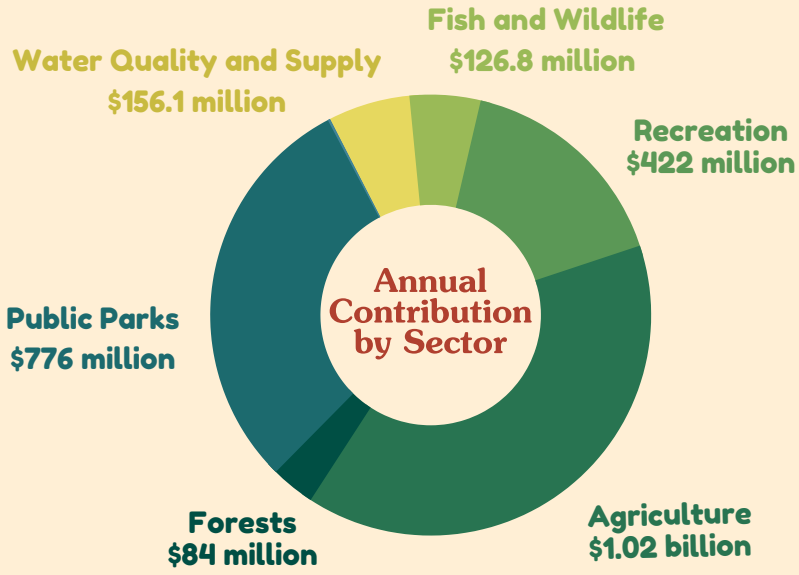
Economic Value of the Nanticoke Watershed

Prepared for
Nanticoke Watershed Alliance

Prepared by:

Gerald J. Kauffman, Director
Martha Narvaez, Policy Scientist
Andrew Homsey, GIS Services Manager
Kelly Jacobs, Graduate Research Assistant
Water Resources Center
Newark, Delaware



Annual Contributions to Local Economies

- **$461 Million** in wages
- **$3.73 Billion** in natural benefits
- **$2.6 Million** in economic value

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March 2020

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University of Delaware
Water Resources Center
Newark, Delaware

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Executive Summary

The water, natural resources and ecosystems contained in the Nanticoke watershed are an economic engine for the region. This report examines the economic value of these resources in three distinct ways and indicates the natural resources in the Nanticoke watershed contribute between $461 million and $3.7 billion annually to the regional Delaware and Maryland economies. This report examines the economic value in three distinct ways:

1. **Economic value directly related to the Nanticoke watershed's water resources and habitats.** The Nanticoke watershed contributes $2.6 billion in annual economic activity from water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits.
2. **Value of goods and services provided by the Nanticoke watershed's ecosystems.** Using natural capital as a measure of value, habitat in the Nanticoke watershed provides $3.73 billion annually in ecosystem goods and services (i.e. oxygen production, flood reduction, crop pollination, etc.) in 2020 dollars, with a net present value (NPV) of $121 billion calculated over a 100-year period.
3. **Employment related to the Nanticoke watershed's resources and habitats.** Using employment as a measure of value, natural resources within the Nanticoke watershed directly and indirectly supports over 19,800 jobs with over $461 million in annual wages.

The purpose of these estimates is to demonstrate that the Nanticoke watershed provides real and significant economic benefits to the regional economy in Delaware and Maryland and are worthy of investment to keep these natural resources healthy and productive. Estimates were made by taking values from existing literature and studies and applying them to the Nanticoke watershed using ecological economics and benefits-transfer techniques described in this report. Values are converted to (year) dollars based on the change in the Northeast Region Consumer Price Index except where noted.

Note that the values in the three categories are not summed because there is some overlap between certain values within each category that could result in double counting. For example, the jobs of fishermen that contribute to employment and wages are also a factor in the economic activity generated from fishing, and the ecosystem values of forests for water quality benefits may be at least partially captured in the economic value of water supply. Accurately determining (and eliminating) this overlap is difficult within the scope of this analysis. Some values were not included in these estimates because the data to assess them either are not readily available or do not exist. For example, the full amount of economic activity and jobs associated with the industries that rely on the Nanticoke watershed for their processes is not included here, because identifying those companies and gathering information on their economic activity is beyond the scope of this analysis.

1. Introduction

Objectives

This report summarizes the economic value of water, natural resources, and ecosystems in the Nanticoke watershed—Kent and Sussex Counties in Delaware and Caroline, Dorchester, and Wicomico Counties in Maryland—estimated as:

1. Economic activity including market and non-market value of water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits.
2. Ecosystem goods and services (i.e. oxygen production, flood reduction, crop pollination, etc.) value provided by habitat such as wetlands, beaches, open water, forests, and farms.
3. Jobs and wages directly and indirectly associated with the Nanticoke watershed.

These estimates demonstrate that the Nanticoke watershed provides significant economic benefits to the regional economy and are worthy of investment to keep them healthy and productive. Value-transfer techniques were applied by selecting data from published literature and applying them to the Nanticoke watershed using ecological economics techniques.

Values in the three categories above are not summed because there may be overlap and double-counting. For example, the jobs of fishermen are also a factor in economic activity from fishing. The ecosystem values of forests for water-quality benefits are at least partially captured in the economic value of water supply. Accounting for this overlap is difficult. **However, each of the above estimates clearly indicates that the Nanticoke watershed is an economic engine that contributes between $461 million and $3.7 billion annually to the Delaware and Maryland economies.**

The estimates presented in this report can be considered in the low range because the data to assess economic value are not readily available in some categories. For example, the full amount of economic activity and jobs associated with the companies and industries that rely on the watershed for their processes is not included here, because identifying those companies and gathering information on their economic activity is complicated and beyond the scope of this analysis. Since some estimates were made by taking values from existing literature, the values for various activities differ greatly in how they were determined and applied to the creek's water resources, making it difficult to accurately compare values across uses.

History

During 1608, English Captain John Smith decided to take a journey upstream to explore the Chesapeake Bay's tributaries. Over the course of his journey, Smith was the first to map the Chesapeake Bay area, including the Nanticoke River. In fact, he named the river after a Native American group living in what is now modern day Vienna, Maryland. Smith estimated that 200 Nanticoke warriors plus their families lived in the area. In the Algonquian language, the word Nanticoke translates to "people of the tidewaters." The Nanticoke people's close proximity to the water made it easy for hunting, fishing, and farming.

The Watershed

Beginning in Kent County, Delaware, the Nanticoke River flows southwest to the Chesapeake Bay through Sussex Country, Delaware and three counties in Maryland (Figure 1). The Nanticoke watershed spans 530,000 acres and is 88.5 miles in length. Between Delaware and Maryland, the watershed drains a total of 826.6 square miles. The majority of the land area is relatively flat, and the highest point of elevation within the watershed is 19.8 feet. Approximately 60% of the Nanticoke watershed lies in Delaware and 40% lies in Maryland (Table 1). Notable towns within the watershed include Greenwood, Bridgeville, Seaford, Laurel and Bethel (Delaware), as well as Bivalve, Nanticoke, Sharptown, and Vienna (Maryland).

Adjacent to the west of the Nanticoke River lies a body of water known as Fishing Bay. Located in Dorchester County, Maryland. Fishing Bay and its tributaries drain into the Chesapeake Bay. Fishing Bay is made up of two natural areas, the Blackwater National Wildlife Refuge and the Fishing Bay Wildlife Management Area (WMA). According to Maryland's Department of Natural Resources, Fishing Bay WMA is 28,000 acres, making it the state's largest WMA and largest parcel of publicly-owned tidal wetlands. In fact, approximately 80% of Fishing Bay WMA is made up of tidal marshes.

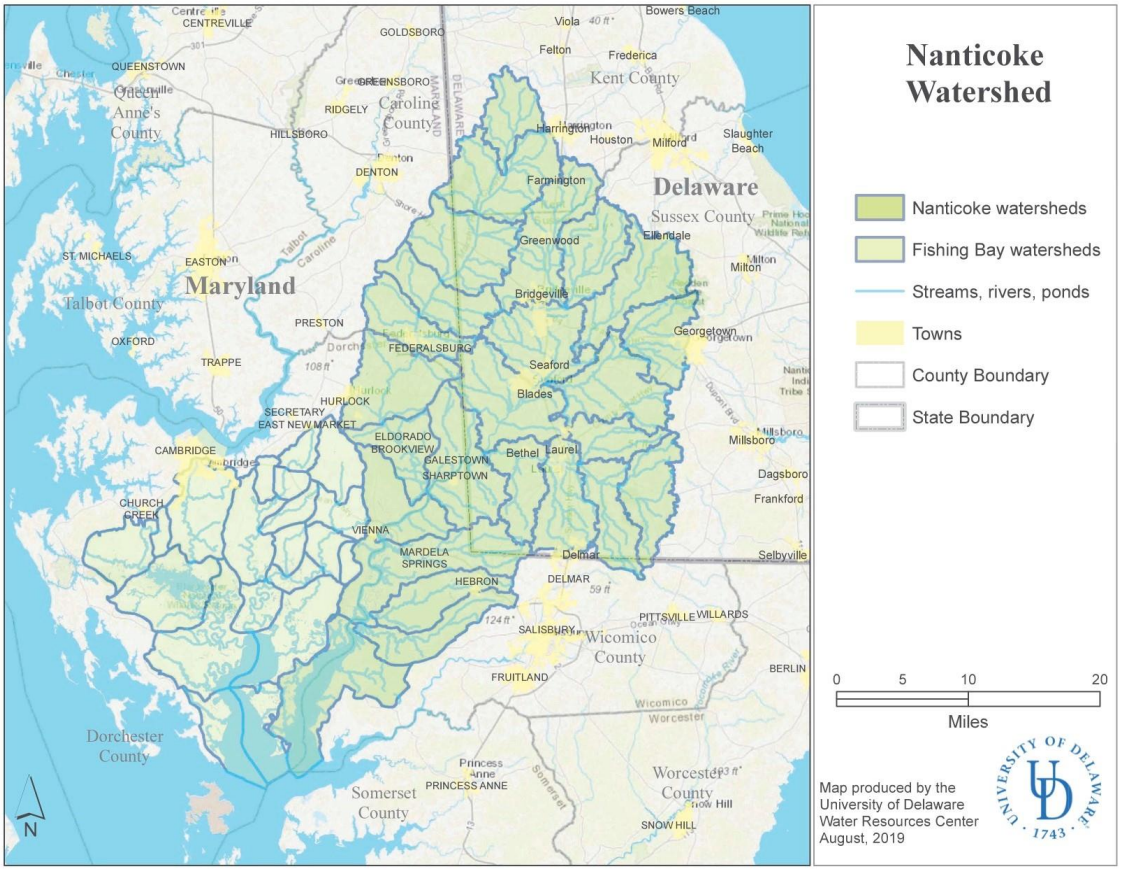

Figure 1. The Nanticoke watershed

Table 1. States in the Nanticoke watershed

State	Area (mi^2)	Area (%)
Delaware	497.0	60%
Maryland	329.6	40%
Total	826.6	100%

Land Use

Land use in the Nanticoke watershed is broken down into 8 distinct land use categories based on county (Table 2). The exact distributions are as follows: agriculture (53%), freshwater wetlands (21%), forested (14%), open water (4%), developed (4%), saltwater wetlands (3%), and barren/other (0.1%) (Table 3 and Figure 2).

Table 2. Total land use in the Nanticoke watershed

Land Use	Kent DE, 2010 (mi^2)	Sussex DE, 2010 (mi^2)	Caroline MD, 2010 (mi^2)	Dorchester MD, 2010 (mi^2)	Wicomico MD, 2010 (mi^2)
Developed, High Intensity	0.1	5.0	0.5	0.5	0.4
Developed, Low Intensity	1.0	18.8	2.0	2.2	3.3
Agriculture/Pasture/Scrub	45.5	244.5	38.4	58.9	54.7
Forested	5.4	57.2	9.9	14.7	26.0
Open Water	0.0	2.7	0.1	15.1	17.1
Freshwater Wetlands	22.2	93.9	12.4	22.5	27.0
Saltwater Wetlands	0.0	0.0	0.0	13.0	10.3
Barren/Other	0.0	0.7	0.2	0.0	0.1
Total	74.2	422.8	63.5	126.9	138.9
Land Use	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Developed, High Intensity	0%	1.2%	0.7%	0.4%	0.3%
Developed, Low Intensity	1.3%	4.4%	3.2%	1.7%	2.4%
Agriculture/Pasture/Scrub	61.3%	57.8%	60.5%	46.4%	39.4%
Forested	7.2%	13.5%	15.5%	11.6%	18.7%
Open Water	0.0%	0.6%	0.2%	11.9%	12.3%
Freshwater Wetlands	29.9%	22.2%	19.5%	17.7%	19.5%
Saltwater Wetlands	0.0%	0.0%	0.0%	10.3%	7.4%
Barren/Other	0.0%	0.2%	0.2%	0.0%	0.1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table 3. Total land use in the Nanticoke watershed

Land Use	Total Sq. Mi.	% of Total
Developed, High Intensity	6.5	0.79%
Developed, Low Intensity	27.3	3.30%
Agriculture/Pasture/Scrub	442	53.49%
Forested	113.2	13.70%
Open Water	35	4.24%
Freshwater Wetlands	178.0	21.55%
Saltwater Wetlands	23.3	2.83%
Barren/Other	1	0.12%
Total	**826.3**	**100.00%**

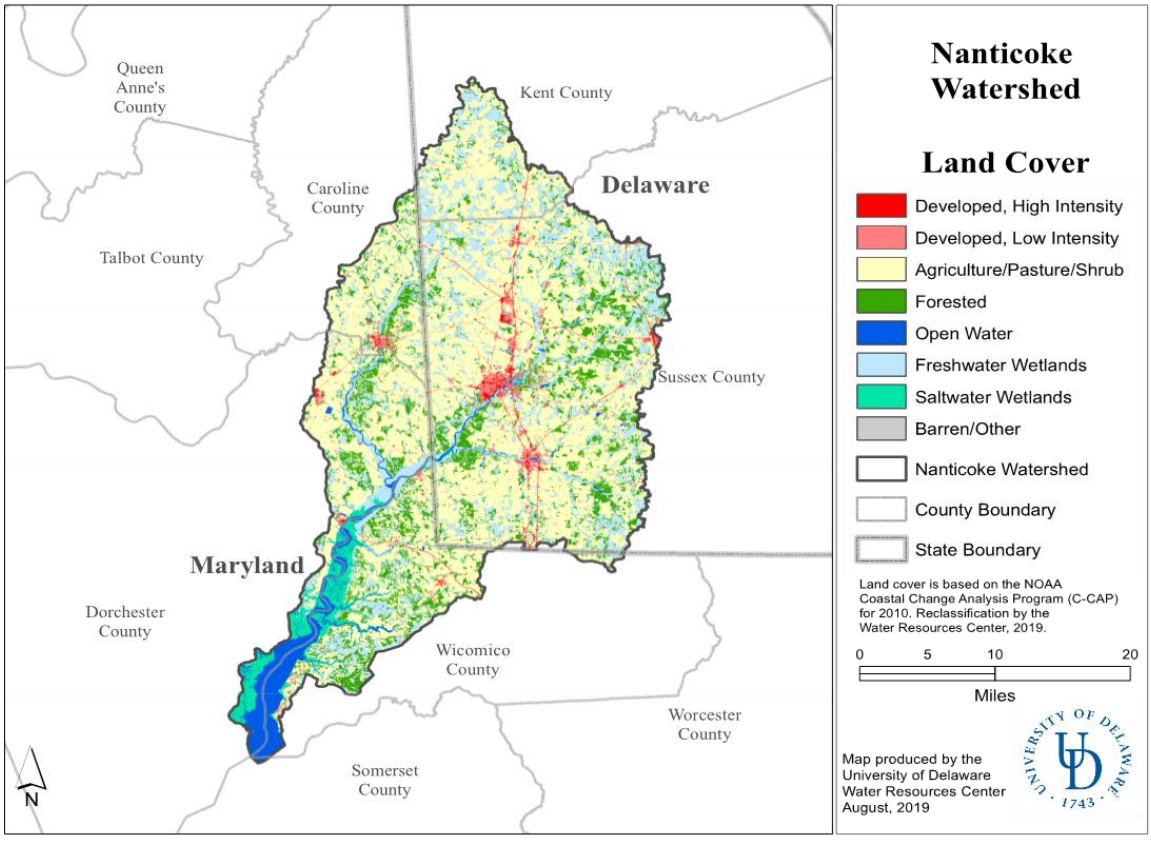

Figure 2. Land cover in the Nanticoke watershed

Table 4. Land cover change in the Nanticoke watershed

Land Use	1996 (mi^2)	2010 (mi^2)	Change (mi^2)
Developed, High Intensity	5.33	6.42	1.09
Developed, Low Intensity	25.44	27.27	1.83
Agriculture/Pasture/Scrub	437.06	442.09	5.03
Forested	115.11	113.08	(2.04)
Open Water	34.73	35.09	0.36
Freshwater Wetlands	184.6	178.05	(6.59)
Saltwater Wetlands	23.37	23.35	(0.02)
Barren/Other	0.62	0.94	0.32
Total	**826.3**	**826.3**	**0.0**

Population

In 2010 the 826 square mile Nanticoke watershed in Kent and Sussex Counties (Delaware) and Caroline, Dorchester, and Wicomico Counties (Maryland) was home to a population of 90,195 (U.S. Census Bureau). Within the watershed, 76.5% of the population resides in Delaware and 23.5% in Maryland (Table 5). Between 2000 and 2010, the population within all five counties of the watershed increased, with the largest increase in Sussex County, Delaware (Table 6). The Nanticoke watershed has a low population density with focused development in a few small towns, including Seaford, Delaware and Sharptown, Maryland (Figure 3).

Table 5. Population within the Nanticoke watershed

State	Population	%
Delaware	69,016	76.5%
Maryland	21,179	23.5%
Total	**90,195**	**100%**

Table 6. Population change in the Nanticoke watershed, 2000-2010

State/County	Area (mi^2)	2000 pop.	2010 pop.	Change	2000 (people/sq. mi.)	2010 (people/sq. mi.)
Delaware	497	59,194	69,016	9,822	119	139
Kent County	74.3	3,443	3,857	414	46	52
Sussex County	422.8	55,751	65,159	9,408	132	154
Maryland	329.6	19,805	21,179	1,374	60	64
Caroline County	63.4	5,588	5,674	86	88	89
Dorchester County	126.9	5,472	5,599	127	43	44
Wicomico County	138.9	8,745	9,906	1,161	63	71
Total	**826.6**	**78,999**	**90,195**	**11,196**	**96**	**109**

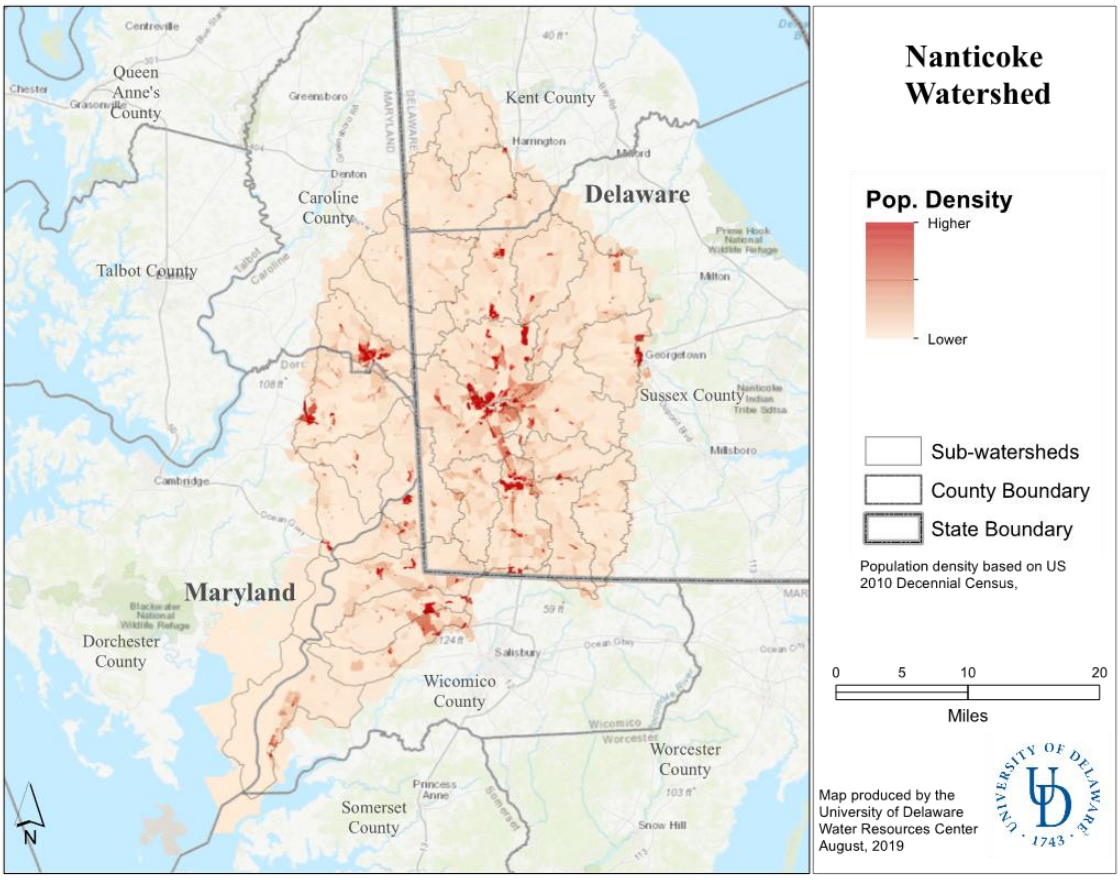

Figure 3. Population density in the Nanticoke watershed

2. Methods

Overview

The University of Delaware derived the economic value of the Nanticoke watershed from published studies that employed the following valuation techniques:

Avoided Cost: Society sustains costs if certain ecosystems are not present or are lost. For instance, the loss of wetlands may increase economic costs from flood damage.

Replacement Cost: Natural services are lost and replaced by more expensive human systems. For instance, forests provide water-filtration benefits that would be replaced by costly water-filtration plants.

Net Factor Income by Enhancement of Income: Improved water quality is known to enhance fishing productivity and boost fishing jobs/wages.

Travel Cost: Visitors are willing to pay to travel and purchase food and lodging to visit ecosystems and natural resources for tourism, boating, hunting, fishing, and birding.

Hedonic Pricing: Residents may be willing to pay more for higher property values along scenic river coastlines with improved water quality.

Contingent Valuation: Valuation by survey of individual preferences to preserve ecosystems. People may be willing to pay more in fees or water rates to preserve river water quality.

Scope of Work

The University of Delaware established the economic value of the Nanticoke watershed according to the following scope of work.

1. Area of Interest: The area of interest is defined as the Kent and Sussex Counties (Delaware) and Caroline, Dorchester, and Wicomico Counties (Maryland). The University of Delaware developed ArcGIS map layers of watersheds, population, ecosystems, habitat, and land use/land cover to perform the analysis.

2. Literature Review: Gather published literature and socioeconomic data relevant to the Nanticoke watershed including databases from the U.S. Census Bureau, U.S. Bureau of Labor Statistics, U.S. Department of Agriculture, U.S. Forest Service, and U.S. Fish and Wildlife Service.

3. Annual Economic Value: Estimate the direct (market) and indirect (non-market) economic value of agriculture, water quality, water supply, fishing, hunting, recreation, boating, ecotourism, and navigation by utilizing population, employment, industrial activity, and land-use data. Total economic activity is the sum of direct and indirect uses, option demand, and non-use values (Ingraham and Foster 2008). Direct-use (market) values are derived from the sale or

purchase of natural goods such as drinking water, boating, recreation, and commercial fishing. Indirect (non-market) values are benefits from ecosystems such as water filtration by forests and flood control/habitat protection from wetlands. Option demand is public willingness to pay for benefits from water quality or scenic value of the water resources. Non-use (existence) values are treasured by a public who may never visit the resource but are willing to pay to preserve the existence of the resource. Values are converted to 2020 dollars based on the change in the Consumer Price Index (CPI) in the Northeast Region as reported by the Bureau of Labor Statistics.

4. Ecosystem Services: Tabulate the market value of natural resources (ecosystem services value) in the Nanticoke watershed for habitat such as wetlands, forests, farmland, and open water. Ecosystem services (ecological services) are economic benefits provided to society by nature such as water filtration, flood reduction, and drinking water supply. Using ArcGIS, map and tabulate ecosystem areas (acres) using land cover data in the following classifications: (a) freshwater wetlands, (b) marine, (c) farmland, (d), forest, (e) barren, (f) saltwater wetland, (g) urban, (h) beach/dune, and (i) open freshwater. Review published research studies and gather economic value ($/acre) data for these ecosystem goods and services: (a) carbon sequestration, (b) flood control, (c) drinking water supply, (d) water-quality filtration, (e) waste treatment and assimilation, (f) nutrient regulation, (g) fish and wildlife habitat, (h) recreation and aesthetics. Compute ecosystem services value by multiplying land-use area (acres) by ecosystem value ($/acre).

Ecosystem services are estimated using value (benefits) transfer where published data and literature from similar watersheds are reviewed and applied to the resource in question. Value-transfer techniques include selecting data from published literature from another watershed or study area and applying the dollars-per-acre values to Nanticoke watershed land-use areas. While primary research data from the area in question is preferable and is used in many cases in this report, value transfer is the next best practical way to value ecosystems, especially when, in the absence of such data, the worth of ecosystems have previously been deemed zero.

5. Jobs and Wages: Obtain employment and wage data from the U.S. Department of Labor, U.S. Census Bureau, National Ocean Economics Program, and other sources. Estimate direct/indirect jobs by North American Industry Classification System (NAICS) codes such as shipbuilding, marine transportation/ports, fisheries, recreation, minerals, trade, agriculture, and others. NAICS data were supplemented with farm jobs data from the USDA Agricultural Statistics Bureau, U.S. Fish and Wildlife Service ecotourism jobs data, and jobs provided by water purveyors and watershed organizations.

6. Report: Prepare a report and GIS mapping that summarizes (1) annual economic value of activities related to the Nanticoke watershed, (2) ecosystem goods and services (natural capital), and (3) jobs and wages directly and indirectly related to the watershed in 2020 dollars.

3. Economic Value

Hodge and Dunn (1992) illustrated the total economic value of water resources based on use and non-use values. Use values include direct values, such as market goods from sales of crops, fish, and timber; unpriced benefits from recreation and aesthetic view sheds; and ecological-function values (ecosystem services) from flood control, water storage, and waste- assimilation services of wetland and forest habitat. Non-use values include future-option values such as future drug discoveries from wetland plants and future recreation, existence values from satisfaction that a water resource exists but may never be visited, and bequest values such as preserving water quality for future generations.

The economic value of the Nanticoke watershed from water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits exceeds $2.6 billion (Tables 7 and 8).

Table 7. Annual value of the Nanticoke watershed, by sector

Sector	**Annual Value**
Water Quality	$29.3 million
Water Supply	$128.2 million
Fish/Wildlife	$135 million
Recreation	$422 million
Agriculture	$1.02 billion
Forests	$84 million
Public Parks	$776 million
Port Navigation	$4.5 million
Total	**$2.6 billion**

Table 8. Annual economic value of the Nanticoke watershed

Activity	Economic Value ($ million)	Source
Water Quality		
Boatable (Pop. 90,195 @ WTP = $17.79/person)	1.6	Helm, Parsons, & Bondelid (2003)
Fishable (Pop. 90,195 @ WTP = $17.81/person)	1.6	Helm, Parsons, & Bondelid (2003)
Swimmable (Pop. 90,195 @WTP = $151.98/person)	14	Helm, Parsons, & Bondelid (2003)
Increased Property Value (+8% over 20 years)	4	EPA (1973), Austin et al. (2007)
Water Treatment by Forests ($33/mgd @	0.051	Trust for Public Land & AWWA (2004)
Wastewater Treatment (4.38 mgd @ $5/1,000 gal)	8	MDOE & VIMS (2013)
Water Supply		
Public Water Supply (4.23 mgd @ $1.168/1,000 gal)	1.8	NJWSA (2012)
Irrigation Water Supply (261 mgd @ $1.31/1,000 gal)	125	Frederick et al. (1996), USDA (2019)
Industrial Water Supply (4.41 mgd @ $0.87/1,000 gal)	1.4	Frederick et al. (1996), USGS (2010)
Fish/Wildlife		
National Wildlife Refuge (222,792 visits/yr)	7.8	Carver & Caudill (2017)
Blue Crab	4.4	NOEP (2016), MDE (2015)
Fishing ($24 to $49/trip/day)	45	USFWS (2011)
Hunting ($14 to $45/trip/day)	19	USFWS (2011)
Wildlife/Bird-Watching ($23 to $66/trip/day)	59	USFWS (2011)
Recreation		
Outdoor Recreation (43,657 participants)	269	Outdoor Industry Association (2016)
Powerboating	149.5	National Marine Manufacturers Assoc. (2014)
State Parks (Trap Pond)	3.5	Rockport Analytics (2017)
Agriculture		
Nursery, Crop, Poultry, Livestock	1,017	USDA Census of Agriculture (2014)
Forests		
Carbon Storage ($827/ac)	59	Nowak et al. & U.S. Forest Service (2008)
Carbon Sequestration ($29/ac)	2	Nowak et al. & U.S. Forest Service (2008)
Air-Pollution Removal ($266/ac)	19	Nowak et al. & U.S. Forest Service (2008)
Building Energy Savings ($56/ac)	4	Nowak et al. & U.S. Forest Service (2008)
Avoided Carbon Emissions ($3/ac)	0.22	Nowak et al. & U.S. Forest Service (2008)
Public Parks		
Health Benefits ($9,734/ac)	576	Trust for Public Land (2009)
Community Cohesion ($2,383/ac)	141	Trust for Public Land (2009)
Stormwater Benefit ($921/ac)	54	Trust for Public Land (2009)
Air-Pollution Control ($88/ac)	5	Trust for Public Land (2009)
Port Navigation		
Navigation Use Value	4.5	Frederick et al. (1996)
Nanticoke Watershed	**2,596**	

Water Quality

Improved Water Quality

Helm, Parsons, and Bondelid (2003) measured the economic benefits of water-quality improvements to recreational users in the New England states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut and found per person willingness to pay (WTP) for good water quality ranged from $8.25 for boating, $8.26 for fishing, and $70.47 for swimming in 1994 dollars. Adjusting to 2020 dollars based on the change in the Consumer Price Index (CPI) in the Northeast Region as reported by the Bureau of Labor Statistics, per person WTP is estimated at $17.79 for boating, $17.81 for fishing, and $151.98 for swimming uses (Table 9).

Table 9. Annual WTP for water quality benefits

WQ Use Support	WTP per person[1] ($1994)	WTP per person[2] ($2020)
Boatable	$8.25	$17.79
Fishable	$8.26	$17.81
Swimmable	$70.47	$151.98
Total	**$86.98**	**$187.58**

In 2010, the Nanticoke watershed population reached 90,195 (U.S. Census, 2010). Based on value transfer data from the study in six New England states, WTP for improved water quality in the Nanticoke boasts over $7.9 million in monetary value. The greatest WTP value comes from a swimmable quality level at $6,436,809, followed by boatable and fishable qualities at $753,460 and $754,307, respectively (Table 10).

Table 10. Annual WTP for water quality benefits in the Nanticoke watershed

WQ Use Support	Population	WTP/person ($2020)	WTP ($2020)
Boatable	90,195	$17.79	$1,604,569
Fishable	90,195	$17.81	$1,606,373
Swimmable	90,195	$151.98	$13,707,836
Nanticoke Watershed Total	**90,195**	**$187.58**	**$16,918,778**
Boatable	69,016	$17.79	$1,227,795
Fishable	69,016	$17.81	$1,229,175
Swimmable	69,016	$151.98	$10,489,052
Delaware	**69,016**	**$187.58**	**$12,946,021**
Boatable	21,179	$17.79	$376,774
Fishable	21,179	$17.81	$377,198
Swimmable	21,179	$151.98	$3,218,784
Maryland	**21,179**	**$187.58**	**$3,972,757**

[1] Helm, Parsons, and Bondelid (2003).
[2] Adjusted to 2017 based on 3% annual change in Northeast Region CPI.

Increased Property Value

Studies along rivers and bays in the U.S. indicate that improved water quality can increase shoreline property values by 4% to 18% (Table 11). The EPA (1973) estimated improved water quality can raise property values by up to 18% next to the water, 8% at 1,000 feet from the water, and 4% at 2,000 feet from the water. Leggett et al. (2000) estimated improved bacteria levels to meet water quality standards along the western shore of the Chesapeake Bay in Maryland could raise property values by 6%. Poor et al. (2007) studied 1,377 residential property sales in the St. Mary's River watershed on the western shore of Chesapeake Bay and concluded that a 1 mg/l increase in dissolved inorganic nitrogen reduced the average ($200,936) property value of a house by $17,642 or 8.8%. Austin et al. (2007) from the Brookings Institution projected that investing $26 billion to restore the Great Lakes would increase shore property values by 10%.

Table 11. Increased property value resulting from improved water quality

Study	Watershed	Increased Property Value
EPA (1973)	San Diego Bay, CA	
-Next to water	Kanawha, OH	18%
-1,000 feet from water	Willamette River, OR	8%
-2,000 feet from water		4%
Leggett et al. (2000)	Chesapeake Bay	6%
Poor et al. (2007)	Chesapeake Bay	9%
Austin et al. (2007)	Great Lakes	10%

With improved water quality, property values within 2,000 feet of the Nanticoke River and its tidal tributaries are estimated to increase by 8% which is the adjusted midpoint between 18% next to the water and 4% at 2000 feet from the water. The Nanticoke River is bounded by a 322-mile shoreline with 36 miles in Delaware and 286 miles in Maryland. In 2019, the average land value in Dorchester County, Maryland near the water was $23,177 per acre. Therefore, properties within 2,000 feet of the river have an estimated value of $997.1 million. Property values within 2,000 feet of the water would increase by 8% or $79.8 million due to improved water quality (Table 12). Since increased property value is a one-time benefit, the annual value over a 20-year period is estimated at $4 million or $720,000 in Delaware and $3.27 million in Maryland.

Table 12. Added property value due to improved water quality in Nanticoke watershed

State	River Shore (mi)	River Shore (ft)	Area within 2000ft of River (ac)	Property Value @ $23,177/ac ($ million)	Increased Value @ 8% ($ million)	Annual Value 20 yr ($ million)
DE	36.24	191,347	7,757	179.8	14.4	0.72
MD	286.2	1,511,136	35,262	817.3	65.4	3.27
Total	**322.44**	**1,702,483**	**43,019**	**997.1**	**79.8**	**4**

Water Treatment by Forests

Forests provide significant water-quality and water-treatment benefits. The Trust for Public Land and American Water Works Association (2004) found for every 10% increase in forested watershed land, drinking water treatment and chemical costs are reduced by approximately 20% (Table 13). If the public drinking water supply is 4.23 mgd and forests cover 72,400 acres (113 mi^2 or 13.7%) of the Nanticoke watershed, then loss of these forests would increase drinking water treatment costs by $33 per mgd ($139/mgd @ 0% forested minus $106/mgd @ 14% forested) or $140/day or $51,000/year.

Table 13. Drinking water treatment costs based on percent of forested watershed

Watershed Forested	Treatment Costs ($/mg)	Change in Costs
0%	$139	21%
10%	$115	19%
20%	$93	20%
30%	$73	21%
40%	$58	21%
50%	$46	21%
60%	$37	19%

Wastewater Treatment

Five wastewater treatment plants have a total capacity of 4.38 mgd that discharge to the Nanticoke watershed (Table 14). The average wastewater rate in the watershed is $5 per 1,000 gallons which for an average residence of 4 people (at 50 gpcd) is a fee of $365 per year. The total market value based on treated wastewater rates in the Nanticoke watershed is $21,900 per day or $8 million per year.

Table 14. Wastewater discharge capacity in the Nanticoke watershed

State	Wastewater Utility	Flow (mgd)
DE	Bridgeville WWTP	0.292
DE	Laurel WWTP	0.3
DE	City of Seaford WWTP	2
MD	Hurlock WWTP	1.65
MD	Vienna WWTP	0.1375
Total		**4.38**

Water Supply

Public Water Supply

The New Jersey Water Supply Authority (2012) established the value of raw (untreated) public water supplies from the Manasquan system at $1,168 per million gallons. At $1,168 per million gallons, the value of untreated public water supplies in the Nanticoke watershed 4.23 mgd is $4,941 per day or $1.8 million per year (Table 15).

Data for all of the major municipalities in the Nanticoke watershed were included except Sharptown, Maryland due to a lack of information. However, Sharptown has a relatively small population, slightly larger than the town of Vienna's population. Therefore, the public water supplied to Sharptown is negligible in the context of this calculation.

Table 15. Public water supply of the municipalities in the Nanticoke watershed

State	Municipality	Public Water Supply (mgd)
DE	Blades	0.25
DE	Bridgeville	0.48
DE	Delmar	0.4
DE	Greenwood	0.09
DE	Laurel	0.73
DE	Seaford	1.91
MD	Hebron	0.3
MD	Vienna	0.072
Total		**4.23**

Irrigation Water Supply

In a study of the economic value of freshwater in the United States, Resources for the Future (Frederick et al. 1996) estimated the median value of irrigation water withdrawals was $198/ac-ft in 1996 dollars or $402/ac-ft ($1.31/1,000 gal) in 2020 dollars, adjusting for 3% annual change in the CPI (Table 16). During 2010, 282,880 acres of cropland in the Nanticoke watershed (53.5% of watershed) were cultivated and 100,480 acres were irrigated (USDA 2017). These values are based on 2010 land use data and county-level data from USDA Census, scaled by proportion of farmland within the watershed. Annual irrigation-water needs from June through September are 9 inches for corn, soybeans, and grain (2,600 gpd/ac for 100,480 irrigated acres or 261 mgd). In the Nanticoke watershed, the annual value of water needed to irrigate 9 inches of water over 100,480 acres at a use value of $402/ac-ft is $125 million.

Table 16. Freshwater-use values in the United States

Use	1996 Median ($/acre-ft)	2020 Median ($/acre-ft)	2020 Median ($/1,000 gal)
Navigation	$10	$20.33	$0.07
Irrigation	$198	$402.49	$1.31
Industrial Process	$132	$268.33	$0.87
Thermoelectric Power	$29	$58.95	$0.19

Thermoelectric-Power Water Supply

There are no thermoelectric power plants in the Nanticoke watershed.

Industrial Water Supply

Industrial-water withdrawals totaled 4.41 mgd in the Nanticoke watershed. If the median market value of industrial withdrawals is $132/ac-ft in 1996 dollars (Frederick et al. 1996) or $246/ac-ft. ($0.87/1,000 gal) in 2020 dollars, then the value of industrial-water withdrawals (4.41 mgd) in the Nanticoke watershed is $3,837 per day or $1.4 million per year.

Fish/Wildlife

National Wildlife Refuge

There is one national wildlife refuge (NWR) located just outside of the Nanticoke watershed, located near Fishing Bay in Dorchester County. Blackwater National Wildlife Refuge was established in 1933 as a refuge for migratory birds using the Atlantic Flyaway. Today, Blackwater NWR is more than 28,000 acres in size and is home to one-third of the state of Maryland's tidal wetlands. According to Carver and Caudill (2017), Blackwater NWR receives 222,792 recreation visitors annually, which amounts to $7.8 million in total economic output. Additionally, Blackwater NWR employs 63 people who make $2.3 million in wages (Table 17).

Table 17. Contributions to local economy from Blackwater National Wildlife Refuge

Refuge	Total Recreation Visits	Total Economic Output	Total Employment Income	Total Jobs
Blackwater NWR	222,792	$7,790,800	$2,314,600	63

Blue Crab

According to a dredge survey by the Chesapeake Bay Program in 2019, there are a total of 594 million blue crabs in the Bay. The Chesapeake Bay surface area is equal to 4,479 square miles, while the Nanticoke estuary surface area is equal to 28.6 square miles. By proportion, there are approximately 3.79 million blue crabs in the Nanticoke. If 1.5 blue crabs make up one pound, then 3.79 million crabs equal 2.53 million pounds. At $1.74 per pound, the annual value of the Bay's blue crab fishery potential is approximately $4.4 million.

Fishing, Hunting, and Bird/Wildlife Watching

In Delaware and Maryland, the U. S. Fish and Wildlife Service (2011) estimated the annual economic value of recreational fishing, hunting, birding/wildlife-viewing activities totaled was $1.6 billion (Table 18). Trip expenditures include purchases and sales of food and lodging, transportation, and hunting, fishing, and wildlife watching equipment. Average daily trip expenditures range from $24 to $49/trip for fishing, $14 to $45/trip for hunting, and $23 to

$66/trip for wildlife/bird-watching. Much of the fishing, hunting, and birding/wildlife recreation occur on farms, forests, wetlands, and open water ecosystems such as Trap Pond State Park and Blackwater National Wildlife Refuge.

The Nanticoke watershed covers 826 square miles, including 26% of the total land area in Delaware and 3% of the land area in Maryland. Scaling by the ratio of watershed area to state land area, the estimated annual economic value of fishing, hunting, and wild- life/birdwatching recreation in the Nanticoke watershed is $123 million including $45 million from fishing, $19 million from hunting, and $59 million from wildlife/bird watching.

Table 18. Value of fishing, hunting, wildlife/birding recreation in the Nanticoke watershed

Recreation Activity	Delaware[1] ($ million)	Maryland[1] ($ million)	Total[1] ($ million)
Fishing	104	535	639
Hunting	41	264	305
Wildlife/Bird-Watching	169	483	652
Total	**315**	**1,283**	**1,596**
	DE in Watershed[2] ($ million)	**MD in Watershed[2] ($ million)**	**Total in Watershed[2] ($ million)**
Fishing	27	18	45
Hunting	10	9	19
Wildlife/Bird-Watching	43	16	59
Total	**80**	**43**	**123**

Recreation

Outdoor Recreation

The Outdoor Industry Association (2016) concluded 3.5 million people participated in recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing in Delaware and Maryland and therefore contributing $17.1 billion and 138,000 jobs to the regional economy. Given that the population of the two states totals 7 million--967,171 (Delaware) and 6.043 million (Maryland)--by proportion outdoor recreation activity in the Nanticoke watershed with a year-round population of 90,195 contributes $269 million in consumer spending to the economy and 2,440 jobs with $83.4 million in wages (Table 19).

[1] USFWS 2011.
[2] Scaled by ratio of Nanticoke watershed area to state areas (26% DE and 3% MD).

Table 19. Economic value of recreation in the Nanticoke watershed

Economic Activity	Delaware[1]	Maryland[3]	Total[3]
Consumer Spending	$3.1 billion	$14 billion	$17.1 billion
Participants	467,000	3 million	3.5 million
Jobs	29,000	109,000	138,000
Wages	$959 million	$4.4 billion	$5.4 billion
Economic Activity	**DE in Watershed[2]**	**MD in Watershed[4]**	**Total in Nanticoke Watershed[4]**
Consumer Spending	$220 million	$49 million	$269 million
Participants	33,157	10,500	43,657
Jobs	2,059	381	2,440
Wages	$68 million	$15.4 million	$83.4 million

Powerboating

The National Marine Manufacturers Association (2014) announced that Delaware and Maryland ranked 9th and 23rd in the U.S. respectively in total expenditures for new powerboats, outboard engines, boat trailers, and accessories. Table 20 summarizes powerboat expenditures scaled by ratio of land area in the watershed to area of each state. Powerboat expenditures within the Nanticoke watershed are estimated at $149.5 million/year.

Table 20. Recreational powerboat expenditures in the Nanticoke watershed

State	Rank Expenditures	Powerboat Expenditures	% of Land of States in Watershed	Watershed Expenditures
Delaware	9	$544 million	26%	$141.4 million
Maryland	23	$270 million	3%	$8.1 million
Total		**$814 million**		**$149.5 million**

State Parks

The Nanticoke watershed contains one state park, Trap Pond, located near Laurel, Delaware in Sussex County. Trap Pond State Park spans 3,653 acres (5.7mi^2) with 116,626 visitors per year. At $259 per visit estimated by an economic study of the Delaware State Park system (Rockport Analytics 2017), the 116,626 visitors to the state park in the Nanticoke watershed contribute $30 million annually to the regional economy (Table 21).

[1] Outdoor Industry Association 2016.
[2] Scaled by proportion of Nanticoke watershed to state-wide population.

Table 21. Delaware state parks visitation & visitor spending FY 2016/17

State Park	Attendance	$/Visitor-Day	Spending
Trap Pond State Park, DE	116,626	$259	$30,206,134

Agriculture

In 2017, the value of agricultural products sold in Kent County and Sussex Counties, Delaware; Caroline, Dorchester, and Wicomico Counties, Maryland was $2.2 billion (USDA 2017). Scaling by the ratio of farmland in the watershed to farmland in the counties, the annual market value of agricultural products sold in the Nanticoke watershed was $1.02 billion on 1,413 farms from nurseries, vegetables, fruit, horses, grain, poultry, and cattle (Table 22). However, the poultry industry dominates the agricultural land in the Nanticoke watershed, especially in Sussex County, Delaware.

Table 22. Economic value of agriculture in the Nanticoke watershed

County	Total Farmland (mi^2)	Farmland in Watershed (mi^2)	Farms in County	Farms in Watershed	Economic Value in County ($ million)	Economic Value in Watershed ($ million)
Kent	243	45.5	822	153	391	73
Sussex	379	244.5	1,119	721	1,000	645
Caroline	170	38.4	588	132	277	63
Dorchester	152	58.9	371	143	189	73
Wicomico	102	54.7	494	264	304	163
Total	**1,046**	**442**	**3,394**	**1,413**	**2,161**	**1,017**

Forests

The U.S. Forest Service (Nowak et al. 2008) estimated that forests provide environmental benefits such as carbon storage of $5.9 million ($827/acre) and air-pollution removal of $1.9 million ($266/acre/year). Applying these multipliers, 72,448 acres (113 mi^2) of forests in the Nanticoke watershed have benefits of carbon storage ($60 million), carbon sequestration ($2 million), air-pollution removal ($19 million), building energy savings ($4 million), and avoided carbon emissions ($220,000). Forests in the Nanticoke watershed provide environmental benefits by regulating climate change, cooling, and air-emissions control including 1.6 million tons of carbon storage 56,090 tons of carbon sequestration, 1,603 tons of air-pollution removal, and 5,609 tons of avoided carbon emissions (Tables 23 and 24).

Table 23. Economic/environmental benefits of forests in the Nanticoke watershed

Benefits	New Castle County[1]		Nanticoke Watershed[2]	
	Environmental (ton/acre)	Economic ($/acre)	Environmental (ton)	Economic ($)
Carbon Storage	40	827	1,602,560	59,914,496
Carbon Sequestration	1.4	29	56,090	2,100,992
Air Pollution Control	0.04	266	1,603	19,271,168
Energy Savings		56		4,057,088
Avoided Carbon Emissions	0.14	3	5,609	217,344

Table 24. Economic benefits of forests by state in the Nanticoke watershed

Benefits	New Castle County[3] ($/acre)	Delaware[4] ($)	Maryland[5] ($)	Nanticoke Watershed ($)
Carbon Storage	827	33,132,928	26,781,568	59,914,496
Carbon Sequestration	29	1,161,856	939,136	2,100,992
Air Pollution Control	266	10,657,024	8,614,144	19,271,168
Energy Savings	56	2,243,584	1,813,504	4,057,088
Avoided Carbon Emissions	3	120,192	97,152	217,344
Total	**1,181**	**47,315,584**	**38,245,504**	**85,561,088**

Public Parks

Public parks and open space are a critical component of maintaining overall watershed health. It has been found that preserving land for open space adds direct and indirect economic benefits. Properties that are adjacent to or are near high quality public protected lands are more desirable and have a more significant property value. Open space benefits also include: filtering of drinking water, replenishment of water supply, provision of natural flood mitigation, and filtering of air pollutants.

The Trust for Public Land (2009) found the 444-acre City of Wilmington park system provides annual economic value and savings to the public from:

- Health benefits from exercise in the parks ($4,322,000 or $9,734/acre)
- Community-cohesion benefits from people socializing in the parks ($1,058,000 or $2,383/acre)

[1] Nowak et al. (2008).
[2] Computed for 72,448 acres of forest in the Nanticoke watershed.
[3] Nowak et al. (2008).
[4] Computed for 40,064 acres of forest in Delaware.
[5] Computed for 32,384 acres of forest in Maryland.

- Water pollution-mitigation benefits from parks in treating stormwater ($409,000 or $921/acre)
- Air pollution–mitigation value from tree and shrub absorption ($39,000 or $88/acre).

Assuming the data gathered for the City of Wilmington study is appropriate for value transfer, public parks in the Nanticoke watershed provide the following economic benefits (Table 25):

- Health benefits from exercise in the parks ($576 million)
- Community-cohesion benefits from people socializing in the parks ($141 million)
- Water pollution-mitigation benefits from parks in treating stormwater ($54 million)
- Air pollution-mitigation value from tree and shrub absorption ($5 million)

Table 25. Value of public parks in the Nanticoke watershed

Total Park Land (acres)	Health Benefits @ $9,734/ac	Community Cohesion @ $2,383/ac	Stormwater Benefit @ $921/ac	Air Pollution @ $88/ac	Total
59,171	$575,980,514	$141,004,493	$54,496,491	$5,207,048	$776,688,546

Port Navigation

Assuming that the Nanticoke River is uniformly 10 feet deep, the economic value of navigation capabilities is estimated at $4.5 million. Approximately 22,400 acres of open water exist in the Nanticoke watershed. Multiplying 22,400 acres by a depth of 10 feet provides the volume of water that is considered to be navigable in the watershed, 224,000 acre-feet. In the Resources for the Future study (Frederick et al. 1996), researchers estimated the median use-value of navigation was $10/ac-ft in 1996 dollars or $20.33/ac-ft in 2020 dollars, adjusting for 3% annual change in the CPI. Therefore, the navigation use-value in 2020 dollars is equal to $4.5 million

4. Ecosystem Services

Ecosystem services (natural capital) are the sum of goods (commodities like water, crops, and timber that can be sold) and services (functions like flood control, water filtration, and fisheries habitat) provided by watershed habitat such as wetlands, forests, farms, and open water. The following studies were examined to estimate ecosystem-services values for the Nanticoke watershed:

- Cecil County green infrastructure study by the Conservation Fund, Annapolis, Md. (2007)
- Mates and Reyes with the New Jersey Department of Environmental Protection (NJDEP) and the University of Vermont (2007)
- Ecosystem services value of forests by the Wilderness Society (2001)
- Ecosystem services value of Peconic Estuary watershed by University of Rhode Island (2002)
- U.S. National Wildlife Refuges by University of Maryland and Nature Conservancy (2008)
- Economic value of ecosystem services in Massachusetts by the Audubon Society (2003)

Related Research

Ecosystem services include air filtration, water filtration, recycling nutrients, soil conservation, pollinating crops and plants, climate regulation, carbon sequestration, flood/stormwater control, and hydrologic-cycle regulation. Ecological resources provide marketable goods and services such as timber, fish and wildlife recreation, hiking, and boating/kayaking.

Mates and Reyes (2007) partnered with the NJDEP and University of Vermont and estimated the value of New Jersey's natural capital at $20 billion/year in 2004 dollars with a net present value (NPV) of $681 billion. NPV takes the value of a dollar today and projects it into the future summed annually over a lifetime (say, 100 years), given the annual value is discounted by a rate (3%) due to inflation based on the Consumer Price Index.

There have been additional studies that have calculated the value of natural capital in ecosystems along the Atlantic seaboard and across the United States. Weber (2007) from the Conservation Fund found the largest ecosystem services values in Cecil County, Maryland are from stormwater/flood control, water supply, and clean water functions (Table 26). The Wilderness Society (Krieger, 2001) concluded that forest ecosystem services for climate regulation, water supply, water quality, and recreation benefits totaled $392/acre in 1994 dollars or $845/acre in 2020 dollars based on change in the Northeast Region CPI (Table 27). A contingent value study by University of Rhode Island economists found that natural resources values in the Peconic Estuary watershed in Suffolk County on Long Island, NY ranged from $6,560/acre for wetlands to $9,979/acre for farmland in 1995 dollars (Johnston et al., 2002). The University of Maryland studied the U.S. National Wildlife Refuge System and determined that ecosystem values of freshwater wetlands and forests are $6,268/acre and $845/acre, respectively (Ingraham and Foster, 2008). The Audubon Society found the economic value of ecosystems in Massachusetts ranged from $984/acre for forests to $15,452/acre for saltwater wetlands (Breunig 2003). The

USDA Census of Agriculture (2017) reported the market value of agricultural products sold from cropland in Kent and Sussex Counties, Delaware; and Caroline, Dorchester, and Wicomico Counties, Maryland was $917/acre.

Table 28 compares ecosystem services values from other watersheds. Data from the NJDEP study and crop value of Ocean County agriculture are used for value transfer to the Nanticoke watershed as the study area shares similar ecosystems (forests/wetlands), climate (humid continental at 40 degrees north in latitude), physiographic provinces (Coastal Plain), aquifers, and soils. NJDEP ecosystem-services values are lower than both Cecil County's ecosystem values for wetlands and forests and Massachusetts Audubon's ecosystem values for wetlands. NJDEP estimates are higher than the Wilderness Society's ecosystem values for forests and the U.S. Wildlife Refuge's ecosystem values for freshwater wetlands and forests.

Table 26. Ecosystem service values for Cecil County, Maryland

Ecosystem Service	Upland Forest ($/ac/yr)	Riparian Forest/Wetland ($/ac/yr)	Nonriparian Wetland ($/ac/yr)	Tidal Marsh ($/ac/yr)
Carbon sequestration	31	65	65	65
Clean air	191	191	191	
Soil and peat formation	17	946	450	1,351
Stormwater/flood control	679	32,000	32,000	1,430
Water supply	8,630	8,630	8,630	
Clean water	1,100	1,925	1,100	11,000
Erosion/sediment control	151	3,418	151	12,700
Water temperature regulation		4,450		
Pest control	50	50	50	
Pollination	75	75	75	
Wood products	142			
Recreation, fish, wildlife habitat	486	534	534	544
Community services savings	439	439	439	439
Increase in property values	42	42		
Total	**12,033**	**52,765**	**43,685**	**27,529**

Table 27. Forest ecosystem service values for U.S. temperate forests

Ecosystem Good/Service	1994 Value[1] ($/ac)	2020 Value[2] ($/ac)
Climate regulation	57.1	123.1
Disturbance regulation	0.8	1.7
Water regulation	0.8	1.7
Water supply	1.2	2.6
Erosion/sediment control	38.8	83.7
Soil formation	4	8.6
Nutrient cycling	146.1	315.1
Waste treatment	35.2	75.9
Biological control	0.8	1.7
Food production	17.4	37.5
Raw materials	55.8	120.3
Genetic resources	6.5	14
Recreation	26.7	57.6
Cultural	0.8	1.7
Total	**392.1**	**845.2**

Table 28. Comparison of ecosystem goods and services values from various studies

Ecosystem	Cecil Co. Md. 2006 ($/ac/yr)	NJDEP 2007 ($/ac/yr)	Wilderness Society 2001 ($/ac/yr)	Peconic Estuary 1995 ($/ac/yr)	U.S. Wildlife 2008 ($/ac/yr)	Mass. Audubon 2003 ($/ac/yr)	USDA Census 2017 ($/ac/yr)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	2,976
Forest land	12,033	1,712	641		845	984	
Saltwater wetland	28,146	6,269		6,560		12,580	
Undeveloped				2,080			
Urban		296					
Beach/dune		42,149					
Open freshwater		1,686			217	983	
Riparian buffer	52,765	3,500					
Shellfish areas				4,555			

[1] Krieger 2001.
[2] Adjusted to 2020 dollars based on change in Northeast Region CPI (BLS).

Watershed Ecosystem Services

The estimated value of ecosystem goods and services provided by the Nanticoke watershed (826.3 mi^2 or 528,832 acres) is $3.7 billion (in 2017 dollars) with a net present value (NPV) of $121 billion (Table 29). Present value refers to the current value of a future sum of money, while net present value may be defined as the difference between the present value of cash inflows and outflows over a period of time. By state, the ecosystem services value of the Nanticoke watershed is $2.3 billion in Delaware and $1.4 billion in Maryland (Figure 4). Ecosystems in the watershed (Figure 5) include farmland (53.5%), freshwater wetlands (21.6%), forests (13.7%), open water (4.2%), urban (4.1%), saltwater wetlands (2.3%), and barren/other (0.1%). Freshwater wetlands ($1,969 million), farmland ($1,377 million), and forests ($322 million) provide the highest ecosystems services values (Figures 6 and 7). Figure 8 summarizes the low, mid-range, and high values for ecosystem services in the Nanticoke watershed.

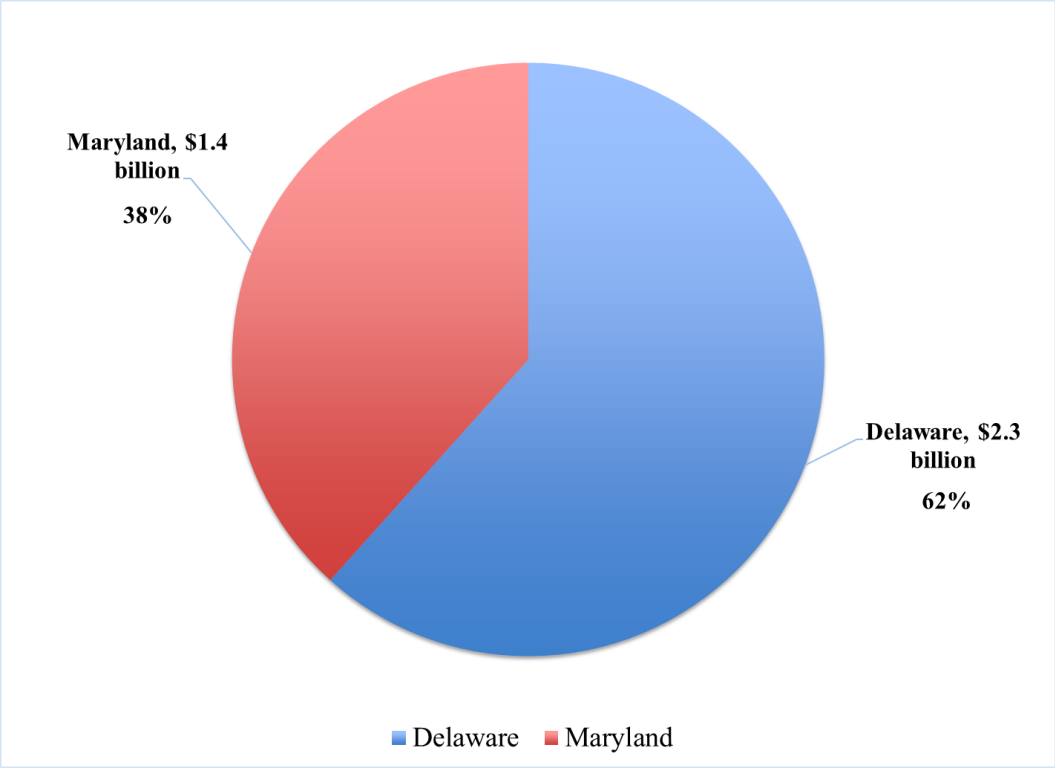

Figure 4. Ecosystem services value of the Nanticoke watershed, by state

Table 29. Value of ecosystem goods and services in the Nanticoke watershed

Ecosystem	Area (ac)	Services ($/ac/yr)	PV ($)	NPV ($)
Nanticoke Watershed	**528,832**		**3,736,903,552**	**121,449,365,440**
Freshwater wetlands	113,920	17,332	1,974,461,440	64,169,996,800
Farmland	282,880	4,871	1,377,908,480	44,782,025,600
Forest	72,448	2,517	182,351,616	5,926,427,520
Saltwater wetlands	14,912	9,208	137,309,696	4,462,565,120
Barren land	640	0	0	0
Urban	21,632	435	9,409,920	305,822,400
Open water	22,400	2,476	55,462,400	1,802,528,000
Delaware	**318,080**		**2,303,946,304**	**74,878,254,880**
Freshwater wetlands	74,304	17,332	1,287,836,928	41,854,700,160
Farmland	185,600	4,871	904,057,600	29,381,872,000
Forest	40,064	2,517	100,841,088	3,277,335,360
Saltwater wetlands	0	9,208	0	0
Barren land	448	0	0	0
Urban	15,936	435	6,932,160	225,295,200
Open water	1,728	2,476	4,278,528	139,052,160
Maryland	**210,752**		**1,432,957,248**	**46,571,110,560**
Freshwater wetlands	39,616	17,332	686,624,512	22,315,296,640
Farmland	97,280	4,871	473,850,880	15,400,153,600
Forest	32,384	2,517	81,510,528	2,649,092,160
Saltwater wetlands	14,912	9,208	137,309,696	4,462,565,120
Barren land	192	0	0	0
Urban	5,696	435	2,477,760	80,527,200
Open water	20,672	2,476	51,183,872	1,663,475,840

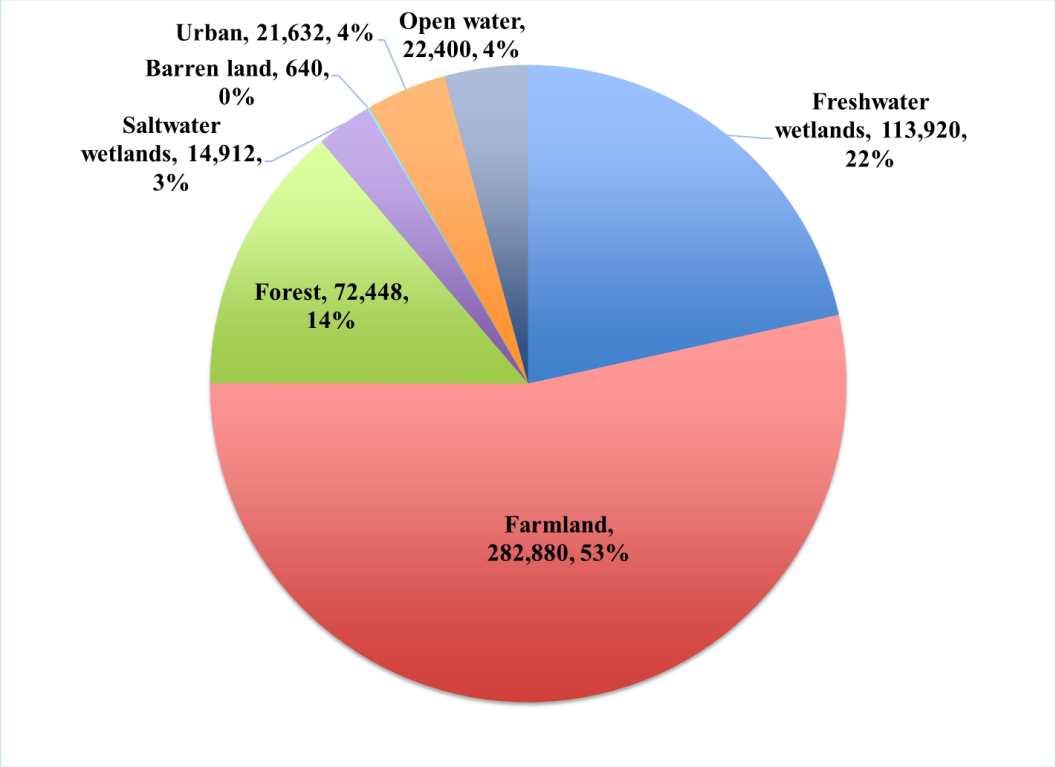

Figure 5. Ecosystems acreage in the Nanticoke watershed

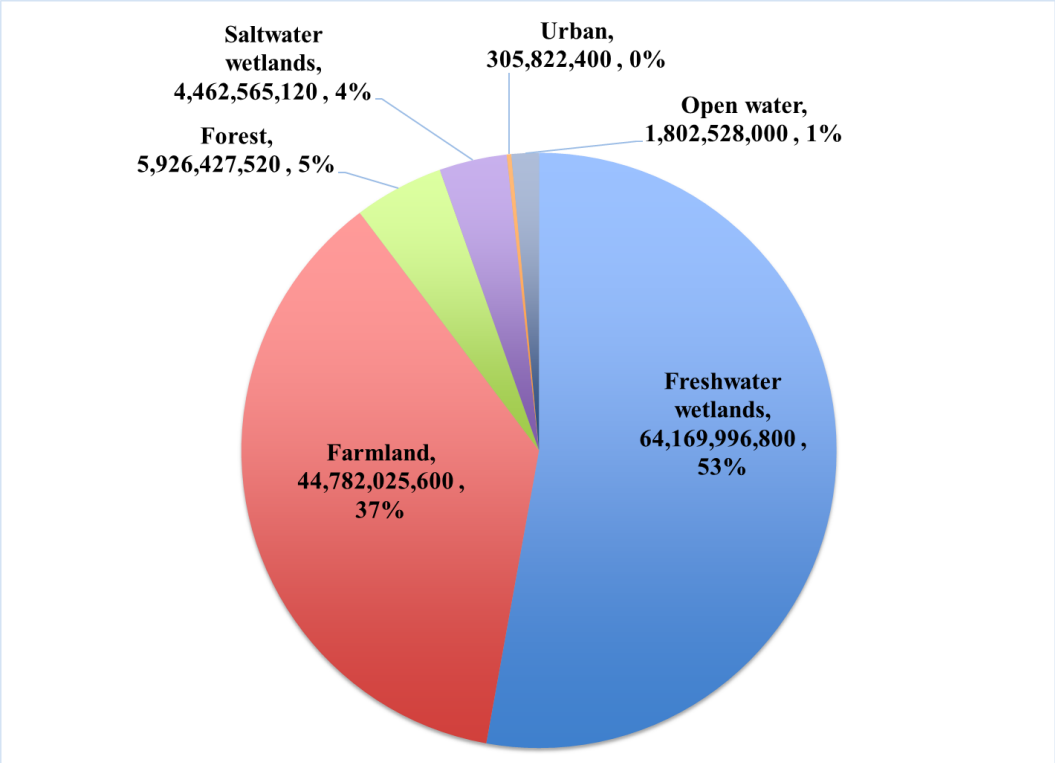

Figure 6. Annual value (dollars) of ecosystem services in the Nanticoke watershed

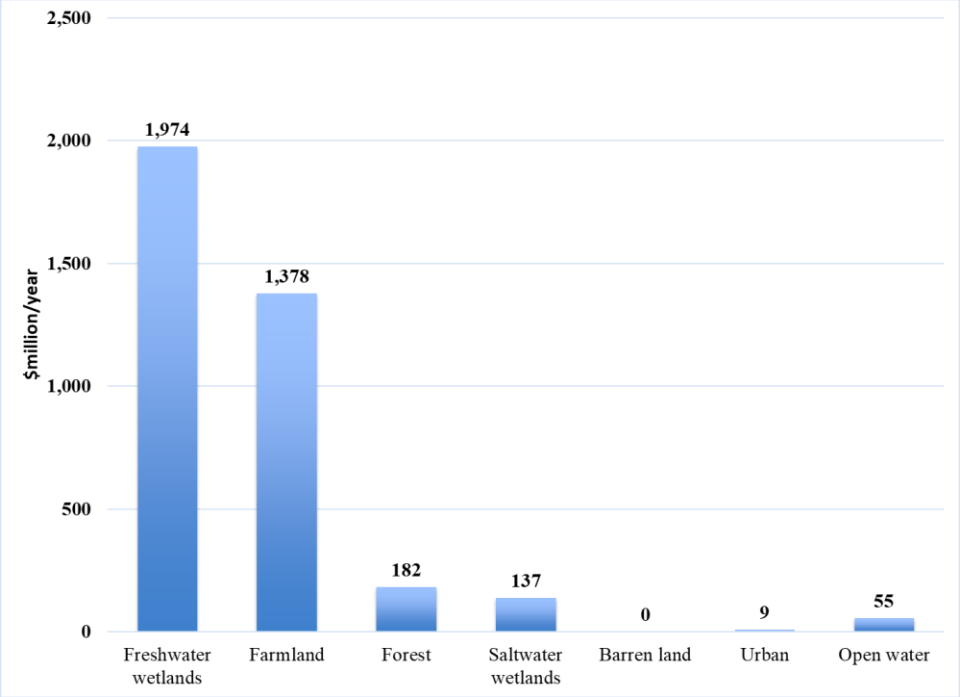

Figure 7. Annual value of ecosystem services in the Nanticoke watershed, millions of dollars

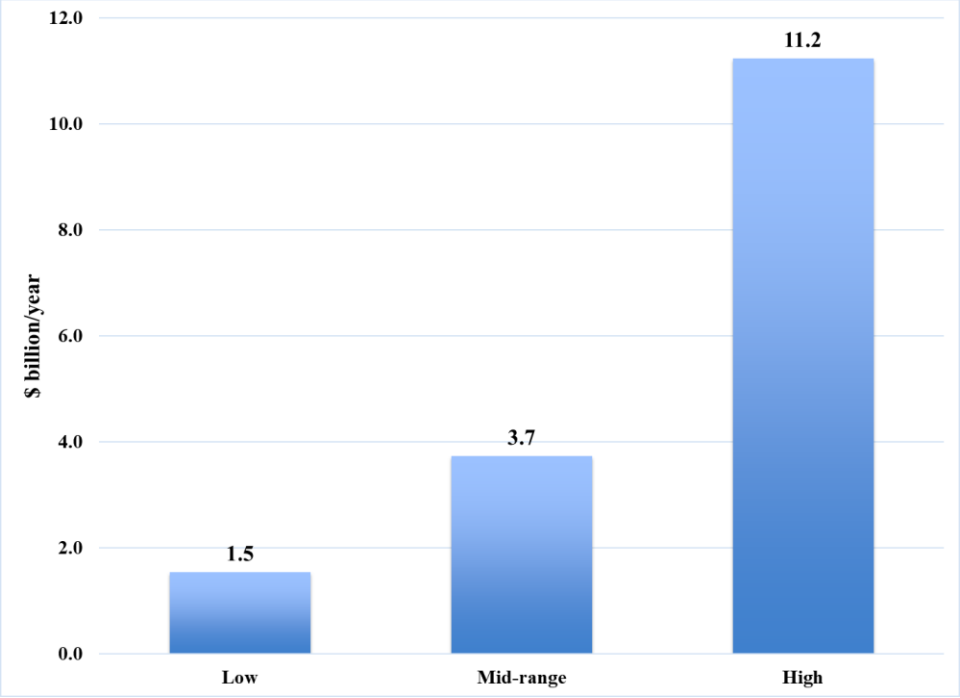

Figure 8. Range of annual ecosystem services value estimates in the Nanticoke watershed, billions of dollars

Ecosystem services in the Nanticoke watershed using the NJDEP and USDA crop values are worth $3.7 billion in 2017 dollars or $121.4 billion (NPV), which are in the middle of the range based on value transfer from other watersheds (Table 30). If lower per-acre estimates of ecosystem services from other studies were used instead of the NJDEP values, ecosystem services in the Nanticoke watershed would be $1.5 billion per year with NPV of $50.3 billion (Table 31). If higher per-acre estimates from other studies were used, the value of ecosystems in the Nanticoke watershed would be $11.2 billion with NPV of $365.1 billion (Table 32).

Table 30. Low, mid-range, and high values of ecosystem services in the Nanticoke watershed

Estimate	PV ($B)	NPV ($B)
Low	1.5	50.3
Mid-range	3.7	121.4
High	11.2	365.1

Table 31. Low range of ecosystem services in the Nanticoke watershed

Ecosystem	Area (ac)	Services ($/ac/yr)	PV ($)	NPV ($)
Freshwater wetlands	113,920	7,709[5]	875,742,400	28,461,628,000
Farmland	282,880	1,706[6]	482,593,280	15,684,281,600
Forest	72,448	788[3]	57,089,024	1,855,393,280
Saltwater wetlands	14,912	7,710[2]	117,438,720	3,816,758,400
Barren land	640	0	0	0
Urban	21,632	364[2]	7,874,048	255,906,560
Open water	22,400	267[5]	5,980,800	194,376,000
Total	**528,832**		**1,546,717,952**	**50,268,333,440**

Table 32. High range of ecosystem services in the Nanticoke watershed

Ecosystem	Area (ac)	Services ($/ac/yr)	PV ($)	NPV ($)
Freshwater wetlands	113,920	53,727[1]	6,120,579,840	198,918,844,800
Farmland	282,880	12,273[4]	3,471,786,240	112,833,052,800
Forest	72,448	14,799[1]	1,072,157,952	34,845,133,440
Saltwater wetlands	14,912	34,616[1]	516,193,792	16,776,298,240
Barren land	640	0	0	0
Urban	21,632	364[2]	7,874,048	255,906,560
Open water	22,400	2,074[2]	46,457,600	1,509,872,000
Total	**528,832**		**11,235,049,472**	**365,139,107,840**

[1] Cecil Co., MD 2006.
[2] NJDEP 2007.
[3] Wilderness Society 2001.
[4] Peconic Estuary 1995.
[5] Ingraham and Foster 2008.
[6] Breunig 2003.

5. Jobs and Wages

The economy in Kent and Sussex Counties, Delaware; and Caroline, Dorchester, and Wicomico Counties, Maryland supports 214,590 jobs with $8.2 billion in annual wages (NOEP 2016). The Nanticoke watershed within these counties is a job engine with water resources and habitat that supports 18,499 direct and indirect jobs with over $438 million in annual wages in the coastal, agriculture, fishing/hunting/birding, tourism, recreation, and water supply sectors (Table 33).

Table 33. Jobs and wages directly and indirectly related to the Nanticoke watershed

Sector	Jobs	Wages ($ million)	Data Source
Direct Watershed-Related	4,384	99.7	U.S. Bureau of Labor Statistics (2016)
Indirect Watershed-Related	5,259	79.8	U.S. Census Bureau (2016)
Fishing/Hunting/Birding	3,744	123	U.S. Fish and Wildlife Service (2011)
National Wildlife Refuge	63	2.3	U.S. Fish and Wildlife Service (2014)
Outdoor Recreation	2,647	90.6	Outdoor Industry Association (2016)
State Parks	58	1.7	Mates and Reyes (2006)
Farm	2,195	36.6	USDA Agriculture Census (2017)
Wetlands	110	2.54	NOAA Office for Coastal Management (2013)
Watershed Organizations	4	0.13	Nanticoke Watershed Alliance (2019)
Water Supply Utilities	20	1.1	American Water Works Association (2004)
Wastewater Utilities	15	0.825	MDOE and VMS (2013)
Nanticoke Watershed	**18,499**	**438**	

Jobs and wages in the Nanticoke watershed were obtained from U.S. Bureau of Labor Statistics (2018) and U.S. Census Bureau (2018) databases. Note the NAICS database does not include jobs for certain known water-related industries, such as commercial fishing and boat building therefore the columns are left blank. Hence, watershed-related jobs are likely to be undercounted. Nanticoke watershed-related jobs are tabulated for three categories: (1) total jobs within Kent and Sussex Counties, Delaware; and Caroline, Dorchester, and Wicomico Counties, Maryland (2) direct and indirect Nanticoke watershed jobs and (3) jobs in watershed-related categories such as farm, fishing, hunting, boating, etc.

Total jobs in Kent and Sussex Counties, Delaware; and Caroline, Dorchester, and Wicomico Counties, Maryland by NAICS code from U.S. Bureau of Labor Statistics (2018) indicate there were 214,590 jobs with wages of $8.2 billion (Table 34).

Table 34. Nanticoke watershed employment and wages by county, 2018

County	Employed	Wages ($ million)
Kent, Delaware	66,719	2,900
Sussex, Delaware	81,813	3,300
Caroline, Maryland	9,821	4.1
Dorchester, Maryland	10,880	4.4
Wicomico, Maryland	45,357	2,000
Total	**214,590**	**8,209**

Direct/Indirect Water Jobs

Direct watershed-related jobs such as water/sewer construction, living resources, maritime, tourism/recreation, ports, environmental services, and water/wastewater management were identified for each NAICS code in Kent and Sussex Counties, Delaware; and Caroline, Dorchester, and Wicomico Counties, Maryland. Industries directly associated with the Nanticoke watershed (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employed 4,384 people with $99.7 million in wages (Table 35). Indirect jobs and wages funded by the purchase of goods/services by direct jobs earners are estimated by a multiplier of 2.2 for direct jobs and 1.8 for direct wages (Latham and Stapleford, 1990). The United Nations Environment Programme (2011) estimates each tourism job generates 1.5 indirect jobs. For this report, we assume that each direct watershed job funds 1.2 indirect jobs and a dollar in direct wages funds $0.80 in indirect wages. Indirect jobs in the watershed (based on multipliers of 2.2 for jobs and 1.8 for salaries) employed 5,259 people with $79.8 million in wages (Table 36).

Table 35. Nanticoke watershed jobs and wages in 2018

Category	Jobs	Wages ($ million)
Total for 5 Counties	36,619	1,357
Direct Watershed-Related	4,384	99.7
Indirect Watershed-Related	5,259	79.8

Table 36. Direct/indirect watershed-related jobs[1] in the Nanticoke watershed, 2018

Sector	North American Industry Classification System (NAICS)	NAICS Code	Direct Watershed Jobs	Direct Annual Wages (x$1,000)	Indirect Watershed Jobs	Indirect Annual Wages (x$1,000)
Construction	Water and sewer construction	23711	47	2,236	56	1,789
Living Resources	Agriculture and forestry	115	76	3,463	91	2,770
	Seafood prep/packaging	3117	14	438	17	350
	Fish & seafood wholesalers	42446	8	219	10	175
	Fish and seafood markets	44522	21	922	25	738
	Fruit and vegetable markets	44523	2	39	2	31
Minerals	Mining, quarrying	21	10	551	12	441
Tourism/Recreation	Sporting/recreational goods	42391	3	153	4	122
	Sporting goods stores	4511	1	31	1	25
	Boat dealers	441222	60	2662	72	2,130
	Golf courses	71391	199	5,392	239	4,314
	Marinas	71393	8	248	10	198
	Fitness/recreational sports	71394	179	2,246	215	1,797
	Accommodation	721	734	17,141	881	13,713
	Hotels and motels	72111	511	11,040	613	8,832
	Bed-and-breakfast inns	721191	10	203	12	162
	Recreational vehicle, camps	7212	96	2,612	115	2,090
	Full-service restaurants	7221	1,869	29,852	2,243	23,882
	Food service contractors	72231	52	1,439	62	1,151
Transportation	Coastal, water transport	483	7	373	8	298
	Scenic/sightseeing transport	487	6	85	7	68
Environmental	Architectural, engineering	5413	141	8,220	169	6,576
	Environmental, conservation	813312	2	63	2	50
	Civic and social organizations	8134	222	4,110	266	3,288
Water/Wastewater	Waste management services	562	106	5,967	127	4,774
Total			**4,384**	**99,705**	**5,259**	**79,764**

[1] Direct jobs/wages are those directly related to the Nanticoke watershed using county level data and scaling by proportion of county population within the watershed. Indirect jobs/wages are derived from purchases of goods and services by direct jobs earners by multipliers of 2.2 for jobs and 1.8 for wages.

National Coastal Economy

The National Ocean Economics Program (NOEP) (2016) summarized the coastal economy in the United States for the following industrial sectors: Marine Transportation, Tourism and Recreation, Living Marine Resources, Marine Construction, Ship and Boat Building, Mineral Extraction (Table 37). According to the NOEP, the coastal economy in Kent and Sussex Counties, Delaware and Caroline, Dorchester, and Wicomico Counties, Maryland, which are located in the Nanticoke watershed, contributed 35,409 jobs, representing $1.4 billion in annual wages and $3.4 billion toward the five counties' gross domestic product or GDP (Table 38).

Table 37. Sectors and industries in the coastal economy

Sector	Industry	NAICS Code
Construction	Marine Construction	237120, 237990
Living Resources	Fishing	
	Fish Hatcheries & Aquaculture	112511, 112512
	Seafood Markets	445220
	Seafood Processing	311711, 311712
Offshore Minerals	Limestone, Sand, & Gravel	212321, 212322
	Oil & Gas Exploration	211111, 213111
	Oil & Gas Production	213112, 541360
Ship and Boat Building	Boat Building & Repair	336611
	Ship Building & Repair	336612
Tourism and Recreation	Amusement & Recreation Services	487990, 611620, 532292, 713990
	Boat Dealers	441222
	Eating & Drinking Places	722110, 722211, 722212, 722213
	Hotels & Lodging Places	721110, 721191
	Marinas	713930
	Recreation Vehicle Parks & Campgrounds	721211
	Scenic Water Tours	487210
	Sporting Goods Retailers	339920
	Zoos, Aquaria	712130, 712190
Transportation	Deep Sea Freight Transportation	483111, 483113
	Marine Passenger Transportation	483112
	Marine Transpotation Services	483114
	Search & Navigation Equipment	334511
	Warehousing	4931100, 493120, 493130

Table 38. Coastal employment, wages, and GDP in the Nanticoke watershed

Sector	Employment	Wages ($ million)	GDP ($ million)
Construction	2,189	106.6	219
Financial Activities	1,309	71.2	539
Education/Health Services	8,613	434.9	434
Information	246	14.7	71
Leisure/Hospitality	5,746	117	227
Manufacturing	4,388	198	621
Natural Resources/Mining	436	16.7	22
Other Services	1,145	34.3	88
Professional/Business	3,210	153.1	271
Public Administration	533	28.6	242
Trade/Transportation/Utilities	7,594	272.5	627
Total	**35,409**	**1,447.6**	**3,361**

Recreation Jobs

Fishing/Hunting/Wildlife Recreation

The average annual salary per ecotourism job is $32,843 using figures from the 2011 U.S. Fish and Wildlife Service survey of fishing, hunting, and wildlife-associated recreation. Fishing, hunting, and bird/wildlife-associated recreation in the Nanticoke watershed account for $123 million in annual economic activity. At an average salary of $32,843, fishing, hunting, and bird/wildlife-associated recreation accounts for 3,744 jobs in the Nanticoke watershed (Table 39). While this estimate of ecotourism jobs is not exact, it provides a reasonable estimate of the jobs provided by fishing, hunting, and bird/wildlife-associated recreation in the Nanticoke watershed.

Table 39. Value of fishing, hunting, wildlife/birding jobs in the Nanticoke watershed

Recreation Activity	DE in Watershed ($ million)	DE Jobs in Watershed	MD in Watershed ($ million)	MD Jobs in Watershed	Total in Watershed ($ million)	Total Jobs in Watershed
Fishing	27	822	18	548	45	1,370
Hunting	10	304	9	274	19	578
Wildlife/Bird-Watching	43	1,309	16	487	59	1,796
Total	**80**	**2,435**	**43**	**1,309**	**123**	**3,744**

National Wildlife Refuge

The U.S. Fish and Wildlife Service (Carver and Caudill 2017) estimated the 28,000-acre Blackwater Wildlife Refuge contributed to 63 jobs with $2.3 million in annual wages.

Outdoor Recreation

The Outdoor Industry Association (2016) concluded that outdoor recreation contributed to 138,000 jobs in Delaware and Maryland. Given the population of the two states within the watershed total is 90,195, by proportion outdoor recreation activity in the Nanticoke watershed contributes 2,647 jobs and $90.6 million in wages (Table 40).

Table 40. Outdoor recreation jobs in the Nanticoke watershed

County, State	Total Jobs in State	Watershed Jobs	Total Wages in State ($ million)	Total Wages in Watershed ($ million)
Kent, DE	29,000	125	959	4.2
Sussex, DE	29,000	2,120	959	70.1
Caroline, MD	109,000	108	4,400	4.4
Dorchester, MD	109,000	106	4,400	4.3
Wicomico, MD	109,000	188	4,400	7.6
Total	**138,000**	**2,647**	**5,359**	**90.6**

State Parks

There is one state park within the Nanticoke watershed – Trap Pond State Park, located in Delaware, with roughly 117,000 annual visitors. Mates and Reyes (2006) from the NJDEP reported an estimate of $21 per visit, 14.2 million visitors per year from 2000-2005 to the New Jersey state park and forest system supported about 7,000 jobs. If 14.2 million visitors to New Jersey state parks supported 7,000 jobs, then the 117,000 annual visitors in Trap Pond State Park in the Nanticoke watershed supports 58 jobs. According to the Delaware Office of Management and Budget, the average park ranger salary is roughly $30,000, which would translate to approximately $1.73 million in wages.

Farm and Wetland Jobs

Farm Jobs

In 2017, there were a total of 3,394 farms in Kent, Sussex, Caroline, Dorchester, and Wicomico Counties, which were made up of 669,440 acres of land (USDA 2017). By scaling this data according to the percentage of farmland within the Nanticoke watershed, this accounts for a total of 1,413 farms (Table 39). USDA data also indicated that these farms employ about 2,195 people within the Nanticoke watershed. The total farm wages are $36.6 million.

Table 41. Farm jobs in the Nanticoke watershed

County	Total Farmland (mi^2)	Farmland in Watershed (mi^2)	%	Farms in County	Farms in Watershed	Farm Laborers in Watershed	Farm Wages ($ million)
Kent	243	45.5	18.7%	822	153	172	2.6
Sussex	379	244.5	64.5%	1,119	721	1,310	19.8
Caroline	170	38.4	22.6%	588	132	148	1.9
Dorchester	152	58.9	38.8%	371	143	159	3.7
Wicomico	102	54.7	53.6%	494	264	406	8.6
Total	**1,046**	**442**	**40.3%**	**3,394**	**1,413**	**2,195**	**36.6**

Wetland Jobs

The NOAA Office for Coastal Management (2013) estimates that the 201 mi^2 wetlands in the Nanticoke watershed support 110 commercial fishing jobs in the watershed and $2.54 million in wages (Table 42).

Table 42. Commercial fishing jobs related to wetlands in the Nanticoke watershed

County	Jobs in County	Jobs in Watershed	Self-Employed Revenue ($ million)	Self-Employed Revenue in Watershed
Kent	69	2	2.6	61,880
Sussex	109	36	2.2	724,240
Caroline	46	8	0.97	166,452
Dorchester	345	59	8.3	1,421,790
Wicomico	45	5	1.7	170,510
Total	**614**	**110**	**$15.8**	**$2,544,872**

Environmental Jobs

Watershed Organization Jobs

Within the Nanticoke Watershed, there is one nonprofit watershed organization that is not entirely volunteer-based, the Nanticoke Watershed Alliance. The Alliance employs three full-time staff members and one part-time employee to work on programs to protect the Nanticoke watershed. These watershed organization jobs account for $132,000 in annual wages. Other volunteer-based organizations active in the watershed include Friends of the Nanticoke River, Nanticoke River Watershed Conservancy, and Trap Pond Partners.

Water Supply Jobs

Public/private water utilities withdraw 4.23 mgd of drinking water from groundwater supplies in the Nanticoke watershed. According to the American Water Works Association, the average salary of a water-system employee is $55,407. The number of jobs was calculated based on the assumption that one employee is needed for every 0.2 mgd, up until six employees. Water supply utilities in the watershed employ at least 20 jobs with annual wages of $1.1 million (Table 41).

Table 43. Public water supply jobs in the Nanticoke watershed

State	Water Purveyor	Capacity (mgd)	Jobs	Salaries
DE	Blades	0.25	1	55,407
DE	Bridgeville	0.48	2	110,814
DE	Delmar	0.4	2	110,814
DE	Greenwood	0.09	1	55,407
DE	Laurel	0.73	6	332,442
DE	Seaford	1.91	6	332,442
MD	Hebron	0.3	1	55,407
MD	Sharptown	--	--	--
MD	Vienna	0.072	1	55,407
Total		**4.23**	**20**	**$1,108,140**

Wastewater Utility Jobs

Public wastewater utilities discharge 4.38 mgd to the Nanticoke watershed. The five wastewater utilities employ approximately 15 staff, at an average salary of $55,000 the annual wages are $825,000 (Table 44). Employment information for Laurel and Vienna's wastewater treatment facilities could not be located. Therefore, estimates were made based on flow compared to Bridgeville's wastewater treatment facility.

Table 44. Wastewater discharge capacity in the Nanticoke watershed

State	Wastewater Utility	Flow (mgd)	Jobs	Salaries ($)
DE	Bridgeville WWTP	0.292	2	110,000
DE	Laurel WWTP	0.3	2	110,000
DE	City of Seaford WWTP	2	6	330,000
MD	Hurlock WWTP	1.65	3	165,000
MD	Vienna WWTP	0.1375	2	110,000
Total		**4.38**	**15**	**825,000**

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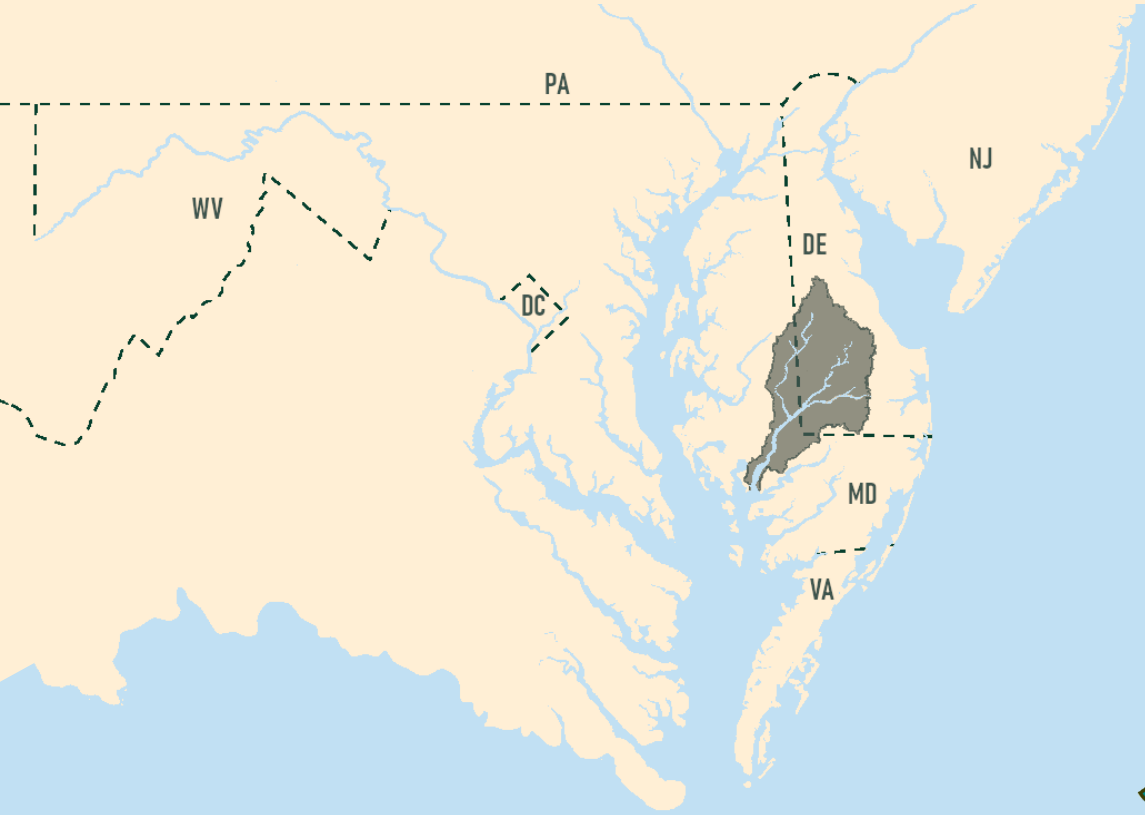
The water, natural resources, and ecosystems contained in the Nanticoke River watershed are an economic engine for the region.

The Nanticoke River and its watershed, all the land that drains into the river, provide real and significant economic benefits and are worthy of investment to keep their natural resources healthy and productive.

The Nanticoke Watershed Alliance does a variety of different things to help protect the river. We are a non-advocacy group, so we never work to change laws. Instead, we listen to the local farmers, homeowners, businesses, and governments that work with us to create realistic solutions that make everyone happy.



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