complete a SFAP by June 2010. Additional requirements include a review at least every five years and an update at least every ten years. Most states, like Delaware, have a deadline of December 2020 to submit an updated and revised SFAP to the U.S. Forest Service (USFS) to secure S&PF funding for core forestry programs.

Once again, Geographic Information System (GIS) technology was used to complete the rural priority landscape area process. GIS allows for complex analyses of geographic data on standard desktop computers using sophisticated computer software. The Delaware Forest Service (DFS) has routinely used GIS technology for the past 20 years for a variety of purposes. All DFS foresters have been capable users since 2005. Furthermore, the Delaware Department of Agriculture (DDA) has had a full-time GIS coordinator on staff since 2015. Therefore, the DFS had been pre-positioned to carry out this complex analysis without additional software or training. The DDA GIS coordinator handled data management, processing, and analyses for this study.

The GIS analysis used for this study involved the overlay of 21 datasets. Some layers were recommended by USFS guidelines. Other layers were added by DFS staff members because they were clearly relevant in Delaware. A few additional layers were incorporated based on recommendations made by members of the Forest Stewardship Committee in 2019.

This analysis was used to identify the critical forested landscapes in rural areas—a second and separate (see Section VII) analysis identified critical urban forests. Therefore, this process only included forest and agricultural lands (as recommended by the USFS because agricultural land can be converted to forestland) and land located outside of municipal boundaries.

Once the 21 input layers were assembled, they were combined in an overlay process. A composite score was calculated for each 30-meter by 30-meter area in the state (representing about a quarter of an acre) based on the presence or absence of each of the input layers for that area. Layers were weighted according to average scoring of committee members, so that higher-scoring layers had greater impact in the composite score.

The goal with this analysis was to build on the Forest Stewardship Spatial Analysis Project (SAP) methodology developed in 2006 that relied on a weighted overlay analysis. The current analysis differed from SAP in several key areas. Unlike SAP, this analysis included public lands and incorporated nearly twice as many layers to compute priority scores. Urban areas were not included in SAP but are included in Section VII—Urban Priority Landscape Areas—though the input layers and ranking system were different.

The 21 data layers included in the State Assessment GIS analysis included the following (presented in order of their weighting):

1. Forest Fragmentation
2. Delaware Habitats of Conservation Concern
3. Riparian Areas
4. Forest Cover
5. Forest Health Risk
6. High Productivity Soils
7. Proximity to Existing Sawmills
8. Wetlands
9. Resilient Land (TNC)
10. Wildland/Urban Interface (WUI)
11. Natural Areas
12. Low Development Risk
13. Protected Lands
14. Historical/Cultural Sites
15. Conservation Easements
16. Forest Legacy Areas
17. Commercial Forest Plantation Act (CFPA) Properties
18. High-Priority Watersheds
19. Groundwater Recharge/Drinking Water
20. Wildfire Risk
21. Impaired Air Quality

Additional layers recommended by the USFS or the Stewardship Committee that were not incorporated into the analysis included the following:

Zoning Map – Zoning data is variable by county and does not provide the information the committee desired (projection of new development). An existing dataset, wildland urban interface, tends to show developing areas and that layer was given a higher weight as a substitute.

Landowner Incentive Program – Partially redundant with conservation easements and incorporated areas, other data is confidential.

Recreation Map – Recreation areas are included in the public protected lands data.

Regional Flow – Regional flow is a component of Resilient Land data already being used (The Nature Conservancy).

Sea Level Rise – 100-year estimates are available, but far exceed the 10 year scope of this assessment.





Forest health, and the potential for future threats to forest health, is vital to understanding the condition of Delaware's forests and guide future forest management.

Input Layers

A more detailed description of each of the 21 input layers used to determine the rural priority landscape area follows.

1. Forest Fragmentation

The DFS originally mapped contiguous forested areas that cover at least 250 acres for the 2010 assessment. A forest block was not considered contiguous if it was bisected by a paved road. Instead, forest areas on either side of roads were separate blocks for acreage determination. This data was updated for 2020 by examining contiguous forested areas using 2017 aerial imagery. Forestland that had been cleared for other uses (agriculture or development) was removed and block sizes were recalculated. Blocks that fell below 250 acres were then removed. While relatively small for some areas of the country, a 250-acre contiguous forested area is significant in Delaware. Large areas of contiguous forest are important for a variety of reasons, including habitat for forest-interior dwelling species. Large forested areas also present more opportunities for forest management activities.

2. Delaware Habitats of Conservation Concern

The Delaware Ecological Network (DEN) is a statewide conservation network developed from GIS and field-collected data. The DEN, based on principles of landscape ecology and conservation biology, provides a consistent framework to help identify and prioritize areas for natural resource protection. DEN incorporates Habitats of Conservation Concern for rare/threatened/ endangered species along with corridors connecting core ecosystem areas.

3. Riparian Areas

Riparian forested buffers improve water quality by filtering sediments and other pollutants before they reach streams and other waterways. These forests also moderate stream water temperatures and provide travel corridors and other habitat for many wildlife species. The riparian areas layer was created using a 100 foot buffer on each side of statewide streams and water bodies, which created 200 foot wide riparian areas along all waterways.

4. Forest Cover

Forest cover is obviously an important component of a State Forest Resource Assessment. A Delaware 1-meter landcover dataset was developed by the University of Vermont Spatial Analysis Laboratory, in collaboration with the USFS, and funding by the William Penn Foundation, National Park Service, and the EPA. <https://drbproject.org/products/>

This landcover data is based on 2014 LIDAR, along with 2013 and 2012 aerial imagery. It included forest canopy categories which we extracted to create a forest canopy layer for this analysis. Although this analysis includes both forest and agricultural lands because croplands can be converted to forest (afforested), existing forest cover, represented by this layer, received higher weighting.

5. Forest Health Risk

Forest health, and the potential for future threats to forest health, is vital to understanding the condition of Delaware's forests and helps guide future forest management decisions. This layer, provided by the USFS, helps assess forest health. It is based on Forest Inventory and Analysis (FIA) data and predicts the amount of mortality through basal area loss (a measure of forest stocking) due to forest insects and diseases over the next ten years at a one-kilometer scale. Because most of Delaware has an estimated future loss of zero, areas with estimated loss greater than 5% were used as the forest health risk input.

6. High Productivity Soils

Soil and water are essential for forests. Therefore, an assessment of a state's soils is an important component of a forest resource assessment because one may wish to consider soil quality when focusing forest conservation efforts. For this analysis, high productivity soils were defined as:

- For Kent and Sussex Counties, soils capable of producing loblolly pine annual growth increments of 320 board-feet per acre, per year, at age 50. This includes Evesboro loamy sand (but not Evesboro sand), Fallsington, Kalmia, Matawan, Pocomoke, Sassafras, and Woodstown soils.
- For New Castle County, soils capable of producing yellow-poplar annual growth increments of at least 300 board-feet per acre, per year, at age 50. Included are Bayboro, Butlertown, Codorus, Delanco, Evesboro, Fallsington, Hatboro, Johnston, Klej, Matapeake, Mixed alluvial, Rumford, Sassafras, and Woodstown soils.

7. Proximity to Existing Sawmills

Access to stable and diverse forest markets is important to keep private forestlands as forests. Without viable markets to generate income, many forest landowners will convert their forests to other uses. Traditional forest markets, such as primary wood processors (e.g., sawmills, paper mills, plywood mills, etc.), are a major component of forest markets. The DFS staff mapped sawmills, log concentration yards, and chip mills in the area. A 10-mile buffer around mills represents the area from which logs could be delivered at a very low hauling cost. Ten miles is conservative, but larger buffers would cover the entire state and therefore have no impact on the analysis. Facilities in Maryland were included if they were within ten miles of Delaware.

8. Wetlands

This layer from the Department of Natural Resources and Environmental Control (DNREC), Division of Watershed Stewardship includes all Delaware wetlands.

9. Resilient Lands

Resilient Lands is The Nature Conservancy's project to identify land with sufficient variability and microclimate options that enable species and ecosystems to persist in the face of climate change and which will maintain this ability over time. A site's resilience score estimates its capacity to maintain species diversity and ecological function as the climate changes. The score is relative to all other sites with the same geophysical setting and is described on a relative basis as above or below average. This layer included all sites with final resilience scores classified as slightly above, above, or far above average.

10. Wildland/Urban Interface (WUI)

The wildland/urban interface (WUI) demonstrates where urban areas are expanding. Therefore, it is likely that forests and other undeveloped lands in these areas will soon be impacted and/or replaced by development. Identifying these areas is important to a forest resource assessment as it can help focus where to spend limited public funds on forestry projects. USFS WUI data were used by extracting areas classified as:

- Medium Density Intermix – Housing density between 49.4 and 41.3/sq km and wildland vegetation > 50%.



- Medium Density Interface – Housing density between 49.4 and 741.3/sq km, wildland vegetation $\leq 50\%$ but within 2.4 km of an area with $\geq 75\%$ wildland vegetation.

<https://www.fs.usda.gov/rds/archive/catalog/RDS-2015-0012-2>



11. Natural Areas

Many of the most ecologically diverse habitats are found in forests. Conserving and protecting these areas is important to ensure that the plant and animal species found in these habitats continue to thrive. Delaware law (Title 7, Chapter 73) establishes a process to identify Natural Areas—those tracts that contain the best examples of diverse flora and fauna. This data layer contains Delaware’s Natural Areas identified by DNREC.

12. Low Development Risk

Loss of forestland to development is unavoidable. Future investments in forest conservation and forest management are usually more worthwhile in areas not targeted for development by state and local governments because these areas will not have the infrastructure (e.g., better roads, central sewer and water, etc.) necessary to support widespread, dense development. Delaware has identified four levels for state investment—Levels 1–3 include existing urban areas and those rural-urban fringe areas targeted for development in the future. Level 4, most of the state, is comprised of rural areas where no state-supported infrastructure improvements are planned and, thus, population growth is not desired. This data layer contains the Level 4 areas within Delaware’s existing 2015 State Strategies dataset.

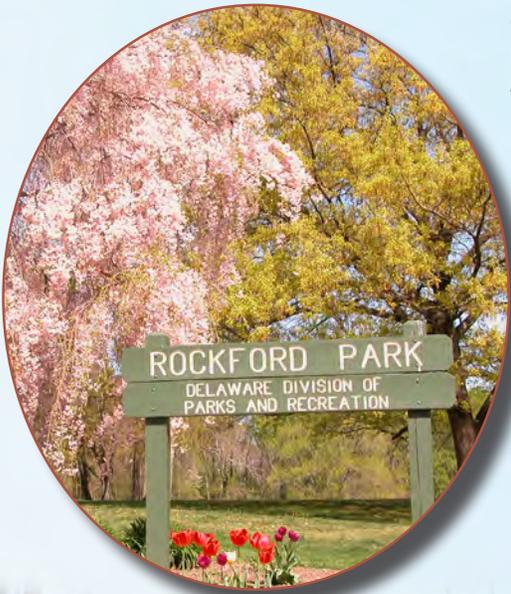


13. Protected Lands

This input contains all properties owned in fee simple (no easements) by federal, state, county, and local governments as well as non-governmental organizations (NGOs) with natural resource protection missions. This data layer attempts to capture public and NGO lands because these properties are likely to remain undeveloped. These properties often serve as the “core” areas for forest protection efforts. Expanding these core areas with additional purchases, easements on adjoining private lands, etc., can help maintain, expand, and connect large patches of forests. Knowing the location of these parcels can help guide future forest conservation efforts and investments.

The ownerships included in this layer are:

- State Parks
- State Fish & Wildlife lands
- Federal Fish & Wildlife lands
- State Forests
- Stockley Center
- NGO lands
 - Mt. Cuba Center
 - The Nature Conservancy



- Delaware Nature Society
- Delaware Wild Lands, Inc.
- Nanticoke River Watershed Alliance
- Hoopes Reservoir parcels owned by the City of Wilmington
- National Guard properties
- County Parks
- Other County-owned lands
- DeIDOT Open Space and other properties
- Community Open Space properties, where available

14. Historical/Cultural Sites

Historical and cultural sites are important to a state's history and recreational economy. Protecting these sites from land-use conversion helps ensure their preservation. DNREC Division of Historical & Cultural Affairs maintains data locating Delaware's 9,150 National Historic Landmark and National Historic Register places, along with four scenic byways, and 89 historic districts. A ½-mile radius around each site was used to represent a buffer. Forest cover around these sites can maintain and enhance their aesthetic value and provide other economic and environmental benefits (e.g., wildlife habitat, riparian buffers, etc.).

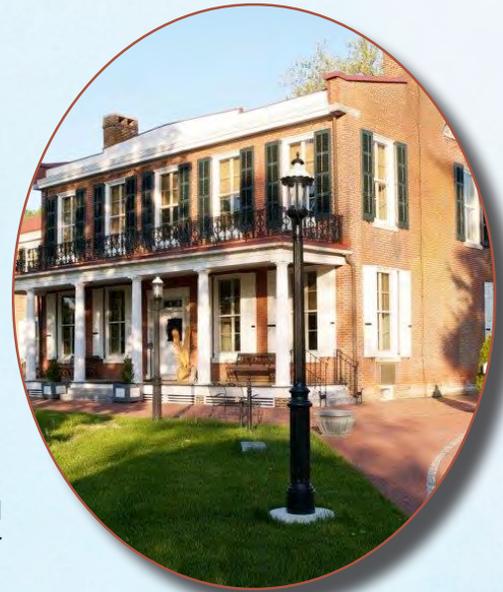
15. Conservation Easements

Conservation easements permanently protect land from development. Therefore, it is likely that forests under conservation easements will remain forested. In some circumstances, it is worthwhile to target technical and financial assistance to these areas because there is little danger of a change in land use. This input layer includes the following:

- Delaware Forest Service Easements (including Forest Legacy Easements)
- DNREC (Parks & Recreation, Fish & Wildlife) Easements
- Delaware Aglands Preservation Foundation Easements
- Delaware Forestland Preservation Program Easements
- Delaware Young Farmer Agricultural Easements
- DeIDOT Corridor Capacity Program Easements
- NRCS Wetland Reserve Easements

16. Forest Legacy Areas

This layer contains Delaware's four Forest Legacy Areas that were approved by the Secretary of Agriculture in 1998 as well as all subsequent revisions approved by the USFS. These are the areas where Delaware can use federal Forest Legacy Program funds to protect working forestlands and were identified as high priority areas in Delaware's Forest Legacy Assessment of Need. Forest Legacy Areas are to be incorporated into the State Assessment as stipulated by USFS guidelines.



Buena Vista in New Castle





Identifying areas that are most prone to high-intensity wildfires can help foresters better plan for and mitigate this threat.

17. Commercial Forest Plantation Act (CFPA) Properties

This data layer, maintained by the DFS, contains forestland enrolled in Delaware's Commercial Forest Plantation Act (CFPA). This tax abatement program provides a 30-year property tax exemption for privately owned forests at least 10 acres in size and that are managed for timber production following a forest management plan approved by the DFS. These properties are also typically well-managed and are more likely to remain forested, which is important information for the State Assessment.

18. High-Priority Watersheds

Clean water is a priority for all citizens. Unfortunately, many of Delaware's waterbodies do not meet the EPA definition of swimmable and fishable. Forests and forest management can help improve water quality, such as through the establishment of riparian forested buffers. The DNREC Division of Watershed Stewardship determines priority watersheds which were used for this data layer.

19. Groundwater Recharge/Drinking Water

Groundwater is the primary source for drinking water in Delaware. Forestland is widely recognized as providing clean, abundant water. Therefore, protecting the state's highest-quality forested groundwater areas is an important long-term strategy. This dataset contains the groundwater recharge areas classified as excellent by the Delaware Division of Water.

20. Wildfire Risk

Wildfires can pose a substantial risk to forest health. Identifying areas that are most prone to high-intensity wildfires can help foresters better plan for and mitigate this threat. While Delaware does not often experience intense wildfires, there are two cover types that are susceptible to incendiary fires— young loblolly pine plantations and areas dominated by the invasive reed, *Phragmites australis* (Fuel Model 3). Areas classified as moderate, high, or very high hazard were extracted from USFS LANDFIRE program's Wildfire Hazard Potential (2018) dataset for this analysis.

<https://www.landfire.gov/getdata.php>

21. Impaired Air Quality

Air quality is important for all life—plant and animal. Forests improve air quality by removing particulates and other pollutants. Therefore, governments may wish to target forest conservation efforts in areas with poor air quality. DNREC's Division of Air Quality issued its Delaware Annual Air Quality Report in 2017 and reported the following:

- All three counties had exceedances of ozone standards in 2007, New Castle County had more violations than Kent and Sussex. But since then there has been a downward trend in the three-year average ozone ppm value and starting in 2013 Kent and Sussex Counties have been below the 2015 standard while New Castle County was still in non-attainment.
- New Castle County failed to meet PM_{2.5} standards (PM_{2.5} refers to fine inhalable particles, with diameters generally 2.5 micrometers and smaller) during every year from 2001 through 2007. Kent and Sussex Counties did not have any PM_{2.5} violations during this same time period. However, since 2007, all three counties have met the annual standard.

Based on these and other historical findings by Delaware's air quality management agency, the boundary of New Castle County was used to map Delaware's poor air quality area.

Overlay Methodology

Each input layer was converted to a raster dataset (cells). A resolution of 30 meters was chosen as a compromise between limitations of existing data resolution and the desired high-resolution final product. This resolution is approximately equal to quarter-acre resolution, meaning there are about five million raster cells in the State.

All layers were “clipped” to a statewide layer consisting of forest cover and cropland, excluding all forest and cropland within municipal boundaries. This means that any land uses other than cropland or forest, and any lands of any type within municipal boundaries, were not included in the model. We included cropland because agricultural land can be converted to forest via planting or abandonment. We did not include municipal areas because a separate (and different) analysis was conducted for urban areas.

The following weighting scheme, based on the votes of Stewardship Committee members present at the June 2019 meeting, was utilized:

<u>Input Layer</u>	<u>Committee Rank</u>	<u>GIS Weighting</u>
Forest Fragmentation	1	2.0
Del. Habitats of Conservation Concern	2	1.9
Riparian Areas	3	1.7
Forest Cover	4	1.6
Forest Health Risk	5	1.3
High Productivity Soils	6	1.3
Proximity to Sawmills	7	1.3
Wetlands	8	1.1
Resilient Lands (TNC)	9	1.1
Wildland Urban Interface (WUI)	10	1.0
Natural Areas	11	1.0
Low Development Risk	12	1.0
Protected Lands	13	1.0
Historical/Cultural Sites	14	.9
Conservation Easements	15	.8
Forest Legacy Areas	16	.8
Commercial Forest Plantation Act (CFPA)	17	.8
High-Priority Watersheds	18	.8
Groundwater Recharge/Drinking Water	19	.7
Wildfire Risk	20	.7
Impaired Air Quality	21	.5



For each raster cell, each input layer present was included in the final score for that cell using a simple “present/not present” process. In other words, if a cell overlapped an input layer, then the cell received the weighted value for that layer and that value was included in the composite score. Consider the following example from a single cell near Georgetown in Redden State Forest:

<u>Input Layer</u>	<u>Final Score</u>	<u>Present</u>	<u>Final Weight</u>
Forest Fragmentation		Yes	2.0
Del. Habitats of Conservation Concern		Yes	1.9
Riparian Areas		No	0
Forest Cover		Yes	1.6
Forest Health Risk		Yes	1.3
High Productivity Soils		Yes	1.3
Proximity to Sawmills		Yes	1.3
Wetlands		No	0
Resilient Lands (TNC)		No	0
Wildland Urban Interface (WUI)		No	0
Natural Areas		Yes	1.0
Low Development Risk		Yes	1.0
Protected Lands		Yes	1.0
Historical/Cultural Sites		No	0
Conservation Easements		No	0
Forest Legacy Areas		Yes	.8
Commercial Forest Plantation Act		No	0
High-Priority Watersheds		Yes	.8
Groundwater Recharge/Drinking Water		No	0
Wildfire Risk		No	0
Impaired Air Quality		No	0
Total Composite Score			14.0

Note that the highest possible score would be 23.5 if all input layers were present in a cell, though no cell in Delaware scored higher than 16.3. Weights were specifically chosen with a sum of 23.5 so that the composite scores would be comparable to 2010 assessment scores which had the same total. In addition, a 2010 input raster was used as the raster analysis environment settings to ensure that 2020 raster cells were aligned with cells from the 2010 analysis, which is necessary for comparisons.

Rural Priority Landscape Area

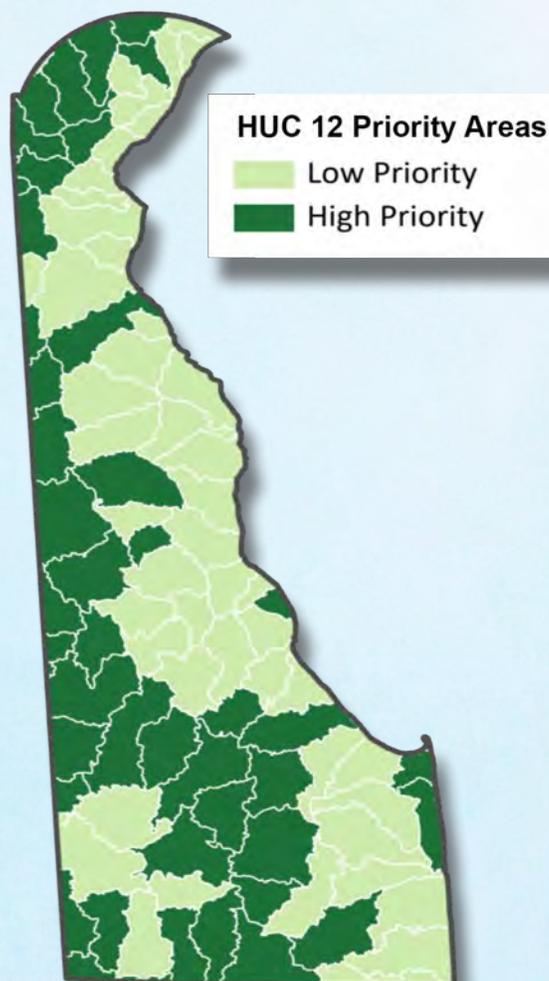
The final product from the weighted overlay of the 21 input layers had a resolution of 30 meters (Figure 45). Thus, a single acre of land could have high, medium, and low-priority cells. To match the 2010 assessment, priority values were averaged over each HUC 12 watershed (a local sub-watershed level that captures tributary systems). Delaware contains about 100 HUC 12 watersheds (or portions thereof) with an average area of about 13,000 acres.

Figure 45. Initial statewide composite map layer.



Source: Delaware Department of Agriculture

Figure 46. Draft priority area map by HUC watershed.



Source: Delaware Department of Agriculture

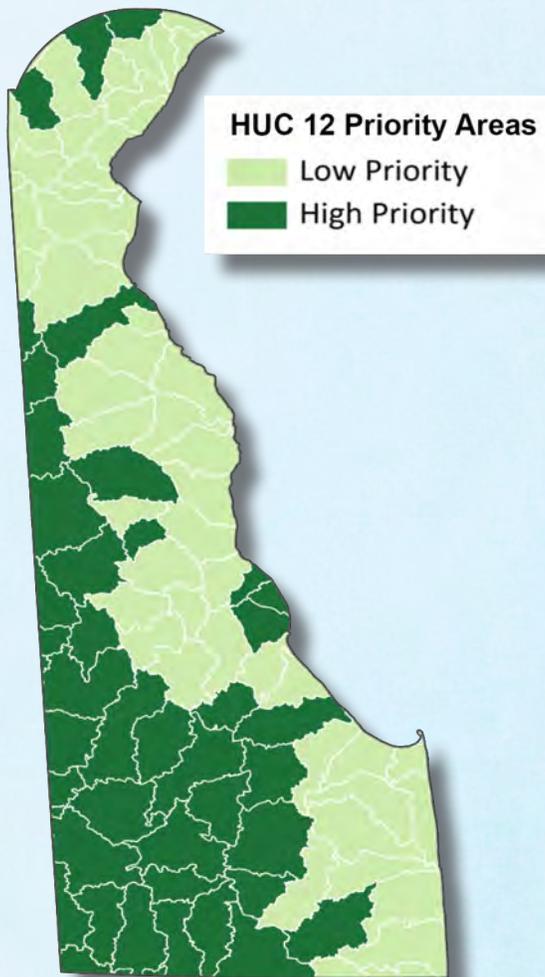
One additional analysis was used to prioritize each HUC 12 watershed as either high priority or low priority—the raster data was processed in Spatial Analyst using the Zonal Statistics tool. The composite scores for every cell within a given HUC 12 watershed were evaluated and a final mean value of those cells was assigned to that watershed. Mean composite scores for watersheds ranged from 2.9 to 10.7. A value of 5.35 was used as a cutoff for ‘high priority’ watersheds to be comparable with the 2010 assessment. This resulted in 43 of Delaware’s 100 HUC 12 watersheds receiving high priority (Figure 46).

This map was then reviewed by the Forest Stewardship Committee. While the Committee generally agreed with the final result, members felt unanimously that some changes were needed. Specifically, several watersheds in eastern Sussex County were removed from the high priority list because of limited opportunities for forestry activities in those areas. And several watersheds in southwestern Sussex County were added to the high priority list because of the high potential for successful forestry-related efforts and their location within the Chesapeake Bay watershed.

These changes were made, and a final map was produced (Figures 47 and 48). The Committee noted that this result was very similar to the natural resource prioritization efforts by other organizations including The Nature Conservancy and The Conservation Fund.

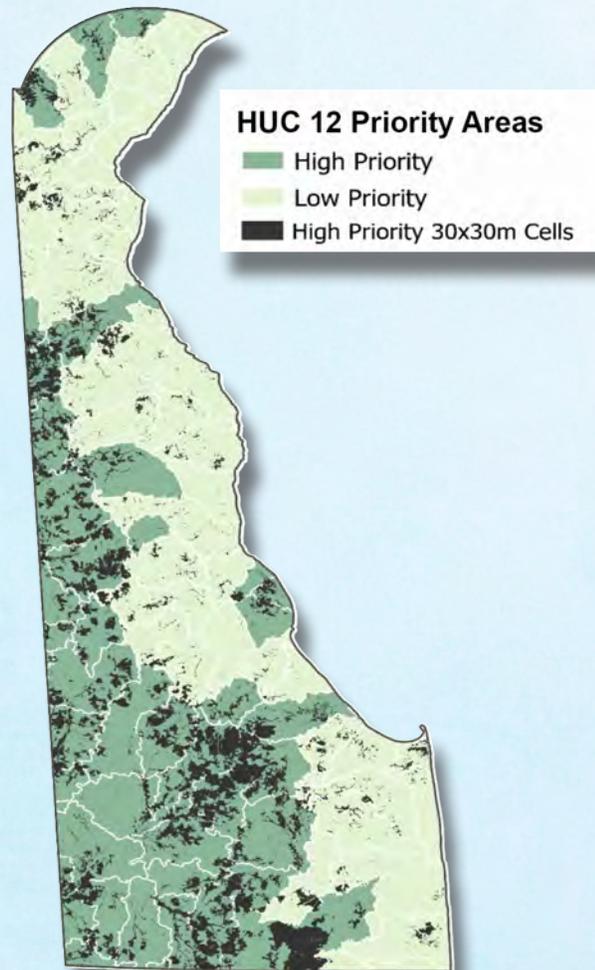


Figure 47. State Stewardship Committee priority HUC watershed map.



Source: Delaware Department of Agriculture

Figure 48. Detailed map of underlying pixel data for State Stewardship Committee priority area map.



Source: Delaware Department of Agriculture

Rural Priority Landscape Area Description

The State of Delaware occupies approximately 1.25 million acres along the mid-Atlantic coast, of which 442,593 acres are identified as the Priority Landscape Area (medium and high priority). Within the medium and high priority area, 336,000 acres are forested or 93% of the state's forestland base. This area spans both physiographic provinces (Piedmont and Coastal Plain) and all three counties—New Castle, Kent, and Sussex. The Piedmont province is found in the northernmost portion of the state (New Castle County) and is characterized by low rolling hills. The Coastal Plain province (Kent and Sussex County) lies south of the Piedmont province and is characterized by little topographic relief with extensive streams and tidal estuaries. The Priority Landscape Area encompasses 44 HUC 12 watersheds and four major drainage basins—Piedmont, Delaware Estuary, Chesapeake Bay, and Inland Bays.

Land ownership within the priority area includes many significant private and public land holdings. The Department of Agriculture's Forest Service manages over 21,100 acres, encompassing three State Forests—Blackbird (New Castle), Taber (Kent), and Redden (Sussex). The Delaware Division of Fish & Wildlife manages more than 57,000 acres of public land and the Division of Parks & Recreation manages just over 26,000 acres.



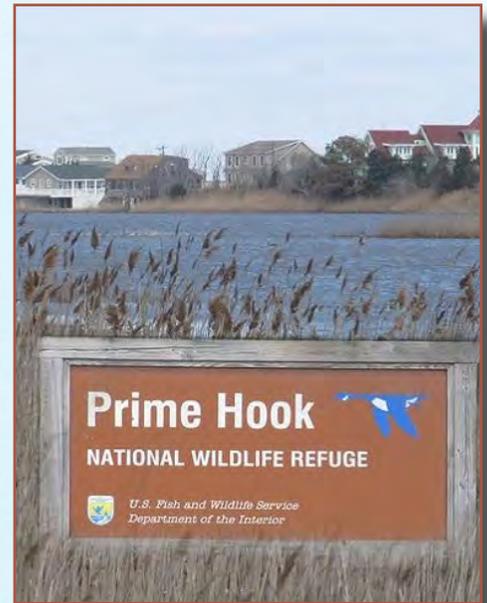
Prime Hook National Wildlife Refuge, located approximately ten miles north of Lewes, contains over 10,000 acres devoted to habitat protection for waterfowl, migratory birds, and other threatened and endangered species.

Private land within the rural priority area is protected by several non-profit conservation entities such as Delaware Wild Lands, Inc. (>19,000 acres), The Nature Conservancy (>5,000 acres), Delaware Nature Society (nearly 2,000 acres), and the Nanticoke River Watershed Conservancy (>500 acres). Private property owners also have the option of retaining the title to their land and placing it under a legally binding easement that prohibits or severely restricts future development. The Department of Natural Resources and Environmental Control (DNREC) maintains these types of easements on over 2,400 acres of land with various landowners. In addition, the Delaware Agricultural Land Preservation Foundation holds easements on approximately 139,000 acres of land, of which 27% is forested. The Delaware Forest Service (DFS) also holds easements on approximately 6,870 acres of working forests.

Though comparatively small, Delaware is rich in natural resources—from beaches to uplands, brackish and freshwater wetlands, and an abundance of flora and fauna—all defining Delaware’s natural heritage. The landscape has changed considerably since early European settlers arrived. Great majestic forests once dominated the landscape. However, many of these forests have been logged or converted to farmland. Today, land is transforming faster than ever before with much of the state becoming enveloped with development. This new growth has left habitats encroached, fragmented, water quality impaired, and has displaced many plant and animal species.

Land-use Planning

State, county, and local governments regulate land-use planning. Development projects within municipalities are subject to land-use reviews through local governments. However, most non-incorporated areas of the state are subject to reviews under the corresponding county office—New Castle County Department of Land Use, Kent County Department of Planning Services, and Sussex County Planning and Zoning Department. Overall planning guidance is coordinated through the Office of State Planning Coordination (OSPC), which reports to the Governor’s Office and directs state, county, and local planning efforts. Prior to submission to local governments, all major land-use changes are subject to review by state agencies (Chapter 92, Title 29 of Delaware Code). The DFS provides developers and local governments with alternatives to minimize development impacts, including recommendations for construction practices and subdivision layouts to preserve trees whenever and wherever practical.



The Delaware Estuary covers 520,960 acres, spans 16 watersheds and stretches north to the upper reaches of the Chesapeake and Delaware Canal and south to the Broadkill River.



Five Divisions of the Rural Priority Landscape Area

Delaware's rural priority landscape area spans four major drainage basins and one unique watershed. While all are similar in many respects, each is uniquely important. The watersheds found in Delaware are vital to Delaware's environment and economy because they provide homes for many plant and animal species, drinking water for residents, agricultural irrigation, and water to many industries. Below is a summary of each unique landscape division.

1. Delaware Estuary

The Delaware Estuary (520,960 acres) spans 16 watersheds and stretches north to the upper reaches of the Chesapeake and Delaware (C&D) Canal and south to the Broadkill River. This area includes 40,040 acres of rural forests on the Atlantic Coastal Plain, of which 25% is permanently protected through public land holdings and conservation easements. Of the high priority rural forest, 37% is publicly owned—the majority of which is managed by the Division of Fish & Wildlife (2,524 acres). The northernmost rural forests include areas along the western portions of Glasgow north of the C&D Canal. These forests, many of which are enrolled in the Commercial Forest Plantation Act, have been actively managed through private ownership. The southernmost forests serve as critical riparian buffers to impaired riverine systems such as Broadkill, Saint Jones, Murderkill, and Mispillion. Of the forests located in this basin, 30% serve as excellent ground water recharge areas.

The Delaware Bay's wetlands and tidal flats provide homes for many birds, mammals, fish, reptiles, amphibians, and invertebrates. This includes some endangered species like Atlantic sturgeon (*Acipenser brevirostrum*) and black skimmer (*Rynchops niger*). The wetlands found here are extremely important as they are designated as a Ramsar site, largely due to the association with migratory birds and the critical foraging/nesting grounds they provide. A Ramsar site is a wetland of international significance, based on representativeness, uniqueness or of biodiversity values designated by the National Ramsar Committee—a body of scientific and technical experts also called the National Wetland Committee. This area is also part of the Atlantic Flyway and is crucial to migrating waterfowl of concern, such as Canada geese (*Branta canadensis*) and black ducks (*Anas rubripes*). Likewise, millions of shorebirds use this area as a stop to feed upon invertebrates and horseshoe crab eggs before migrating to Arctic nesting grounds. In the southern portion of the Delaware Estuary, south to Prime Hook National Wildlife Refuge, habitat restoration programs are centered on stabilizing population numbers of the formerly federally endangered Delmarva fox squirrel (*Sciurus niger cinereus*), which was delisted in 2015. Many of the state's occurrences of the Delmarva Atlantic white-cedar (*Chamaecyparis thyoides*) swamp community are found along ponds and dams in the eastern portion of the basin, particularly along the Broadkill. Atlantic white-cedar swamps are habitats with unique soil characteristics and are home to many rare plant species including: grass-pink orchid (*Calopogon tuberosus*), coast sedge (*Carex exilis*), roundleaf sundew (*Drosera rotundifolia*), purple pitcher-plant (*Sarracenia purpurea*), curly-grass fern (*Schizaea pusilla*), and bog fern (*Parathelypteris simulate*). Stresses to the Delaware Estuary include incompatible development, unsustainable agriculture, climate change, altered hydrological regime, clearing of forests, and invasive species.

2. Blackbird Creek

The Blackbird Creek is a subset of the Delaware Estuary—it is of utmost ecological importance and therefore warrants a separate description within the high priority area. This designation is largely based on its tidal wetlands and forests as important features representing unique and high-quality areas of natural diversity. The Blackbird Creek spans approximately 19,000 acres and is nearly 34% (6,500 acres) forested in the most urbanized county of the state. 21% of the forests in Blackbird Creek are permanently protected including a portion of Blackbird State Forest (1,706 acres). Tidal wetlands dominate the far eastern portion and a high density of small, isolated wetlands occurs throughout the western portion of the area.

This area is home to the largest concentration of Coastal Plain seasonal ponds in Delaware. Coastal Plain ponds, also called Delmarva Bays, are unique, isolated, irregularly inundated freshwater depressional wetlands that offer habitat for many rare species. Rare plant species associated with the ponds include: rose coreopsis (*Coreopsis rosea*), Hirst Brother's panic grass (*Dichanthelium hirstii*), teal love-grass (*Eragrostis hypnoides*), Carolina redroot (*Lachnanthes caroliniana*), creeping St. John's-wort (*Hypericum adpressum*), and awned meadow beauty (*Rhexia aristosa*). Reptiles and amphibians include: tiger salamander (*Ambystoma tigrinum*), Cope's gray tree frog (*Hyla chrysoscelis*), barking tree frog (*Hyla gratiosa*), rough green snake (*Opheodrys aestivus*), brown creeper (*Certhia americana*), and four-toed salamander (*Hemidactylium scutatum*).

Additionally, Blackbird Creek lies within the Blackbird-Millington Corridor. This corridor is recognized as one of Delaware's most important areas of "Green Infrastructure"—a network of farms, forests, and other natural areas that supports native species, maintains ecological processes, sustains air and water resources, and contributes to the health and quality of life for communities and people. Natural resource use continues to play an important but changing role in the area over time. From 1937 to 1997, cultivated land in the Blackbird Creek watershed decreased by 16% and estuarine water and tidal mud-flats in the eastern part of the area increased. The decline of agriculture on the Delmarva Peninsula, and its likely replacement with development, is a major concern. Blackbird Creek represents a tremendous water pollution control opportunity as 25% of the forests lie in excellent recharge areas.

3. Inland Bays

Delaware's Inland Bays, totaling over 103,000 acres, consist of three interconnected bodies of water—Indian River Bay, Little Assawoman Bay, and Rehoboth Bay—located in the southeastern part of Delaware in Sussex County. There are 44,000 acres of forests within the Inland Bay portion of the priority forest area and of that approximately 11,370 acres (25%) are permanently protected. 79% of the protected land is owned by non-governmental organizations.

The Inland Bays historically have provided nursery areas and habitats for a variety of shellfish, finfish, and other wildlife. Over the past century, many of these desirable species have declined in numbers due to the loss of suitable habitat and the unavailability of appropriate food. The loss of valuable habitat is an important symptom of the stressed conditions of the Inland Bays. Developed lands now comprise more than one-fourth of the total Inland Bays area. This ever-increasing growth stresses the area and creates new management challenges such as nutrient overloads, harmful algal blooms, and red/brown tides. Federally threatened species such as the piping plover (*Charadrius melodus*) and swamp pink (*Helonias bullata*) plant have suffered due to habitat loss, encroachment, and destruction.

Blackbird Creek spans approximately 19,000 acres and is nearly 34% forested (6,500 acres) in the most urbanized county of the state.



The Inland Bays total over 103,000 acres and consist of three interconnected bodies of water—Indian River Bay, Little Assawoman Bay, and Rehoboth Bay.



The Piedmont Basin includes the northernmost portions of the state. Almost 50% of the forests here are permanently protected through public lands or conservation easements.



BRANDYWINE CREEK
STATE PARK



The Inland Bays are degraded waters of Exceptional Recreational and Ecological Significance (ERES) with a commitment of restoration to a healthy condition by government and stakeholder groups. Pollution Control Strategies (PCS) adopted by DNREC in 2008 clearly illustrate the importance of forested buffers in the Inland Bays. DNREC formally proposed a regulation that includes provisions requiring riparian buffers and improved stormwater management. Riparian buffers along primary waters (state regulated wetlands, tidal and permanent) and secondary water features (seasonal ponds, ditches near forests, etc.) must be established as land is developed. These buffers must be 100-foot wide on primary waters and 60-foot wide on secondary waters. Conversely, buffers are not required within existing, developed lands or agricultural lands.

4. Piedmont Basin

The Piedmont Basin includes the northernmost portions of the state. This area comprises approximately 32,000 acres, of which 10,000 acres lie within the priority forest area of the Piedmont Physiographic province. These forests are the most extensive mature piedmont forests. Almost 50% of the forests here are permanently protected through public lands or conservation easements. The Brandywine Creek State Park and White Clay Creek State Park comprise the majority of the land, which is managed by the Division of Parks & Recreation. Delaware Nature Society (>1,200 acres), Brandywine Conservancy (483 acres), and DNREC (236 acres) hold the majority of the conservation easements.

Two unique communities found in the Piedmont province of Delaware are Piedmont Streamside Seepage Wetlands and Piedmont Tuliptree Rich Woods. Piedmont Streamside Seepage Wetlands are freshwater wetlands that occur at the base of steep slopes and are fed by groundwater year-round. These wetlands are typically dominated by spotted jewel-weed (*Impatiens capensis*), sensitive fern (*Onoclea sensibilis*), and tussock sedge (*Carex stricta*)—an important plant associated with the federally listed endangered bog turtle (*Glyptemys muhlenbergii*). Piedmont Tuliptree Rich Woods are dominated by tulip-poplar (*Liriodendron tulipifera*), northern red oak (*Quercus rubra*), and a diverse herbaceous layer that includes species like mayapple (*Podophyllum peltatum*) and Christmas fern (*Polystichum arcostichoides*). Rare species associated with this community include American ginseng (*Panax quinquefolius*), golden-seal (*Hydrastis canadensis*), green violet (*Hybanthus concolor*), and white baneberry (*Actaea pachypoda*).

The Piedmont Basin encompasses six watersheds: Naamans Creek, Shellpot Creek, Brandywine Creek, Red Clay Creek, White Clay Creek, and the Christiana River. More than half of the stream segments found in these watersheds are identified as impaired from nonpoint source pollution. In addition, habitat loss, the proliferation of invasive species, and ecosystem degradation are widely recognized as major factors in the decline of native plant and animal populations. Today, most of the forests in this area are less than 50 acres in size with little to no forest interior, 75–100 years old, and heavily infested with literally dozens of aggressive, non-native plant species.



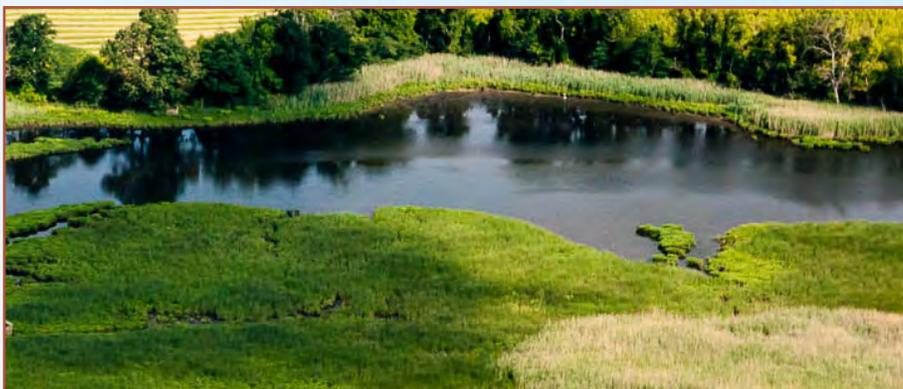
5. Chesapeake Basin

The Chesapeake Basin, at over 451,000 acres, includes 15 watersheds and approximately 160,000 acres defined as priority forest area. The basin extends northward from the State's southern border, encompassing nearly half of Sussex County, crossing through the western third of Kent County, and extending into New Castle County west of Middletown. Of the 160,000 acres of this critical forested area, 46% or 74,677 acres are permanently protected. Public land accounts for 33,275 acres. These lands are managed by the DFS and DNREC's Divisions of Fish & Wildlife and Parks & Recreation. Additionally, non-governmental organizations own 567 acres within the watershed. Conservation easements are held through the Department of Agriculture (34,386 acres) and DNREC (332 acres). Forestland ownership is still primarily non-industrial, however, DFS holds easements on some industrial forest tracts, including lands owned by the Glatfelter Pulp Wood Company. These lands account for 5,894 acres of the forests in the Chesapeake Basin.

Many habitats, identified in the Delaware Wildlife Action Plan, are found in this basin such as coastal marine waters, marshes, freshwater streams, wetlands, upland forests, and meadows. Many of these habitats are crucial for rare, threatened, or endangered species. Critical habitats consisting of forested blocks of 250 acres or more are vital for those species of greatest conservation need. The basin also features unique communities such as the northernmost natural stand of baldcypress (*Taxodium distichum*) found in Trap Pond State Park. Agriculture still remains a vital part of the economy, although its role is diminishing. Soils are favorable for agricultural production and are illustrated by the large number of farms under conservation easements (395 parcels totaling 35,000 acres).

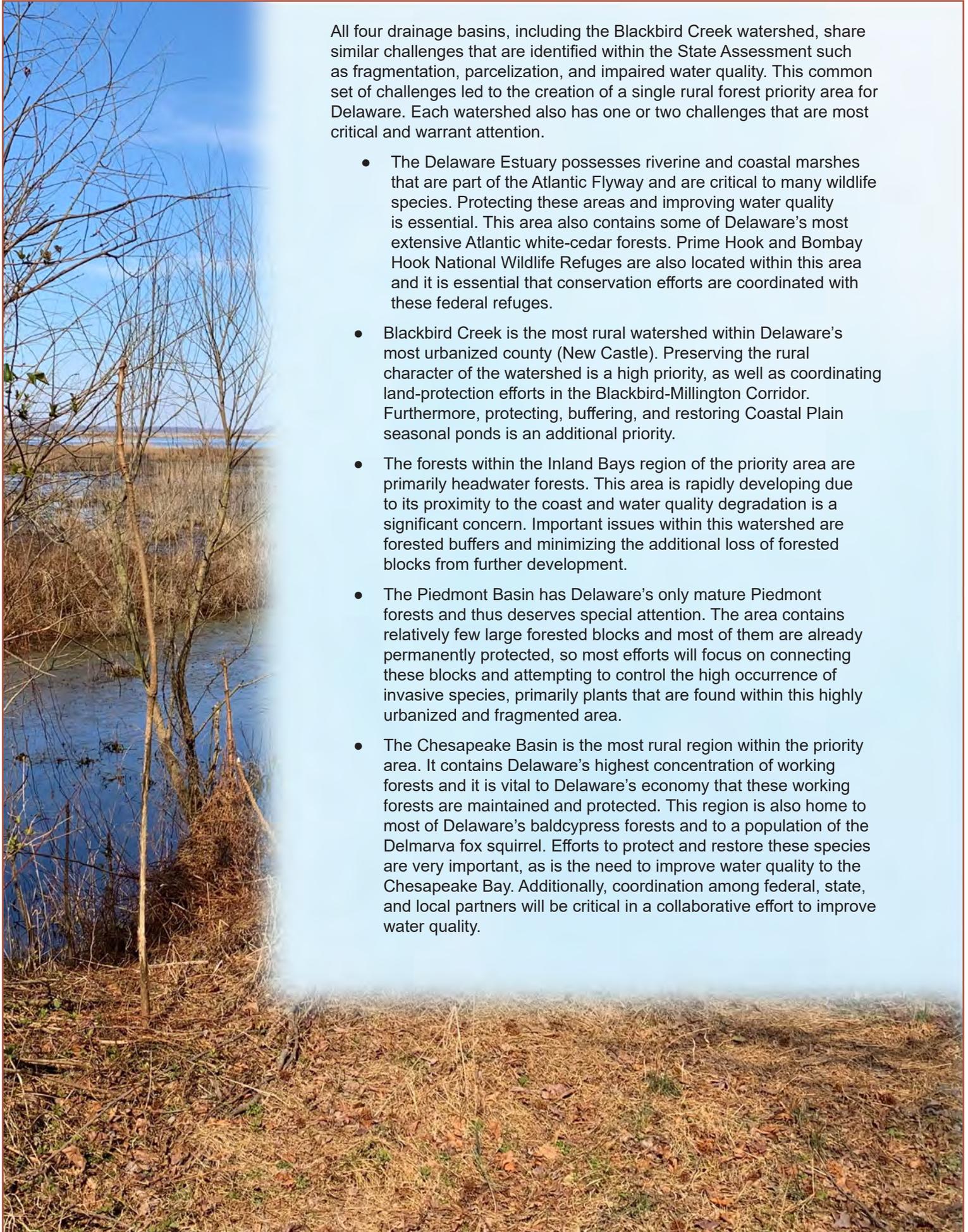
Population growth rates in Sussex County are the fastest in the state, leading to new development and urban sprawl. This has created a new set of water quality stressors in the Basin. Unfortunately, most development (to accommodate this influx of new residents) is served by septic systems as feasibility studies have found that public sewer is not practical in most rural areas. DNREC water quality analyses of the Chesapeake Basin have shown that the waters are impaired by high levels of bacteria and designated water body uses are not fully supported due to pollution levels. DNREC has set Total Maximum Daily Loads (TMDL) in response to the listing of water bodies in the 303(d) report of the Federal Clean Water Act (CWA). To combat water quality issues surrounding the Chesapeake Drainage Area and Chesapeake Bay, former President Barack Obama signed an Executive Order that recognizes the Chesapeake Bay as a national treasure and called on the federal government to lead a renewed effort to restore and protect the nation's largest estuary and its watershed.

Summary



The Chesapeake Basin, at over 451,000 acres, includes 15 watersheds and approximately 160,000 acres defined as a priority forest area.





All four drainage basins, including the Blackbird Creek watershed, share similar challenges that are identified within the State Assessment such as fragmentation, parcelization, and impaired water quality. This common set of challenges led to the creation of a single rural forest priority area for Delaware. Each watershed also has one or two challenges that are most critical and warrant attention.

- The Delaware Estuary possesses riverine and coastal marshes that are part of the Atlantic Flyway and are critical to many wildlife species. Protecting these areas and improving water quality is essential. This area also contains some of Delaware's most extensive Atlantic white-cedar forests. Prime Hook and Bombay Hook National Wildlife Refuges are also located within this area and it is essential that conservation efforts are coordinated with these federal refuges.
- Blackbird Creek is the most rural watershed within Delaware's most urbanized county (New Castle). Preserving the rural character of the watershed is a high priority, as well as coordinating land-protection efforts in the Blackbird-Millington Corridor. Furthermore, protecting, buffering, and restoring Coastal Plain seasonal ponds is an additional priority.
- The forests within the Inland Bays region of the priority area are primarily headwater forests. This area is rapidly developing due to its proximity to the coast and water quality degradation is a significant concern. Important issues within this watershed are forested buffers and minimizing the additional loss of forested blocks from further development.
- The Piedmont Basin has Delaware's only mature Piedmont forests and thus deserves special attention. The area contains relatively few large forested blocks and most of them are already permanently protected, so most efforts will focus on connecting these blocks and attempting to control the high occurrence of invasive species, primarily plants that are found within this highly urbanized and fragmented area.
- The Chesapeake Basin is the most rural region within the priority area. It contains Delaware's highest concentration of working forests and it is vital to Delaware's economy that these working forests are maintained and protected. This region is also home to most of Delaware's baldcypress forests and to a population of the Delmarva fox squirrel. Efforts to protect and restore these species are very important, as is the need to improve water quality to the Chesapeake Bay. Additionally, coordination among federal, state, and local partners will be critical in a collaborative effort to improve water quality.

VII. Urban Priority Landscape Areas

Overview

Urban and community forests are the collection of trees growing within a city, town, or community. The care and management of these trees is the priority of the Urban and Community Forestry (U&CF) program. Urban and community areas in Delaware have grown significantly in the past decade, with steady population growth in all three counties of the state. Additionally, trees in urban areas of the State of Delaware have many or even more of the challenges that are found in rural forests. Public awareness of the need for tree care, increasing tree canopy, and protecting trees from pest and disease risks are a few of the obstacles to managing urban forests. The goal of this assessment is to identify priority areas of focus for assistance as well as priority issues statewide to focus efforts for the next ten years.

The incorporated 57 municipalities were evaluated using a Geographic Information System (GIS). The model for the analysis was a formula that weighted each community according to the following criteria:

1. Percentage of urban tree canopy (UTC) (25%)
 - Total tree canopy (50% of UTC)
 - Roadside tree canopy (50% of UTC)
2. Impervious surface index (IMP) (25%)
3. Population index (20%)
 - Population density per square mile index (PD) (75% of PD)
 - Presence in census urban area (CUA) (25% of PD)
4. Opportunity zone presence (OPZ) (10%)
5. Pest risk index (PR) (10%)
6. Community investment score (CI) (10%)
 - Four factors (see text) each worth 25% of the total CI score

For “index” criteria, the actual value was converted to a 0–1 index using the following formula to normalize values. $Value_{city}$ is the actual measured value for a municipality, $Value_{min}$ and $Value_{max}$ are the minimum and maximum observed values for all municipalities in Delaware. Other values were calculated as shown below.

Urban and community areas in Delaware have grown significantly in the past decade. Delaware has seen steady growth in all three counties of the state.



$UCF_{index} =$

$$25 \left(1 - \frac{UTC_{city} + UTC_{road}}{2} \right) + 25(IMP_{city}) + 15 \left(\frac{PD_{city} - PD_{min}}{PD_{max} - PD_{min}} \right) + 5 \left(CUA_{true} \begin{cases} x = 1 \\ x = 0 \end{cases} \right) \\ + 10 \left(OPZ_{true} \begin{cases} x = 1 \\ x = 0 \end{cases} \right) + 10 \left(\frac{PR_{city} - PR_{min}}{PR_{max} - PR_{min}} \right) + 10 \left(\sum_{i=1}^4 CI_{i=true} \begin{cases} x = 0.25 \\ x = 0 \end{cases} \right)$$

The goal is to prioritize work and expenditures in municipalities with low tree canopy—where there is the most room for improvement.



Input Layers

The data for the urban analysis is described further below:

1. Urban Tree Canopy (UTC)

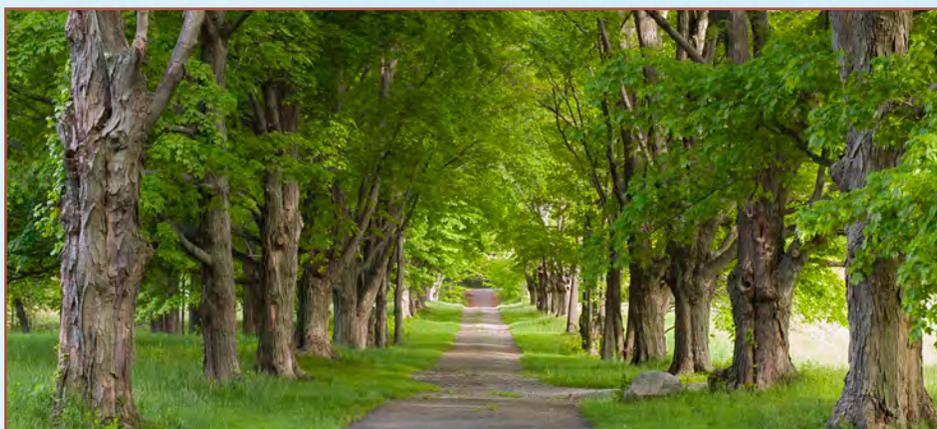
Urban tree canopy is obviously an important component of an urban forest resource assessment. The goal is to prioritize work and expenditures in municipalities with low tree canopy—where there is the most room for improvement—so the inverse of the calculated tree canopy index is used.

Using a 2014 statewide tree canopy dataset (described in the rural priority section), two measures of urban tree canopy were calculated. The average of these two measures was used for this component.

- Total tree canopy is the area of a town covered by tree canopy divided by the total area.
- Roadside tree canopy is a subset of overall canopy that calculates canopy cover within 10 feet of the roads within each town. The 10-foot buffer is not meant to capture the entire canopy (a single tree's canopy spread is often much wider) but serves as a sample area for calculating a roadside canopy cover. The goal is to estimate street tree canopy for each town, because:
 - Street trees have a high visual impact for residents evaluating the quality of their urban forest,
 - Street tree plantings are often targeted by urban tree projects, both for the visual impact and because street trees are often the only opportunity for municipal governments to improve urban forest on privately-owned land, and
 - In some towns and communities where street/residential canopy is largely absent, the overall UTC is higher because of large woodlots within their boundary limits. Often, these areas are annexed rural lands awaiting development. Roadside tree canopy inclusion serves to moderate that effect.

2. Impervious Surface Index

Impervious cover was derived from the same landcover data used to create the canopy cover data (described in the rural assessment under forest cover). Impervious classes were extracted, and percent impervious cover was calculated as the area with impervious cover divided by total area.



3. Population Index

Population density was used to measure the pressure a town’s population places on its forest resources. The population index contains two weighted components—population density (75%) and presence in a U.S. Census urban area (25%). The urban area component was added because raw population density can be deceiving in cases where a small population lives in a very small area. For instance, in the 2010 assessment one small, rural town had higher population density than Dover, the state capital, in spite of the fact that its total population was only 78.

- Actual population density was calculated as the population of each community (2010 Census) divided by the size of each community in square miles.
- Presence in a U.S. Census Urban Cluster was determined by comparing municipal boundaries with Urban Cluster data published by the U.S. Census. The score is a simple presence/absence where a municipality that overlaps an urban cluster receives full points for this component, otherwise it receives a zero.

4. Opportunity Zones

Opportunity zones are an economic development tool designed as revitalization programs in economically-distressed communities in Delaware. Delaware’s opportunity zones were selected by Governor Carney in 2018 and then are designated by the U.S. Department of the Treasury. There are 25 opportunity zones in Delaware that cover both rural and metropolitan areas. By incorporating this factor, it will help support urban forestry programs in areas of economic need. Municipalities received full points if they overlapped an opportunity zone, zero if they did not.

5. Pest Risk Index

Potential for future threats to forest health is critical to understanding the condition of urban forests. This layer, provided by the U.S. Forest Service, is based on Forest Inventory and Analysis (FIA) data and predicts the amount of mortality through basal area loss due to forest insects and diseases over the next ten years at a one-kilometer scale. This component was calculated as the percent of the municipal area with an estimated loss greater than 5%.

6. Community Investment Score

The community investment score measures how prepared communities are to implement a Delaware Forest Service (DFS)-supported urban forestry project. Each of these factors is worth 25% of the community investment score.

- A city manager (or equivalent) who can apply for and serve as point of contact for DFS urban forestry projects.
- Community-owned parks or community control of street trees. Communities with neither of these usually have trouble finding land for urban forestry projects.
- A municipal tree ordinance shows prior commitment to urban trees and can facilitate other factors in an urban forestry project.
- A municipal tree budget shows commitment to urban trees and increases a town’s ability to provide match for grant programs.

An important note is that these factors are under the control of each individual community, relative to other assessment factors. For instance, a community could pass a tree ordinance and add tree care to their budget, and this would increase their priority score in a future update of this assessment. This gives communities the capacity to improve their own score.

Table 24. Urban priority rankings.

<i>Community</i>	<i>Score</i>
Wilmington	70.9
Georgetown	61.4
Newark	59.7
Newport	59.0
Smyrna	56.1
Seaford	55.7
Dover	55.4
New Castle	55.1
Elsmere	54.2
Milford	54.1
Bellefonte	52.2
Laurel	49.2
Dewey Beach	48.2
Clayton	47.3
Middletown	47.2
Fenwick Island	46.9
Wyoming	46.5
Townsend	46.0
Bethany Beach	43.2
Rehoboth Beach	43.0
Harrington	43.0
Felton	42.7
South Bethany	42.0
Camden	41.4
Frankford	41.1
Blades	41.0
Dagsboro	40.5
Milton	40.4
Lewes	40.0
Cheswold	39.7
Little Creek	39.7
Millsboro	39.6
Delmar	38.0
Ocean View	36.7
Odessa	36.4
Greenwood	35.0
Hartly	34.9
Bowers Beach	34.2
Millville	34.2
Delaware City	33.3
Kenton	33.1
Houston	32.4
Frederica	32.2
Bridgeville	31.9
Magnolia	31.5
Viola	31.3
Woodside	31.1
Farmington	30.7
Selbyville	29.1
Ellendale	28.9
Leipsic	26.3
Bethel	25.6
Henlopen Acres	25.5
Ardentown	24.9
Slaughter Beach	24.1
Arden	22.2
Ardencroft	21.5

Table 25. Urban priority communities.

Community	Total Acres	2010 Population	Pop Dens/ Sq Mi	Canopy Acres	Roadside Canopy Acres	Total Canopy Percent	City Manager	Priority Score
Wilmington	6,739	70,851	6,729	1,464	177	24.3	Yes	70.9
Georgetown	3,193	6,422	1,287	993	20	31.7	Yes	61.4
Newark	5,989	31,454	3,361	2,273	102	39.7	Yes	59.7
Newport	314	1,055	2,148	63	3	21.1	Yes	59.0
Smyrna	3,755	10,023	1,708	560	22	15.5	Yes	56.1
Seaford	3,212	6,928	1,381	789	32	25.6	Yes	55.7
Dover	14,938	36,047	1,544	3,845	132	26.6	Yes	55.4
New Castle	1,821	5,285	1,857	493	17	28.0	Yes	55.1
Elsmere	636	6,131	6,167	203	15	34.2	Yes	54.2
Milford	6,207	9,559	986	1,284	31	21.2	Yes	54.1
Bellefonte	113	1,193	6,781	38	5	38.7	No	52.2
Laurel	1,725	3,708	1,376	448	13	26.7	Yes	49.2
Dewey Beach	198	341	1,103	44	6	25.5	Yes	48.2
Clayton	1,200	2,918	1,556	217	5	18.5	No	47.3
Middletown	7,467	18,871	1,618	934	17	12.7	Yes	47.2

Urban Priority Landscape Areas

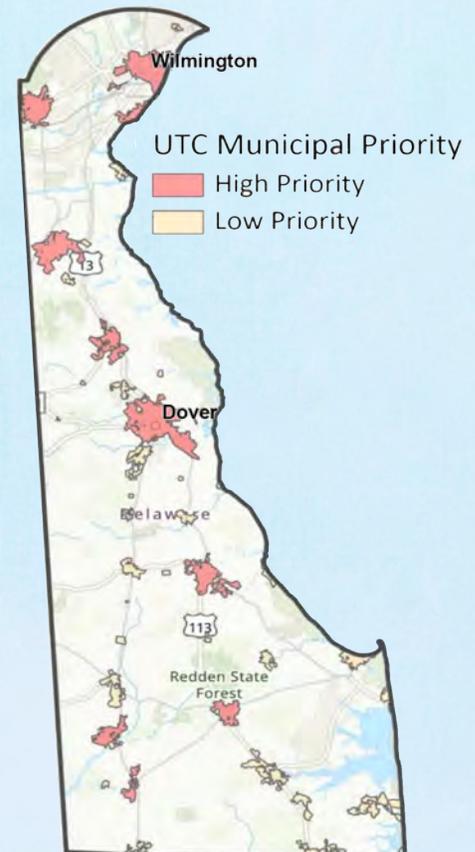
The result of the analysis yielded an indexed list of all 57 communities in Delaware ranging from zero to one-hundred. Higher ranking indicates higher priority for U&CF program delivery. However, lower ranked communities will benefit with targeted U&CF resources. The scores based on the weighted equation ranged from 70.9 to 21.5 (Table 24). The DFS decided that the first 15 communities would be a reasonable threshold for the high priority urban forestry areas. The cutoff for the priority areas was 47.2 This was based on previous experience working throughout the state in these areas and the need and potential for urban forestry resources (Table 25 and Figure 49).

Of these 15 high priority areas determined by the DFS, four of the municipalities are within the Chesapeake Bay watershed. These areas are also experiencing growth and expansion. As these communities grow it is important to consider water quality issues and working with municipal governments to increase tree canopy and decrease impervious surfaces, which often result from widespread development.

A majority of the 57 communities (nearly three-quarters), fall within Delaware opportunity zones and including opportunity zones into the equation has allowed the DFS to better identify areas of resource need. For example, 20 of 25 Delaware opportunity zones are within brownfield redevelopment sites. This may provide the opportunity to incorporate urban forestry during mitigation planning to encourage green infrastructure.

Though the high priority communities lie within the top 15 of the priority indices, there are other municipalities throughout the state that should fall under priority communities deserving assistance. These communities may have all the parameters of the feasibility score but need assistance from the U&CF program. The converse will also be considered when identifying areas in Delaware with low feasibility scores but may have opportunity to grow the urban forestry management component in the community.

Figure 49. Urban priority areas based on composite scores (high cutoff = 47.2).



Source: Delaware Department of Agriculture.

Wildland Fire Preparedness Priority

Wildfires pose a substantial risk to some communities. While Delaware does not often experience intense wildfires, there are two cover types that are susceptible to incendiary fires, including one that is found within/adjacent to many communities—areas dominated by the invasive reed, *Phragmites australis* (Fuel Model 3). Identifying these areas allows the DFS to help those communities prepare for this risk. Wildland fire risk is estimated as the percentage of municipal land covered by each of the following datasets. The DFS examined these results to determine the high-priority communities for wildland fire preparedness (Table 26).

1. USFS LANDFIRE Wildfire Hazard Potential
Areas classified as moderate, high, or very high hazard were extracted from the 2018 Wildfire Hazard Potential dataset for this analysis.
<https://www.landfire.gov/getdata.php>
2. USFS Wildland Urban Interface
USFS Wildland Urban Interface data were used by extracting areas classified as:
 - Medium Density Intermix: housing density between 49.4–741.3/sq km and wildland vegetation >50%.
 - Medium Density Interface: housing density between 49.4–741.3/sq km, wildland vegetation ≤ 50% but within 2.4 km of an area with ≥75% wildland vegetation.
<https://www.fs.usda.gov/rds/archive/catalog/RDS-2015-0012-2>

Several other factors were taken into consideration for ranking communities besides the DFS data layers and Landfire GIS analysis. These included the following:

- Potential for fire spread to nearby structures,
- Access to evacuation routes,
- Fires over 10 acres in the last five years, and



Table 26. Wildland Urban Interface (WUI) priority communities.

Community	Total Acres	2010 Population	Pop Dens/ Sq Mi	Wildfire Hazard Acres	Wildfire Hazard %	WUI Acres	WUI %
Frederica	827	774	599	199	24	0	0
Lewes	2,199	2,747	800	166	8	25	1
Slaughter Beach	235	207	565	102	44	39	17
New Castle	1,821	5,285	1,857	44	2	168	9
Leipsic	101	183	1,157	35	34	0	0
Delaware City	1,164	1,695	932	34	3	21	2
Bowers Beach	109	335	1,971	29	27	53	49
Odessa	299	364	779	25	8	2	1
Bethany Beach	695	1,060	976	17	2	0	0
Rehoboth Beach	543	1,327	1,564	7	1	27	5
South Bethany	263	449	1,092	2	1	1	0
Henlopen Acres	149	122	523	0	0	70	47
Little Creek	60	224	2,397	0	0	51	85
Fenwick Island	189	379	1,283	0	0	0	0
Dewey Beach	198	341	1,103	0	0	0	0

VIII. Multi-State Regional Priority Landscape Areas



The Delaware Forest Service (DFS), working with the U.S. Forest Service, the Northeast-Midwest State Foresters Alliance (NMSFA), and the Delaware Forest Stewardship Committee identified the following multi-state regional priority areas:

- Chesapeake Bay Watershed
- Delmarva Peninsula and Mid-Atlantic Coastal Plain
- Interstate 95 Corridor
- Delaware River Watershed
- Blackbird-Millington Corridor

All of these areas, except for the Blackbird-Millington Corridor, are listed in the 2016 U.S. Forest Service, Eastern Region State and Private Forestry publication NA-FR-02-16 entitled *Multi-State Priority Areas in the Northeast and Midwest* (Philip A. DeSenze, Compiler, 75 pp.).

Chesapeake Bay Watershed

Roughly 30% of Delaware—along the western section of the state including all three counties—drains into the Chesapeake Bay watershed. Delaware's portion of the total watershed is about 1%. Delaware is classified as a headwaters state for the bay—it is within the watershed but not adjacent to the Chesapeake Bay. Nearly all of the Chesapeake Bay watershed within Delaware was identified as part of the rural forest priority area, which further demonstrates the importance of the Chesapeake Bay watershed to our state. While many regions of the watershed are heavily urbanized, Delaware's portion of the Chesapeake Bay watershed is still quite rural with only a handful of small towns. The DFS will continue to work with its partners, both within and outside Delaware, to maintain and restore forests in this watershed, particularly focusing on opportunities to preserve and restore riparian and headwater forests and large forested blocks. Below is a description of the Chesapeake Bay watershed developed by the U.S. Forest Service including priorities and partnerships germane to Delaware.

Several natural resource and conservation efforts have taken place over the past decade to clean up and restore the Chesapeake Bay. This is recognized as a high national priority, involving federal agencies, including the Environmental Protection Agency, Department of Agriculture, and Department of the Interior, as well as state agencies and other partners. States are involved in various efforts to reforest Chesapeake Bay tributaries, reduce sediment loads into those streams, minimize urban impacts, and restore the bay to its former condition. Since 2008 these efforts have protected over 150,000 acres of high-value private working forests from development. Additionally, the Eastern Region State and Private Forestry and Chesapeake Bay Program completed and jointly released an updated *“Chesapeake Forest Restoration Strategy”* in 2020. This document outlines forest restoration in urban and community, agricultural, and natural landscapes. All of the states listed below also signed on to an agreement of shared stewardship with the U.S. Forest Service in 2020.

States:

Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, District of Columbia

Area contains the following America's Great Outdoors priorities:

Landscapes of National Significance

- *Captain John Smith Chesapeake National Historic Trail* – District of Columbia, Delaware, Maryland, Virginia

Rivers and Water Trails

- *Nanticoke River – Captain John Smith Chesapeake Connecting Trail* – Delaware

Existing Partnerships

- Atlantic Coastal Fish Habitat Partnership
- Atlantic Coast Migratory Bird Habitat Joint Venture
- Chesapeake Bay Commission
- Chesapeake Bay Program
- Chesapeake Bay Watershed Initiative
- Mid-Atlantic Climate Change Response Framework
- Mid-Atlantic Panel on Aquatic Invasive Species
- North Atlantic Landscape Conservation Cooperative
- Working Lands for Wildlife (bog turtle and golden winged warbler)

Opportunities for Partnership, Cooperation, and Projects

- Support ecosystem markets and land registries to generate additional incentives for continued forest conservation and restoration.
- Work closely with the USDA Natural Resources Conservation Service to prioritize forestry projects under the Chesapeake Bay Watershed Initiative.
- Develop sustainable forestry incentives and policies to stimulate improved forest conservation through:
 1. Tax incentives: income tax credit for developing a forest stewardship plan; expanded property tax rebate for forest stewardship plans.
 2. Effective and equitable regulations, particularly related to harvesting.
 3. Forest enterprise zones to support healthy forest product markets and technical innovation for new markets.
 4. Forest health reserve fund to improve response to forest health threats.
 5. Family forest revolving loan fund to support intact intergenerational transfer of forest land.
- Link forests, storm water, and water supply through Comprehensive Plan elements like Sensitive Areas, Water Resources, and Land Protection Plans, and through new requirements for prioritized environmental site design for storm water.
- Support dedicated land conservation funding through state and local ballot measures.
- Adopt a transferable or refundable tax credit program, or both, for donated conservation easements.





- Support effective Transferable and Purchase of Development Rights programs in local jurisdictions.
- Work with federal, state, and local organizations to improve technical assistance to forest landowners.
- Invest in ongoing conservation education, outreach, and technical assistance to local jurisdiction planners and landowners to improve forest conservation and management, and to schools.

Reference:

Eastern Region State and Private Forestry; Chesapeake Bay Program. 2012. Chesapeake forest restoration strategy. Newtown Square, PA: U.S. Department of Agriculture, Forest Service. 35 p. <http://executiveorder.chesapeakebay.net/chesapeakeforestrestorationstrategy.pdf>. (18 February 2016).

Delmarva Peninsula and Mid-Atlantic Coastal Plain

The Mid-Atlantic Coastal Plain, including the Delmarva Peninsula, was also identified as a multi-state priority area. Nearly all of Delaware is found within the Delmarva Peninsula. Several issues are important across the peninsula including:

- Forest Threats – Development and fragmentation, common invasive species, southern pine beetle, climate change impacts, and in certain areas—wildland fire.
- Forest Types and Wetlands – The area contains unique wetlands such as Delmarva Coastal Plain Ponds, unique forested types, including Atlantic white-cedar bogs and baldcypress, as well as significant areas of working forests, including loblolly pine.
- Forest Markets – The Delmarva Peninsula is basically one forest market. Any efforts to maintain and enhance traditional forest markets as well as develop new markets, including bio-energy, must be coordinated across this region since these markets would utilize wood from throughout the region.

Below is a description of the Delmarva Peninsula and Mid-Atlantic Coastal Plain developed by the U.S. Forest Service including priorities and partnerships relevant to Delaware.

Several issues important across this peninsula include forest threats such as development and fragmentation, the southern pine beetle and other invasive pest and plant species, maintaining unique forest types and wetlands such as the Atlantic white-cedar bogs, and supporting forest markets to utilize wood from throughout the region.

States:

Delaware, Maryland, New Jersey, Virginia

Area contains the following America's Great Outdoors priorities:

Landscapes of National Significance

- *Captain John Smith Chesapeake National Historic Trail* – Delaware, Maryland, Virginia
- *Delaware National Bayshore* – Delaware

Rivers and Water Trails

- *Nanticoke River* – *Captain John Smith Chesapeake Connecting Trail* – Delaware

Existing Partnerships

- Atlantic Coastal Fish Habitat Partnership
- Atlantic Coast Migratory Bird Habitat Joint Venture
- Chesapeake Bay Commission
- Chesapeake Bay Program
- Chesapeake Bay Watershed Initiative
- Mid-Atlantic Climate Change Response Framework
- Mid-Atlantic Panel on Aquatic Invasive Species
- National Water Quality Initiative
Delaware – *Clear Brook-Nanticoke River*
- North Atlantic Landscape Conservation Cooperative
- Working Lands for Wildlife (bog turtle)



Opportunities for Partnership, Cooperation, and Projects

- Land Conversion – The fast pace of land consumption in the region, especially along the I-95 Corridor between Philadelphia, PA, and Newark, NJ, endangers habitat and natural systems while consuming open space. Patterns of growth, along with common threats, like the high cost of housing, rising income inequalities, and climate change, affect the health and future prosperity of the region. Urban forestry and improved land-use planning can mitigate some of these impacts.
- Fragmentation – Fragmentation exacerbates the main problems of habitat loss and the need for fire suppression. Much work remains to be done in planning and creating migration corridors along the coast. Road and highway corridors have accelerated fragmentation and remain a threat to much of the region.
- Southern Pine Beetle – Southern pine beetle is one of the most destructive insects in the southern United States. Beetle outbreaks in the area have increased in recent years, and significant outbreaks are expected in the next few years as drought and other environmental stressors continue to weaken host species such as shortleaf, loblolly, Virginia, and pitch pines. Meanwhile, increasing average temperatures and longer growing seasons have extended the northern range of this pest.

Interstate 95 Corridor

The Interstate 95 (I-95) Corridor includes the very northern portion of Delaware and is the most urbanized portion of the state. Delaware's largest city (Wilmington) is located within the corridor. In addition to urban forestry issues, there are challenges with invasive species, particularly plants, and water quality. Delaware's two municipal water reservoirs are located within the corridor. Additionally, because this is Delaware's most urbanized area, there are opportunities to better educate students and adults to address one of Delaware's issues—*Public Awareness and Appreciation of Forests*. Delaware's urban forest priority area includes the major cities within the corridor—Wilmington and Newark. The rural priority forest area contains three small rural watersheds located just north of the interstate, which contain the best examples of Piedmont forests within the state.

Below is a description of the I-95 Corridor developed by the U.S. Forest Service including priorities and partnerships applicable to Delaware.



Land consumption in the region, especially along the I-95 Corridor, endangers habitat and natural systems while consuming open space.



Forested watersheds along the I-95 Corridor face threats from expanding development, heavy use, and poor urban planning. Degradation of watersheds, forest fragmentation, and a reduction of forested land along the corridor pose severe risks to water quality, forest diversity, and watershed health. Heavy use of the corridor also increases the potential spread of invasive plants and insects.

States:

Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia

Area contains the following America’s Great Outdoors priorities:

Landscapes of National Significance

- *Captain John Smith Chesapeake National Historic Trail* – Delaware, Maryland, Virginia
- *Delaware National Bayshore* – Delaware

Existing Partnerships

- Atlantic Coastal Fish Habitat Partnership
- Atlantic Coast Migratory Bird Habitat Joint Venture
- Chesapeake Bay Commission
- Chesapeake Bay Program
- Chesapeake Bay Watershed Initiative
- Mid-Atlantic Climate Change Response Framework
- Mid-Atlantic Panel on Aquatic Invasive Species
- North Atlantic Landscape Conservation Cooperative
- Working Lands for Wildlife (bog turtle)

Opportunities for Partnership, Cooperation, and Projects

- Link local open space and resource management efforts to broader megaregional conservation goals with meetings and research materials designed to build an understanding of larger issues and trends.
- Link the conservation of critical landscapes and forests to broader public policy goals including reducing greenhouse gas emissions, protecting drinking water, and improving water quality in the Northeast.
- Enhance best practices and coordination across jurisdictional boundaries by convening and promoting partnerships between local, state, and federal government agencies, and other land-use decisionmakers and natural resource managers.
- Expand conservation education programs across the region commensurate with the magnitude of benefits, issues, and tradeoffs related to forest conservation.
- Cooperate across agencies (federal and state) in partnership with land trusts, private landowners, and communities, to identify important landscapes to protect and manage.
- Educate community officials on forest conservation and ensure they have good planning tools, so they can decide zoning ordinances and practices that benefit forests and watersheds.

- Work with urban communities to promote healthy trees and urban forests, which contribute to improved air and water quality, watershed function, energy conservation, and social well-being.

Delaware River Watershed

The Delaware River (and Bay) comprises much of Delaware’s eastern boundary and its estuaries within the state contain some of the most critical lands for migratory birds. Atlantic white-cedar swamps can be found in this watershed and water quality is a top priority. All of these issues were identified within Delaware’s State Assessment and are important items to address. Below is a description of the Delaware River Watershed developed by the U.S. Forest Service including priorities and partnerships pertinent to Delaware.

This watershed’s estuaries contain some of the most important lands for migratory birds within the Atlantic Flyway. In addition, several Atlantic white-cedar swamps are located within estuaries that feed the Delaware River and Bay. This watershed provides drinking water for 17 million people in four states, and water quality is an issue within Delaware’s portion of the watershed. However, a collaborative effort titled the Common Waters Partnership, which is led by the Pinchot Institute, has worked closely with federal, state, and local partners, including the Delaware River Basin Commission, to improve water quality in recent years. In fact, these efforts have been so successful that the partnership has shifted its focus to planning for the impacts of a changing climate to enhance the resilience of this important watershed and landscape in the face of future uncertainty. Additionally, the area of the watershed in and around Philadelphia is now a part of the Urban Waters Federal Partnership, a national multiagency program that helps communities reconnect with and improve their urban waters.

States:

Delaware, New Jersey, New York, Pennsylvania

Area contains the following America’s Great Outdoors priorities:

Landscapes of National Significance

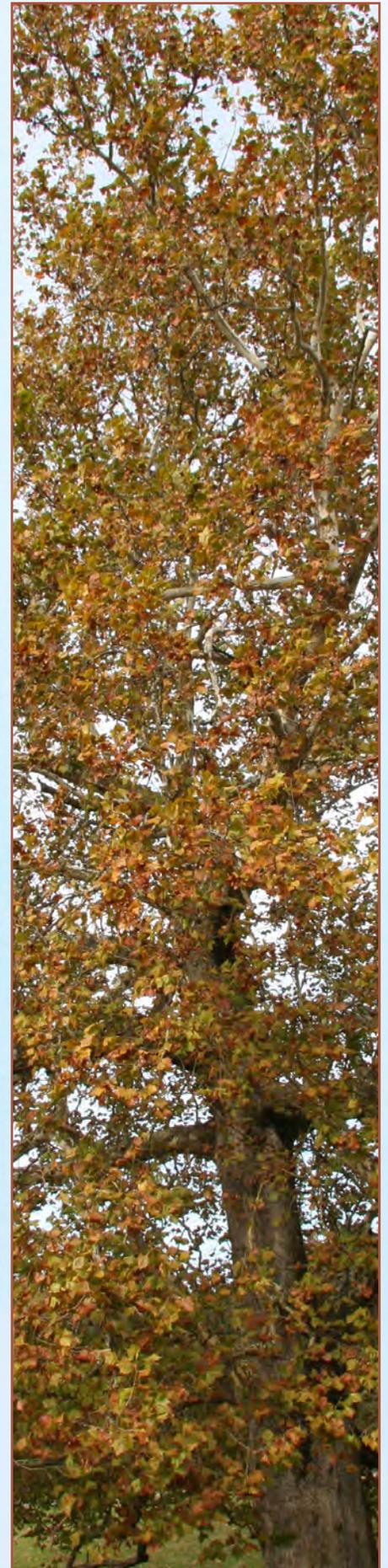
- *Delaware National Bayshore* – Delaware

Existing Partnerships

- Atlantic Coastal Fish Habitat Partnership
- Atlantic Coast Migratory Bird Habitat Joint Venture
- Delaware River Basin Commission
- Mid-Atlantic Climate Change Response Framework
- Mid-Atlantic Panel on Aquatic Invasive Species
- North Atlantic Landscape Conservation Cooperative
- Working Lands for Wildlife (bog turtle and golden winged warbler)

Opportunities for Partnership, Cooperation, and Projects

- Coordinate within the “rivershed,” similar to collaborative processes in place for the Chesapeake Bay and Great Lakes.
- Participate in climate-related work of the Common Waters Initiative.





Blackbird-Millington Corridor

Although not mentioned in the U.S. Forest Service's 2016 publication Multi-State Priority Areas in the Northeast and Midwest, the DFS believes that this conservation corridor is very important to the Delmarva Peninsula, specifically the states of Delaware and Maryland. This corridor is located in the rapidly-growing area of southern New Castle County and encompasses all of the 5,929-acre Blackbird State Forest. On both sides of the state line can be found numerous Coastal Plain ponds including suitable habitat for the state-endangered tiger salamander. In 2004, The Nature Conservancy (TNC) and the Delaware Department of Natural Resources and Environmental Control (DNREC), Division of Fish & Wildlife entered into a partnership in an effort to preserve and enhance the corridor's important natural resources and habitats. This area, stretching from the Cypress Branch and Millington area in Maryland to the Delaware Bay at the mouth of Blackbird Creek is recognized by TNC and other organizations as a regional conservation priority based on three factors:

- A concentration of important ecological features and natural communities – Though it is relatively small and located within 150 miles of three major metropolitan areas, the Blackbird-Millington Corridor contains an abundance of critical plant and wildlife habitat. Large patches of hardwood forests serve as vital habitat for migratory songbirds—they buffer streams, Coastal Plain ponds, and tidal wetlands from pollution and provide waterside nesting and hunting places for raptors.
- Private landowners have a history of balanced stewardship in the corridor – People throughout history have relied on the Blackbird-Millington Corridor's rich landscape of forests, fields, and waterways for food, forest products, transportation, recreation, and inspiration. While this area today is home to a wonderful diversity of plants, animals, and ecological systems, it is also home to people living in rural agricultural communities. With so much of the land to the north and south of the corridor threatened with rapid development, the corridor has retained much of its natural heritage and unique physical features through careful stewardship by farming families and woodlot owners and far-sighted public investment.
- There exists a solid foundation for conservation – The Blackbird-Millington Corridor has a strong history of conservation. Approximately 12,000 acres in the corridor are owned and managed by public agencies for a variety of conservation purposes. Another 10,000 acres are owned and managed privately for conservation or agricultural preservation purposes. Anchoring the corridor are Blackbird State Forest (Delaware) and the Millington Wildlife Management Area (Maryland) providing nearly 10,000 acres of forests, wetlands, and fields which are open to the public for hunting and other outdoor recreational activities.

Source:

Executive Report, Blackbird-Millington Corridor Conservation Area Plan

Because of the location of Blackbird State Forest, the DFS is in an excellent position to enhance the Blackbird-Millington Corridor's ecological value by providing forest stewardship assistance to neighboring forest landowners. Also, any future land acquisitions further add to the amount of protected and connected forestlands in the corridor.

IX. Forest Resource Assessment Summary

Delaware forests play a key role in protecting and enhancing the natural environment that is all around us. One could argue that forests are, in fact, a critical part of the state's infrastructure and as such should be treated with care and managed sustainably. The sheer number of natural benefits forests provide cannot be duplicated by any other ecosystem type. Therefore, it is in everyone's interest to optimize those benefits and protect as much forestland as possible from conversion to non-forest uses. Intact, healthy forests and healthy Delaware communities go hand-in-hand.

This updated *Forest Resource Assessment* presents a comprehensive review of the status of Delaware's forests over the last ten years—rural and urban, public and private. Although Delaware has more forestland today that it did a century ago, remaining forests and their owners face an ever-growing number of threats and challenges. A constant increase in population due to Delaware's relatively mild climate and low tax rates will only add more pressure on developable forestland as time goes by.

For the changes in forest conditions and trends, the *Forest Resource Assessment* was guided by a set of Montréal Process criteria that includes indicators and metrics developed for use at the state level. The Montréal Process Working Group was formed in 1994 as a bold, intergovernmental response to the pressing need for sustainable forest management. The developed criteria have been modified and updated since 1994 but are still as relevant and critical to forest health and functionality today as they were 25 years ago.

The Delaware Forest Service (DFS), working with the Forest Stewardship Committee and many other concerned partners, identified four major issues facing Delaware's forests and forest landowners: *Forest Health and Functionality*, *Forest Markets*, *Sustainable Forest Management*, and *Public Awareness and Appreciation of Forests*. During this process, threats were also identified that if left unchecked would negatively impact Delaware forests. Each of the identified threats, however, also presents multiple opportunities for action by the DFS and its many partners that all have a keen interest in perpetuating the wide array of benefits that come directly from Delaware's healthy forests.

Through a sophisticated GIS analysis, rural and urban priority areas throughout the state were identified using specific ranking criteria. This enables the DFS and its partners to target high-value forested areas of the state for protection and enhancement especially in times of scarce funding. While not all future efforts will be focused in the highest priority areas, they will be favored due to their elevated ecological and economic values.

The updated information contained within this *Forest Resource Assessment* can now act as a solid foundation from which to develop and implement a set of strategies for the specific purpose of protecting Delaware forest ecosystems. The DFS will work with its many partners—both public and private—during the strategy development portion of the *2020 Delaware Forest Action Plan*. Once completed, this plan will set the stage for the future conservation of forestlands in Delaware in the hopes of preserving the many natural benefits healthy forests provide for all Delawareans.



X. Appendices