

**DELAWARE DEPARTMENT of AGRICULTURE
FOREST SERVICE**



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FOREST HEALTH IN DELAWARE

A VISION FOR THE FUTURE



DELAWARE FOREST SERVICE





FOREST HEALTH IN DELAWARE: A MESSAGE FROM THE STATE FORESTER

Forests have played a vital role to Delawareans since before European settlement. They

provide the wood products, oxygen, cleaner air and water, recreational opportunities, and wildlife habitat that we all enjoy every day. The Delaware Forest Service (DFS), within the Delaware Department of Agriculture, is responsible for helping to conserve and protect our forests.

One of the responsibilities of the DFS is to monitor the overall health of our forests and to help ensure that our forests are sustainably managed. Forests are sustainably managed when they yield the products (wood, water, wildlife habitat, etc.) that we need today as well as for future generations. Delaware's forests face a variety of threats, including insects and diseases (both native and non-native), invasive (non-native) plants, and conversion to development at a rapidly increasing rate. In the past, reports concerning forest health often focused only on a few topics, such as the total acreage of forests, the amount of wood (volume) in the forests, and the number of plants and animals found in the forests. While these statistics are important to providing an idea of forest health, they do not provide all of the information needed to determine if the forests within a country, region, or state are healthy and sustainably managed. Other forestry professionals from around the world have also realized this challenge.

In 1995, the United States was one of 12 countries that committed to tracking its efforts in sustainable forest management by collecting data on 67

indicators across seven criteria – this effort is known as the Montreal Process. The seven criteria address all aspects of forests and their management, both biological and social – specifically, biological diversity, productive capacity (such as timber production), forest health, soil and water resources, carbon cycles (sequestration), social aspects, and legal and economic issues. In 1999, the State Foresters from the 20 states in the Northeast, Mid-Atlantic and Great Lake States, as well as the District of Columbia, agreed to collect data for 18 of these indicators to help gauge the overall health of the forests in this region (not all of the 67 indicators are applicable at the state or regional level). Individual states are also using the Montreal Process to help monitor their efforts to sustainably manage their forests. This report is Delaware's first effort to use these same 18 indicators to assess the overall status of our forests. We intend to conduct similar studies every five years so that we can track our progress over time. These trends will help foresters, other natural resource managers, and policymakers to determine what additional actions may be necessary to protect and conserve our forests.

We hope you will review and study the information within this report. Every day, every Delawarean uses products from our forests. It is vital that we all take an interest in our forests to ensure that this renewable resource continues to provide the products that we all enjoy.

E. Austin Short, III
State Forester
Delaware Forest Service





INTRODUCTION

Forests have always been important to the people of Delaware. Native Americans hunted wild game in the earliest forests and used trees to craft a variety of items, ranging from baskets to boats. When the first Europeans arrived, they reported vast forests of magnificent oak and pine trees.

Later, as the area was settled, changes took place. Industries developed around forest products as sawmills, shingle mills, and specialty mills were constructed to take advantage of this vast resource. Trees were harvested without much thought for the future and forest land began to decline. Additionally, most of the forests on productive, well-drained soils were cleared for agriculture.

The original forest of more than one million acres was reduced to a low of 350,000 acres at the beginning of the twentieth century. However, because the natural cover throughout the State is forest, agricultural lands abandoned between the two World Wars quickly reverted to forest as pine and hardwood seedlings colonized old fields. Today, forests cover more than 375,000 acres.

Forests continue to provide a variety of important services to the people of Delaware, such as aesthetic benefits, recreation, timber and other forest products, wildlife habitat, and protection of water quality. The contribution of forests to the State's economy is significant. Forest products businesses employ more than 2,600 people with an annual payroll of nearly \$100 million.

We manage our forests today with a knowledge of forest management techniques that simply was not available to early Delawareans. The first forestry school in the United States was not established until

1898 at the Biltmore Estate in North Carolina. Today, there are many colleges and universities that offer degrees in forestry. Graduate foresters typically have a strong educational background in forest management, biology, policy, and finance.

The Delaware Forestry Department (DFD), formed in 1927, was the first State Agency to address forestry-related issues. The DFD assisted private landowners with forest management. Today, the Delaware Forest Service (DFS) provides the same quality services to private landowners. In addition, DFS has programs in forest health, urban forestry, forest stewardship, wildland fire, and education. The DFS also manages 17,000 acres of State Forest land. The DFS employs 10 foresters to assist in the management of public and private forests in the State.

While new forest management tools help us to manage our forests properly, we face challenges from new directions. In recent years, development has been occurring at a rapid pace. Studies indicate that we lose approximately 3,000 acres of forest land per year to commercial and residential development. Considering the starting point of 383,000 acres in 1999, this loss is not insignificant. In developing areas, forests become fragmented as large contiguous blocks are divided into a patchwork of forest and developed land. This, in turn, leads to additional problems with invasive plant species and degraded interior forest habitat.

The Montreal Process, an international working group dedicated to promoting sustainable forest management, developed a series of Criteria and Indicators (C&I) in 1994. Sustainable management is forest management that provides economic, social, and recreational values to society, without

compromising the ability of forests to provide the same values to future generations. The C&I are used to assess sustainability of forestry practices at State, Regional, or National levels. Each Criterion serves as a category for assessment of sustainability of forest management. Indicators serve as measurable variables that may be used to assess changes over time. Delaware has developed this report using the seven Criteria and 18 Base Indicators from the Montreal Process.

The USDA Forest Service, in accordance with the 1928 McSweeney-McNary Forest Research Act, conducts periodic forest inventories in each State to assess the forest resource and to help identify any trends. Delaware had its first USDA forest inventory in 1956, with subsequent inventories in 1971 and 1986.

The most recent forest inventory, conducted by the Forest Inventory and Analysis Unit (FIA) of USDA's Northeastern Research Station, was carried out in 1999. Approximately 200 plots were visited in forests throughout Delaware. Information was collected about the size, type, and condition of trees present. The FIA Unit summarized the data and provided reports showing the results of the 1999 inventory as well as some comparisons to previous years' inventories.

FIA reports served as the data sources for some of the 18 Indicators in this report. Most information concerning conditions in Delaware's forests such as forest types, ages, size classes, and other biological characteristics came from these reports.

Other information comes from a variety of sources. Geographic Information Systems (GIS) use desktop computer software to map different features such as forest cover, streams, roads, and county boundaries. The Delaware Forest Service routinely uses GIS software to analyze geographic data, and the results of several such analyses are included in this report. For example, the area of forest that acts as riparian buffers was calculated with a GIS tool that identified forested areas within 100 feet of streams.

Other information, such as number of recreational facilities and acres under conservation easement, were obtained from different state agencies. Several recent reports and publications were also used for up-to-date information. All sources are cited in the references.

This report is intended to assess the sustainability of Delaware's forests, and the socio-economic benefits provided by those forests, within the framework of the Criteria and Indicators established by the Montreal Process. It is the responsibility of all citizens, with guidance from the Delaware Forest Service and other agencies, to ensure proper management of this important resource. Sustainable forest management will ensure that the many benefits we enjoy today will also be available, undiminished, to future generations of Delawareans.



CRITERION 1: CONSERVATION AND BIOLOGICAL DIVERSITY

Indicator 1. Area of total land, forest land, and reserved forest land.

Introduction: This Indicator assesses the percentage of the State that is forested, and the percentage of the forested area that is protected. The amount of forest land relative to other cover types provides an initial impression of the importance of the resource. The amount of protected forest indicates the degree to which the resource is sheltered from mismanagement or clearing for development.

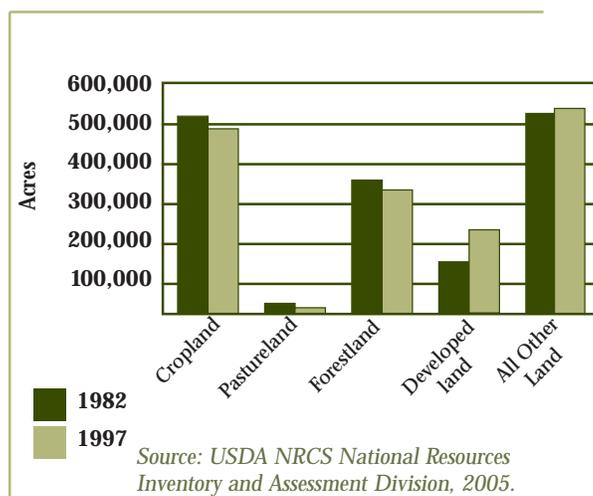
Delaware contains approximately 1.25 million land acres, of which 383,000 are forested (Figure 1). The definition of forest used to determine forest acreage includes traditional, non-urban areas with forest cover. It does not include forested areas in urban and suburban settings or very narrow "strips" of tree cover such as hedgerows in agricultural fields.

Figure 1. The forests of Delaware, 2002.



Cropland, such as soybean and corn fields, occupies approximately 479,000 acres in Delaware. The remaining 388,000 acres are a mixture of urban and suburban areas, marsh, pasture, and open water (Figure 2).

Figure 2. Acres by land cover type, 1982 and 1997.



As in other eastern states, the forested area in Delaware has declined considerably since European colonization in the 1600s. The natural land cover on all but the wettest sites is forest, so during pre-colonial times forests covered approximately 1.1 million acres, or 90 percent of the total land area in the state. As the area was settled, forests on most productive and well-drained soils were removed and replaced with agricultural crops.

Delaware experienced its lowest amount of forest cover around the year 1900, with only 350,000 acres forested. Since then, forest area has fluctuated between 380,000 and 450,000 acres during most of the twentieth century (Table 1). This fluctuation was due in large part to patterns in cultivation and abandonment of agricultural fields.

Table 1. Acres of forest in Delaware.

YEAR	Acres of Forest
1907	350,000
1938	423,000
1953	454,000
1963	392,000
1977	392,000
1987	398,000
1997	389,000
2002	383,000

Source: Smith et al. 2004. *Forest Resources of the United States, 2002. Gen. Tech. Rep. NC-241*

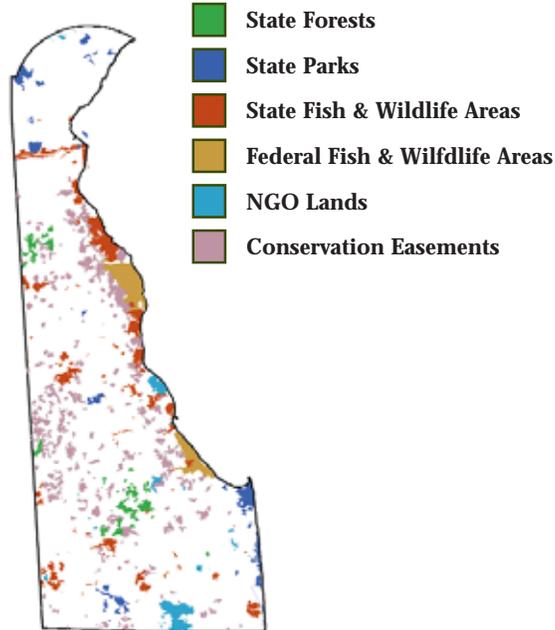
In recent years, many acres have been cleared for development. Land values have increased substantially throughout Delaware since the late 1980s. As a result, many large forest parcels have been subdivided and developed. A 2006 study by the Delaware Forest Service (DFS) showed that between 2002 and 2005, more than 9,400 acres of forest were contained within areas approved for development. Unlike a change from forest to agriculture, where the area may return to forest in the future, development represents a permanent reduction in the forest land base.

None of Delaware's forests are in areas specifically designated as "Reserved," meaning no timber harvest is allowed. However, about 28,000 acres are owned and managed by Non-Governmental Organizations (NGOs) or the State Park System, where silvicultural activities generally are not practiced.

In total, approximately 94,000 acres, or one-quarter of Delaware's forests, are protected from development (Figure 3). These lands include government-owned and NGO tracts, as well as areas protected by permanent conservation easements (including 18,000 acres of forestland protected through easements

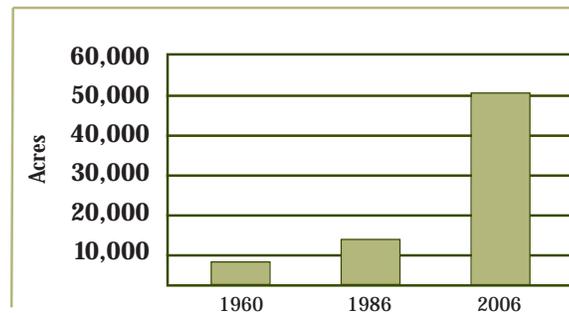
purchased by the Delaware Aglands Preservation Program). Furthermore, approximately 36,000 of these acres are managed by the Delaware Division of Fish and Wildlife and the DFS. These areas are protected from development and are sustainably managed.

Figure 3. State, Federal, and NGO lands.



The amount of forest land owned by state agencies has increased steadily since 1960, as detailed in Figure 4.

Figure 4. Publicly owned forest (State and Federal), 1960–2006.



Source: USDA Forest Service Forest Inventory and Analysis and State Agency reporting.





Conclusions: Although Delaware is the second-smallest state in the United States, more than one-third of the state is forested. Forests, therefore, represent a significant resource. While forest acreage has remained steady for the last century, a new trend in the clearing of forest land for development is of concern.

Indicator 2. Forest type, size class, age class, and successional stage.

Introduction: 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 the trees they contain. Trends or changes in important variables can be identified by comparing current data to data from previous years.

More than half of the forested area in Delaware currently consists of an oak-hickory complex (Figure 5). Pine and oak-pine types comprise approximately one fourth of the total area. Minor hardwood components occupy the remaining 15 percent of the forested acreage.

For the last 50 years, loblolly pine has been steadily decreasing in acreage. In 1957, loblolly pine covered

200,000 acres, whereas in 1999 loblolly stands occupied only 49,000 acres. This 75 percent decline is important because loblolly pine is a very fast-growing and valuable tree, and historically contributed considerably to Delaware's economy.

The decline of loblolly pine is due, at least in part, to trends in growth and removals. Since 1959, removals of softwood growing stock have consistently exceeded growth, while hardwood growth exceeds removal of hardwood growing stock. In many cases, natural regeneration by hardwoods such as oaks and hickories after a loblolly pine harvest results in a hardwood stand in place of the former pine stand. Since 1959, the oak-hickory type has tripled from 80,000 acres to 240,000 acres.

Delaware's forests contained more than 263 million trees in 1999. Stocking, a measure of the number of trees on each acre of forest, was sufficient on only about half of the forestland in the State (Figure 6). Many acres were classified as poorly stocked because there were not enough trees present to fully occupy all available growing space. This condition could be due to several factors, but many areas naturally have sparse forest cover due to low-lying topography and very wet soils.

Figure 5. Forest Types of Delaware, 1957–1999.

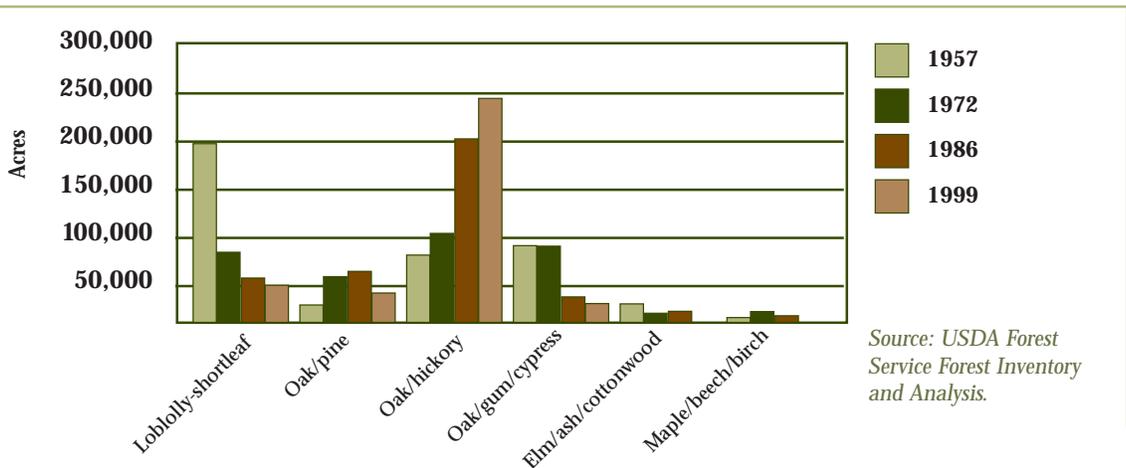
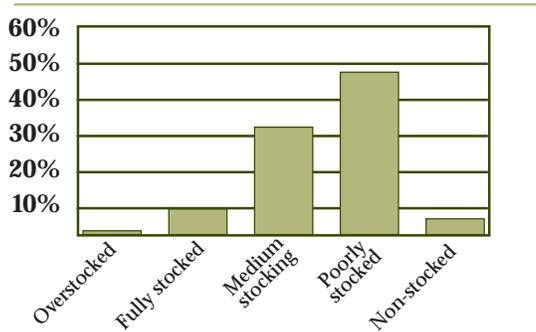


Figure 6.
Stocking classes in Delaware's forests, 1999.



Source: USDA Forest Service Forest Inventory and Analysis.

Net volume of growing stock was approximately 695 million cubic feet (Table 2). Total volume of all trees was 733 million cubic feet. Growing stock does not include non-merchantable species or trees which are unmarketable due to defects. Approximately 95 percent of total volume is marketable and therefore is included in growing stock volume.

Table 2. Net volume of growing stock.

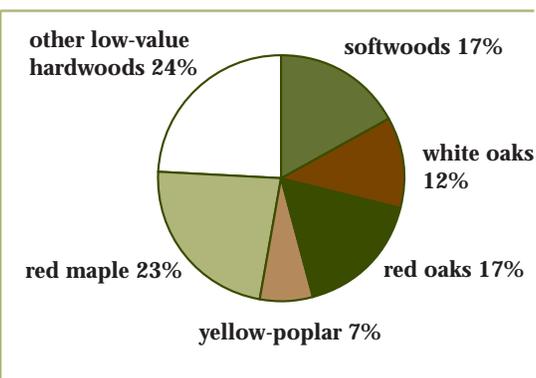
Species Group	Volume (thousand cubic feet)	
	Growing Stock	All Trees
Loblolly and shortleaf pine	102,156,570	103,742,648
Other yellow pines	12,204,171	12,309,601
Other eastern softwoods	185,267	185,267
<i>all softwoods</i>	<i>114,546,008</i>	<i>116,237,516</i>
Select white oaks	78,444,188	78,778,015
Select red oaks	6,610,827	6,610,827
Other white oaks	4,283,688	4,283,688
Other red oaks	108,228,353	114,036,157
Hickory	2,673,410	3,244,028
Soft maple	163,924,233	176,699,680
Beech	10,963,406	11,191,693
Sweetgum	87,639,392	90,485,430
Tupelo and blackgum	30,415,042	31,467,151
Ash	7,849,900	8,203,497
Cottonwood and Aspen	1,992,461	1,992,461
Yellow-poplar	46,374,696	48,243,594
Black walnut	636,997	688,859
Other eastern soft hardwoods	12,401,649	18,094,056
Other eastern hard hardwoods	17,212,840	20,345,649
Western woodland hardwoods	884,452	948,962
Eastern non-commercial hardwoods		1,059,205
<i>all hardwoods</i>	<i>580,535,534</i>	<i>616,372,952</i>
Total	695,081,541	732,610,468

Figure 7 shows the breakdown of growing stock by major species group. Hardwoods accounted for about 83 percent of total volume. Red and white oaks, which are valuable trees for lumber as well as wildlife, made up about one-third of hardwood volume.

Roughly half of all volume consisted of red maple and other low-value hardwoods. The abundance of low-value hardwoods may be due, in part, to the residual effect of poor management of pine stands, as well as damage to oak stands from gypsy moth in the 1970s and 1980s. Proper management of these stands in the future could shift species composition back in favor of oak, pine, and other valuable species. Development of new markets for low-value hardwood products could facilitate proper management.

Conifers accounted for approximately 17 percent of all live tree volume in the state. Loblolly pine comprised about 90 percent of conifer volume, with Virginia pine, baldcypress, and Atlantic white-cedar accounting for most of the remaining volume.

Figure 7.
Growing stock volumes by species, 1999.



Source: USDA Forest Service Forest Inventory and Analysis.





Total growing stock volume has increased by almost 40 percent since 1957 (Table 3). However, softwood and hardwood totals have not changed equally over this time period. Softwood growing stock has declined by one-half while hardwood volume has more than doubled. These changes serve as another indication of the reversion of many pine stands to hardwood stands following timber harvest, a phenomenon discussed previously in this section.

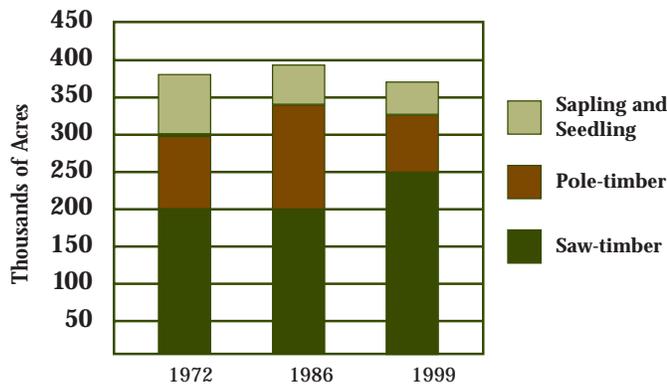
Table 3. Volume of growing stock, 1957–1999.

VOLUME (MILLION Cubic Feet)				
	1957	1972	1986	1999
Softwoods	230	184	164	115
Hardwoods	273	403	496	581
Total	503	587	660	696

Source: USDA Forest Service Forest Inventory and Analysis and USDA Forest Service Resource Bulletins NE-109 and NE-151.

Sawtimber stands accounted for more than half of the forested acreage in the state in 1999 (Figure 8). The remaining forest is divided almost equally between pole-timber stands and sapling/seedling regeneration. Since 1972, as average diameter has increased, more stands have fallen into the sawtimber size class.

Figure 8. Stand size classes 1972–1999.



Source: USDA Forest Service Forest Inventory and Analysis and USDA Forest Service Resource Bulletins NE-109 and NE-151.

Conclusions: The oak-hickory forest type covers more acreage than any other type in Delaware. About half of all growing stock volume consists of red maple and other low-value hardwoods, which are minor components of all types. This indicates a fundamental change since 1957, when about half of all growing stock was loblolly pine and other softwoods. Now, as in the past, most stands are of sawtimber size class.

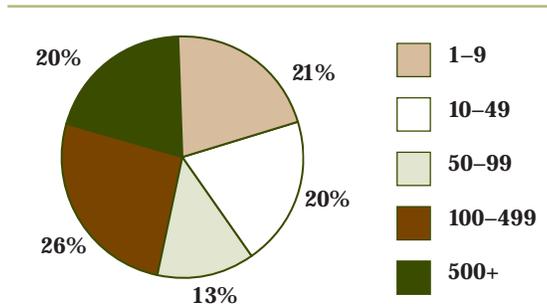
Indicator 3. Extent of forest land conversion, fragmentation, and parcelization.

Introduction: The forest land base is threatened by conversion to other land uses such as agriculture, which may be temporary, or development, which is almost always permanent. Also important is the degree to which remaining forest is fragmented, or broken into smaller contiguous blocks. Forest fragmentation causes several problems which degrade forest health. Invasive species of exotic plants, which tend to become established around forest edges, often out-compete native plants and disrupt forest ecosystems. Also, reduced forest parcel size results in less interior forest for plants and animals that require this specific habitat. A third threat is the reduction in average forest parcel size as large parcels are subdivided. Parcelization increases the number of forest landowners, and can make the task of properly managing the forest resources of the State more difficult overall.

The average size of privately owned forest parcels in 2003 was 9.5 acres in the mid-Atlantic region, which includes Delaware, Maryland, and New Jersey.

As shown in Figure 9, 41 percent of forest ownerships were less than 50 acres. Only 20 percent of all parcels were 500 acres or larger. The average forest parcel in 1975 was 32 acres, indicating that there are more owners with smaller woodlots today than there were 30 years ago.

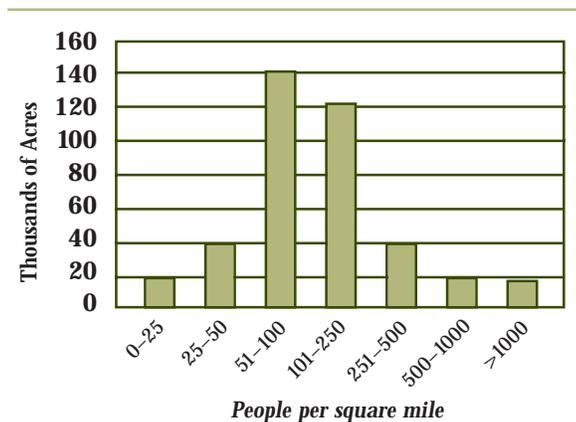
Figure 9. Privately-owned forest parcel acreage, 2003.



Source: US Census Bureau and US Geological Survey.

Two-thirds of Delaware's forests are located in areas with population densities between 51 and 250 people per square mile (Figure 10). The population of Delaware in 2002 was 806,105, so the average population per square mile statewide is slightly more than 400 people. As one would expect, populations are concentrated in urban areas. Rural areas with fewer residents tend to have a higher proportion of forest land.

Figure 10. Forest land by population density class.



Source: USDA Forest Service Forest Inventory and Analysis.

Currently, approximately 13 percent of Delaware's forest has been displaced by urban areas. A recent study estimated that by 2050, 43 percent of Delaware's forest land will have been subsumed by urban growth. In other words, in the year 2050, almost half 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 forest into expanding urban areas (Source: Nowak et al. 2005. The Increasing Influence of Urban Environments on US Forest Management. Journal of Forestry, December 2005).

An analysis by the DFS compared forest cover in 1937 to forest cover in 2002 using aerial photographs and Geographic Information Systems software. Of the acres that were forested in 1937, approximately 72 percent were also forested in 2002. Many of these areas were harvested during the 65 years between the two dates in the study; however, the land remained in forest as stands were replanted or regenerated naturally. The other 28 percent of the forested acreage was cleared for other land uses during the intervening period. Of course, some areas that were not forested in 1937, particularly some agricultural fields, were forested in 2002.

Conclusions: Average woodland parcel size is less than 10 acres, and population density is relatively high. Stewardship efforts must be of sufficient scale to target the large number of landowners responsible for managing these small woodlots. Forest fragmentation continues to be an important issue as interior forest habitat is reduced and edge habitat increases. Coupled with an increased human presence in the urban-wildland interface, these changes often result in additional problems with invasive plants and reduced habitat for native plants and wildlife. Conversion of forest to urban and suburban areas is expected to continue rapidly for the next 50 years.





Indicator 4. Status of forest/woodland communities and species of concern.

Introduction: Forests typically contain a wide variety of plants, and healthy forests provide important habitat for various animals. Some rare plants are found only in specific types of forest, and some rare animals require forest habitat for their survival. Recognizing and understanding the rare, threatened, and endangered species of plants and animals found in our forests is the first step in their conservation.

Of the 377 animal species native to Delaware, one is extinct, and 14 are vulnerable to some degree (Table 4). The remaining 362 species, or 96 percent, are secure.

Table 4. Status of native animal populations.

Informal Taxa	Vulnerable	Secure	Extinct	Grand Total
Amphibians	0	25	0	25
Reptiles	0	29	0	29
Birds	0	179	1	180
Fishes	0	10	0	10
Mammals	1	42	0	43
Insects	13	77	0	90
Total	14	362	1	377

Source: USFS Region 9 Species Analysis, NatureServe Central Databases, 2005.

The North American Breeding Bird Survey studied trends in woodland breeding bird populations from 1966 to 2004. The results indicate that of 36 bird

species in Delaware, 31 were stable with no significant trend. Four species had increasing trends, and one had a decreasing trend (Source: U.S. Geological Survey Patuxent Wildlife Center).

The Delmarva fox squirrel (*Sciurus niger cinereus*), is the only mammal in Delaware listed as an endangered species. The Delmarva fox squirrel has been reduced to a small portion of its original native range due to habitat loss and hunting. Reintroduction and preservation efforts in Delaware have resulted in some disagreements among landowners and government officials in permissible land uses. A Habitat Conservation Plan (HCP) will be developed by 2008 which will incorporate the measures needed to restore populations to healthy levels. An HCP Advisory Team and an HCP Science Team have been formed to assist in the development of the Plan with recommendations on policy and science matters, respectively.

The Delaware Division of Fish and Wildlife has listed additional species as endangered at the State level. Included are two forest amphibians, and 12 birds that are either woodland-dependent or build their nests in trees. While these species are not on the Federal Endangered Species List, State authorities believe there is reason for concern. Measures have been implemented to protect these species and to monitor their populations through periodic surveys.

The Delaware Natural Heritage Program states that of Delaware's 1,571 native vascular plants (species and varieties), 629, or 40 percent, are a conservation concern. The primary cause of decline is loss of habitat including wetlands and upland forests.

Conclusions: The majority of Delaware's animal populations are not immediately threatened; however, the Delmarva fox squirrel has generated considerable controversy as reintroduction efforts constrain land use activities on nearby properties. Habitat loss has also placed a large percentage of Delaware's plants at risk. Forest management standards should be structured to protect critical wildlife habitat.

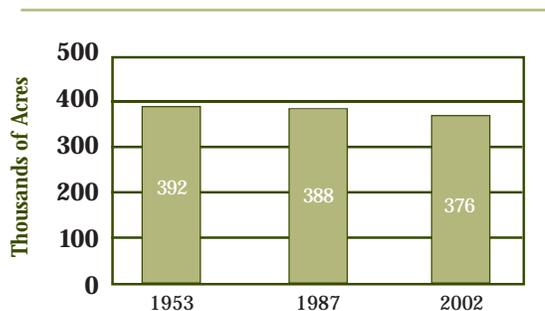
CRITERION 2: MAINTENANCE OF PRODUCTIVE CAPACITY OF FOREST ECOSYSTEMS

Indicator 5. Area of timberland.

Introduction: Timberland is defined as any forest land capable of producing trees which 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.

Of the state's 383,000 forested acres, 376,000, or 98 percent, are classified as timberland. The remaining two percent of the state's forest land is located in areas where regulations prohibit timber harvest. Timberland acreage has declined slightly since 1950, as shown in Figure 11.

Figure 11. Acres of timberland in 1953, 1987, and 2002.



Source: USDA Forest Service Forest Inventory and Analysis.

Conclusions: Area of timberland has remained constant relative to total forest acreage over the last 50 years; however, some forest lands have been purchased and placed under management by agencies which do not allow timber harvest. Additionally, an increase in the rate of development has impacted the forest land base. As a result, total acreage of timberland has declined slightly.

Indicator 6. Annual removal of merchantable wood volume compared to net growth.

Introduction: 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.

Growth of all species has exceeded removal for more than 40 years (Table 5). However, removal of softwood growing stock has consistently exceeded growth. This fact is partly responsible for the decline of loblolly pine since the mid-twentieth century (see discussion under Indicator 2). At the same time, hardwood growth has exceeded hardwood removal of growing stock for every measurement period since 1959. As loblolly pine stands are replaced by oak-hickory stands, and total hardwood acreage increases, hardwood growth continues to increase. Because pine acreage has declined, net softwood growth has been reduced, despite sustainable management of individual pine stands.





Table 5. Growth and removals of growing stock, millions of cubic feet, 1959–1999.

	Softwoods			Hardwoods		
	Growth	Removal	Net	Growth	Removal	Net
1959	6.5	9	-2.5	12.5	4.5	8
1971	4.6	8.1	-3.5	14.6	4.4	10.2
1987	4.1	4.6	-0.5	9.4	4.7	4.7
1999	4.2	6.7	-2.5	12.1	7.7	4.4

Source: USDA Forest Service Forest Inventory and Analysis.

Conclusions: While overall growth exceeds total removal by timber harvest, important changes in the forest resource have taken place. Softwood removal has exceeded softwood growth for decades, resulting in a decline in the total acreage of loblolly pine, a valuable and fast-growing timber tree. As loblolly pine stands revert to hardwood stands following harvest, hardwood growth has remained high despite increased removals in recent years. These changes suggest the possibility of new and expanded markets for hardwood products.

CRITERION 3: MAINTENANCE OF FOREST ECOSYSTEM HEALTH AND VITALITY

Indicator 7. Area of forest land affected by potentially damaging agents.

Introduction: Damaging agents include insects and diseases that can kill trees, 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.

During the past 20 years, an average of 800 acres of forest land have been damaged by wildfire each year (Annual Wildfire Summary Reports and Federal Agency reporting). In 2002, a record 2,950 acres were damaged, largely as a result of unusually dry conditions and one large fire in central Delaware.



Wildfires can damage stands of loblolly pine, especially younger stands where trees have not yet developed thick bark.

Since 1895, the earliest year for which data are available, northern Delaware has experienced an average of 1.9 months of drought per year. Southern Delaware has averaged 2.3 months of drought per year. 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). Drought can kill trees outright, but is a larger concern as an inducer of stress in trees. Stress predisposes trees to insect and disease problems which do not normally affect healthy trees.

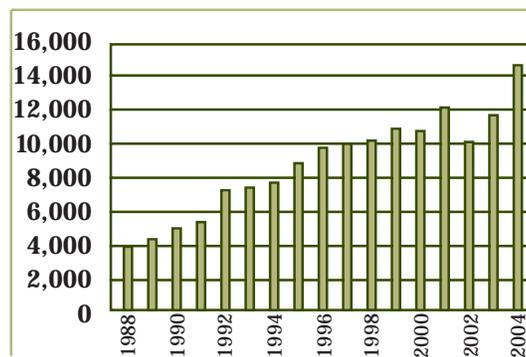
In 1996, tree mortality resulted in an estimated loss of 4.1 million cubic feet of growing stock. In 2002, this figure was an estimated 7.9 million cubic feet (USDA Forest Inventory and Analysis data). 7.9 million cubic feet equals about one percent of all growing stock and is an acceptable level of mortality in a healthy forest. Every year some trees in any forest die as a result of competition for light and other resources, as well as events such as wind breakage, lightning, and insects and diseases.

Several native and exotic pests have historically affected Delaware's rural and urban forests. The southern pine beetle, a native insect, periodically causes localized mortality in stands of loblolly pine. The American chestnut, a stately tree once common in Delaware's woods, has been virtually eliminated by the chestnut blight fungus which appeared in the early 1900s. Another exotic fungus causes Dutch elm disease, which has killed many of the American elms that once graced the towns and cities of Delaware. The gypsy moth, a European species, periodically causes considerable damage to oak forests. The DFS and other agencies monitor pest populations and survey for new threats to help safeguard Delaware's forests.

White-tailed deer (*Odocoileus virginianus*) enjoy near-ideal habitat throughout Delaware. As a result, in some portions of the state, deer populations have reached densities of 200 per square mile. In recent years, hunting regulations have been changed to allow more deer to be killed and to encourage the

harvest of does, which is the most efficient means of reducing deer densities. The annual deer harvest has tripled since 1990 (Figure 12), but populations remain high.

Figure 12. Delaware white-tailed deer harvest, 1988–2004.



Source: Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife.

High deer densities can result in browse damage to understory plants in the forest. Studies in other states have shown that populations of more than 20 to 25 deer per square mile can 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 has been initiated by the DFS to quantify the browse effect in Delaware's hardwood forests. The study will monitor understory vegetation at fenced sites, and at control plots without fencing, over a 10-year period.





A DFS botanist inventories the plant community at a deer exclosure control plot.

Bacterial leaf scorch (BLS), caused by *Xylella fastidiosa*, has emerged as a serious new forest health challenge in Delaware. BLS is a disease which primarily affects the red oaks and causes wilting, crown dieback, and death. Until 2005, this disease had only been confirmed in urban areas in northern New Castle County. The DFS, working with the USDA Forest Service, initiated a statewide survey in 2006 and submitted 50 tissue samples for analysis by the University of Delaware Plant Diagnostic Clinic. The results indicate that BLS is common in urban areas throughout Delaware. Of greater concern is the fact that the disease was also found in native forests far removed from urban areas. Previously, BLS had never been found outside of urban areas in any state. This new development will require considerable attention and a response plan will be developed in coming months.



A bucket truck facilitates inspection of ash trees for the Emerald Ash Borer.

Several exotic insects and diseases threaten the forests of Delaware but have not yet been detected. Included are Sirex wood wasp (*Sirex noctilio*), Asian longhorned beetle (*Anoplophora glabripennis*), emerald ash borer (*Agrilus planipennis*), and sudden oak death (*Phytophthora ramorum*). State forestry and other agencies are engaged in vigilant early detection programs for these pests.

Conclusions: Neither the normal "background" mortality rate nor the occurrence of wildfires presents a major threat to Delaware's forest resources. Constant browse damage to seedlings by a large deer herd has likely begun to alter species composition in hardwood forests throughout the State. Several exotic insects and diseases also present significant potential threats; therefore, surveys to assess current threats and to detect new pests will continue to be vital to forest health.

CRITERION 4. CONSERVATION AND MAINTENANCE OF SOIL AND WATER RESOURCES

Indicator 8. Soil quality on forest land.

Introduction: Plants require soil to grow. Soil quality has a major influence on 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; the native vegetation on all but the wettest sites was forest. Today, soil drainage is one of the primary factors determining forest cover type, growth rate, and operational limitations.

Most of Delaware's forests occur on three broad soil types, (1) Piedmont soils, (2) Coastal Plain well-drained soils, and (3) Coastal Plain poorly drained soils. While all types are capable of producing good growth, native cover types and equipment limitations differ.

Figure 13. The physiographic provinces of Delaware.



The Piedmont physiographic province accounts for about five percent of the land area of 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, beech, hickory, and yellow-poplar.

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

Well-drained soils on the Coastal Plain benefit from at least minimal elevation above low lying areas. The native cover type on these soils is mixed hardwoods

and, in the southern part of the state, loblolly pine. 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 per acre at age 50 according to USDA NRCS Soil Survey publications.

The other predominant Coastal Plain soil type occurs in soils that have poor drainage and/or a high water table. Native forest cover usually includes red maple, blackgum, holly, sweetgum, and water-tolerant oaks, with some loblolly pine in the southern half of Delaware. While loblolly pine stands on these soils may yield over 16,000 board feet per acre at age 50, seasonal wetness often restricts access for timber harvest.

Conclusions: Forest soils are generally productive for tree growth. Equipment limitations on wetter soils represent the only major soil-related operational constraint on forest management activities.

Indicator 9. Area of forest land adjacent to surface water, and forest land by watershed.

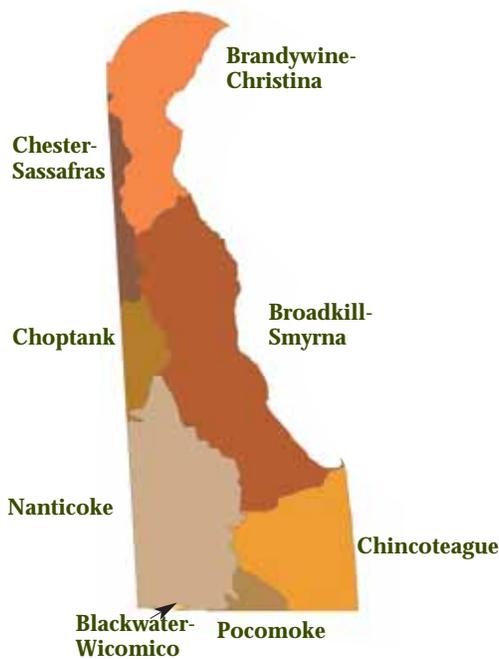
Introduction: Forested areas are important to water quality. Within forests, rainwater percolates into the ground and recharges the aquifers that provide us with drinking water. Forests typically do not act as sources of pollutants, so, other things being equal, watersheds with more forest cover tend to have cleaner water. Along streams, forest cover provides shade to regulate water temperature and roots reduce soil erosion. Trees take up 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.





The United States Geological Survey utilizes an 8-digit Hydrologic Unit Code (HUC) to identify major watersheds. Under this system, Delaware contains all or part of eight 8-digit HUC watersheds (Figure 14).

Figure 14. Major watersheds of Delaware.



Overall, Delaware is about 35 percent forested. Forest cover varies by watershed from a low of 21 percent to a high of 58% (Table 6). The Pocomoke, Nanticoke, and Choptank watersheds in the southwestern portion of the state contain the highest proportion of forest.

Table 6. Forest land by watershed.

Watershed	Forest Acres	Total Acres	% Forest
Pocomoke	15,794	27,294	58%
Chincoteague	61,832	175,140	35%
Blackwater-Wicomico	401	1,646	24%
Nanticoke	126,023	313,346	40%
Broadkill-Smyrna	90,162	404,728	22%
Choptank	25,791	61,125	42%
Chester-Sassafras	17,382	47,031	37%
Brandywine-Christina	45,615	219,690	21%

Geographic Information System (GIS) technology allows sophisticated analysis of geographic data on standard desktop computers. A GIS proximity study was carried out to identify all forest land in the state which 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. Buffer areas also serve as wildlife corridors and provide aesthetic benefits in many cases.

In all, approximately 34,800 acres of forest are acting as buffers using the 100-foot criterion. This acreage represents about nine percent of Delaware’s forest land.

Delaware has approximately 3,100 miles of rivers and streams. About 40 percent of these stream miles are currently buffered by at least 100 feet of forest on both sides. The other 60 percent do not benefit from forest buffers and are located primarily in agricultural and urban areas where pollution may be occurring at higher rates.

Conclusions: The percentage of forest cover varies significantly by watershed, with the densest cover in the southwest quadrant of the state. Roughly one-tenth of the forest land in Delaware is in riparian buffers, so management should be tailored to reduce sedimentation of waterways during silvicultural activities. Since more than half of Delaware's stream miles do not have riparian buffers, opportunities are available to establish buffers on agricultural lands and in urban areas. Riparian buffers can protect water quality in urban and agricultural areas as well as in traditional forest settings.

Indicator 10. Water quality in forested areas.

Introduction: Human populations must have sources of clean water to survive. Clean water is also important for fishing, swimming, and other forms of recreation. Forests play an important role in protecting and improving water quality. The use of Best Management Practices (BMPs) when harvesting timber helps to maintain water quality in forested areas.

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. The cause of impairment in most cases is an excess 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. Nitrogen is also a known carcinogen. Nitrogen and phosphorus pollution comes from many sources, including fertilizer applied by farmers and homeowners, domestic and wild animals, and septic systems.

In order 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 the nutrient problem generally credit forests as the most beneficial land use in terms of nitrogen and phosphorus pollution rates. Creating forestland (i.e., afforestation) from a different type of land use 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.

When trees are harvested for commercial use, operators must obtain permits from the DFS. 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 and Guidelines."

A new BMP monitoring program has been developed to quantify the success of timber harvest BMPs. Data are collected at harvest sites to determine rate of soil erosion and other measurable factors. Delaware and several other states are currently field testing the BMP monitoring program. Eventually, this program should improve effectiveness of BMPs and contribute to additional improvements in water quality.





Conclusions: Like most states, Delaware faces important water quality challenges; however, forest management activities are generally not believed to contribute to the water quality problem. A new initiative currently underway in Delaware should help to improve the effectiveness of timber harvest Best Management Practices even further.

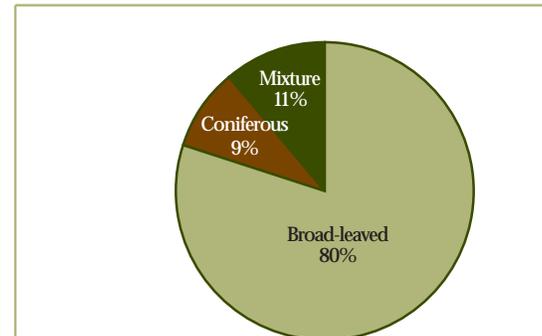
CRITERION 5: MAINTENANCE OF FOREST CONTRIBUTION TO GLOBAL CARBON CYCLES.

Indicator 11. Forest ecosystem biomass and forest carbon pools.

Introduction: Trees store carbon in their xylem (wood) and other tissues. Carbon storage is important because carbon (in the form of carbon dioxide) is believed to contribute to global warming via the “greenhouse effect.” Carbon dioxide concentrations in the atmosphere have been rising 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.

Data from the 1999 growing season place the above ground live tree carbon storage in Delaware’s forests at 12.6 million U.S. tons. Four-fifths of the aboveground carbon is found in broadleaved stands (Figure 15).

Figure 15. Aboveground live tree carbon by forest type.



Source: USDA Forest Service Forest Inventory and Analysis.

Dead, understory, litter, and below ground components account for an additional 6.6 million U.S. tons, for a total forest carbon pool of 19.2 million tons in 1999. A detailed breakdown of the carbon pool in Delaware’s forests is located in Table 7.

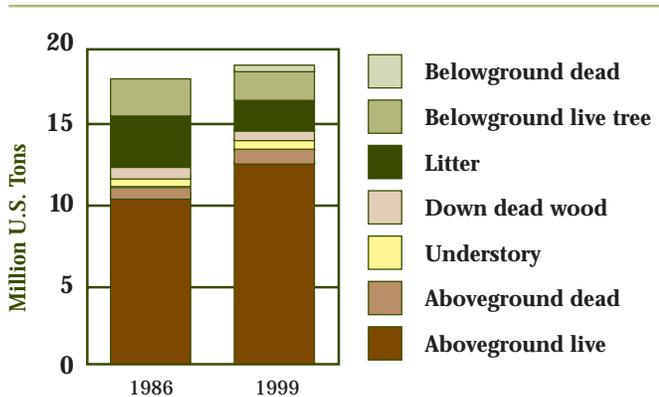
Table 7. Total forest carbon pool by forest component, 1999.

Component	U.S. Tons (Millions)
Aboveground live tree	12.6
Aboveground standing dead	0.6
Understory	0.4
Down dead wood	1.0
Litter	2.1
Belowground live roots	2.4
Belowground dead roots	0.1
Total	19.2

Source: USDA Forest Service Forest Inventory and Analysis.

Figure 16 shows the change in carbon storage for the period 1986-1999. Total carbon storage increased by seven percent from 18.0 to 19.2 million tons.

Figure 16. Carbon pools of Delaware's forests.



Source: USDA Forest Service Forest Inventory and Analysis.

Conclusions: Forests in Delaware currently contain about twenty million tons of carbon. Forest management activities can lead to increased growth rates and increased uptake of carbon in vigorously growing stands. Thus, the current level of carbon storage can be maintained or increased while still allowing for a viable timber industry.

CRITERION 6: MAINTENANCE AND ENHANCEMENT OF LONG-TERM MULTIPLE SOCIO-ECONOMIC BENEFITS TO MEET THE NEEDS OF SOCIETIES

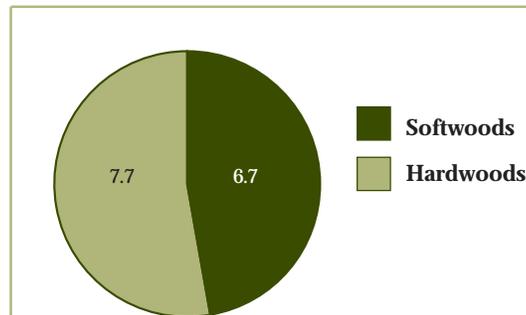
Indicator 12. Wood and wood products production, consumption, and trade.

Introduction: Wood products have always been critical to the economy of the United States. 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 1962, the total consumption in the United States of solid wood products, paper, and pulp was 11.6 billion cubic feet. By 1998, consumption of these products had grown to 19.6 billion feet, an increase of 69 percent (McKeever 2002). As the nation's appetite for wood products increases and the forest land base decreases, new tools to maximize growth and utilization must be developed.

In 1999, approximately 14.4 million cubic feet of growing stock were removed through timber harvest in Delaware. Volumes of softwoods and hardwoods were nearly equal (Figure 17).

Figure 17. 1999 removals, millions of cubic feet.



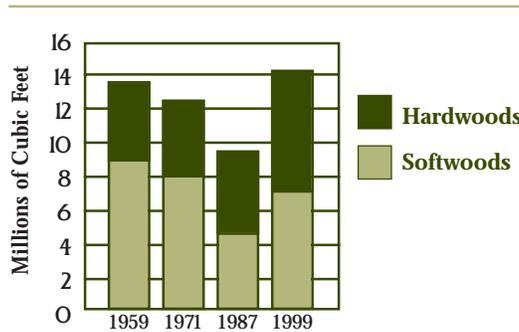
Source: USDA Forest Service Forest Inventory and Analysis.

Historic removals since 1959 have not fluctuated greatly. Annual removals for the last 50 years have ranged from approximately 10 to 15 million cubic feet (Figure 18). This reflects the fact that Delaware's forested acreage has remained fairly constant during this time period, as discussed under Indicator 1, "Area of Total Land, Forest Land, and Reserved Land." The proportion of hardwood to softwood volume has increased considerably, however, due to the replacement of loblolly pine stands by hardwood stands discussed previously.





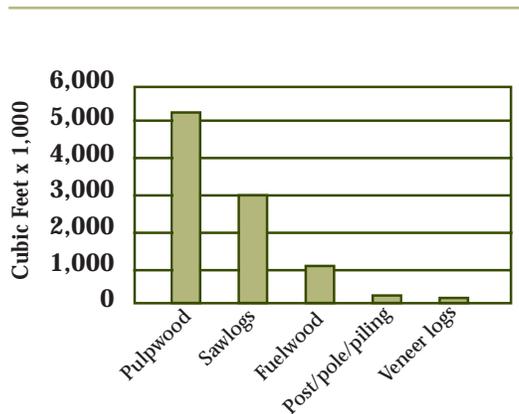
Figure 18. Annual growing stock removals, 1959–1999.



Source: USDA Forest Service Forest Inventory and Analysis.

Pulpwood and sawlogs accounted for more than 85 percent of the total volume harvested in 2002 (Figure 19). The remaining volume consisted of veneer logs, fuelwood, and posts, pilings, and poles.

Figure 19. Timber harvest by product class, 2002.



Source: USDA Forest Service Forest Inventory and Analysis, Timber Product Output.

Conclusions: Annual removals of hardwoods and softwoods are approximately equal even though softwoods accounted for only 16 percent of all growing stock in 1999. The majority of the volume harvested falls into pulpwood and sawlog product classes.

Indicator 13. Outdoor recreational participation and facilities.

Introduction: 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 to understand the importance of recreational opportunities in our forests.

Forests offer a wide variety of opportunities for outdoor recreation. Table 8 details public participation in 12 outdoor activities. Most of these activities occur in part or entirely within forested areas.

Table 8. Outdoor recreation, 2004, age 16 and older.

Activity	Percent participating	Number of participants (1,000s)
Viewing scenery	76	461
Picnicking	51	308
Swimming	47	284
Camping	26	161
Fishing	22	135
Day hiking	22	133
Driving off-road	14	84
Canoeing	10	62
Horseback riding	5	30
Hunting	4	24

Source: National Survey on Recreation and the Environment, 2000-2004.

In 2005, there were more than 315 miles of trails open to the public, an increase of 31 percent over 1995 levels. In addition to hiking, about 125 of these trail miles were open to horseback riding and mountain biking.

Recreation areas are also available for public use (Table 9). The number of state-owned recreational areas available to the public has increased during the last 10 years.

Table 9. Recreational areas.

Recreation Area Type	1995	2005
Picnic areas	20	27
Shooting ranges	0	1
Campgrounds	21	29
Areas with lodges	5	5
Areas with cabins & cottages	2	3
Boat launches	8	12
Beaches	36	40

Source: Delaware State Agency reporting.

Delaware contains more than 25,000 acres of Federal land managed by the U.S. Fish and Wildlife Service. State Parks, State Fish and Wildlife Areas, and State Forests account for an additional 95,000 acres. Forest covers about 45 percent of these State and Federal lands, all of which are open for public recreation.

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 50,000 acres of forest on state and federal lands, is available to the public.

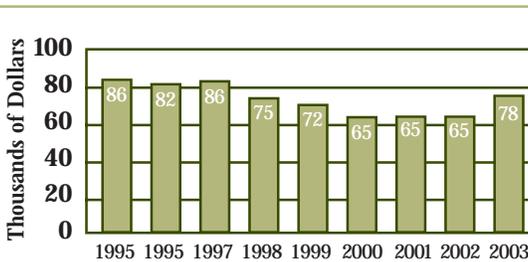
Indicator 14. Investments in forest health, management, research, and wood processing.

Introduction: Maintenance of forest health requires funding. Surveys for insects and diseases, monitoring of forest conditions, tree planting, and research in forestry all require time and money. The amount invested in forest health and research indicates the probable effectiveness of forest health efforts in the state.

Delaware does not receive funding for USDA Forest Service Research and Development. Delaware has neither a National Forest nor a USFS Research Station.

Since 1995, Delaware has received between \$60,000 and \$90,000 annually in Federal funding for forestry research at universities (Figure 20).

Figure 20. USFS university funding for forestry research.



Source: USDA Cooperative State Research, Education, and Extension Service, 2005.

In Federal Fiscal Year 2005, Delaware received more than \$1,750,000 in USDA Forest Service funds to assist in forestry programs in the state. Approximately \$1 million was allocated to the Forest Legacy Program to protect working forest lands by outright purchase or purchase of conservation easements. The remaining \$750,000 was split among stewardship, fire, forest health, and urban forestry programs.

The Conservation Reserve Enhancement Program (CREP) evolved in 1999 as a cooperative agreement among the Farm Service Agency, the Natural Resources Conservation Service, and the State of Delaware. The CREP offers cost-share payments to agricultural landowners for five conservation practices. Practices are designed to improve water quality by establishing buffers along waterways on marginal farmland. Practice CP3A, "Hardwood Tree Planting," involves the afforestation of fields with a mixture of hardwood tree species. More acres have been enrolled in CP3A than in all other practices combined. Currently, nearly 3,200 acres are under active CP3A contracts.





FLEP cost-share funds are used to reforest harvested areas with loblolly pine and other species.

The Forest Land Enhancement Program (FLEP) offers cost-share payments to landowners for forest management activities including reforestation, site preparation, and timber stand improvement. In 2005, 540 acres received FLEP payments totaling approximately \$25,000.

A state-funded cost-share program also offers incentives to non-industrial private forest owners for management activities related to forest health. Established in 2005, the program has already distributed more than \$40,000 in payments for practices on about 900 acres. Practices have included reforestation, timber stand improvement, and fire risk reduction. If funding continues at current levels, it may be expected that at least 600 acres per year will be enrolled.

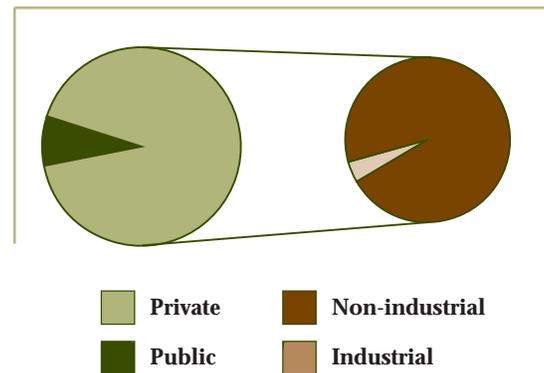
Conclusions: Delaware receives approximately \$2 million annually from the federal government for forestry-related programs and activities. Most of these monies are dedicated to the Forest Legacy Program and other landowner assistance programs managed by the DFS. Three cost-share programs, CREP, FLEP, and a state-funded program, have been successful incentives to private landowners for healthy forest management.

Indicator 15. Forest ownership, land use, and specially designated areas.

Introduction: The breakdown of forest ownership between public and private sectors gives an indication of the percentage of forest land that is protected from conversion to other uses. By further categorizing private forests, an understanding can be gained of the amount of forest land available for long-term production of forest products.

92 percent of Delaware's forests are privately owned (Figure 21). State and federal government own the other 8 percent. Of the 351,000 acres of private forest, non-industrial landowners own 96 percent. Industrial ownership accounts for only about 15,000 acres. Glatfelter Pulpwood Company was the sole industrial forest landowner in Delaware in 2005.

Figure 21. Forest Land Ownership.



Public ownership includes state and federal lands managed by several agencies, as shown in Figures 22 and 23. State ownership has increased considerably over the last 10 years as private lands have been purchased or donated to the State Forest System, State Parks, and Fish and Wildlife.

Figure 22. Public ownership, 1995 and 2005.

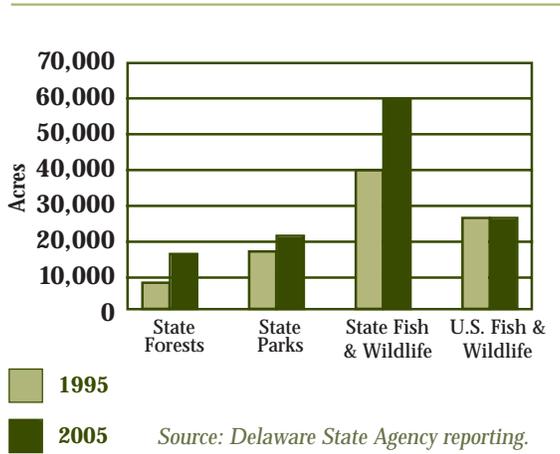
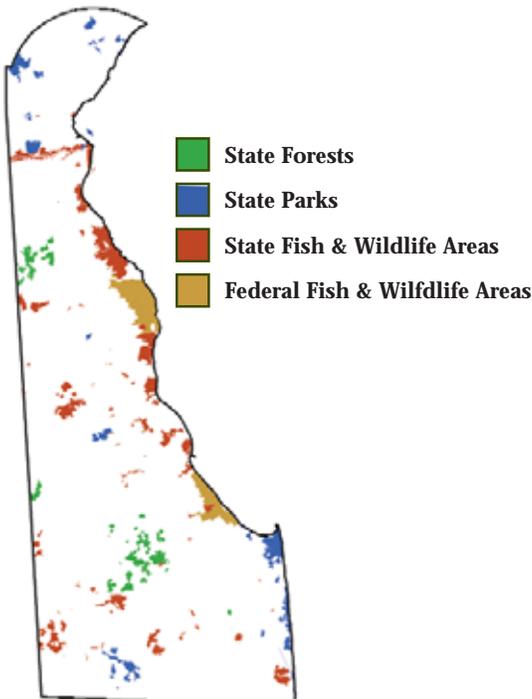
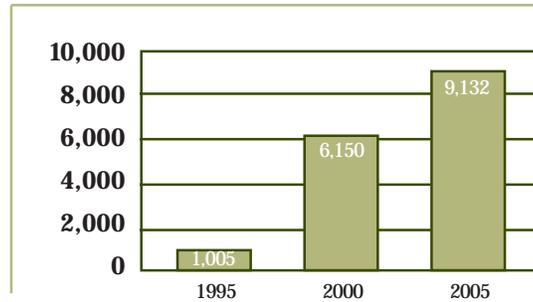


Figure 23. Public ownership in 2005.



The State of Delaware holds conservation easements on private lands. Easements vary in their requirements and what activities are allowed, but in all cases silvicultural activities are carefully controlled. Total acreage of conservation easements held by the State has increased nearly tenfold since 1995 (Figure 24).

Figure 24. State conservation easements, 1995–2005.

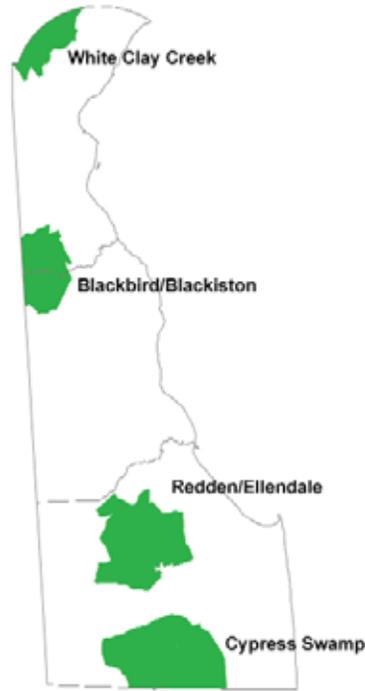


The Forest Legacy Program provides USDA Forest Service funding for protection of forest lands through outright purchase or through the creation of conservation easements. Funds may only be used in certain geographic areas (Figure 25). As of 2005, 1,356 acres of forest have been protected under the Forest Legacy Program. Three parcels totaling 448 acres have been purchased for Redden State Forest, and one 908-acre conservation easement has been established.





Figure 25. Forest Legacy areas.

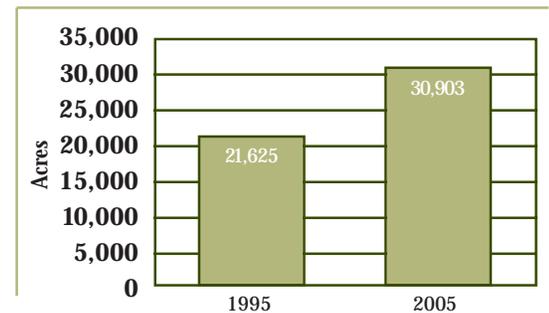


Delaware's Forestland Preservation Program came into existence in 2005. Funding is expected in coming years to allow the Program to become active. The Program will allow landowners to enroll their forest lands in a legally binding agreement which will ensure the forest is not sold or cleared for development. In return, the landowners will receive compensation from a specially designated fund, while continuing to manage their forests for timber and other products.

The Delaware Agricultural Lands Preservation Foundation purchases development rights from landowners and establishes permanent agricultural conservation easements. These easements provide permanent protection from development. Forested areas within agricultural conservation easements may be cleared for agriculture but will never be developed. In January 2006, these easements included 18,236 acres of forest.

Delaware's Commercial Forest Plantation Act (CFPA) offers a 30-year property tax exemption to forest landowners who have Forest Stewardship Plans developed for their woodlots. In 2005, 30,903 acres of private forest had received CFPA tax exemption. The 10-year period from 1995 through 2005 saw an increase in CFPA acreage of nearly 50 percent (Figure 26).

Figure 26. Active CFPA enrollment, 1995 and 2005.



Source: Delaware Forest Service.

The Sustainable Forestry Initiative (SFI), a program developed by the American Forest and Paper Association, provides certification for forest lands with management plans that meet certain sustainability criteria. The Glatfelter Pulpwood Company, a private landowner, owns and manages 14,364 SFI-certified acres in Delaware.

Conclusions: Most of Delaware's forests are privately owned, so programs designed for private non-industrial forest landowners will be important. Special programs such as those offered by the Forest Legacy Program and the Commercial Forest Plantation Act have been successful in Delaware.

Indicator 16. Employment and wages in forestry-related sectors.

Introduction: Sustainable forest management requires an economic infrastructure for the production of end-use products from raw materials. 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.

In 2002 there were more than 2,600 people employed in the forest products manufacturing industry in Delaware. This represents about five people per 1,000 between the ages of 18 and 65. The average rate of pay for these individuals was about \$15 per hour, and they had a total payroll of \$92 million. 63 establishments producing a variety of products including furniture, custom millwork, cabinets, and other wood products employed these citizens.

Employment in timber-based industries has risen since 1954, when there were 1,800 people employed in these industries (Table 10).

Table 10. Employment in timber-related industries.

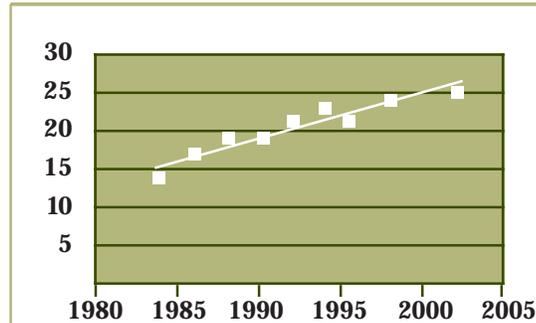
Year	# Employed
1954	1,800
1967	2,200
2002	2,600

Source: U.S. Census Bureau Economic Census.

The DFS employed 25 full-time personnel in 2005. This included four managerial positions, 10 professional staff, nine forest technicians, and two clerical positions. Five seasonal positions were also filled.

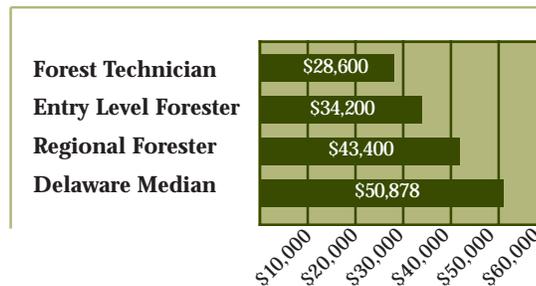
In 1984, the DFS employed only 13 full-time, permanent staff. Staffing has increased steadily over the past 20 years (Figure 27).

Figure 27. Delaware Forest Service staffing levels, 1984–2002.



Average salaries for DFS foresters ranged from \$34,200 for entry-level positions to \$43,400 for Regional Managers in 2002 (Figure 28). Forest technicians earn an average of \$28,600 per year. Census data indicate the median per capita income in Delaware for the three-year period ending in 2002 was \$50,878.

Figure 28. Incomes in 2002.



Source: National Association of State Foresters, State Forestry Statistics.

Conclusions: Forest products industries employ thousands of Delawareans and constitute an important sector of the economy. While employment by the Delaware Forest Service has grown in the last 15 years, professional forestry opportunities are still limited, and foresters earn less than the median state income.



CRITERION 7: LEGAL, INSTITUTIONAL, AND ECONOMIC FRAMEWORK FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT

Indicator 17. Forest management standards/guidelines.

Introduction: Forest management guidelines are used to ensure sustainable management of forests on private and public lands. Delaware has incorporated the major management standards into laws enforced by the permitting authority, the Delaware Forest Service.

The Delaware Seed Tree Law applies to timber harvests of 10 acres or more where 25 percent of the canopy consists of pine and/or yellow-poplar. The law requires that provisions be made to ensure 400 healthy pine and/or yellow-poplar seedlings per acre following harvest. Reforestation may be attained by planting or, where conditions permit, through natural regeneration. Since 2000, an average of 32 harvest operations per year have triggered Seed Tree Law reforestation requirements (Table 11). These operations affect approximately 1,600 acres each year.

Table 11. Number of timber harvest operations affected by the Delaware Seed Tree Law, 2000–2005.

Year	Operations	Acres	Acres Regenerated	
			Planted	Natural
2000	53	3,107	2,344	763
2001	27	1,200	835	365
2002	38	1,789	1,540	249
2003	33	1,782	1,681	101
2004	21	1,105	520	585
2005	21	863	397	466

Source: Delaware Forest Service.

The Erosion and Sedimentation Law requires the use of Best Management Practices (BMPs) during timber harvest activities. 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 carries out enforcement of the E&S Law. Enforcement options, though seldom required, include cease-and-desist orders and fines of up to \$5,000 per offense.

The DFS issues timber harvest permits, which are required by law. Foresters ensure that proposed harvests comply with the Seed Tree Law and E&S requirements. Foresters perform site inspections to ensure that the provisions of the harvest permits are met. Details on E&S permitting for the years 2000 through 2005 are contained in Table 12.

Table 12. E&S (timber harvest) permitting, 2000–2005.

Year	Permits	Acres	Inspections
2000	145	6,172	307
2001	114	5,107	286
2002	136	4,401	312
2003	142	5,122	275
2004	125	5,288	253
2005	138	5,045	216

Source: USDA Performance, Management, and Accountability System (PMAS).

Conclusions: The DFS works to protect forest resources and water quality by enforcing existing regulations.

Indicator 18. Forest-related planning, assessment, policy, and law.

Introduction: Laws addressing forest management place 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 stewardship plans incorporate a number of goals into a long-term management plan for the forest landowner. Stewardship plans developed by state-employed foresters include sections on wildlife, timber quality, and water quality protection. Table 13 details forest stewardship plan activity on private lands for the years 1997 through 2005.

Table 13. New forest stewardship plans, 1997-2005.

Year	Acres	#Plans
1997	5,016	104
1998	4,305	64
1999	1,939	38
2000	1,203	27
2001	2,777	57
2002	1,543	31
2003	3,584	69
2004	2,312	39
2005	2,067	31

Source: Delaware Forest Service.

There are 235 participating Tree Farmers in Delaware, certified by the American Tree Farm System. These Tree Farms contain 27,850 acres of forestland. Certified Tree Farms are managed under the provisions of a forest stewardship plan written by a qualified forester. Tree Farms are managed for long-term sustainability and achievement of multiple goals. They are inspected at least once every five years by a certified tree farm inspector to assure plan compliance and to inspect for damaging insects or diseases.

Delaware's three State Forests are managed with the assistance of forest management plans prepared by staff foresters. The three State Forest management plans are being updated in 2006. State Parks and Fish and 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.

Title 29 of the Delaware Code established the Governor's Council on Forestry. The seven members of the Council are appointed by the Governor for three-year terms. The Council advises the Delaware Forest Service on important issues including forest health, fire prevention, and invasive species. A parallel group, the Delaware Community Forestry Council, performs a similar function in the urban forestry arena.

The two primary laws affecting forest management in the State are the Delaware Seed Tree Law and the E&S law, both discussed in detail under Indicator 17 (Forest Management Standards). State laws designate the DFS as the authority in implementing and enforcing laws related to forestry.





Delaware Code (Title 25 Chapter 14) includes a Timber Trespass Law intended to protect private landowners. In cases where trees are harvested without the landowner's permission, 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: Planning is accomplished at the individual landowner level through forest stewardship plans. Two Forest Advisory Councils assist the DFS in the identification of important forestry issues and the development of programs.

CONCLUSION

Delaware's forests provide multiple values to society. Many Delawareans derive their livelihoods, in whole or in part, directly or indirectly, from the oak, hickory, and pine forests in the state. Forests also provide less tangible benefits in the form of wildlife habitat, aesthetic values, protection of water and soil quality, and recreation.

Overall, the forests that cover one-third of the state remain in fairly good health. A variety of tree, shrub, and vine species of different ages and sizes are found in our woods. These forests provide habitat for many animal species, the majority of which have healthy populations.

However, over the last five years forests have been cleared for development at an increasing pace. At the current rate of loss, we can expect to reach our lowest-

ever percentage of forest cover in just 10 years. In the past, fluctuations in forest acreage were due largely to cultivation and abandonment of farm fields; however, development constitutes a permanent loss of forest.

The Delaware Forest Service promotes responsible management of Delaware's forest resources. By providing technical assistance and education to private landowners, the DFS strives to make a difference at the individual woodlot level. The DFS also assists with various programs offering private landowners financial incentives to establish and properly manage forests. This multi-pronged approach aims to conserve the renewable forest resource for future generations.

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