Economic Benefits and Jobs Provided by Delaware Watersheds

January 2012

written by
Martha Corrozi Narvaez *and* ***Gerald Kauffman***
with contributions from
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prepared for

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Institute for Public Administration
School of Public Policy & Administration
College of Arts & Sciences
University of Delaware
www.ipa.udel.edu
serving the public good, shaping tomorrow's leaders

UNIVERSITY OF DELAWARE

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Preface

Located along the Eastern Seaboard, Delaware is tremendously rich in natural resources and habitat. Although the second smallest state, it is rich in water resources—25 miles of ocean coastline, 841 square miles of bay, 2,509 miles of rivers and streams, and 2,934 acres of lakes and ponds. The water, natural resources, and ecosystems contained in Delaware's watersheds are a valuable economic resource to the state.

Researchers at the Institute for Public Administration's Water Resources Agency (WRA) conclude that Delaware's water supplies and natural resources constitute a substantial economic engine, which contributes somewhere between $2 billion and $6.7 billion to the regional economy in Delaware. Moreover, Delaware watersheds represent an economic engine responsible for more than 70,000 jobs and providing over $2 billion in wages.

WRA project director Gerald Kauffman and associate policy scientist Martha Corrozi Narvaez led a team of IPA researchers—associate policy scientist Andrew Homsey and assistant policy scientist Nicole Minni, who provided GIS mapping support, and research assistants Erin McVey, Catherine Cruz-Ortiz, and Chelsea Halley, who collected ecosystem services and jobs data—in preparation of the writing of this important document.

This report demonstrates that the natural resources of Delaware's watersheds provide real and significant economic benefits to the state and are worthy of investment to keep them healthy and productive.

Jerome R. Lewis, Ph.D.
Director, Institute for Public Administration

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Executive Summary

Abstract

The water, natural resources, and ecosystems contained in Delaware's watersheds are an economic engine for the state. These resources provide tremendous economic value to the state and the surrounding region. This report examines that value in three distinct ways:

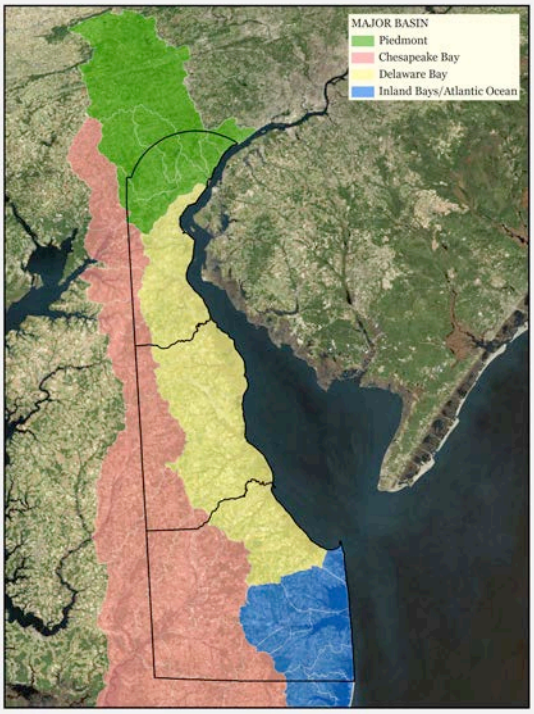
- **Economic value directly related to Delaware's water resources and habitats—**Using economic activity as a measure of value, Delaware watersheds contribute over $6 billion in annual economic activity from water quality, flood control, water supply, fishing and wildlife viewing, recreation, agriculture, ports, forests, and parks.

- **Value of the goods and services provided by Delaware's ecosystems**—Using ecosystem goods and services as a measure of value, the ecosystems of Delaware provide $6.7 billion annually in goods and services in 2010 dollars, with a net present value of $216.6 billion calculated over a 100-year period.

- **Employment related to Delaware's water resources and habitats—**Using employment as a measure of value, Delaware's water resources and habitat directly and indirectly support over 70,000 jobs with over $2 billion in wages annually. This does not include the thousands or, perhaps, millions of jobs in companies and industries that rely on Delaware's waters for their industrial and commercial processes.

The purpose of these estimates is to demonstrate that Delaware watersheds provide real and significant economic benefits to the state and are worthy of investment to keep them healthy and productive. All were made by taking values from existing literature and studies and applying them to Delaware using ecological economics and benefits-transfer techniques described in this report. All values in are in 2010 dollars except where noted.

It is important to note that the values in the three categories above cannot be summed because there is some measure of 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 should be at least partially captured in the economic value of water supply. Accurately determining (and eliminating) this overlap is difficult, if not impossible, within the scope of this analysis. **However, each of the above estimates clearly**



Delaware Watershed Basins

indicates Delaware watersheds are an economic engine that contributes between $2 billion and $6.7 billion annually to the state's economy.

It is also important to note that the estimates presented in this report are not all-inclusive, due to a lack of data for some economic sectors, nor are they meant to be used to compare and contrast uses of Delaware's water resources for their value. 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 many companies and industries that rely on Delaware's waters for their industrial processes is not included here, because identifying those companies and gathering information on their economic activity is beyond the scope of this analysis. Since all estimates were made by taking values from existing literature and studies, the values for various activities and resources vary greatly in how they were determined and applied to Delaware, making it difficult to accurately compare values across uses and activities. Gathering more complex, tailored, or primary data on Delaware watersheds would improve the comparability of information across uses as well as make value estimates more comprehensive. Further research is recommended to gather updated Delaware-specific valuation data.

The field of ecosystem services valuation in particular is still a new and growing field. As knowledge and understanding of these valuation techniques grows and is applied to more resources, we will continue to incorporate them in our understanding of the value of Delaware's watersheds. However, it is also important to note that we may never be able to fully describe in economic terms the real value of the Delaware watersheds and all of their benefits to the people of this state and region.

Delaware Watersheds

The entire state of Delaware is drained by four basins; the Piedmont, Delaware Estuary, and Inland Bays basins flow east, and the Chesapeake Bay basin flows west. Within these four major basins there are 46 watersheds that flow from Piedmont and Coastal physiographic provinces to the tidal river and bay.

Piedmont Basin – Empties into the Delaware River, is part of the Delaware Estuary, and comprises 605 square miles, 80 percent of which lies in Pennsylvania.

Delaware Bay and Estuary Basin – Located in eastern New Castle, Kent, and Sussex counties and drains runoff from 520,960 acres, or 814 square miles, to the Delaware Bay.

Inland Bays/Atlantic Ocean Basin - Comprises 313 square miles of eastern Sussex County, Delaware.

Chesapeake Basin – Drains to the nation's largest estuary, the Chesapeake Bay, and encompasses a 769-square-mile area of land in western New Castle, Kent, and Sussex Counties.

In Delaware in 2007, 39 percent of the land is agriculture, 18 percent is forest, 17 percent is saltwater/freshwater wetland, 15 percent is urban, 8 percent is marine, and 3 percent is open freshwater.

Between 2000 and 2010, Delaware population grew by 14.6 percent. According to the U.S. Census Bureau, in 2010, 897,934 people live in Delaware with a population density of 1,000 per square mile. Sixty percent of the population resides in New Castle County, 18 percent reside in Kent County, and 22 percent reside in Sussex County. Just less than 400,000 people were employed in Delaware; 68 percent of those jobs were in New Castle County, 15 percent in Kent County, and 17 percent in Sussex County.

Annual Economic Value

The economic value of Delaware watersheds is over $6 billion in annual market and non-market value. Market value is determined by the sale/purchase of watershed goods, such as drinking water, fish, hunting supplies or powerboats. Non-market value is provided by ecosystems, such as pollution removal by forests, public willingness to pay for improved water quality, forest carbon-storage benefits, and health benefits of parks. Note that the totals for both market and non-market values are rounded down to ensure that values are not overstated (Table E1).

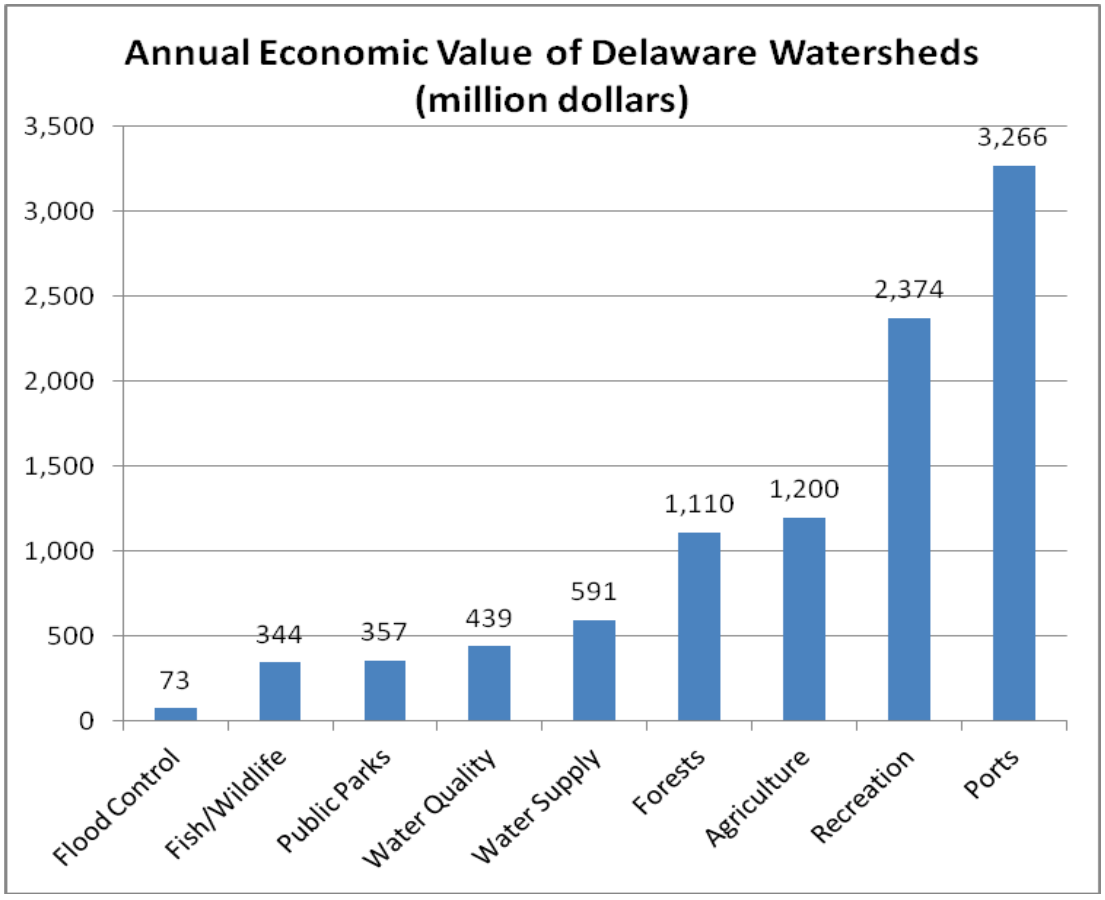


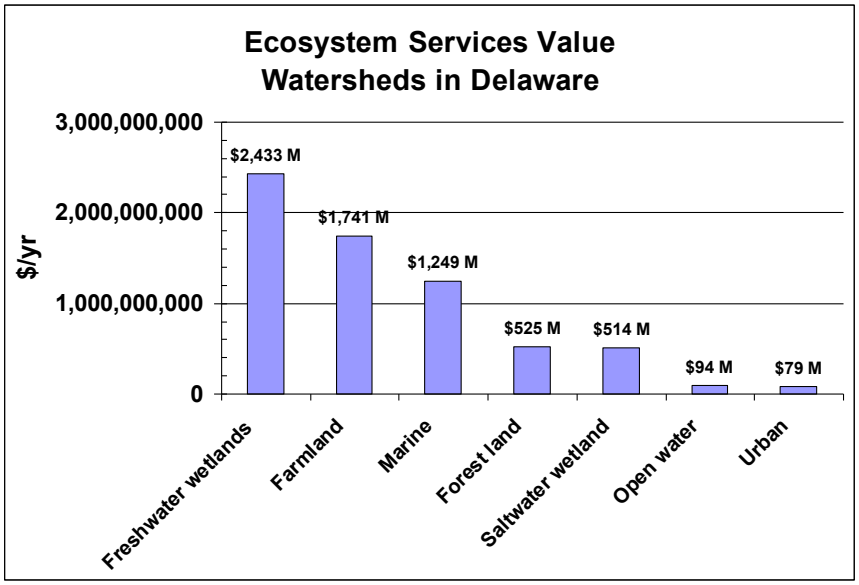
Table E1. Annual Economic Value of Delaware Watersheds	$million
Market Value	>$5 billion
Water Quality	
Increased Property Value (+6% over 20 years)	39
Water Treatment by Forests ($41/mgd)	2
Wastewater Treatment	245
Flood Control Benefits	
Stormwater Detention (+2-5%)	42-105
Water Supply	
Drinking Water Supply ($4.78/1,000 gallons)	518
Irrigation Water Supply ($300/acre-foot)	22-24
Thermoelectric Power Water Supply ($44/acre-foot)	41
Industrial Water Supply ($200/acre-foot)	9
Fish/Wildlife	
Wetlands	6
National Wildlife Refuges	20
Commercial Fish Landings ($0.60/lb)	9
Fishing (11-18 trips/angler, $17-$53/trip)	109
Hunting (16 trips/hunter, $16-50/trip)	46
Wildlife/Bird-watching (8-13 trips/yr, $15-$27/trip)	147
Recreation	
Tourism	1,900
Power-Boating	344
Agriculture	
Crop, poultry, livestock value ($1,800/acre)	1,200
Ports	
Navigation ($15/acre-foot)	66
Port Activity	3,200
Non-Market Value	**>$1 billion**
Recreation	
Swimming ($13.40/trip)	1
Boating ($30/trip)	6
Fishing ($62.79/trip)	56
Wildlife/Bird watching ($77.73/trip)	67
Water Quality	
Improved Stream Water Quality/Willingness to Pay	153
Forests	
Carbon Storage ($827/acre)	220
Carbon Sequestration ($29/acre)	8
Air-Pollution Removal ($266/acre)	71
Building Energy Savings ($56/acre)	15
Avoided Carbon Emissions ($3/acre)	796
Public Parks	
Health Benefits ($9,734/acre)	265
Community Cohesion ($2,383/acre)	65
Stormwater Benefit ($921/acre)	25
Air-Pollution Control ($88/acre)	2

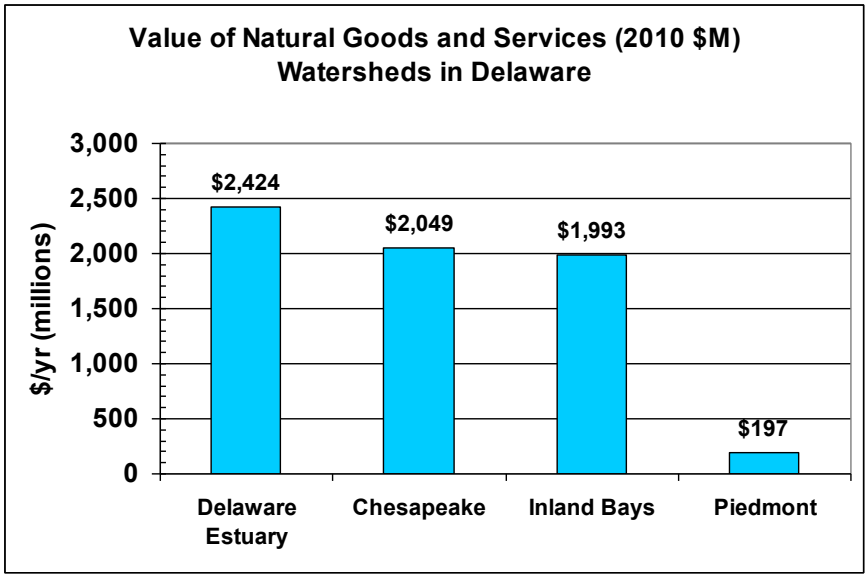
Ecosystem Services

Delaware is rich in natural resources and habitat, as measured by the economic value of ecosystem goods and services. Ecosystem goods are benefits provided by the sale of watershed products, such as drinking water and fish. Ecosystem services are economic benefits provided to society by nature, such as water filtration, flood reduction, and carbon storage. The value of natural goods and services from ecosystems in Delaware watersheds is $6.7 billion (in 2010 dollars) with net present value (NPV) of $216.6 billion, using a discount rate of 3 percent over 100 years (Table E2).

Table E2. Ecosystem Goods and Services Value of the Delaware Watersheds

Ecosystem	Area (acres)	$/acre/year 2010	$/year 2010	NPV $
Freshwater wetlands	178,632	13,621	2,433,081,000	79,075,132,489
Marine	124,879	10,006	1,249,541,955	40,610,113,531
Farmland	590,150	2,949	1,740,640,688	56,570,822,374
Forest land	265,476	1,978	525,143,567	17,067,165,922
Saltwater wetlands	71,001	7,235	513,691,702	16,694,980,313
Barren land	6,459	0	0	0
Urban	229,827	342	78,511,742	2,551,631,623
Beach/dune	588	48,644	28,579,665	928,839,116
Open water	48,253	1,946	93,891,133	3,051,461,812
State Total	**1,515,265**		**6,663,081,452**	**216,550,147,180**





Jobs and Wages

Delaware watersheds are jobs engines with water resources and habitat that supports over 70,000 direct and indirect jobs with over $2 billion in annual wages in the coastal, farm, ecotourism, watershed-organization, water supply/wastewater, recreation, and port industries (Table 39).

Table E3. Jobs and Wages Related to Delaware Watersheds

Sector	Jobs	Wages ($)	Data Source
Direct Watershed-related	18,926	402,000,000	U.S. Bureau of Labor Statistics (2009)
Indirect Watershed-related	22,711	322,000,000	U.S. Census Bureau (2009)
Coastal	15,174	268,000,000	Nat'l Coastal Econ. Program (2009)
Farm	28,328	1,410,000,000	Awokuse et al. (2010)
Fishing/Hunting/Birding	9,248	304,000,000	U.S. Fish and Wildlife Service (2008)
National Wildlife Refuge	198	5,500,000	Carver and Caudill (2007)
Wetlands	584	19,300,000	NOAA Coastal Services Center (2011)
Watershed Organizations	115	5,520,000	WRA and DRBC (2010)
Ports	4,601	307,000,000	Martins Associates (2007))
Tourism	31,050	931,000,000	Delaware Tourism Office (2008)
Water Supply Utilities	275	15,000,000	WRA and DRBC (2010)
Wastewater Utilities	207	9,000,000	WRA and DRBC (2010)
Delaware Watershed totals	**>70,000**	**>$2 billion**	

1. Introduction

Objectives

This report summarizes the socioeconomic value of water, natural resources, and ecosystems in Delaware's watersheds estimated as:

1. Economic activity including market and non-market value of agriculture, water supply, fishing, hunting, recreation, boating, ecotourism, and navigation/port benefits.
2. Ecosystem goods and services (natural capital) value provided by habitat such as wetlands, forests, farms, and open water.
3. Jobs and wages directly and indirectly associated with Delaware's watersheds.

These estimates demonstrate that the natural resources of Delaware's watersheds provide real and significant economic benefits to the state and are worthy of investment to keep them healthy and productive. Value-transfer techniques were applied by selecting data from existing studies and applying them to Delaware using ecological-economics techniques.

Values in the three categories cannot be summed because there may be overlap 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. The ecosystem values of forests for water-quality benefits should be at least partially captured in the economic value of water supply. Accounting for this overlap is difficult, if not impossible, within the scope of this analysis. **However, each of the above estimates clearly indicates that Delaware's watersheds are an economic engine that contributes between $2 billion and $6.7 billion to our state's economy.**

The estimates presented in this report are not comprehensive, nor are they meant to be used to compare/contrast uses of the state's water resources for their value. Some values were not included in these estimates because the data to assess them are not readily available. For example, the full amount of economic activity and jobs associated with the many companies and industries that rely on Delaware's waters for their industrial 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 all estimates were made by taking values from existing literature, the values for various activities differ greatly in how they were determined and applied to Delaware's water resources making it difficult to accurately compare values across uses.

Other values, like the value of freshwater mussels for filtering water, are not included in this work because they are not yet well documented in the literature on valuation. The field of ecosystem services valuation in particular is still a new and growing field. As our knowledge and understanding of these valuation techniques grows and is applied to more resources, we must continue to incorporate them in our understanding of the value of Delaware's water resources.

An Economic Engine

Delaware is located on the Atlantic Coast in the Mid-Atlantic region and surrounded by several major bodies of water—Delaware River, Delaware Bay, Chesapeake Bay, and the Atlantic Ocean. Water is an abundant resource in the First State and makes Delaware a truly unique place. Whether it's the pristine beaches, the natural beauty and biology of the streams and creeks, the invigorating recreational opportunities, or the essential services that the First State's water resources provide, it is a driving force and an essential component of Delaware's economy.

In 2010 more than 300 million gallons per day of drinking water and industrial-process water were withdrawn from the rivers, streams, and aquifers in Delaware's watersheds to sustain the state's jobs and domestic, commercial, and industrial economy. The river, bay, beaches, wetlands, and forests support a multi-billion dollar coastal tourism, recreation, and hunting/fishing/birding economy.

Society tends to underprice water, based on its marginal value for single uses (i.e., drinking water), and not consider its full value of water for all uses, such as recreation and tourism. The following report tabulates the substantial economic value and worth of watersheds in Delaware—the 2nd smallest state by area and the 6th most densely populated state in the nation. The report attempts to quantify the highest multi-objective value of water *in toto* for its wide range of habitat, recreation, ecological, and industrial benefits throughout the state of Delaware.

The Watersheds

The state of Delaware occupies four major basins—Piedmont, Delaware Bay and Estuary, Inland Bays, and Chesapeake Bay (Figure 1).

Delaware is situated on the Delmarva Peninsula and includes (DNREC, 2010):

- 25 miles of ocean coastline
- 841 square miles of bay
- 2,509 miles of rivers and streams
- 2,934 acres of lakes and ponds

In addition:

- 86 percent of Delaware rivers/streams impaired for swimming due to high bacteria
- 97 percent of Delaware rivers/streams do not meet fish and wildlife water quality standards
- 44 percent of Delaware ponds and lakes do not meet swimming uses
- 89 percent of ponds and lakes do not support fish and wildlife uses
- >100 miles of waters have fish-consumption advisories from high PCBs, metals, pesticides

Within Delaware's four major basins there are 46 watersheds that flow from Piedmont and Coastal Plain physiographic provinces to the tidal river and bay.

Piedmont

The entire Piedmont Basin, 80 percent of which is in Pennsylvania, empties into the Delaware River and is part of the Delaware Estuary. The Piedmont Basin contains the following watersheds:

- Brandywine Creek
- Red Clay Creek
- White Clay Creek
- Christina River
- Naamans Creek
- Shellpot Creek

The Piedmont Basin supplies a significant source of freshwater from surface water and groundwater sources. The geologically unique Fall Line located in the Piedmont Basin runs along a line between Newark and Wilmington and separates the hilly, rocky, Piedmont from the flat, sandy Coastal Plain provinces. This transition zone supports a wide array of flora and fauna.

Delaware Bay and Estuary

The Delaware Bay and Estuary Basin is located in eastern New Castle, Kent, and Sussex counties and drains runoff from the Delaware Bay and Delaware Estuary. The basin drains 520,960 acres, or 814 square miles, and encompasses the following watersheds:

- Delaware River
- Army Creek
- Red Lion Creek
- Dragon Run Creek
- Chesapeake & Delaware Canal East
- Appoquinimink River
- Blackbird Creek
- Delaware Bay
- Smyrna River
- Leipsic River
- Little Creek
- St. Jones River
- Murderkill River
- Mispillion River
- Cedar Creek
- Broadkill River

The Delaware Bay and Estuary Basin lies entirely within the Atlantic Coastal Plain physiographic province. Topography in the northern part of the basin is dominantly undulating and rolling with moderate dissection. In the southern portion of the drainage basin, flatter (slope

gradients <1%) landscapes dominate. Some of the most productive farms in Delaware, some of which are still owned by the original families, are located within this basin.

Inland Bays/Atlantic Ocean

The Inland Bays/Atlantic Ocean Basin comprises 313 square miles of eastern Sussex County, Delaware. The Inland Bays/Atlantic Ocean Basin lies entirely within the Atlantic Coastal Plain physiographic province. The dominant physiographic features of the basin are the three "inland bays" that are located just landward of the Atlantic Ocean shoreline. From north to south, these are Rehoboth Bay, Indian River Bay, and Little Assawoman Bay. Rehoboth Bay includes the following watersheds:

- Lewes-Rehoboth Canal
- Rehoboth Bay Watershed

The Indian River Bay includes the following watersheds:

- Indian River
- Iron Branch
- Indian River Bay

The Little Assawoman Bay includes the following watersheds:

- Little Assawoman
- Assawoman
- Buntings Branch

Other distinctive physiographic characteristics include the flat topography and man-made drainage ditches that are used to drain soils with perennially high water tables, which are mostly limited to the area south of Millsboro and Indian River Bay.

The Inland Bays Watershed supports Delaware's ocean and coastal tourism economy and contains rapidly growing industries of poultry farming and second-home residential development. More than 11 miles of Delaware's ocean coast are developed with homes and businesses. The majority of them are located on the barrier island—the thin strip of land separating the ocean from the Inland Bays. Sea-level rise, storms, and other natural coastal-transport processes are causing the barrier island system to migrate in a landward direction.

Chesapeake Bay

The Chesapeake Bay Basin drains to the nation's largest estuary, the Chesapeake Bay. As an estuary, the Chesapeake Bay contains a mixture of fresh and saltwater, creating an ideal habitat for a diverse array of plants and animals. The bay's welfare is heavily reliant on the land use of the basin, since Delaware's portion of the Chesapeake Basin contains headwater areas, the area where a waterway originates. The basin encompasses a 769-square-mile area of land in western

New Castle, Kent, and Sussex Counties. More geological formations exist in the Chesapeake Basin than in any of the other three basins. Delaware's Coastal Plain contains very thick sedimentary deposits. These unique deposits were able to form because of Delaware's position along what used to be an extremely active continental plate boundary. The basin encompasses the following 16 watersheds:

- Bohemia Creek
- Broad Creek
- C&D Canal West
- Deep Creek
- Elk Creek
- Gravelly Branch
- Gum Branch
- Marshyhope Creek
- Nanticoke River
- Perch Creek
- Pocomoke River
- Sassafras River
- Wicomico River

In Delaware in 2007, 39 percent of the land is agriculture, 18 percent is forest, 17 percent is saltwater/freshwater wetland, 15 percent is urban, 8 percent is marine, and 3 percent is open freshwater (Table 1 and Figure 2). The entire state of Delaware is drained by four basins; the Piedmont, Delaware Estuary, and Inland Bays basins flow east, and the Chesapeake Bay Basin flows west (Figure 1).

Table 1. ***Land Use in Delaware Watersheds***

Ecosystem	Piedmont (acre)	Delaware Estuary (acres)	Chesapeake Bay (acres)	Inland Bays/ Atlantic Ocean (acres)	Total (acres)
Freshwater wetlands	4,732	58,390	81,130	34,379	178,632
Marine	799	16,274	233	107,573	124,879
Farmland	9,588	254,143	245,509	80,910	590,150
Forest	32,189	95,346	102,306	35,635	265,476
Saltwater wetland	919	61,617	353	8,111	71,001
Barren land	234	2,305	844	3,076	6,459
Urban	67,357	123,048	17,019	22,403	229,827
Beach/Dune	42	256	74	216	588
Open freshwater	575	14,056	1,780	31,842	48,253
Total	116,435	625,435	449,248	324,145	1,515,263
Ecosystem	**Piedmont**	**Delaware Estuary**	**Chesapeake Bay**	**Inland Bays/ Atlantic Ocean**	**Total**
Freshwater wetlands	4.1%	9.3%	18.1%	10. 6%	11.8%
Marine	0.7%	2.6%	0.1%	33.2%	8.2%
Farmland	8.2%	40.6%	54.6%	25.0%	38.9%
Forest	27.6%	15.2%	22.8%	11.0%	17.5%
Saltwater wetland	0.8%	9.9%	0.1%	2.5%	4.7%
Barren land	0.2%	0.4%	0.2%	0.9%	0.4%
Urban	57.8%	19.7%	3.8%	6.9%	15.2%
Beach/Dune	0.0%	0.0%	0.0%	0.1%	0.0%
Open freshwater	0.5%	2.2%	0.4%	9.8%	3.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: NOAA CSC, 2007

Figure 1. ***Major Basins and Watershed Boundaries in Delaware***

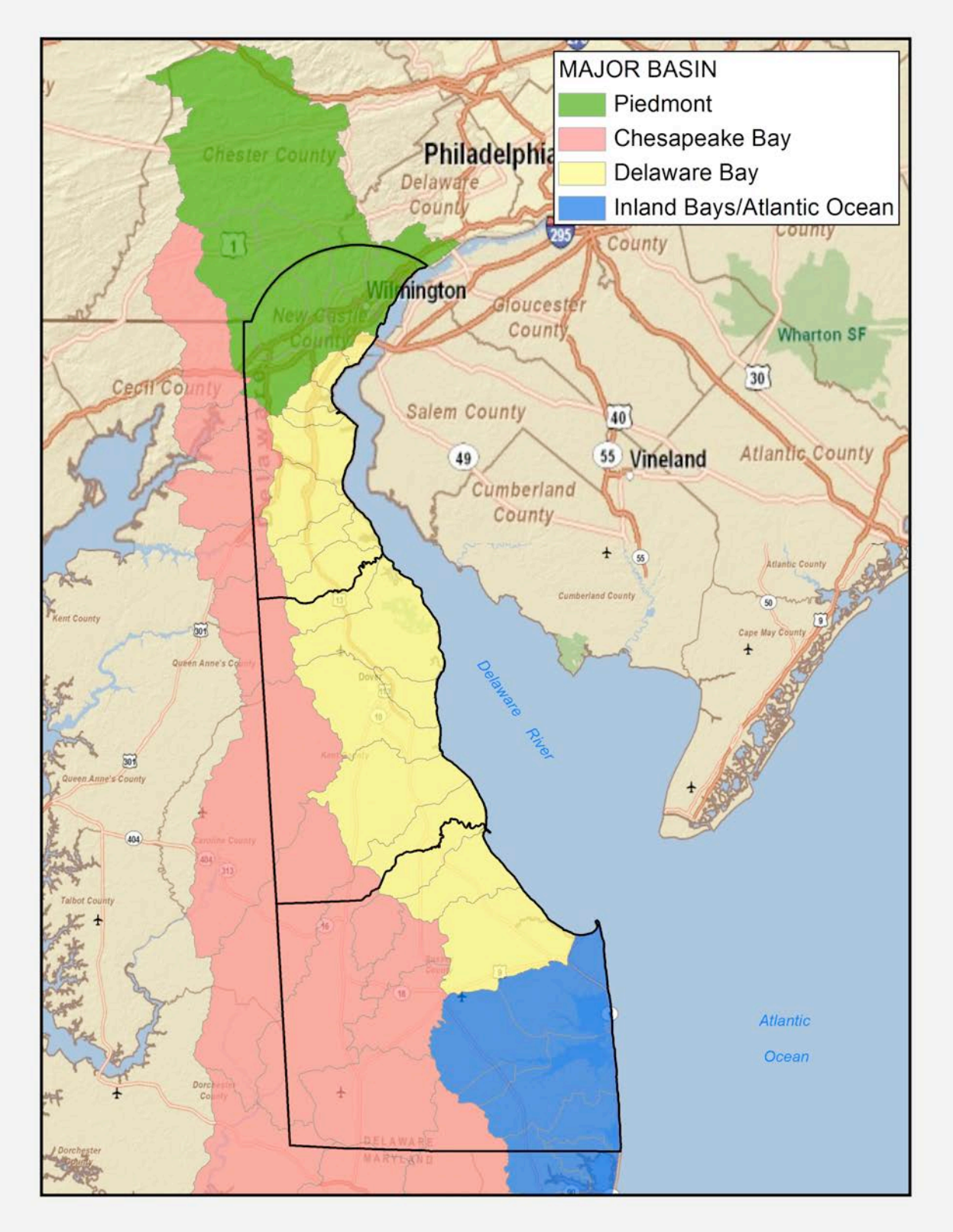
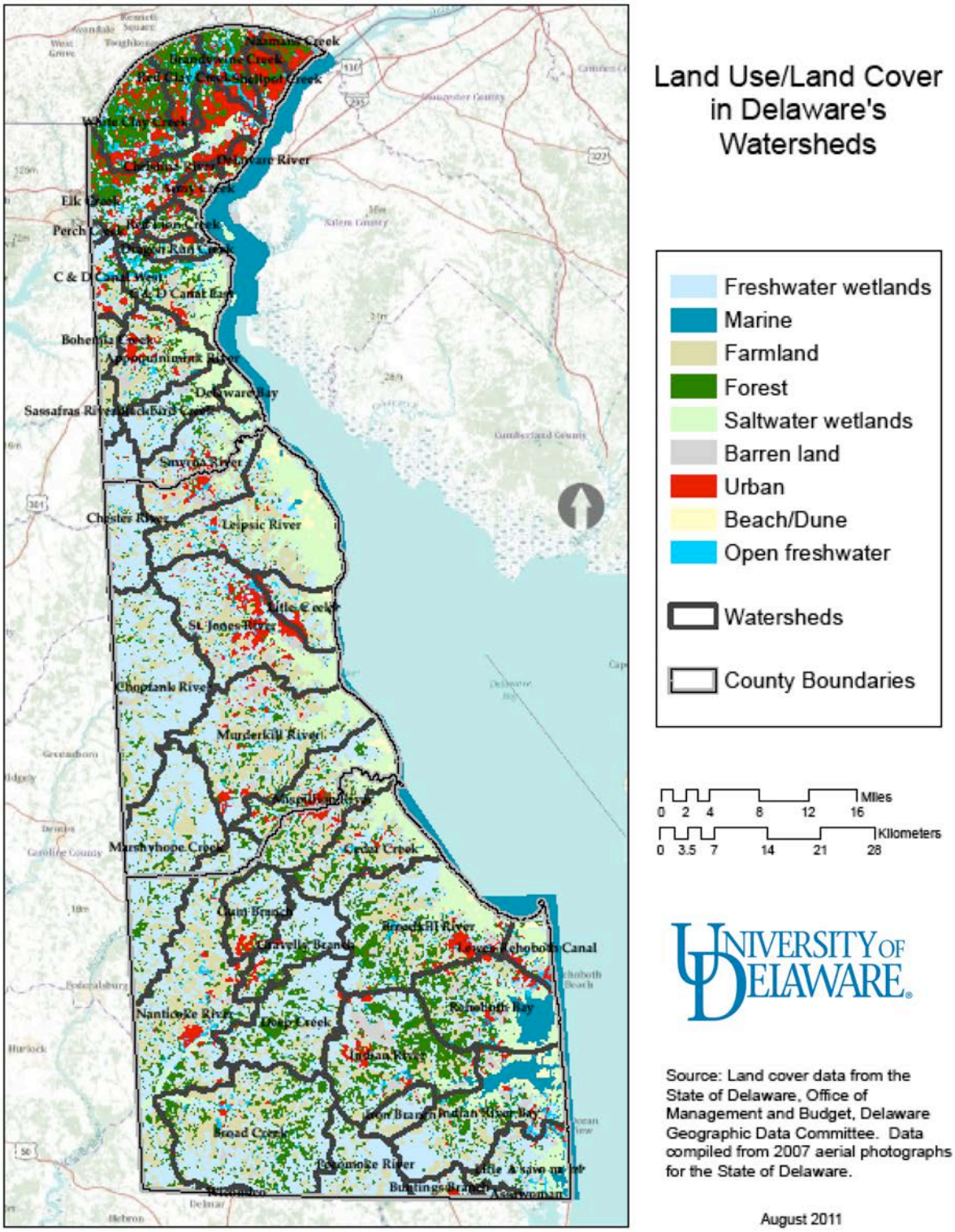


Figure 2. ***Land Use/Land Cover in Delaware's Watersheds (NOAA CSC, 2007)***



Demographics

According to the U.S. Census Bureau, in 2010, 897,934 people live in Delaware on 1,956 square miles—a population density of just over 450/sq. mi. (Table 2). New Castle County is the most populous county, comprising 60 percent of the population (538,479); 162,310 people reside in Kent County (18%), and 197,145 reside in Sussex County (22%). Just less than 400,000 people were employed in Delaware, with 267,683 jobs in New Castle County (68%), 60,964 jobs in Kent County (15%), and 67,447 (17%) jobs in Sussex County (Table 2).

Table 2. ***Land Area, Population, and Employment in Delaware***

State/County	Area (sq. mi.)	Population[1] 2010	Employment[2] 2010
New Castle	426	538,479	267,683
Kent	590	162,310	60,964
Sussex	940	197,145	67,447
Delaware	**1,956**	**897,934**	**396,094**

1. U.S. Census Bureau, 2010
2. U.S. Bureau of Labor Statistics, 2011

Between 2000 and 2010, Delaware population grew by 14.6 percent or 114,334 people (Table 3 and 5). Over the last decade, population increased by over 25 percent in Kent and Sussex counties and by 7.6 percent in New Castle County. By 2030, the population in Delaware is projected to grow by 156,697 (18%) to over a million people (Table 4).

Table 3. ***Population Change in Delaware by County, 2000-2010***

State/county	Pop. 2000	Pop. 2010	Change	% Change
New Castle	500,265	538,479	38,214	7.6
Kent	126,697	162,310	35,613	28.1
Sussex	156,638	197,145	40,507	25.9
Delaware	**783,600**	**897,934**	**114,334**	**14.6**

Source: U.S. Census Bureau, 2010

Table 4. ***Population Projections in Delaware, 2010-2030***

County	Actual Population 2010[1]	Projected Population 2020[2]	Projected Population 2030[2]	2010-2030 Change	2010-2030 % Change
New Castle	538,479	567,764	589,267	50,788	9
Kent	162,310	178,817	192,853	30,543	19
Sussex	197,145	235,341	272,511	75,366	38
Total	**897,934**	**981,922**	**1,054,631**	**156,697**	**18**

1. U.S. Census Bureau, 2010
2. Delaware Population Consortium, 2010

Table 5. ***2010 Population Density in Delaware by Watershed***

Watershed	Area (sq. mi.)	Population	Population Density (people/sq. mi.)
Piedmont			
Brandywine Creek	23	44,098	1,920
Christina River	67	175,572	2,615
Naamans Creek	10	35,783	3,512
Red Clay Creek	21	24,523	1,163
Shellpot Creek	14	37,992	2,646
White Clay Creek	46	95,579	2,070
Delaware Bay and Estuary			
Appoquinimink River	46	24,113	520
Army Creek	10	21,305	2,124
Blackbird Creek	31	5,465	177
Broadkill River	107	23,216	217
C & D Canal East	44	12,148	276
Cedar Creek	52	7,334	140
Delaware Bay	10	393	41
Delaware River	6	16,879	2,597
Dragon Run Creek	10	6,429	620
Leipsic River	105	16,201	155
Little Creek	23	8,269	356
Mispillion River	76	18,155	238
Murderkill River	107	25,364	238
Red Lion Creek	11	11,716	1,070
Smyrna River	64	20,577	322
St. Jones River	90	68,323	759
Chesapeake Bay			
Bohemia Creek	9	3,755	428
Broad Creek	120	17,700	148
C & D Canal West	17	10,666	614
Chester River	40	5,150	130
Choptank River	97	10,289	106
Deep Creek	63	10,333	163
Elk Creek	0	314	730
Gravelly Branch	38	3,668	96
Gum Branch	30	2,768	92
Marshyhope Creek	96	7,576	79
Nanticoke River	144	30,000	208
Perch Creek	2	2,368	1,172
Pocomoke River	35	2,068	60
Sassafras River	8	1,979	246
Wicomico	2	352	173
Inland Bays			
Assawoman	7	2,344	316
Buntings Branch	10	1,802	183
Indian River	86	17,237	200
Indian River Bay	86	21,498	249
Iron Branch	15	4,617	299
Lewes-Rehoboth Canal	17	7,782	465
Little Assawoman	33	8,838	267
Rehoboth Bay	72	22,113	308
Total	**2,004**	**894,651**	**446**

2. Methods

Valuation Techniques

The University of Delaware derived the economic value of Delaware's watersheds from published studies that employed the following valuation techniques:

Avoided Cost: Society sustains costs if certain ecosystems were not present or are lost. For instance, the loss of wetlands may increase economic cost 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 bay and 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 and bay water quality.

Scope of Work

The University of Delaware established the socioeconomic value of Delaware's watersheds according to the following scope of work.

1. Area of Interest: The area of interest is defined as the watersheds of Delaware and the water resources in Delaware. The University of Deaware 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 watersheds of Delaware 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 in Delaware 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.

4. Ecosystem Services: Tabulate the market value of natural resources (ecosystem services value) in Delaware's watersheds 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 2007 NOAA Coastal Services Center (CSC) 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 in Delaware's watersheds 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 Delaware land-use areas. While primary research data from the area in question (Delaware) is preferable and is used in some 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. Future economic valuation research is recommended to develop primary ecosystem service values for Delaware.

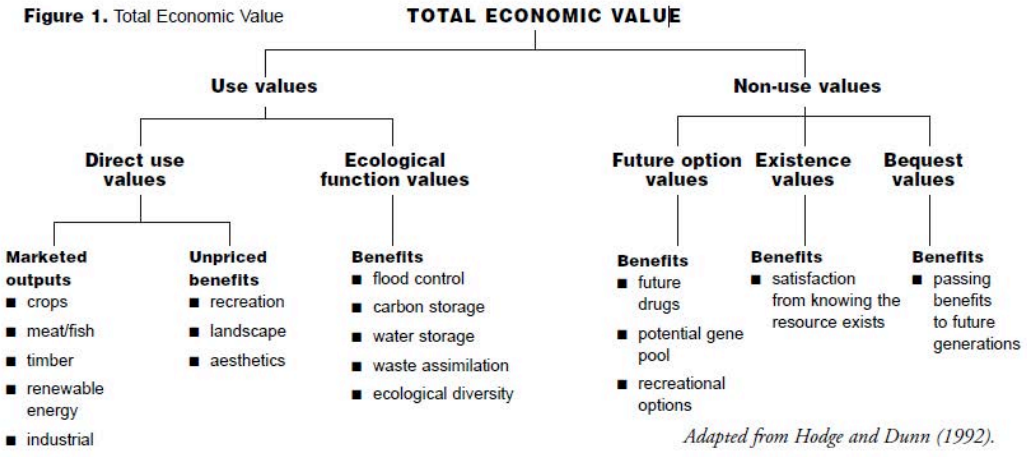
5. Jobs and wages: Obtain employment and wage data from the U.S. Department of Labor, U.S. Census Bureau, National Ocean Economics Program, and other sources. Calculate direct/indirect jobs in Delaware by North American Industry Classification System (NAICS) codes such as shipbuilding, marine transportation/ports, 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 wastewater-treatment utilities.

6. Report: Prepare a report and GIS mapping that summarizes (1) annual economic value of activities related to Delaware's watersheds, (2) ecosystem goods and services (natural capital), and (3) jobs and wages directly and indirectly related to Delaware's watersheds in 2010 dollars.

3. Economic Value

Figure 3 illustrates the total economic value of water resources computed from use and non-use values (Hodge and Dunn, 1992). Use values include direct values, such as market goods from the sales of crops, fish, and timber; unpriced benefits from recreation and aesthetic viewsheds; 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.

Figure 3. ***Economic Value of Water Resources***



Source: Hodge and Dunn, 1992

The value of the Delaware Estuary watershed from recreation, water quality, water supply, fish/wildlife, flood control benefits, agriculture, public parks, forests and maritime transportation benefits exceeds $6 billion (Figure 4 and Table 6).

- Water Quality $439M
- Flood Control $73M
- Water Supply $591M
- Fish/Wildlife $344M
- Recreation $2,374M
- Agriculture $1,200M
- Ports $3,266M
- Forests $1,110M
- Public Parks $357M

Total >$6B

Figure 4. ***Annual Economic Value of Delaware Watersheds***

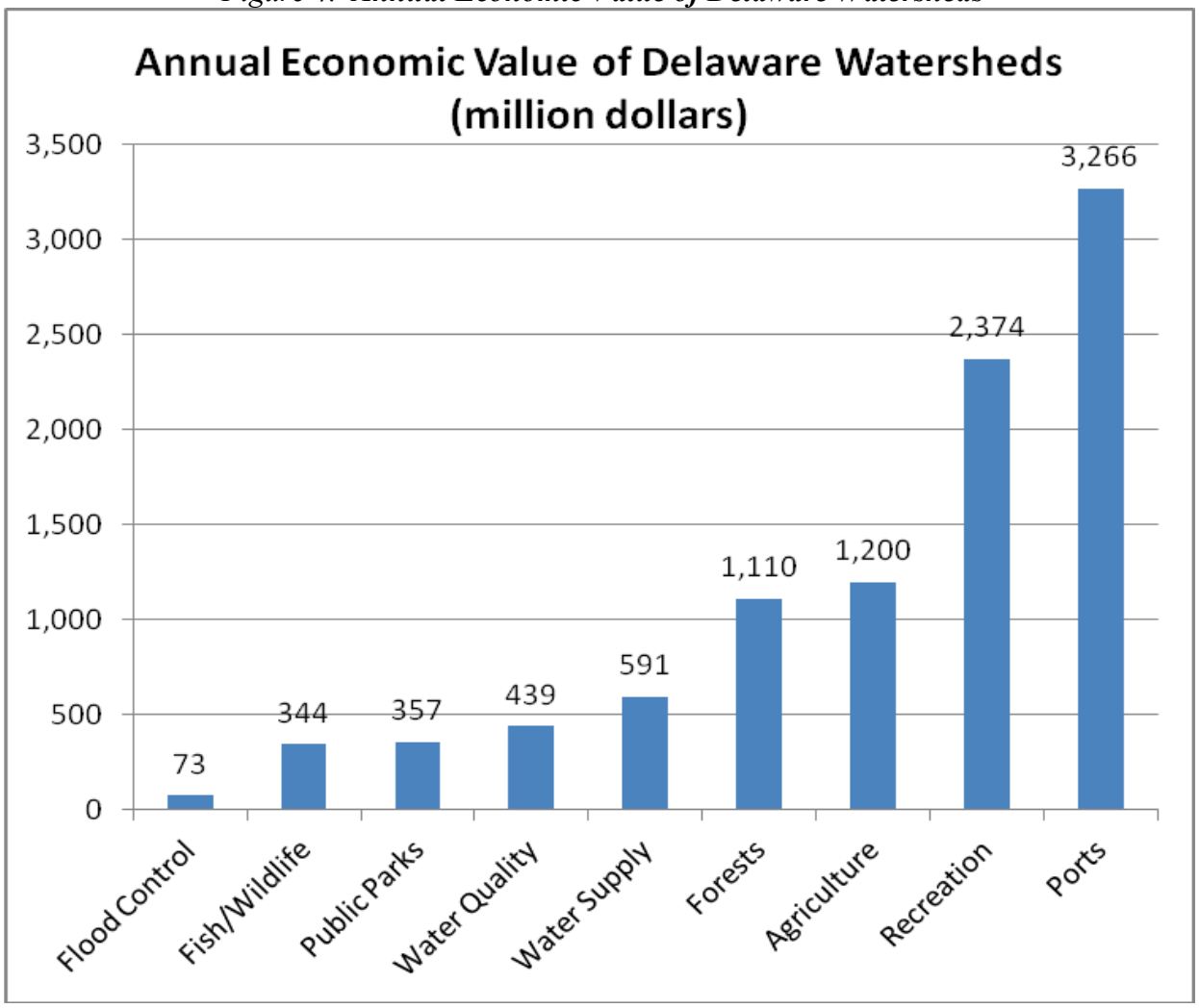


Table 6. ***Annual Economic Value in Delaware Watersheds***

Activity	2010 ($ million)	Source
Market Value		
Water Quality		
Increased Property Value (+6% over 20 years)	39	EPA (1973), Brookings Institute (2010)
Water Treatment by Forests ($41/mgd)	2	Trust for Public Land, AWWA (2004)
Wastewater Treatment	245	DNREC (2010), WRA
Flood Control		
Stormwater Detention (+2-5%)	42-105	Braden and Johnston (2004)
Water Supply		
Drinking Water Supply ($4.78/1,000 gallons)	518	WRA and DNREC (2010)
Irrigation Water Supply ($300/acre-foot)	22-24	Resources for the Future (1996), USDA
Thermoelectric-Power Water Supply ($44/acre-	41	EIA (2002), NETL (2009)
Industrial Water Supply ($200/acre-foot)	9	Resources for the Future (1996), USGS
Fish/Wildlife		
Wetlands	13	NOAA Coastal Services Center (2011)
National Wildlife Refuge	20	Carver and Caudill (2007)
Commercial Fish Landings ($0.60/lb)	9	NMFS, Nat'l Ocean Econ. Program (2007)
Fishing (11-18 trips/angler, $17-$53/trip)	109	U.S. Fish and Wildlife Service (2008)
Hunting (16 trips/hunter, $16-50/trip)	46	U.S. Fish and Wildlife Service (2008)
Wildlife/Bird-watching (8-13 trips/yr, $15-	147	U.S. Fish and Wildlife Service (2008)
Recreation		
Tourism	1,900	Delaware Tourism Office (2008)
Power-Boating	344	NMMA (2010)
Agriculture		
Crop, poultry, livestock value ($1,800/acre)	1,200	USDA Census of Agriculture 2007 (2009)
Ports		
Navigation ($15/acre-foot)	66	Resources for the Future (1996)
Port Activity	3,200	Economy League of Greater Phila. (2008)
Non-Market Value		
Recreation		
Swimming ($13.40/trip)	1	University of Rhode Island (2002)
Boating ($30/trip)	6	University of Rhode Island (2002)
Fishing ($62.79/trip)	56	University of Rhode Island (2002)
Wildlife/bird watching ($77.73/trip)	67	University of Rhode Island (2002)
Water Quality		
Improved Stream Water Quality/Willingness to	153	University of Maryland (1989)
Forests		
Carbon Storage ($827/acre)	220	U.S. Forest Service, Del. Ctr. Hort. (2008)
Carbon Sequestration ($29/acre)	8	U.S. Forest Service, Del. Ctr. Hort. (2008)
Air-Pollution Removal ($266/acre)	71	U.S. Forest Service, Del. Ctr. Hort. (2008)
Building Energy Savings ($56/acre)	15	U.S. Forest Service, Del. Ctr. Hort. (2008)
Avoided Carbon Emissions ($3/acre)	796	U.S. Forest Service, Del. Ctr. Hort. (2008)
Public Parks		
Health Benefits ($9,734/acre)	265	Trust for Public Land
Community Cohesion ($2,383/acre)	65	Trust for Public Land
Stormwater Benefit ($921/acre)	25	Trust for Public Land
Air-Pollution Control ($88/acre)	2	Trust for Public Land
Delaware Watersheds	**>$6 billion**	

Note: Total economic value is rounded down to avoid double-counting.

Market Value

Water Quality

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 percent (Table 7). The EPA (1973) estimated improved water quality can raise property values by up to 18 percent next to the water, 8 percent at 1,000 feet from the water, and 4 percent 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 percent. The Brookings Institute (2007) projected that investing $26 billion to restore the Great Lakes would increase shore property values by 10 percent.

Table 7. ***Increased Property Values Resulting from Improved Water Quality***

Study	Watershed	Increased Property Value
EPA (1973)	San Diego Bay, Calif.	
- Next to water	Kanawha, Ohio	18%
- 1000 ft from water	Willamette River, Ore.	8%
- 2000 ft from water		4%
Leggett et al. (2000)	Chesapeake Bay	6%
Brookings Institute (2007)	Great Lakes	10%

Property values within 1,000 feet of the shore are estimated to increase by 6 percent due to stormwater management, which improves water quality to meet bacteria standards in Delaware watersheds. About 86 percent of the 2,509 miles of Delaware streams or 2,158 miles are impaired for bacteria. If the median property value in Delaware is $25,000 per acre, then properties within a 1,000 feet corridor along 2,158 impaired stream miles in Delaware have an estimated value of $13.1 billion. Property values within 1,000 feet of the water would increase by $784 million (6%) due to water quality improvements in Delaware watersheds (Table 8). Since the increase in property value is a one-time benefit, the annual value over a 20-year period where water quality has improved in Delaware's waters is estimated at $39.2 million.

Table 8. ***Added Property Value Due to Improved Water Quality in Delaware's Watersheds***

Impaired Streams[1] (mi)	Streams (ft)	Area within 1000 ft of Stream (ac)	Property Value @ $25,000/ac	Increased Value @ 6%
2,158	11,394,240	523,000	$13,075,000,000	$784,000,000

1.Impaired streams for bacteria as per DNREC Sec. 303d Report, 2010

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 percent increase in

forested watershed land, drinking water treatment and chemical costs are reduced by approximately 20 percent (Table 9). If the public drinking water supply is 100 million gallons per day (mgd) and forests cover 265,476 acres (414 sq. mi. or 18 percent) of Delaware watersheds, then loss of these forests would increase drinking water–treatment costs by $41 per mgd ($139 per mgd @ 0% forested minus $98 per mgd @ 18% forested) or $4,100/day or $1,496,000/year.

Table 9. ***Drinking Water–Treatment Costs Based on Percent of Forested Watershed***

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

Source: Trust for Public Land and AWWA, 2004

Wastewater Treatment

The water resources in the state of Delaware provide significant wastewater-treatment and -assimilation services. According to DNREC's Surface Water Discharges Section, there are 21 permitted surface-discharge sewage-treatment plants in Delaware. Three are located in the Piedmont Basin, eight in the Delaware Bay and Estuary Basin, five in the Inland Bays Basin, and five in the Chesapeake Bay Basin. The NPDES wastewater dischargers in Delaware possess Federal and state water-quality permits to treat and discharge 168 million gallons per day to the watershed (Table 10). An analysis of wastewater utilities conducted by WRA computes that the average wastewater rate in the watershed is $4.00 per 1,000 gallons, which, for an average residence of four people (at 50 gpcd), is a fee of $290 per year. The total market value based on treated-wastewater rates in Delaware's watersheds is $671,680 per day or $245 million per year (Table 11).

Table 10. ***Surface Water–Discharge Sewage-Treatment Plants in Delaware***

Watershed	NPDES ID	Sewage-Treatment Plant	Discharge (mgd)
Piedmont Basin			
Delaware River	DE0020320	Wilmington WWTP	134.00
Red Clay Creek	DE0021709	Greenville Country Club	0.02
Brandywine Creek	DE0021768	Winterthur	0.03
Delaware Bay and Estuary Basin			
Delaware River	DE0021555	Delaware City STP	0.57
	DE0021539	Port Penn STP	0.05
C&D Canal East	DE0050083	Lums Pond State Park	0.11
Appoquinimink River	DE0050547	Middletown-Odessa-Townsend	0.50
Smyrna River	DE0051063	Hanover Foods	0.00
Murderkill River	DE0020036	Harrington STP	0.75
	DE0020338	Kent County STP	15.00
Broadkill River	DE0021491	Milton STP	0.35
Inland Bays Basin			
Lewes-Rehoboth Canal	DE0021512	Lewes STP	1.50
	DE0020028	Rehoboth Beach STP	3.40
Indian River	DE0050164	Millsboro STP	0.57
Little Assawoman Bay	DE0020010	Selbyville STP	1.25
	DE0050008	South Coastal Reg'l STP	6.00
Chesapeake Bay Basin			
Broad Creek	DE0020125	Laurel STP	0.70
Nanticoke River	DE0050725	Mobile Gardens Trailer Park	0.03
	DE0020249	Bridgeville STP	0.80
	DE0020265	Seaford STP	2.00
	DE0000035	Invista	0.31
Total			**167.92**

Source: DNREC, Surface Water Discharges Section, August 2010

Table 11. ***Value of NPDES Surface Water–Discharge Sewage-Treatment Plants in Delaware***

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	$/day ($4.00/1,000gal)	$/Year
Piedmont Basin				
DE0020320	Wilmington WWTP	134.000	536,000	195,640,000
DE0021709	Greenville Country Club	0.015	60	21,900
DE0021768	Winterthur	0.025	100	36,500
Delaware Bay and Estuary Basin				
DE0021555	Delaware City STP	0.570	2,280	832,200
DE0021539	Port Penn STP	0.050	200	73,000
DE0050083	Lums Pond State Park	0.105	420	153,300
DE0050547	Middletown-Odessa-Townsend	0.500	2,000	730,000
DE0051063	Hanover Foods	0.000	0	0
DE0020036	Harrington STP	0.750	3,000	1,095,000
DE0020338	Kent County STP	15.000	60,000	21,900,000
DE0021491	Milton STP	0.350	1,400	511,000
Inland Bays Basin				
DE0021512	Lewes STP	1.500	6,000	2,190,000
DE0020028	Rehoboth Beach STP	3.400	13,600	4,964,000
DE0050164	Millsboro STP	0.566	2,264	826,360
DE0020010	Selbyville STP	1.250	5,000	1,825,000
DE0050008	South Coastal Reg'l STP	6.000	24,000	8,760,000
Chesapeake Bay Basin				
DE0020125	Laurel STP	0.700	2,800	1,022,000
DE0050725	Mobile Gardens Trailer Park	0.028	112	40,880
DE0020249	Bridgeville STP	0.800	3,200	1,168,000
DE0020265	Seaford STP	2.000	8,000	2,920,000
DE0000035	Invista	0.311	1,244	454,060
Total		**167.920**	**$671,680**	**$245,163,200**

Flood Control Benefits

Stormwater Detention

Braden and Johnston (2004) from the University of Illinois estimate that onsite stormwater detention provides flood mitigation and water quality protection services totaling 2 to 5 percent of property value on average for all properties in the floodplain (Wise et al.). If 211,840 acres (331 sq. mi. or 17%) of Delaware's land mass is within a FEMA-mapped 100-year floodplain and the average value of floodplain land is $10,000/acre, then the total value of floodplain land in Delaware is $2.1 billion. Based on the assumption that onsite stormwater detention increases downstream property values by 2 to 5 percent, stormwater detention then provides $42 to $105 million in economic benefits to downstream floodplain property owners in Delaware.

Water Supply

Drinking Water Supply

Seventy-five percent of the drinking water for New Castle County comes from the streams of the Christina Basin, which include the Brandywine, Red Clay, and White Clay Creeks, and the Christina River. The only four public surface-water intakes in the state are located in the Piedmont Basin. Groundwater sources supply the remaining 25 percent of New Castle County's drinking water. Kent and Sussex Counties rely solely on groundwater for their drinking water supply.

Table 12 provides a list of the largest public water suppliers in Delaware, which include the three largest withdrawers—United Water Delaware, the City of Wilmington, and the City of Dover.

The annual value of raw (untreated) public water supplies in Delaware (297 mgd) is $108 million per year. Water purveyors in Delaware estimate the value of raw water supply is $1.00/1,000 gallons from the cost of services studies for rate setting by the Public Service Commission. When treated and delivered to customers, the market value of drinking water supplies is $518 million (Table 13). The average value of treated drinking water, based on rates set by public and private water purveyors in Delaware, is $4.78 per 1,000 gallons (Corrozi and Seymour, 2008).

Table 12. ***Largest Public Water Withdrawals in Delaware***

Delaware Water Purveyor	Withdrawal (mgd)
Wilmington	25.0
United Water Delaware	18.5
Newark	6.0
Dover	5.5
Milford	3.4
Lewes	1.9
Harrington	0.7
Tidewater Utilities	0.6
Milton	0.6
Dover Air Force Base	0.6
New Castle Mun. Services Comm.	0.4
Smyrna	0.4
Camden-Wyoming Water Authority	0.3

Source: DRBC and DNREC, 2010

Table 13. ***Economic Value of Delaware's Public Water Supply***

Basin	PWS	Capacity[1] (gpm)	Capacity (gpd)	Value/day Del. untreated[2] ($1/1,000 gal)	Value/year Del. untreated ($1/1,000 gal)	Value/year Del. treated[3] ($4.78/1,000 gal)
Chesapeake Bay	C	17,785	25,610,400	$25,610	$9,347,796	$44,682,465
	NTNC	5,177	7,454,880	$7,455	$2,721,031	$13,006,529
	TNC	245	352,800	$353	$128,772	$615,530
	Total	**23,207**	**33,418,080**	**$33,418**	**$12,197,599**	**$58,304,524**
Delaware Bay	C	68,891	99,203,040	$99,203	$36,209,110	$173,079,544
	NTNC	26,433	38,063,520	$38,064	$13,893,185	$66,409,423
	TNC	1,625	2,340,000	$2,340	$854,100	$4,082,598
	Total	**96,949**	**139,606,560**	**$139,607**	**$50,956,394**	**$243,571,565**
Inland Bays/Atlantic	C	32,444	46,719,360	$46,719	$17,052,566	$81,511,267
	NTNC	4,310	6,206,400	$6,206	$2,265,336	$10,828,306
	TNC	1,032	1,486,080	$1,486	$542,419	$2,592,764
	Total	**37,786**	**54,411,840**	**$54,412**	**$19,860,322**	**$94,932,337**
Piedmont	C	47,475	68,364,000	$68,364	$24,952,860	$119,274,671
	NTNC	923	1,329,120	$1,329	$485,129	$2,318,916
	TNC	25	36,000	$36	$13,140	$62,809
	Total	**48,423**	**69,729,120**	**$69,729**	**$25,451,129**	**$121,656,396**
State Totals	C	166,595	239,896,800	$239,897	$87,562,332	$418,547,947
	NTNC	36,843	53,053,920	$53,054	$19,364,681	$92,563,174
	TNC	2,927	4,214,880	$4,215	$1,538,431	$7,353,701
	Total	**206,365**	**297,165,600**	**$297,166**	**$108,465,444**	**$518,464,822**

C=Community, NTNC=Non-transient Non-community, and TNC=Transient Non-community
1. DNREC Division of Water
2. WRA, 2010
3. Corrozi and Seymour, 2008

Irrigation Water Supply

In a study of the economic value of freshwater in the United States, Resources for the Future estimated the median market value of irrigation water withdrawals is $198/acre-ft in 1996 dollars (Frederick et al., 1996) or $300/acre-ft ($0.92/1,000 gal) in 2010 dollars, adjusting for 3 percent annually (Table 14). In 2007 Delaware had 432,773 acres of cropland (29% of the state's area), 104,562 acres of which were irrigated (USDA, 2009). New Castle, Kent, and Sussex counties had 2,711, 29,066, and 72,785 acres of irrigated cropland, respectively (Table 15). Annual irrigation-water needs from June through September are nine inches in Delaware for corn, soybeans, and grain (2,600 gpd/acre or 417 mgd). In Delaware, the total annual value of water demand to irrigate 104,562 acres for agriculture is $23.5 million. The total annual value of water demand to irrigate 2,711 acres in New Castle County is just over $0.5 million, to irrigate 29,066 acres in Kent County is $6.5 million, and to irrigate 72,785 acres in Sussex County is $16.4 million (Table 16). The value of irrigation water demand = (9 in./12 in./ft.) (104,562 acres) ($300/acre-ft.) = $23,526,450/yr.

Table 14. ***Freshwater-Use Values in the United States***

Use	1996 Median[1] ($/acre-ft.)	2010 Median[2] ($/acre-ft.)	2010 Median ($/1,000 gal)
Navigation	10	15	0.02
Irrigation	198	300	0.92
Industrial Process	132	200	0.61
Thermoelectric Power	29	44	0.14

1. Frederick et al., 1996
2. Adjusted to 2010 dollars at 3% annually

Table 15. ***Value of Agriculture Irrigation in Delaware Using Ag Census Data***

County	Cropland[1] (acres)	Irrigation[1] (acres)	Value of irrigation[2] @ $300/acre-ft.
New Castle	51,913	2,711	$609,975
Kent	146,536	29,066	$6,539,850
Sussex	234,324	72,785	$16,376,625
Delaware	**432,773**	**104,562**	**$23,526,450**

1. Census of Agriculture, 2007 (USDA 2009)
2. Frederick et al., 1996
3. USGS, 2005

The USGS (2005) estimated that there are 65.1 mgd used for irrigation in Delaware. The median market value of irrigation-water withdrawals is $198/acre-ft. in 1996 dollars (Frederick et al., 1996) or $300/acre-ft. ($0.92/1,000 gal) in 2010 dollars, adjusting at 3 percent annually. Therefore, the total annual value of water demand to irrigate cropland in Delaware is $21.9 million (Table 16).

Table 16. ***Value of Agriculture Irrigation in Delaware Using USGS Data***

Irrigation[1] (mgd)	Value of irrigation/day[2] @ $0.92/1,000 gal	Value of irrigation/year[2] @ $0.92/1,000 gal
65.1 mgd	$59,892	$21,860,580

1. USGS, 2005 2. Frederick et al., 1996

Using data from both the USDA and USGS, the total annual value of water demand to irrigate the cropland in Delaware ranges from $21.9–$23.5 million.

Thermoelectric-Power Water Supply

Thermoelectric power plants, which evaporate water during cooling, produce more than 89 percent of the energy in the United States. Delaware watersheds provide a source of cooling water to run the following coal, and gas-fired power plants in Delaware:

- Delmarva Delaware City Power Plant
- Conective Edgemoor Power Plant
- NRG Indian River Power Plant
- Lewes City Power Plant
- Invista Seaford Power Plant

The USGS (2005) estimates that Delaware's waters provide 805 mgd (422 mgd fresh and 383 mgd saline) of cooling water to run the power plants in Delaware. About 95 percent of the cooling water returns to the waterway (non-consumptive), and 5 percent evaporates (consumptive). The median economic value of thermoelectric-power water withdrawals in 1996 dollars is $29/acre-ft. ($0.09/1,000 gal) with a range of $9 to $63/acre-ft. (Frederick et al., 1996). Adjusting at 3 percent annually, the median value of thermoelectric-plant water withdrawals in 2010 dollars is $44 per acre-ft. or $0.14/1,000 gallons. The annual value of power-plant water withdrawals in Delaware is just over $41 million (Table 17).

Table 17. ***Thermoelectric Power Plant Water Withdrawals in Delaware***

Power Plant[1]	Withdrawal[2] (mgd)	Value/day[3] ($0.14/,1000 gal)	Value/year ($0.14/1,000 gal)
Delmarva Delaware City			
Conectiv Edgemoor			
Lewes City			
Invista Seaford			
NRG Indian River			
Total	**805**	**$112,700**	**$41,135,500**

1.EIA, 2002, DRBC, 2010, NETL, 2009.
2. USGS, 2005. 3. Frederick et al., 1996 (adjusted to 2010 dollars at 3% annually).

Industrial Water Supply

The USGS (2005) estimates that industrial-water withdrawals total 41.4 mgd in Delaware watersheds. A study of the economic value of freshwater in the United States indicates the median market value of industrial withdrawals is $132/acre-ft. in 1996 dollars (Frederick et al. 1996) or $200/acre-ft. ($0.61/1,000 gal) in 2010 dollars adjusting at 3 percent annually. The value of industrial-water withdrawals based on 41.4 mgd in Delaware watersheds is $25,254 per day or $9,217,710 per year.

Fish/Wildlife

Wetlands

The NOAA Coastal Services Center (2011) estimates that coastal wetlands habitat supports 584 commercial, creational, and charter fishing jobs in Delaware with $13.4 million in business output and 19.3 million in wages.

National Wildlife Refuge

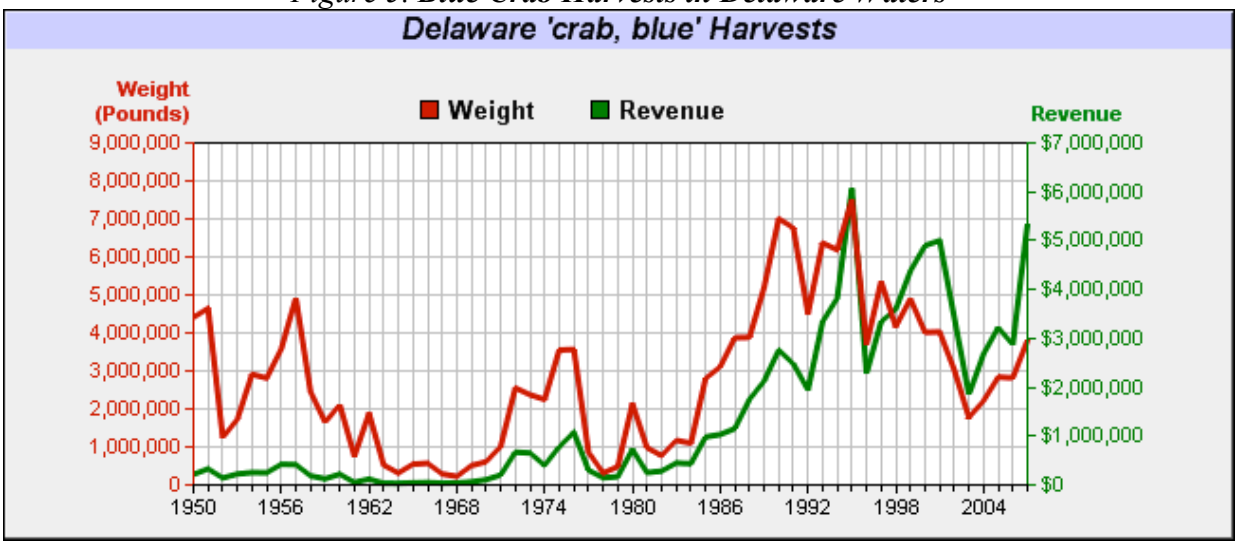
The U.S. Fish and Wildlife Service estimates that the 16,000 acre Bombay Hook National Wildlife Refuge (NWR) in Delaware was the 4th most visited refuge in the nation, as it recorded nearly 271,000 recreational visits in 2006 with 80 percent of its visitors from other states (Carver and Caudill 2007). The Bombay Hook NWR is the 6th most valuable refuge in the U.S., as it contributed $20.2 million to the local economy from food, lodging, equipment, and transportation expenditures—with $13.4 million from bird watching alone—and was responsible

for 198 jobs with $5.5 million in annual income. With a FY 2006 annual budget of $804,000 and benefits of $20.2 million, the Bombay Hook NWR provides a benefit to cost ratio of 23.4–1.

Commercial Fish Landings

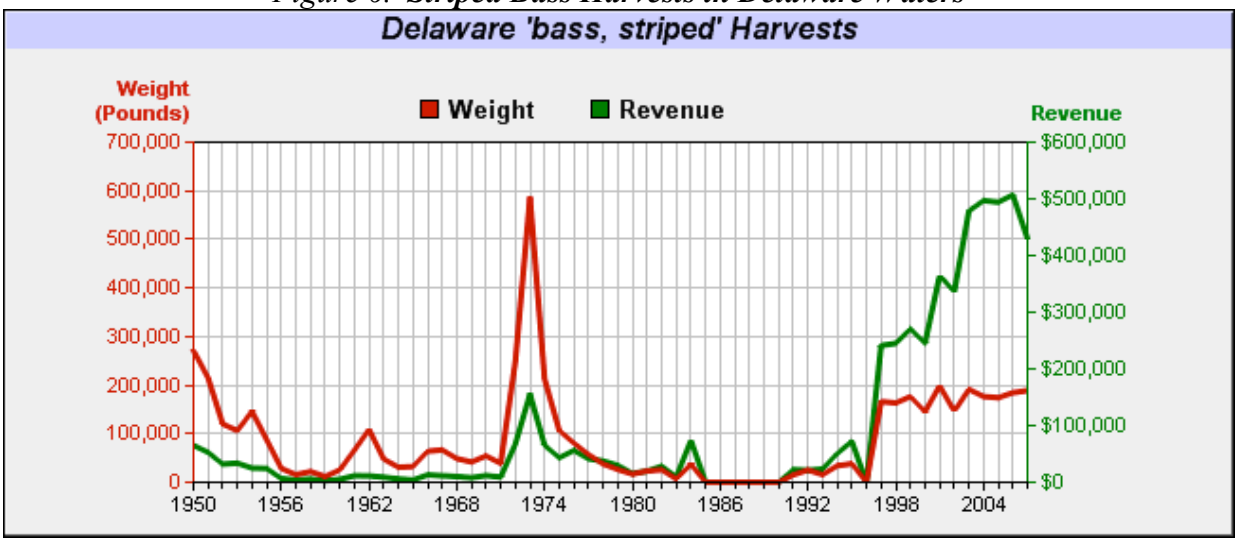
The annual value of commercial fish landings in the waters of Delaware is $7.9 million in 2007 dollars or $8.6 million in 2010 dollars, as reported by the National Marine Fisheries Service and National Ocean Economics Program (2007). Table 18 ranks the most lucrative fisheries in 2010 dollars as blue crab ($5.8 million/year), with the eastern oyster, striped bass, and knobbed whelk each at approximately $0.5 million/year. Figures 5, 6 and 7 and Table 18 show fish harvests by weight and revenue for harvests at Delaware docks.

Figure 5. ***Blue Crab Harvests in Delaware Waters***



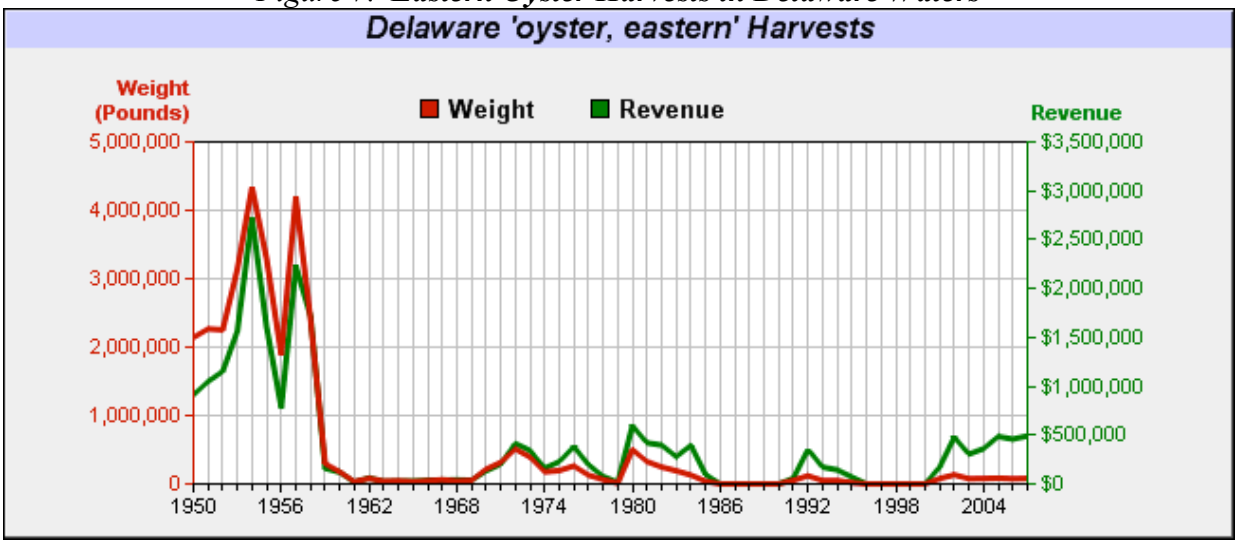
Source: NMFS and NOEP, 2007

Figure 6. ***Striped Bass Harvests in Delaware Waters***



Source: NMFS and NOEP, 2007

Figure 7. ***Eastern Oyster Harvests in Delaware Waters***



Source: NMFS and NOEP 2007

Table 18. ***Value of Commercial Fish Harvests in Delaware***

Commercial Living Marine Species in Delaware, 2007[1]			
Species	**Pounds (2007)**	**Landed Value (2007 dollars)** [2]	**Landed Value (2010 dollars)** [2]
Striped Bass	188,671	$429,994	$469,866
Bluefish	19,565	$8,075	$8,824
Butterfish	946	$843	$921
Common Carp	3,764	$865	$945
Channel Catfish	6,922	$3,929	$4,293
Northern Quahog Clam	44,618	$181,350	$198,166
Blue Crab	3,799,820	$5,329,182	$5,823,341
Horseshoe Crab	229,602	$48,978	$53,520
Atlantic Croaker	13,651	$8,281	$9,049
Black Drum	37,712	$21,867	$23,895
American Eel	139,648	$315,094	$344,312
Conger Eel	1,241	$517	$565
Finfished, UNC Bait and animal food	28	$7	$8
Finfishes, UNC General	5,421	$18,018	$19,689
Flatfish	676	$362	$396
Summer Flounder	5,464	$11,119	$12,150
Blueback Herring	1,434	$609	$665
Northern Kingfish	690	$548	$599
Atlantic Menhaden	85,080	$6,635	$7,250
Eastern Oyster	79,933	$490,465	$535,944
White Perch	55,973	$46,865	$51,211
Black Sea Bass	72,675	$200,902	$219,531
American Shad	71,445	$42,408	$46,340
Shellfish	30,130	$76,119	$83,177
Spot	128,209	$99,995	$109,267
Tautog	1,976	$3,723	$4,068
Weakfish	24,604	$36,177	$39,532
Channeled Whelk	17,139	$54,804	$59,886
Knobbed Whelk	260,078	$456,368	$498,686
Total	**5,327,115**	**$7,894,099**	**$8,626,096**

1. NMFS and National Ocean Economics Program, in 2007 dollars
2. Adjusted to 2010 dollars at 3% annually

Fishing, Hunting, and Bird/Wildlife Watching

In Delaware, the U.S. Fish and Wildlife Service (2008) estimated the annual economic value of recreational fishing, hunting, birding and wildlife-associated activities at $268.8 million in 2006 dollars or $302.6 million in 2010 dollars, adjusting at 3 percent annually (Table 19). Trip-related expenditures include the market value of purchases and sales of food and lodging, transportation, and hunting, fishing, and wildlife-watching equipment. Most fishing, hunting, and wildlife/birding recreation occurs on farms, forests, wetlands, and open-water ecosystems such as the Prime Hook and Bombay Hook National Wildlife Refuges, Cape Henlopen State Park, and other state parks and forests in Delaware and along the state's rivers, bays, and ocean.

Table 19. ***Value of Fishing, Hunting, and Wildlife Recreation in Delaware***

Recreation Activity	Value[1] in 2006 dollars ($ million)	Value in 2010 dollars ($ million)
Fishing	**$96.7**	**$108.9**
Trip-related	$48.5	$54.6
Equipment/Other	$48.2	$54.3
Hunting	**$41.3**	**$46.5**
Trip-related	$13.6	$15.3
Equipment/Other	$27.7	$31.2
Wildlife/Birding	**$130.8**	**$147.2**
Trip-related	$13.1	$14.7
Equipment/Other	$117.7	$132.5
Total	**$268.8**	**$302.6**

1. USFWS, Survey conducted in 2006, report issued 2008.

Recreation

Tourism

A vibrant tourism economy relies on clean water and healthy habitat in Delaware watersheds. According to the Delaware Tourism Office (2008), the Delaware tourism economy produced a total market value of goods and services during Fiscal Year 2008 of at least $1.9 billion.

- In 2008 there were 6.9 million visitors to the state of Delaware.
- The tourism industry generated just under $408 million in state and local government taxes/fees in FY 2008, an average of about $59 per visitor.

Power-Boating

Delaware is home to a robust boating industry that relies on clean water. According to the National Marine Manufacturer's Association (2010), in a national ranking by state, Delaware ranked 7th in total expenditures ($343,743,963) for new powerboats, engine, trailer, and

accessory purchases. In 2009 Delaware ranked 40th in boat registrations (61,523 registrations) (NMMA, 2010).

Agriculture

Crop, Poultry, Livestock

In the watersheds of Delaware, the USDA National Agricultural Statistics Service (2009) estimates the annual market value of agricultural products sold is $1.2 billion (2010 dollars) on 510,253 acres (797 sq. mi.) for crops such as corn, wheat, oats, barley, soybeans, potatoes, and vegetables, livestock, and poultry. Sussex County has the highest value of agricultural products of the three counties in Delaware at $927.6 million, and Kent and New Castle County have a significantly lower agriculture value—$205.9 million and $49.9 million, respectively. The average value of agriculture products sold in the state is $1,791/acre (Table 20).

Table 20. ***Value of Cropland and Agriculture in Delaware***

County	Farmland by County[1] (acres)	Ag Products Sold Value by County[1] in 2007 dollars ($ million)	Ag Products Sold Value by County in 2010 dollars ($ million)	Ag Products Sold Value by County in 2010 dollars ($/acre)
New Castle	66,981	45.7	49.9	745.5
Kent	173,808	188.4	205.9	1,184.5
Sussex	269,464	848.9	927.6	3,442.4
Total	**510,253**	**$1,083.0**	**$1,183.4**	**$1,790.8 (average)**

1. Census of Agriculture, 2007 (USDA, 2009)

Ports

Navigation

The 130-mile-long Delaware River and Bay ship channel from Cape Henlopen to the head of tide at Trenton has significant instream navigation–use value. The water-resource value from transport shipping is distinct from the port activities described below. The volume of the 216-sq.-mi. Delaware River and Bay within Delaware's boundaries at a mean depth of 32 feet is 4.4 million acre-feet (1.4 trillion gallons). Frederick et al. (1996) concluded the median navigation-use value in the U.S. is $10/acre-foot in 1996 dollars ($15/acre-foot in 2010 dollars adjusting for 3% annually). Therefore, the annual navigation use value of the Delaware River/Bay from the Atlantic Ocean to the Port of Wilmington within state boundaries is $66 million.

Port Activity

The Martin Associates report (2005), prepared for the Diamond State Port Corporation, cited that the marine cargo activity at the Port of Wilmington's terminals generated a total of $3.2 billion of total economic activity in the region. This total economic activity can be broken down into direct business revenue and the value of output to the state. Just over $400 million ($409.1

million) is direct business revenue by the firms dependent on the port's marine terminals and providing maritime services and inland transportation services to the cargo handled at the marine terminals and the vessels calling the terminals. The remaining $2.8 billion represents the value of the output to the state that is created due to the cargo moving via the Diamond State Port Corporation's marine terminals (Martin Associates, 2005).

Located at the confluence of the Delaware and Christina Rivers, the Port of Wilmington was founded in 1923, and is one of the busiest terminals on the Delaware River. The port is a full-service deepwater port and marine terminal. The Port of Wilmington:

- Is the world's largest banana hub.
- Is the leading gateway for imports of fresh fruit and juice concentrate.
- Is the Mid-Atlantic regional port of discharge for Volkswagen America.
- Handles 400 vessels annually.
- Imports and exports over four million tons of cargo annually.
- Generates $7 million in tax revenues to Delaware (Table 21).

Table 21. ***Tax Revenues from the Port of Wilmington, 2005***

Type	Delaware
Individual Income Tax	$2,538,803
Sales and Use Tax	
Corporate Income Tax	$888,055
Selective Tax	$1,075,499
Other State Tax, License, Fees	$2,536,226
Total State and Local Tax	**$7,038,583**

Source: Economy League of Greater Philadelphia, 2008

The City of Wilmington's marine terminal along the Christina River handles commodities such as:

- Containerized cargo (primarily bananas)
- Fresh fruit
- Frozen breakbulk beef
- Iron and steel products
- Lumber and newsprint
- Breakbulk juices
- Autos
- Salt
- Minerals and other dry bulk commodities
- Bulk juice
- Petroleum products

According to the report, Maritime Commerce in Greater Philadelphia (2008), the Port of Wilmington tripled its TEU (twenty-foot equivalent unit) share between 1985 and 2005, increasing from 0.47 to 1.33 percent of the East Coast market and from 0.20 to 0.60 percent of the U.S. market. In the container business, this growth is the largest proportionate growth among

the 20 largest U.S. container ports during this time period. In 2005 the Port of Wilmington contributed 251,000 TEUs, or 1.3 percent of the container market share, of East Coast ports (2005) (Table 22). The port handles 8,445 tons per year, or 1.4 percent of the container market share, of East Coast ports (Table 23).

The Economy League of Greater Philadelphia (2008) reported that among U.S. ports in 2005 the Port of Wilmington ranked:

- 33rd in import tonnage (6,896,499 short tons imported)
- 37th in import cargo value ($5,499,289,565)
- 67th in export tonnage (381,567 short tons exported)
- 24th in export cargo value ($2,175,543,116)

Table 22. **Port of Wilmington Total TEUs as a Share of East Coast and U.S. Markets, 1985-2005**

Year	Total TEUs	Share of East Coast	Share of U.S.
1985	18,790	0.47%	0.20%
1990	91,623	1.58%	0.67%
1995	156,940	1.81%	0.78%
2000	192,091	1.64%	0.70%
2005	250,507	1.33%	0.60%

Source: Economy League of Greater Philadelphia, 2008

Table 23. **Port of Wilmington Total Tonnage as a Share of East Coast and U.S. Markets, 1985-2005**

Year	Tonnage (thousands)	Share of East Coast	Share of U.S.
1985	2,362	0.56%	0.15%
1990	4,209	0.90%	0.20%
1995	4,273	0.96%	0.20%
2000	5,184	0.94%	0.22%
2005	8,445	1.44%	0.36%

Source: Economy League of Greater Philadelphia, 2008

Non-Market Value

Recreation

Boating, Fishing, and Swimming Recreation

Using travel cost–demand methods, Johnston et al. (2002), from the University of Rhode Island, computed the consumer surplus (economic-use value) for swimming, boating, recreational fishing, and bird watching/wildlife viewing in the Peconic Estuary watershed on Long Island, N.Y., at $8.59, $19.23, $40.25, and $49.83 per trip, respectively, in 1995 dollars. Table 24 displays water-quality benefits to recreational users at $130 million per year in Delaware by transferring unit values from the Peconic Estuary, converting 1995 dollars to 2010 dollars at 3 percent per year and multiplying the 2010 figures by number of trips per year. Wildlife viewing/bird watching (51%) and fishing (43%) are the highest recreational benefits, followed by boating (5%) and swimming (1%).

Table 24. ***Total Annual Value of Recreational Benefits in Delaware Watersheds***

Recreational Benefit	Consumer surplus/trip[1] (1995 dollars)	Consumer surplus/trip[2] (2010 dollars)	Trips/year	Annual Value	Portion of Benefit
Swimming	$8.59	$13.40	89,793[3]	$1,203,226	1%
Boating	$19.23	$30.00	211,194[4]	$6,335,820	5%
Fishing	$40.25	$62.79	897,935[4]	$56,381,339	43%
Wildlife/bird watching	$49.83	$77.73	855,000[5]	$66,459,150	51%
Total				**$130,379,535**	**100%**

1. Johnston et al., 2002. 2. 2010 dollars transferred from 1995 dollars at 3% per year. 3. Using 2010 U.S. Census value, 897,934, about 10% of population swims in watershed. 4. NOEP 2009, 16.8% of population enjoys boating at 1.4 trips/person/year and 10.3% of population goes fishing at 1.2 trips/person/year, using 2010 U.S. Census value. 5. USFWS 2006.

Water Quality

Improved Stream Water Quality/Willingness to Pay

The economic benefits of stormwater management to improve water quality is estimated by comparing reduced pollutant loadings from municipal and construction site controls, which result in changes in water-quality classifications among the following uses:

- Non-support (Impaired)
- Boatable
- Fishable
- Swimmable

Carson and Mitchell (1993) conducted a contingent-value (CV) study to estimate the national benefits of freshwater-pollution control to meet the goals of the Clean Water Act. The study

surveyed people's preferences or willingness to pay (WTP) for improved water quality to achieve instream, withdrawal, aesthetic, ecosystem-use benefits and vicarious consumption and stewardship non-use benefits (Table 25). They found that the range of mean annual household WTP to go from non-supported (polluted) to improved water quality was wide—$93 for boatable, $70 for fishable, $78 for swimmable, and $242 for total use support (1990 dollars). Adjusting for inflation at 3 percent annually, mean annual household WTP in 2010 dollars also has a wide range, $168 for boatable, $127 for fishable, $141 for swimmable, and $438 for total use support (Table 26). The major policy implications from this WTP research indicate that the American public is willing to pay up to $438 per year for watershed and stormwater-management controls to achieve boatable, fishable, and swimmable water quality in freshwater rivers and streams.

Table 25. ***Typical Benefits from Improved Freshwater Quality***

Benefit	Category	Examples
Use	Instream	Recreational (fishing, swimming, boating)
		Commercial (fishing, navigation)
	Withdrawal	Municipal(drinking water, waste disposal)
		Agriculture (irrigation)
		Industrial/commercial (waste treatment)
	Aesthetic	Near water recreation (hiking, picnicking, photography)
		Viewing (commuting, office/home views)
	Ecosystem	Hunting/bird watching
		Ecosystem support (food chain)
Nonuse	Vicarious	Significant others (relatives, friends)
		American public
	Stewardship	Inherent (preserving remote wetlands)
		Bequest (family, future generations)

Source: Carson and Mitchell 1993

Table 26. ***Adjusted Annual Household Values for National Water Quality Benefits***

Water Quality Use Support	Mean WTP[1] $1990	Standard Error of Mean ($)	95% Confidence interval ($)	Mean WTP[2] $2010
Boatable	93	8	77-109	168
Fishable	70	6	58-82	127
Swimmable	78	9	60-96	141
Total	**242**	**19**	**205-279**	**438**

1. Carson and Mitchell, 1993 2. Adjusted to 2010 dollars for inflation at 3% annually

In Delaware, the freshwater benefits of watershed management to achieve water-quality goals ranges from $54 million/year for boatable, $41 million for fishable, $45 million for swimmable, and $141 million for total boatable, fishable, and swimmable water-quality uses.

1. Estimate the number of households impacted by water quality changes in proximity to the stream reaches in question. If 97 percent of waterways in Delaware are impaired, according to the Delaware Section 303d report (DNREC 2010), and Delaware's 2010 population is 895,173 (DPC 2010) and the number of households is 332,198 (DPC 2010), then 868,000 people in 322,232 households are affected by impaired-stream water quality in Delaware.

2. Estimate household WTP for incremental water-quality improvements from non-supported to boatable to fishable to swimmable stream uses. Carson and Mitchell (1993) estimated household WTP for improved water quality as $93 for non-support to boatable, $70 boatable to fishable, $78 fishable to swimmable ($241 to achieve total uses) in 1990 dollars. WTP accrues to $168, $127, $141, and $438, for boatable, fishable, swimmable, and total use support, respectively, when adjusted to 2010 dollars at 3% annually to account for inflation, cost of living increases, and increased public attitudes toward clean water.

3. Estimate the total annual benefits of stormwater management in Delaware as $140 million by multiplying the population (868,000) or households (332,232) affected by impaired water quality by household WTP for boatable, fishing, and swimmable uses (Table 27).

Table 27. ***Annual Benefits from Watershed Management and Improved Water Quality in Del.***

Water Quality Use Support	2010 Population[1]	2010 Households[1]	2010 WTP[2] (/household)	WQ Benefits
Boating	868,000	322,232	$168	$54,134,976
Fishing	868,000	322,232	$127	$40,923,464
Swimming	868,000	322,232	$141	$45,434,712
Total	**868,000**	**322,232**	**$436**	**$140,493,152**

1. Population and households impacted by impaired streams. About 97% of Delaware streams are impaired (DNREC 2010).
2. Carson and Mitchell 1993, adjusted to $2010 for inflation at 3% annually

Helm, Parsons, and Bondelid (2003) measured the economic benefits of water-quality improvements to recreational users in the New England states—Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. They found per person WTP for good water quality ranged from $8.25 for boating, $8.26 for fishing, and $70.47 for swimming uses in 1994 dollars. Adjusting to 2010 dollars at 3 percent annually, per person WTP is estimated at $13.20 for boating, $13.22 for fishing, and $112.75 for swimming uses. In Delaware, mean household density is 2.6 people per household, therefore 2010 household WTP from Helm, Parsons, and Bondelid is $34.32 for boating, $34.37 for fishing, and $293.15 for swimming uses (Table 28).

Table 28. ***Annual Willingness to Pay for Water Quality Benefits in New England States***

WQ Use Support	WTP per person[1] (1994 dollars)	WTP per person[2] (2010 dollars)	WTP per household[3] (2010 dollars)
Boatable	8.25	13.20	34.32
Fishable	8.26	13.22	34.37
Swimmable	70.47	112.75	293.15
Total	**86.98**	**139.17**	**361.84**

1. Helm, Parsons, and Bondelid 2003
2. Adjusted to 2010 dollars for inflation at 3% annually
3. Delaware household density of 2.6 persons/household in 2010

Table 29 compares annual household WTP for improved water quality adjusted to 2010 dollars from Carson and Mitchell (1993) and Helm, Parsons, and Bondelid (2003). Multiplying household WTP by the number of households (97%) in Delaware affected by impaired water quality indicates that total WTP ranges from $141 million per year from the Carson and Mitchell (1993) national survey data to $116 million per year from the Parsons et al. (2003) survey of the six New England states. Total WTP in Delaware from both studies are in close agreement ($141 million vs. $116 million) with higher WTP for swimmable uses ($94 million) from the New England states data compared to $45 million for the national survey.

Table 29. ***Comparison of Annual Willingness to Pay for Water Quality Benefits***

WQ Use Support	2010 DE Population[1]	2010 DE Households	WTP per household[2] (2010 dollars)	WTP per household[3] (2010 dollars)	WQ Benefits[2]	WQ Benefits[3]
Boatable	868,000	322,232	168	34	54,134,976	10,955,888
Fishable	868,000	322,232	127	34	40,923,464	10,955,888
Swimmable	868,000	322,232	141	293	45,434,712	94,413,976
Total	**868,000**	**322,232**	**438**	**361**	**141,137,616**	**116,325,752**

1. Population and households impacted by impaired streams. About 97% of Delaware streams are impaired (DNREC 2010)
2. Carson and Mitchell, 1993.
3. Helm, Parsons, and Bondelid 2003. WTP adjusted to 2010 dollars for inflation at 3% annually.

Figure 8. ***Annual Household Willingness to Pay for Improved Water Quality (2010 Dollars)***

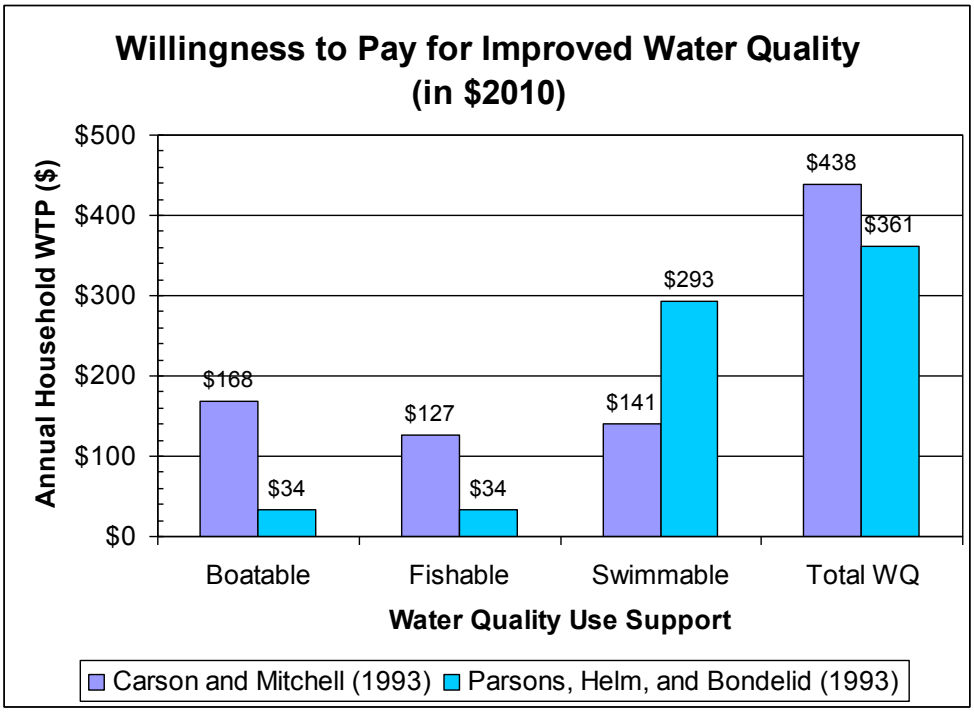
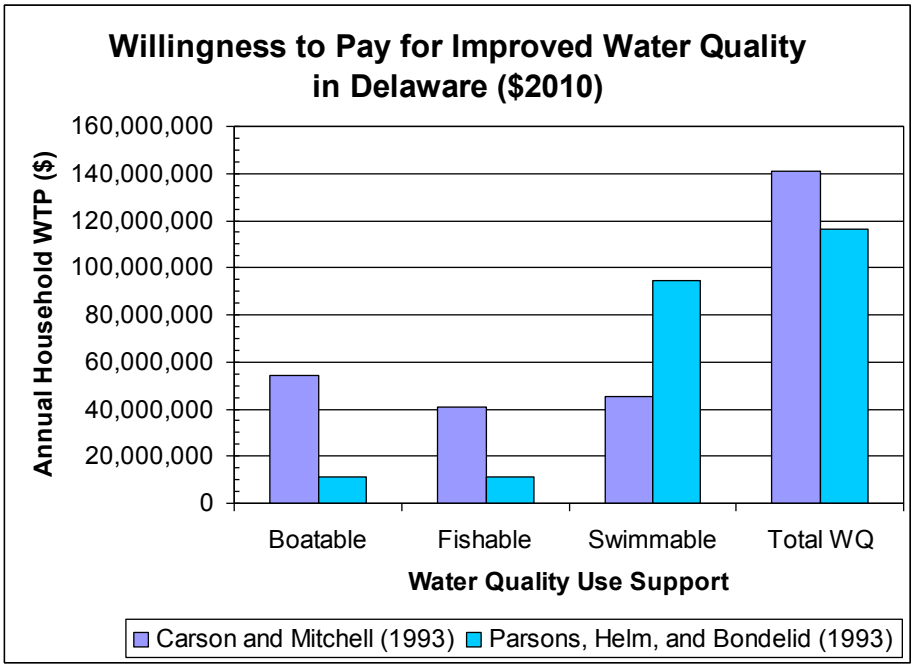


Figure 9. ***Household Willingness to Pay for Improved Water Quality in Delaware***



Forests

The U.S. Forest Service and Delaware Center for Horticulture (Nowak et al., 2008) estimated that 7,137 acres of forests in New Castle County 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, 265,476 acres (415 sq. mi.) of forests in Delaware have benefits of carbon storage ($220 million), carbon sequestration ($7.7 million), air-pollution removal ($71 million), and building-energy savings ($15 million). In addition, forests in Delaware watersheds provide environmental benefits by regulating climate change, cooling, and air-emissions control including 11 million tons of carbon-storage capacity, 371,666 tons of carbon sequestration, 10,619 tons of air-pollution removal, 37,167 tons of avoided carbon-emissions capacity (Table 30 and 31).

Table 30. ***Economic and Environmental Benefits of Forests in Delaware***

Benefits	Forests New Castle County[1]		Forests State of Delaware[2]	
	Environmental (tons/acre)	Economic (value/acre)	Environmental (tons)	Economic (value)
Carbon Storage	40.00	$827	10,619,040	$219,548,652
Carbon Sequestration	1.40	$29	371,666	$7,698,804
Air Pollution Control	0.04	$266	10,619	$70,616,616
Energy Savings		$56		$14,866,656
Avoided Carbon Emissions	0.14	$3	37,167	$796,428

1. Nowak et al. 2008 2. Computed for 265,476 acres of forests in Delaware

Table 31. ***Economic and Environmental Benefits of Forests in Delaware Watersheds***

Forest Benefits	Piedmont ($)	Delaware Bay ($)	Chesapeake ($)	Inland Bays ($)	Total ($)
Carbon Storage	26,620,303	78,851,142	84,607,062	29,470,145	219,548,652
Carbon Sequestration	933,481	2,765,034	2,966,874	1,033,415	7,698,804
Air Pollution Control	8,562,274	25,362,036	27,213,396	9,478,910	70,616,616
Energy Savings	1,802,584	5,339,376	5,729,136	1,995,560	14,866,656
Avoided Carbon Emissions	96,567	286,038	306,918	106,905	796,428

[1] Computed for the following acreage in each basin: 32,189 (Piedmont), 95,346 (Delaware Bay), 102,306 (Chesapeake), and 35,635 (Inland Bays).

Public Parks

The Trust for Public Land (2009) found that the 444-acre City of Wilmington park and recreation 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).
- 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 (benefits) transfer, public parks in Delaware's watersheds provide the following annual economic benefits (Table 32):

- Health benefits from exercise in the parks ($264,618,790).
- Community-cohesion benefits from people socializing in the parks ($64,781,855).
- Water pollution–mitigation benefits from parks in treating stormwater ($25,037,385).
- Air pollution–mitigation value from tree and shrub absorption ($2,392,280).

Table 32. ***Value of Public Parks in Delaware Watersheds***

County	Parks in Watershed (acres)	Health Benefits (at $9,734/acre)	Community Cohesion (at $2,383/acre)	Stormwater Benefit (at $921/acre)	Air Pollution (at $88/acre)
Kent	6,888	$67,047,792	$16,414,104	$6,343,848	$606,144
New Castle	13,744	$133,784,096	$32,751,952	$12,658,224	$1,209,472
Sussex	6,553	$63,786,902	$15,615,799	$6,035,313	$576,664
Delaware	**27,185**	**$264,618,790**	**$64,781,855**	**$25,037,385**	**$2,392,280**

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 Delaware's watersheds:

- Cecil County green infrastructure study by the Conservation Fund, Annapolis, Md. (2007)
- New Jersey Department of Environmental Protection with 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 Refuge System by University of Maryland and the 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. Weber (2007) from the Conservation Fund found the largest ecosystem services values in Cecil County, Md., are from stormwater/flood control, water supply, and clean water functions (Table 33).

The N.J. Department of Environmental Protection (2007) partnered with the 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, based on a discount rate of 3 percent calculated in perpetuity. 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 an interest rate (3%) due to inflation.

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 $631/acre in 2010 dollars at 3 percent annually (Table 34). 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 New York 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 that 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 (2009) indicates that in 2007 the total market value of agricultural crops sold from 510,253 acres of farm land in Delaware was $1,083 billion ($210.6 million in crops and $872.4 million in poultry and livestock) or $2,122/acre.

Table 35 compares ecosystem services values (dollars/acre) from other studies in other watersheds. Data from the NJDEP study and market (goods) value of agriculture are used for value transfer, as Delaware watersheds share similar ecosystems (forests and wetlands), climate (humid continental at 40 degrees north in latitude), physiographic provinces (Piedmont/Coastal Plain), aquifers, and soils. NJDEP ecosystem-services values ($/acre) are lower than those of Cecil County for wetlands and forests and MassAudubon for wetlands. NJDEP estimates are higher than those of the Wilderness Society for forests and U.S. Wildlife Refuge values for freshwater wetlands and forests. Values are adjusted to 2010 dollars based on 3 percent annually. Net present values are calculated based on an annual discount rate of 3 percent in perpetuity (over 100 years in the future).

Table 33. ***Ecosystem Services Values for Cecil County***

Ecosystem Service	Upland Forest ($/ac/yr)	Riparian Forests/ Wetlands ($/ac/yr)	Nonriparian Wetlands ($/ac/yr)	Tidal Marsh ($/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**

Source: Weber, 2007

Table 34. ***Forest Ecosystem Service Values for U.S. Temperate Forests***

Ecosystem Good or Service[1]	1994 Value ($/acre)	2010 Value[2] ($/acre)
Climate regulation	57.1	91.9
Disturbance regulation	0.8	1.3
Water regulation	0.8	1.3
Water supply	1.2	1.9
Erosion and sediment control	38.8	62.5
Soil formation	4.0	6.4
Nutrient cycling	146.1	235.2
Waste Treatment	35.2	56.7
Biological Control	0.8	1.3
Food Production	17.4	28.0
Raw Materials	55.8	89.8
Genetic Resources	6.5	10.5
Recreation	26.7	43.0
Cultural	0.8	1.3
Total	392.1	631.3

1. Krieger, 2001 2. Computed at 3% annually.

Table 35. ***Comparison of Ecosystem Goods and Services Values from Various Studies***

Ecosystem	Cecil Co. Md. 2006 ($/ acre/yr.)	NJDEP 2007 ($/ acre/yr.)	Wilderness Society 2001 ($/acre/yr.)	Peconic Est. 1995 ($/ acre/yr.)	U.S. Wildlife 2008 ($/ acre/yr.)	Mass. Audubon 2003 ($/ acre/yr.)	USDA [1] 2007 ($/ acre/yr.)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	2,388[1]
Forest land	12,033	1,714	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. Value of natural goods only as measured by agricultural crops, livestock, and poultry sold (USDA, 2009).

Watershed Ecosystem Services

The estimated value of goods and services provided in Delaware watersheds (2,368 sq. mi. or 1,515,263 acres) is $6.7 billion (in 2010 dollars) with a net present value (NPV) of $216.6 billion (Table 36). Ecosystem-services areas within the Delaware watersheds comprise farmland (39%), forests (18%), freshwater wetlands (12%), marine (8%), and saltwater wetlands (5%). Just over 15 percent of the watershed land in Delaware is urban/suburban (Figure 10).

Freshwater wetlands, farms, marine habitat, forests, and saltwater wetlands provide the highest total ecosystems goods and services values (Figures 11 and 13). The Delaware Estuary, at $2.4 billion, provides the highest value of annual ecosystem services, and the Chesapeake Bay and Inland Bays follow close behind at $2.0 billion each (Figure 12 and 14). Delaware watersheds with the highest value of annual ecosystem services/acre include the Inland Bays ($6,147/acre), Chesapeake Bay ($4,562/acre), and Delaware Estuary ($3,878/acre) watersheds as these systems have the highest combined amounts of forests, marine, and wetlands habitats (over 75%) (Figure 15).

Table 36. ***Value of Ecosystem Goods and Services in Delaware Watersheds***

Ecosystem	Area (acres)	$/acre/yr	PV $	NPV $
State of Delaware	**1,515,263**		**6,663,081,452**	**216,550,147,180**
Freshwater wetlands	178,632	13,621	2,433,081,000	79,075,132,489
Marine	124,879	10,006	1,249,541,955	40,610,113,531
Farmland	590,150	2,949	1,740,640,688	56,570,822,374
Forest land	265,476	1,978	525,143,567	17,067,165,922
Saltwater wetland	71,001	7,235	513,691,702	16,694,980,313
Barren land	6,459	0	0	0
Urban	229,827	342	78,511,742	2,551,631,623
Beach/dune	588	48,644	28,579,665	928,839,116
Open water	48,253	1,946	93,891,133	3,051,461,812
Piedmont	**116,435**		**197,222,249**	**6,409,723,112**
Freshwater wetlands	4,732	13,621	64,452,985	2,094,722,008
Marine	799	10,006	7,994,818	259,831,575
Farmland	9,588	2,949	28,279,693	919,090,039
Forest land	32,189	1,978	63,673,833	2,069,399,557
Saltwater wetland	919	7,235	6,649,002	216,092,568
Barren land	234	0	0	0
Urban	67,357	342	23,010,027	747,825,890
Beach/dune	42	48,644	2,043,051	66,399,165
Open water	575	1,946	1,118,840	36,362,310
Delaware Estuary	**625,435**		**2,423,972,073**	**78,779,092,340**
Freshwater wetlands	58,390	13,621	795,317,362	25,847,814,257
Marine	16,274	10,006	162,840,906	5,292,329,460
Farmland	254,143	2,949	749,590,681	24,361,697,130
Forest land	95,346	1,978	188,605,634	6,129,683,090
Saltwater wetland	61,617	7,235	445,802,585	14,488,584,028
Barren land	2,305	0	0	0
Urban	123,048	342	42,034,778	1,366,130,274
Beach/dune	256	48,644	12,429,832	403,969,529
Open water	14,056	1,946	27,350,295	888,884,572
Chesapeake Bay	**449,248**		**2,049,307,983**	**66,602,509,460**
Freshwater wetlands	81,130	13,621	1,105,045,825	35,913,989,309
Marine	233	10,006	2,327,602	75,647,066
Farmland	245,509	2,949	724,127,218	23,534,134,598
Forest land	102,306	1,978	202,373,653	6,577,143,722
Saltwater wetland	353	7,235	2,556,702	83,092,815
Barren land	844	0	0	0
Urban	17,019	342	5,813,781	188,947,882
Beach/dune	74	48,644	3,599,662	116,989,004
Open water	1,780	1,946	3,463,540	112,565,064
Inland Bays	**324,145**		**1,992,579,147**	**64,758,822,268**
Freshwater wetlands	34,379	13,621	468,264,828	15,218,606,915
Marine	107,573	10,006	1,076,378,629	34,982,305,430
Farmland	80,910	2,949	238,643,096	7,755,900,607
Forest land	35,635	1,978	70,490,448	2,290,939,552
Saltwater wetland	8,111	7,235	58,683,412	1,907,210,902
Barren land	3,076	0	0	0
Urban	22,403	342	7,653,156	248,727,577
Beach/dune	216	48,644	10,507,121	341,481,418
Open water	31,842	1,946	61,958,457	2,013,649,867

Figure 10. ***Ecosystem Service Areas in Delaware Watersheds***

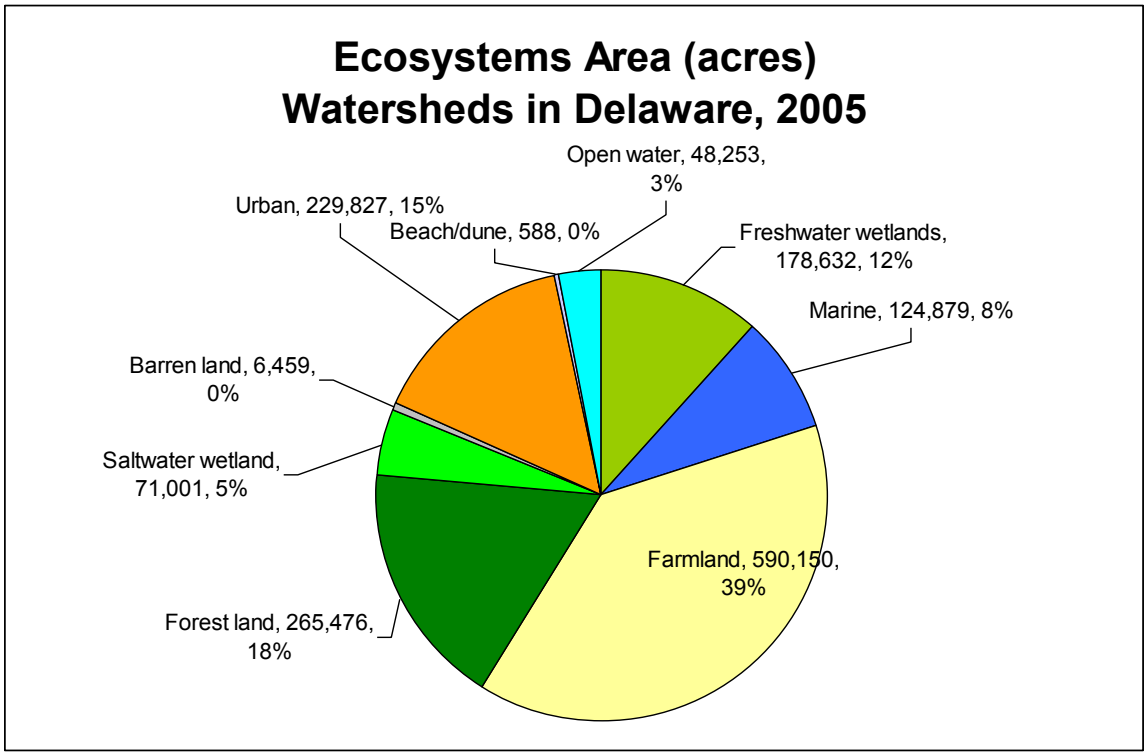


Figure 11. ***Value of Natural Goods and Services by Ecosystem Within Delaware Watersheds***

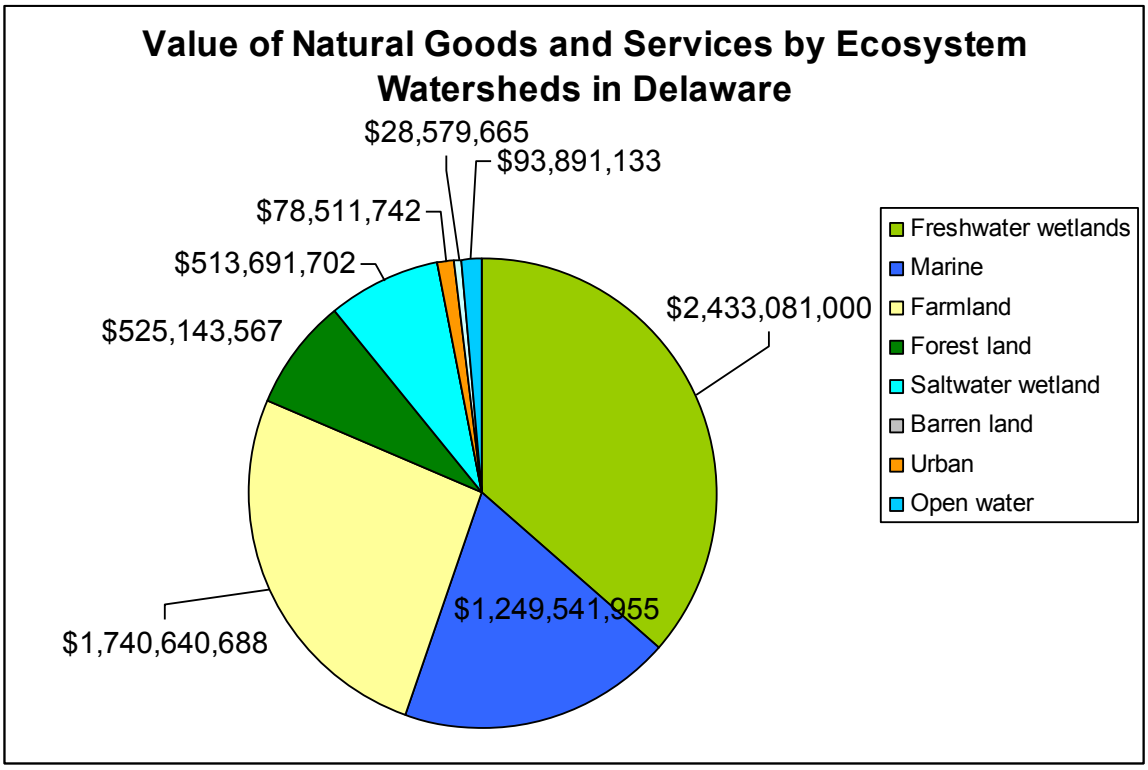


Figure 12. ***Value of Natural Goods and Services by Watershed Within Delaware***

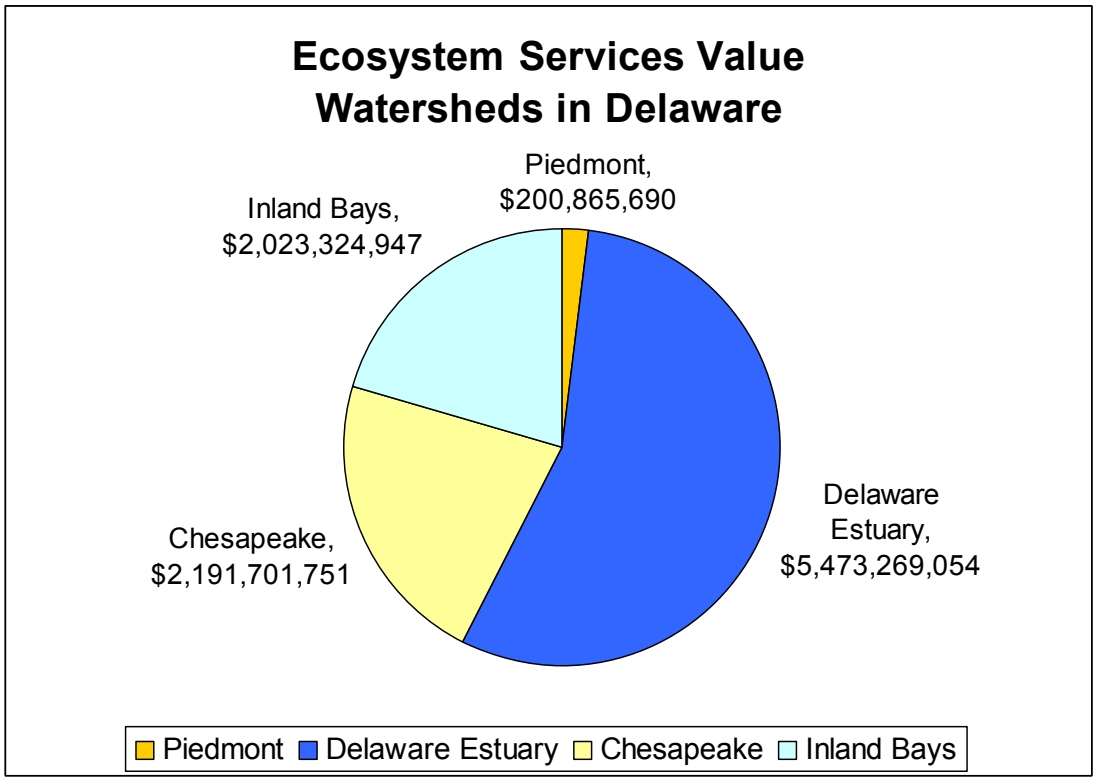


Figure 13. ***Ecosystem Service Value (2010 dollars) Within Delaware Watersheds***

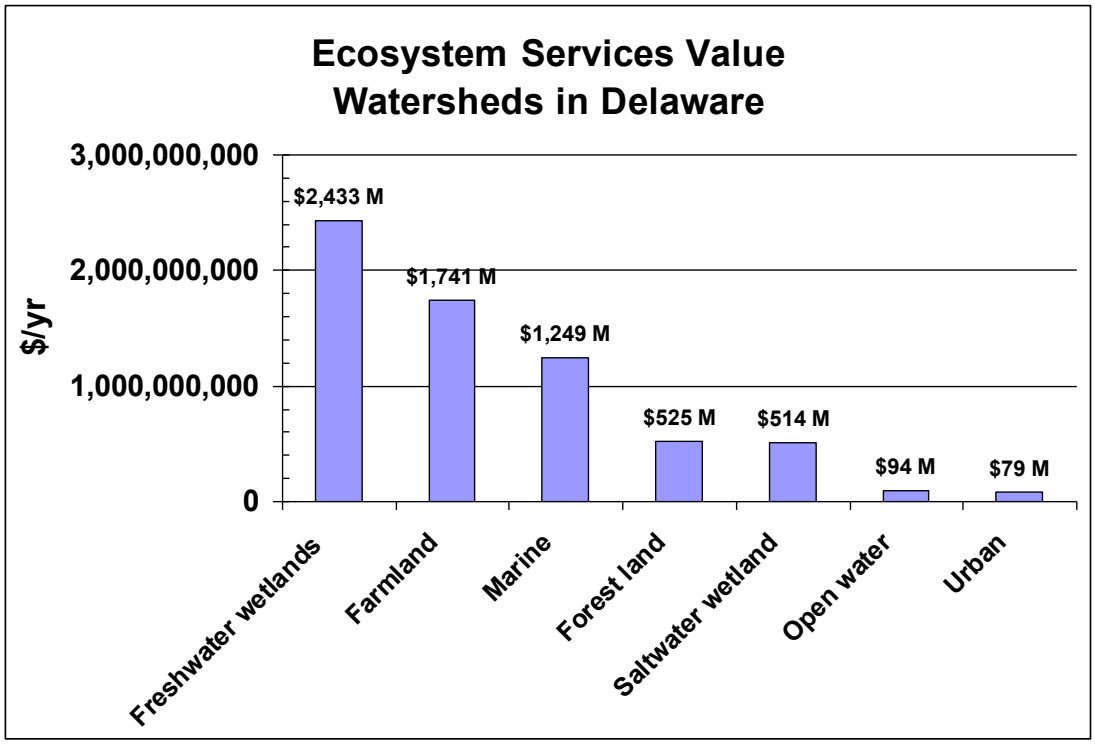


Figure 14. ***Value of Natural Goods and Services by Watershed Within Delaware***

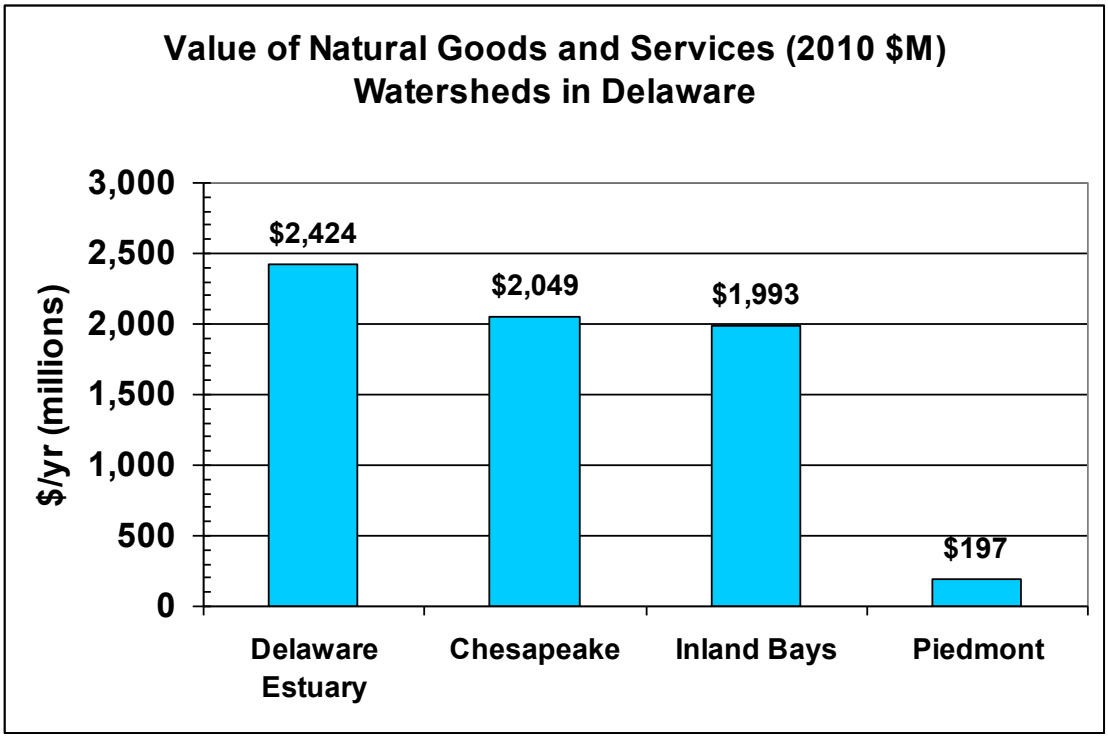
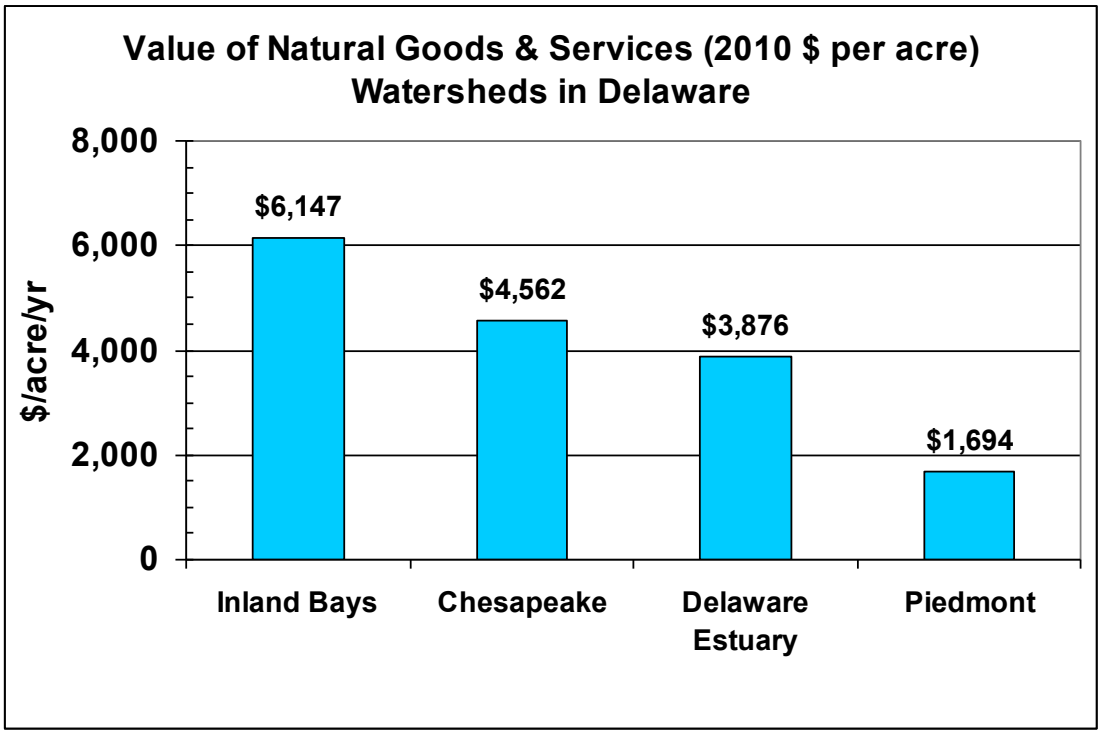


Figure 15. ***Value of Natural Goods and Services by Watershed Within Delaware***



Ecosystem services in Delaware watersheds using the NJDEP and USDA farm-good values are worth $6.7 billion (2010 dollars) or $216.6 billion (NPV), which are conservatively in the lower end of the range. If lower per-acre estimates of ecosystem services from other studies were used instead of the NJDEP values, ecosystem services in Delaware watersheds would be $3.7 billion or NPV = $121.5 billion (Table 37). If higher per-acre estimates from other studies were used, the value of ecosystems in Delaware watersheds would be $20.1 billion or NPV = $654.6 billion (Table 38).

Estimate	PV ($B)	NPV ($B)
Low	3.7	121.5
NJDEP	6.7	216.6
High	20.1	654.6

Table 37. ***Low Range of Ecosystem Services in Delaware Watersheds***

Ecosystem	Area (acres)	$/acre/year	PV ($)	NPV ($)
Freshwater wetlands	178,632	6,268	1,119,662,818	36,389,041,588
Marine	124,879	8,670	1,082,700,043	35,187,751,414
Farmland	590,150	1,387	818,538,139	26,602,489,502
Forest land	265,476	641	170,169,833	5,530,519,578
Saltwater wetland	71,001	6,269	445,102,324	14,465,825,530
Barren land	6,459	0	0	0
Urban	229,827	296	68,028,662	2,210,931,501
Beach/dune	588	42,149	24,763,638	804,818,235
Open water	48,253	217	10,470,901	340,304,283
Total acre	**1,515,265**		**3,739,436,358**	**121,531,681,631**
sq. mi.	**2,368**			

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

Table 38. ***High Range of Ecosystem Services in Delaware Watersheds***

Ecosystem	Area (acre)	$/acre/year	PV ($)	NPV ($)
Freshwater wetlands	178,632	43,685	7,803,521,093	253,614,435,509
Marine	124,879	8,670	1,082,700,043	35,187,751,414
Farmland	590,150	9,979	5,889,107,487	191,395,993,323
Forest land	265,476	12,033	3,194,467,399	103,820,190,465
Saltwater wetland	71,001	28,146	1,998,380,924	64,947,380,025
Barren land	6,459	0	0	0
Urban	229,827	296	68,028,662	2,210,931,501
Beach/dune	588	42,149	24,763,638	804,818,235
Open water	48,253	1,686	81,354,558	2,644,023,135
Total acre	**1,515,265**		**20,142,323,804**	**654,625,523,607**
sq. mi.	**2,368**			

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

Delaware watersheds are jobs engines with water resources and habitat that supports over 70,000 direct and indirect jobs with over $2 billion in annual wages in the coastal, farm, ecotourism, watershed organization, water supply/wastewater, recreation, and port industries (Table 39).

Table 39. ***Jobs and Wages Directly and Indirectly Related to Delaware Watersheds***

Sector	Jobs	Wages ($ million)	Data Source
Direct Watershed-Related	18,926	402	U.S. Bureau of Labor Statistics (2009)
Indirect Watershed-Related	22,711	322	U.S. Census Bureau (2009)
Coastal	15,174	268	National Coastal Econ. Program (2009)
Farm	28,328	1,410	Awokuse et al., (2010)
Fishing/Hunting/Birding	9,248	304	U.S. Fish and Wildlife Service (2008)
National Wildlife Refuge	198	6	Carver and Caudill (2007)
Wetlands	584	19	NOAA Coastal Services Center (2011)
Watershed Organizations	115	5.5	WRA and DRBC (2010)
Ports	4,601	307	Martins Associates (2007))
Tourism	31,050	931	Delaware Tourism Office (2008)
Water Supply Utilities	275	15	WRA and DRBC (2010)
Wastewater Utilities	207	9	WRA and DRBC (2010)
Delaware Watersheds	**>70,000**	**>$2 billion**	

Jobs and wages in Delaware watersheds were obtained from U.S. Bureau of Labor Statistics (2009) and U.S. Census Bureau (2009) databases (Tables 40 and 41, Appendix A). 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, the number of watershed-related jobs is likely undercounted. Delaware watershed-related jobs are tabulated for three scenarios:

1. Total jobs in Delaware counties determined by NAICS code (formerly SIC code).
2. Direct Delaware watershed-related jobs such as water/sewer construction, living resources, maritime, tourism/recreation, ports, environmental services, and water/wastewater management determined for each NAICS code by county and by whole basin.
3. Indirect jobs/wages funded by purchases of goods/services by direct jobs earners estimated by a multiplier of 2.2 to direct jobs and 1.8 to direct wages (Latham and Stapleford, 1990). Therefore, every direct watershed job funds 1.2 indirect jobs, and a dollar in direct wages funds $0.80 in indirect wages.

U.S. Bureau of Labor Statistics data (2009) indicate there were 394,918 jobs in Delaware counties with wages of $18.8 billion including:

- Kent County (60,145 jobs, $2.2 billion in wages)
- New Castle County (266,134 jobs, $14.3 billion in wages)
- Sussex County (68,639 jobs, $2.3 billion in wages)

Organizations directly associated with Delaware watersheds (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employed 18,926 people with $402 million in wages.

Organizations indirectly related to Delaware watersheds (based on multipliers of 2.2 for jobs and 1.8 for salaries) employed 22,711 people with $322 million in wages.

Table 40. ***Delaware Watershed Jobs and Wages, 2009***

State/County	(1) Total Delaware Jobs	(2) Direct Watershed Jobs	(3) Indirect Watershed Jobs	(1) Total Delaware Wages ($ million)	(2) Direct Watershed Wages ($ million)	(3) Indirect Watershed Wages ($ billion)
Delaware	**394,918**	**18,926**	**22,711**	**18,800**	**402**	**322**
Kent	60,145			2,200		
New Castle	266,134			14,300		
Sussex	68,639			2,300		

Jobs and wages: (1) in Delaware counties, (2) direct watershed-related, and (3) indirect watershed related, in 2009.

Table 41. ***Direct and Indirect Watershed-Related Jobs in Delaware, 2009***

Sector	Industry	1997 NAICS Code	Direct Watershed Jobs[1]	Direct Watershed Wages[1] (x$1,000)	Indirect Watershed Jobs[2]	Indirect Watershed Wages[2] (x$1,000)
Construction	Marine-Related	237,120				
	Water and Sewer	23,711	691	27,474	829	21,979
	Construction	237,990	157	7,098	188	5,678
Living Resources	Fish Hatcheries	112,511			0	0
	Aquaculture	112,512			0	0
	Fishing	11,411			0	0
	Finfish Fishing	114,111			0	0
	Shellfish Fishing	114,112			0	0
	Seafood Markets	445,220	49	1,809	59	1,447
	Seafood Process.	31,171			0	0
	Comm. Fisheries				0	0
Minerals	Sand & Gravel	212,321			0	0
		212,322			0	0
	Oil & Gas	541,360	20	940	24	752
Ship/Boat Building	Boat Bldg. Repair	336,612			0	0
	Shipbuilding				0	0
Tourism/Recreation	Recreation	487,990			0	0
		611,620			0	0
		532,292			0	0
	Amusement	713,990	393	5,768	472	4,614
	Boat Dealers	441,222	247	9,361	296	7,489
	Restaurants	722,110	4,643	217,234	5,572	173,787
		722,211	8,496	5,127	10,195	4,102
		722,212	331	4,845	397	3,876
		722,213	1,178	16,886	1,414	13,509
	Hotels & Lodging	721,110	813	14,591	976	11,673
		721,191			0	0
	Marinas	713,930			0	0
	RV Park/Camps	721,211	131	4,514	157	3,611
	Scenic Tours	487,210	22	491	26	393
	Sporting Good	339,920			0	0
	Zoos, Aquaria	712,130			0	0
		712,190			0	0
Transportation	Navigation Shipping	488,330			0	0
	Marine Cargo	488,320	438	19,927	526	15,942
	Search/Navigation	334,511			0	0
	Warehousing	493,110	391	17,174	469	13,739
		493,120			0	0
	Ports				0	0
	Dredging/Disposal				0	0
Environmental	Environ. Organiz.	813,312	98	3,633	118	2,906
	Environ. Consult.	54,162	241	12,267	289	9,814
Water/Wastewater	Water/Sewage	2,213	293	21,549	352	17,239
	Waste Management	562	241	10,120	289	8,096
	Septic Tank	562,991	53	1,738	64	1,390
Total			**18,926**	**402,546**	**22,712**	**322,036**

1. Direct jobs/wages are those directly related to Delaware watersheds. 2. 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 Economic Program (2009) published a report that 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. According to the NOEP (2009), coastal counties in Delaware contributed 15,174 coastal jobs, representing $268 million in annual wages and $489.5 million toward the state GDP (Table 42).

Table 42. ***Coastal Employment, Wages, and GDP in Delaware***

Sector	Employment	Wages ($ million)	GDP ($ million)
Delaware	**15,174**	**268.0**	**489.5**
Marine Construction			
Living Resources	442	10.3	19.2
Offshore Minerals			
Tourism & Recreation	12,997	188.5	373.9
Marine Transportation	2,180	66.0	90.5
Ship and Boat Building			

Source: NOEP, 2009

Farm Jobs

A study by the University of Delaware's College of Agriculture and Natural Resources indicates that the agriculture economy contributes 28,328 direct, indirect, and induced jobs with $1.41 billion in annual wages in Delaware (Awokuse et al., 2010). Sussex County agriculture is responsible for 15,378 jobs, Kent County for 8,502 jobs, and New Castle County for 4,448 jobs (Table1).

Table 43. ***Agriculture Jobs and Wages in Delaware***

State/County	Employment	Wages ($ million)
State of Delaware	**28,328**	**1,410**
Direct	16,565	828
Indirect	5,791	346
Induced	5,972	236
New Castle County	**4,448**	**261**
Direct	2,341	139
Indirect	1,016	71
Induced	1,091	51
Kent County	**8,502**	**438**
Direct	4,609	246
Indirect	2,004	120
Induced	1,889	72
Sussex County	**15,378**	**711**
Direct	9,615	442
Indirect	2,771	156
Induced	2,992	113

Fishing/Hunting/Bird and Wildlife Recreation Jobs

The 2007 NJDEP study estimated the average annual salary per ecotourism job is $32,843, using figures from the 2001 U.S. Fish and Wildlife Service report on fishing, hunting, and wildlife-associated recreation. Fishing, hunting, and bird/wildlife-associated recreation in Delaware watersheds account for $268.8 million in annual economic activity in 2006 dollars. Converting 2006 dollars to 2010 dollars at 3 percent per year, the annual economic activity is $303.7 million, and ecotourism accounts for 9,248 jobs (Table 44). 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 Delaware watersheds.

Table 44. ***Jobs from Fishing, Hunting, and Wildlife Recreation in Delaware Watersheds***

Recreation Activity	Delaware Recreation Activity[1] in 2006 dollars ($ million)	Delaware Recreation Activity in 2010 dollars ($ million)	Delaware Recreation Jobs[2] in 2010 dollars
Fishing	**96.7**	**109.3**	**3,327**
Trip-Related	48.5	54.8	1,669
Equipment/other	48.2	54.5	1,658
Hunting	**41.3**	**46.7**	**1,421**
Trip-Related	13.6	15.4	468
Equipment/other	27.7	31.3	953
Wildlife/Birding	**130.8**	**147.8**	**4,501**
Trip-Related	13.1	14.8	451
Equipment/other	117.7	133.0	4,050
Total	**268.8**	**303.8**	**9,249**

1. USFWS, 2006. 2. Jobs estimated at $32,843 average salary.

Wetland Jobs

The NOAA Coastal Services Center (2011) estimates that coastal wetlands provide habitat that supports 584 commercial, recreational, and charter fishing jobs in Delaware with $13.4 million in business output and 19.3 million in wages (Table 45).

Table 45. ***Fishery Jobs, Wages, and Business Output Supported by Coastal Wetlands in Del.***

Fishing			
	Jobs	**Business Output ($ million)**	**Self-employed Revenue ($ million)**
State of Delaware	**584**	**13.4**	**19.3**
New Castle County	91	1.5	4.3
Kent County	76	0.4	2
Sussex County	129	3.1	3.1

Source: NOAA Coastal Services Center, 2011

Watershed Organization Jobs

More than 20 nonprofit watershed and environmental organizations employ at least 115 staff to work on programs to protect the land and waters that flow through Delaware watersheds (Table 46). Assuming that the average salary is $48,000/person working in a watershed-organization job in Delaware, these jobs account for $5.5 million in annual wages.

Table 46. ***Watershed Organization Jobs in Delaware Watersheds***

Watershed Organization	Town	Jobs	Salaries
Appoquinimink River Association	Middletown	1	48,000
Brandywine Valley Association[1]	West Chester (Pa.)	2	96,000
Brandywine Conservancy[1]	Chadds Ford (Pa.)	7	336,000
Christina Conservancy, Inc.	Wilmington	1	48,000
Chesapeake Bay Foundation[2]	Annapolis (Md.)	1	48,000
Coalition for Natural Stream Valleys	Newark	0	0
Delaware Audubon Society	Wilmington	1	48,000
Delaware Bass Federation	-	-	-
Delaware Center for Horticulture	Wilmington	18	864,000
Delaware Center for the Inland Bays	Rehoboth Beach	6	288,000
Delaware Chapter of the Sierra Club	Wilmington	0	0
Delaware Greenways	Wilmington	6	288,000
Delaware Low-Impact Tourism Experiences (DLITE)	Salisbury (Md.)	1	48,000
Delaware Native Plant Society	Dover	0	0
Delaware Nature Society	Hockessin	20	960,000
Delmarva Ornitholigical Society	-	0	0
Delaware Riverkeeper Network[2]	Bristol (Pa.)	1	48,000
Delaware Rural Water Association	Milford	9	432,000
Delaware Wild Lands	Odessa	5	240,000
Ducks Unlimited	-	-	-
Fairfield Watershed Association	Newark	0	0
Friends of Bombay Hook	Smyrna	1	48,000
Friends of the Delaware Bay	Sussex County	-	-
Friends of Lums Pond	Bear	0	0
Friends of Prime Hook National Wildlife Refuge	Milton	0	0
Friends of the Nanticoke River	Nanticoke (Md.)	0	0
Friends of White Clay Creek State Park	Newark	1	48,000
Green Delaware	Wilmington	-	-
League of Women Voters of Delaware	Wilmington	5	240,000
Naamans Creek Watershed Association	Arden	0	0
Nanticoke River Watershed Preservation Group	-	-	-
Nanticoke Watershed Alliance	Vienna (Md.)	3	144,000
National Wildlife Federation	Annapolis (Md.)	1	48,000
Partnership for the Delaware Estuary	Wilmington	16	768,000
Red Clay Valley Association	West Chester (Pa.)	1	48,000
Save Wetlands and Bays	Millsboro	-	-
Sierra Club	Wilmington	0	0
St. Jones River Greenway Commission	Magnolia	0	0
St. Jones River Watershed Association	Dover	1	48,000
Surfrider Foundation Delaware Chapter	Millsboro	-	-
The Academy of Natural Sciences	Philadelphia (Pa.)	0	0
The Conservation Fund	Centreville	1	48,000
The Nature Conservancy - Delaware Chapter	Wilmington	2	96,000
Urban Environmental Center	Wilmington	1	48,000
Waterfront Watch of Wilmington	Wilmington	1	48,000
White Clay Creek Watershed Association	Newark	0	0
White Clay Creek Watershed Management Committee	Newark	1	48,000
White Clay Flyfishers	Landenburg (Pa.)	-	-
Widener Environmental and Natural Resources Law Clinic[2]	Wilmington	1	48,000
Total in Delaware		**115**	**5,520,000**

1. Prorated for the proportion of the Brandywine Creek that lies in Delaware.
2. Prorated assuming the equivalent of one person works on Delaware-related water issues.

Port Jobs

Martins Associates (2007) reported that the Port of Wilmington, Del.:

- Supports 2,295 direct jobs, 1,766 induced jobs, and 539 indirect jobs for a total of 4,600 jobs (Table 47 and 48).
- Provides $307 million in annual wages with an average salary of $40,890 annually.
- Generates $2.76 billion in annual economic activity.

Table 47. ***Jobs Generated by the Port of Wilmington***

Employment Type	Jobs	Wages	Economic Activity
Direct Jobs	2,295	$93,856,000	
Induced Jobs	1,766	$191,700,000	
Indirect Jobs	539	$21,529,000	
Total Jobs	**4,600**	**$307,085,000**	**$2,762,187,000**

Source: Martins Associates, 2007

Table 48. ***Direct Jobs by Category and Sector at the Port of Wilmington***

Employment Type	Jobs
Surface Transportation	
Rail	10
Truck	783
Subtotal	793
Maritime Services	
Terminal Operations	404
ILA	340
Towing	17
Pilots	39
Agents	15
Surveyors	35
Forwarders	91
Warehouse	321
Government	26
Marine Construction	139
Barge	8
Subtotal	1,435
Port Administration	67
Total	**2,295**

Source: Martins Associates, 2007

Tourism

A vibrant tourism economy relies on clean water and healthy habitat in Delaware watersheds. According to data from the Delaware Tourism Office (2008), the Delaware tourism economy produced total market value of goods and services during FY 2008 of at least $1.9 billion. In 2008, 31,050 people were employed in Delaware's tourism industry (Table 49). The Delaware tourism industry is the 5th largest employer in the state, comprising 8.3 percent of Delaware's employment.

Table 49. ***Tourism Jobs in Delaware***

County	Jobs
Kent	5,390
New Castle	17,930
Sussex	7,730
Total	**31,050**

Source: Delaware Tourism Office, 2008

Water Supply–Utility Jobs

Public and private water utilities withdraw over 102 mgd of drinking water from surface-water and groundwater supplies in Delaware watersheds. According to the American Water Works Association, the average salary of a water-system employee is $55,407. The total number of jobs provided by water utilities in Delaware watersheds is 275, with annual wages of $15 million (Table 50).

Table 50. ***Largest Public Water Withdrawals in Delaware Watersheds***

Water Purveyor	Withdrawal (mgd)	Jobs	Salaries
Delaware	**102.33**	**275**	**$15,236,925**
Artesian Water Company[1]	21.79	66	$3,656,862
Bethany Beach[1]	1.13	3	$166,221
Blades	0.25	2	$110,814
Bridgeville	0.48	1	$55,407
Camden-Wyoming Water Authority	0.30	1	$55,407
Clayton	0.46	26	$1,440,582
Dagsboro	0.10	1	$55,407
Delaware City	0.20	1	$55,407
Delmar[1]	0.40	1	$55,407
Dover	5.50	14	$775,698
Dover Air Force Base	0.57	1	$55,407
Felton	0.11	1	$55,407
Frankford[1]	0.19	1	$55,407
Frederica	0.17	1	$55,407
Georgetown	1.00	1	$55,407
Greenwood[1]	0.09	1	$55,407
Harrington	0.74	1	$55,407
Lewes Board of Public Works	1.93	3	$166,221
Long Neck[1]	1.14	3	$166,221
Laurel[1]	0.73	3	$166,221
Magnolia	0.08	1	$55,407
Milford	3.40	6	$332,442
Millsboro	0.92	8	$443,256
Milton	0.60	4	$221,628
Newark	6.00	7	$387,849
New Castle Mun. Services Comm.	0.40	1	$55,407
Rehoboth Beach[1]	6.90	21	$1,163,547
Seaford	1.91	5	$277,035
Selbyville[1]	0.34	1	$55,407
Smyrna	0.40	1	$55,407
Sussex County	-	-	-
Tidewater Utilities	0.60	2	$110,814
Wilmington	25.00	31	$1,717,617
United Water Delaware	18.50	55	$3,047,385

1. Jobs data not provided, number of jobs estimated using the assumption that 1 mgd = 3 jobs

Wastewater Utility Jobs

Twenty-three wastewater utilities discharge over 168 million gallons per day of treated wastewater to Delaware watersheds. The wage information is computed using the assumption that the average wastewater utility salary is $40,000/year. These wastewater utilities employ 207 employees who earn $9.2 million in wages annually (Table 51).

Table 51. ***Jobs at NPDES Wastewater Utilities in Delaware Watersheds***

NPDES ID	Facility	Discharge (mgd)	Jobs	Salaries
DE0051063	Hanover Foods	0.000	0	0
DE0021709	Greenville Country Club	0.015	2	80,000
DE0021768	Winterthur[1]	0.025	1	40,000
DE0050725	Mobile Gardens Trailer Park	0.028	0	0
DE0021539	Port Penn STP[1]	0.050	1	40,000
DE0050083	Lums Pond State Park	0.105	1	40,000
DE0000035	Invista[1]	0.311	1	40,000
DE0021491	Milton STP	0.350	0	0
DE0050547	Middletown-Odessa-Townsend[1]	0.500	1	40,000
DE0050164	Millsboro STP	0.566	8	320,000
DE0021555	Delaware City STP	0.570	0	0
DE0020125	Laurel STP	0.700	3	120,000
DE0020036	Harrington STP	0.750	1	40,000
DE0020249	Bridgeville STP	0.800	2	80,000
DE0020010	Selbyville STP[1]	1.250	3	120,000
DE0021512	Lewes STP	1.500	4	160,000
DE0020265	Seaford STP	2.000	6	240,000
DE0020028	Rehoboth Beach STP	3.400	11	440,000
DE0050008	South Coastal Regional STP[1]	6.000	18	720,000
DE0020320	Wilmington Wastewater Plant	134.000	90	4,500,000
DE0020338	Kent County STP	15.000	54	2,160,000
Total			**207**	**9,180,000**

1. Jobs data not provided, number of jobs estimated using the assumption that 1 mgd = 3 jobs

Appendix - Employment Codes by Industry, 2009

Industry	NAICS Code
Agriculture, Forestry, Fishing and Hunting	11
Crop Production	111
Animal Production	112
Aquaculture	1125
Forestry and Logging	113
Fishing, Hunting and Trapping	114
Fishing	1141
Support Activities for Agriculture and Forestry	115
Mining, Quarrying, and Oil and Gas Extraction	21
Oil and Gas Extraction	211
Mining (except Oil and Gas)	212
Nonmetallic Mineral Mining and Quarrying	2123
Support Activities for Mining	213
Utilities	22
Utilities	221
Electric Power Generation, Transmission and Distribution	2211
Natural Gas Distribution	2212
Water, Sewage and Other Systems	2213
Construction	23
Construction of Buildings	236
Residential Building Construction	2361
Nonresidential Building Construction	2362
Heavy and Civil Engineering Construction	237
Land Subdivision	2372
Highway, Street, and Bridge Construction	2373
Other Heavy and Civil Engineering Construction	2379
Specialty Trade Contractors	238
Manufacturing	31
Food Manufacturing	311
Seafood Product Preparation and Packaging	3117
Beverage and Tobacco Product Manufacturing	312
Textile Mills	313
Textile Product Mills	314
Apparel Manufacturing	315
Apparel Knitting Mills	3151
Leather and Allied Product Manufacturing	316
Wood Product Manufacturing	321
Paper Manufacturing	322
Petroleum and Coal Products Manufacturing	324
Chemical Manufacturing	325
Basic Chemical Manufacturing	3251
Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	3252
Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	3253
Pharmaceutical and Medicine Manufacturing	3254

		Paint, Coating, and Adhesive Manufacturing	3255
		Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256
		Other Chemical Product and Preparation Manufacturing	3259
	Plastics and Rubber Products Manufacturing		326
	Nonmetallic Mineral Product Manufacturing		327
		Cement and Concrete Product Manufacturing	3273
		Lime and Gypsum Product Manufacturing	3274
		Other Nonmetallic Mineral Product Manufacturing	3279
	Primary Metal Manufacturing		331
	Fabricated Metal Product Manufacturing		332
	Machinery Manufacturing		333
	Computer and Electronic Product Manufacturing		334
		Computer and Peripheral Equipment Manufacturing	3341
		Communications Equipment Manufacturing	3342
		Audio and Video Equipment Manufacturing	3343
		Semiconductor and Other Electronic Component Manufacturing	3344
		Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	3345
		Manufacturing and Reproducing Magnetic and Optical Media	3346
	Electrical Equipment, Appliance, and Component Manufacturing		335
	Transportation Equipment Manufacturing		336
		Motor Vehicle Manufacturing	3361
		Motor Vehicle Body and Trailer Manufacturing	3362
		Motor Vehicle Parts Manufacturing	3363
		Aerospace Product and Parts Manufacturing	3364
		Railroad Rolling Stock Manufacturing	3365
		Ship and Boat Building	3366
		Other Transportation Equipment Manufacturing	3369
	Furniture and Related Product Manufacturing		337
	Miscellaneous Manufacturing		339
Wholesale Trade			42
	Merchant Wholesalers, Durable Goods		423
	Merchant Wholesalers, Nondurable Goods		424
	Wholesale Electronic Markets and Agents and Brokers		425
Retail Trade			44
	Motor Vehicle and Parts Dealers		441
	Furniture and Home Furnishings Stores		442
	Electronics and Appliance Stores		443
		Electronics and Appliance Stores	4431
	Building Material and Garden Equipment and Supplies Dealers		444
	Food and Beverage Stores		445
	Health and Personal Care Stores		446
	Gasoline Stations		447
	Clothing and Clothing Accessories Stores		448
	Sporting Goods, Hobby, Book, and Music Stores		451
	General Merchandise Stores		452
	Miscellaneous Store Retailers		453
	Nonstore Retailers		454
Transportation and Warehousing			48
	Air Transportation		481

		Scheduled Air Transportation	4811
		Nonscheduled Air Transportation	4812
	Rail Transportation		482
		Rail Transportation	4821
	Water Transportation		483
		Deep Sea, Coastal, and Great Lakes Water Transportation	4831
		Inland Water Transportation	4832
		Support Activities for Water Transportation	4883
	Truck Transportation		484
		General Freight Trucking	4841
		Specialized Freight Trucking	4842
	Transit and Ground Passenger Transportation		485
		Urban Transit Systems	4851
		Interurban and Rural Bus Transportation	4852
		Taxi and Limousine Service	4853
		School and Employee Bus Transportation	4854
		Charter Bus Industry	4855
		Other Transit and Ground Passenger Transportation	4859
	Pipeline Transportation		486
		Pipeline Transportation of Crude Oil	4861
Information			51
	Publishing Industries (except Internet)		511
	Motion Picture and Sound Recording Industries		512
	Broadcasting (except Internet)		515
	Telecommunications		517
	Data Processing, Hosting, and Related Services		518
	Other Information Services		519
Finance and Insurance			52
	Monetary Authorities-Central Bank		521
	Credit Intermediation and Related Activities		522
	Securities, Commodity Contracts, and Other Financial Investments and Related Activities		523
	Insurance Carriers and Related Activities		524
	Funds, Trusts, and Other Financial Vehicles		525
Real Estate and Rental and Leasing			53
	Real Estate		531
	Rental and Leasing Services		532
	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)		533
Professional, Scientific, and Technical Services			54
	Professional, Scientific, and Technical Services		541
		Management, Scientific, and Technical Consulting Services	5416
		Scientific Research and Development Services	5417
Management of Companies and Enterprises			55
	Management of Companies and Enterprises		551
Administrative and Support and Waste Management and Remediation Services			56
	Administrative and Support Services		561
		Travel Arrangement and Reservation Services	5615
	Waste Management and Remediation Services		562
Educational Services			61
	Educational Services		611

		Colleges, Universities, and Professional Schools	6113
		Technical and Trade Schools	6115
		Educational Support Services	6117
Health Care and Social Assistance			62
	Ambulatory Health Care Services		621
	Hospitals		622
	Nursing and Residential Care Facilities		623
	Social Assistance		624
Arts, Entertainment, and Recreation			71
	Performing Arts, Spectator Sports, and Related Industries		711
	Museums, Historical Sites, and Similar Institutions		712
	Amusement, Gambling, and Recreation Industries		713
		Other Amusement and Recreation Industries	7139
Accommodation and Food Services			72
	Accommodation		721
		Traveler Accommodation	7211
		RV (Recreational Vehicle) Parks and Recreational Camps	7212
		Rooming and Boarding Houses	7213
	Food Services and Drinking Places		722
Other Services (except Public Administration)			81
	Repair and Maintenance		811
	Personal and Laundry Services		812
	Religious, Grantmaking, Civic, Professional, and Similar Organizations		813
		Social Advocacy Organizations	8133
		Business, Professional, Labor, Political, and Similar Organizations	8139
	Private Households		814
Public Administration			92
	Executive, Legislative, and Other General Government Support		921
	Justice, Public Order, and Safety Activities		922
	Administration of Human Resource Programs		923
	Administration of Environmental Quality Programs		924
	Administration of Housing Programs, Urban Planning, Community Development		925
	Administration of Economic Programs		926
	Space Research and Technology		927
	National Security and International Affairs		928

Source: U. S. Bureau of Labor Statistics

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