Economic Value of the Delaware Estuary Watershed

The Delaware Estuary watershed is the economic engine of the Delaware Valley

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Prepared for:

Partnership for the Delaware Estuary
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Table of Contents

List of Figures

List of Tables

List of Appendices

Economic Value of the Delaware Estuary Watershed

Abstract: What do Boeing, Sunoco, Campbell's Soup, DuPont, Wawa, Starbucks, Iron Hill Brewery, the Philadelphia Eagles, Salem Nuclear Power Plant, and the United States Navy have in common? They all depend on the waters of the Delaware Estuary to sustain their business.

The natural resources of the Delaware Estuary watershed provide tremendous economic value to our region. This report examines that value in three distinct ways:

- **Through economic value directly related to the Delaware Estuary's water resources and habitats.** Using economic activity as a measure of value, we find that the Delaware Estuary contributes over $10 billion in annual economic activity from recreation, water quality and supply, hunting and fishing, forests, agriculture and parks.

- **Through the value of the goods and services provided by the Delaware Estuary's ecosystems.** Using ecosystem goods and services as a measure of value, we find that the ecosystems of the Delaware Estuary provide $12 billion annually in goods and services in 2010 dollars ($2010), with a net present value of $392 billion calculated over a 100-year period.

Delaware Estuary Watershed
(inset: within context of Delaware River Basin)

- **Through employment related to the Delaware Estuary's water resources and habitats.** Using employment as a measure of value, we find that the Delaware Estuary directly and indirectly supports over 500,000 jobs with over $10 billion in wages annually. This does not include the thousands or even millions of jobs in companies and industries that rely on waters of the Delaware Estuary for their industrial and commercial processes.

The purpose of these estimates is to demonstrate that the natural resources of the Delaware Estuary provide real and significant economic benefits to the tri-state region, 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 the Delaware Estuary using ecological economics and benefits transfer techniques described in this report. All values are in 2010 dollars ($2010) 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 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 indicates the Delaware Estuary is an economic engine that contributes over $10 billion annually to our region's economy.**

It is also important to note that the estimates presented in this report are not comprehensive due to lack of data for some economic sectors, nor are they meant to be used to compare and contrast different uses of the estuary for their value. Some values were not included in these estimates because the data to assess them is not readily available, or does not exist. For example, the full amount of economic activity and jobs associated with the many companies and industries that rely on waters of the Delaware Estuary 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 and studies, the values for different activities and resources vary greatly in how they were determined and applied to the Delaware Estuary making it difficult to accurately compare values across uses and activities. Gathering more complex, tailored, or primary data on the Delaware Estuary would improve comparability of information across uses as well as making value estimates more comprehensive. Further research is recommended to gather updated Delaware Estuary-specific economic valuation data.

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 the Delaware Estuary. 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 Estuary and all of its benefits to the people of this region.

Note that Delaware Estuary-related jobs and wages provide sizable Federal, state, and local income tax benefits and offsets that are not computed here except in port activities. If income tax benefits were included in this analysis, the economic value of the Delaware Estuary would increase by at least a quarter to a third.

Executive Summary

Water supplies, natural resources, and ecosystems within the Delaware Estuary watershed:

- Contribute over $10 billion in annual economic value from recreation, water quality, water supply, hunting/fishing, ecotourism, forest, agriculture, open space, and port benefits.

- Provide ecosystem goods and services (natural capital) value of $12 billion per year in 2010 dollars with net present value (NPV) of $392 billion over a period of 100 yrs.

- Are directly/indirectly responsible for over 500,000 jobs with over $10 billion in annual wages.

The purpose of this analysis is to demonstrate that the natural resources of the Delaware Estuary provide real and significant economic benefits to the tri-state region, and are worthy of investment to keep them healthy and productive. It is important to note that the values in the three categories described below can not be summed because there is some measure of overlap between certain values within each category that could result double-counting. Accurately determining (and eliminating) this overlap is difficult, if not impossible, within the scope of this analysis.

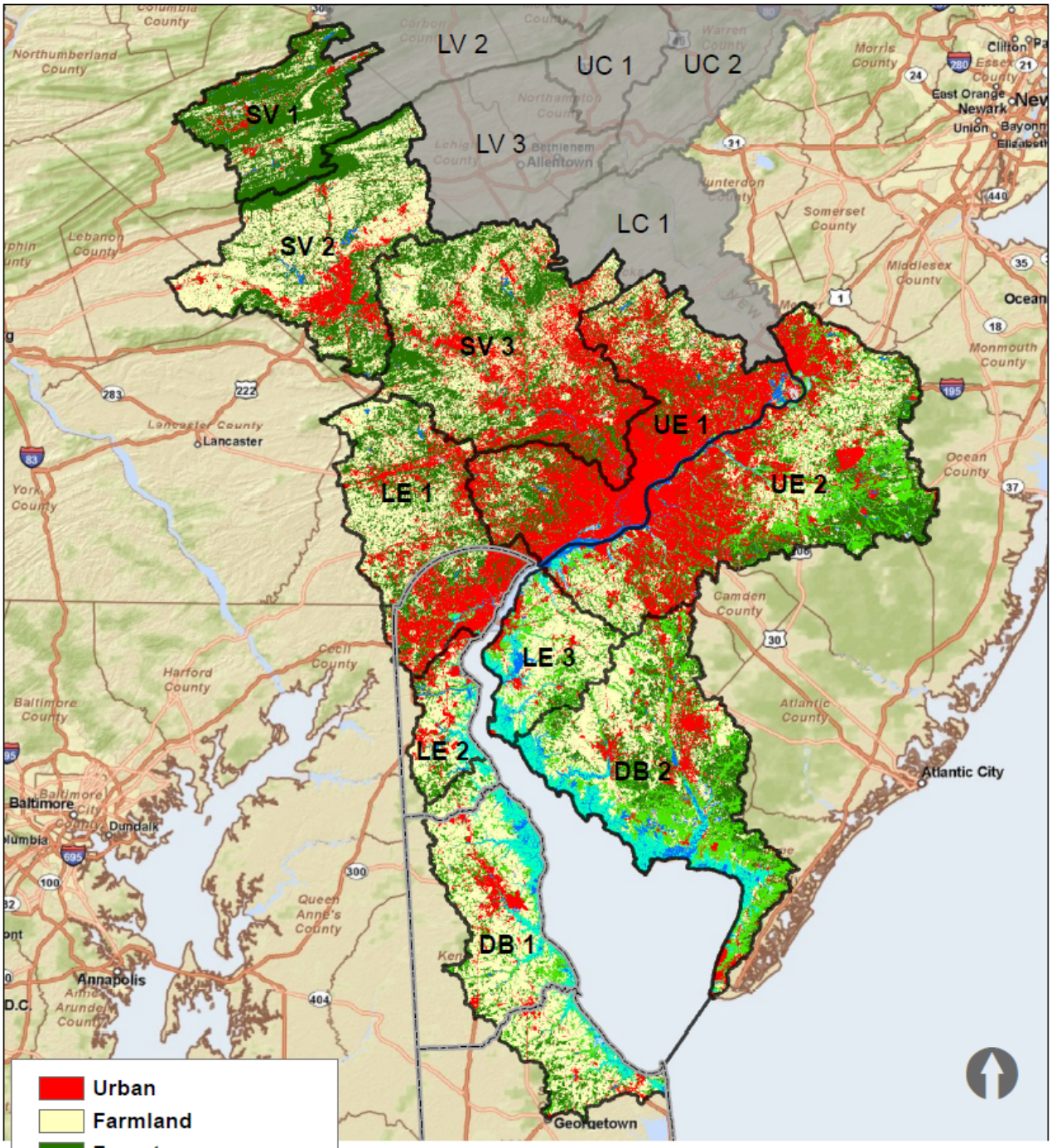
It is also important to note that the estimates presented in this report are not comprehensive, nor are they meant to be used to compare/contrast different uses of the estuary for their value. Some values were not included in these estimates because the data to assess them is not readily available, or does not exist. Since all estimates were made by taking values from existing literature/studies, the values for different activities/resources vary greatly in how they were determined and applied to the Delaware Estuary making it difficult to accurately compare values across uses/activities. Gathering more complex, tailored, or ideally primary data on the Delaware Estuary would improve comparability of information across uses as well as making value estimates more comprehensive.

The Watershed

The Delaware Estuary watershed occupies about 6,000 sq mi in Delaware, New Jersey, Pennsylvania and a small sliver of Maryland. In 2010, 6,700,000 residents lived in the watershed including 642,000 people in Del., 2,300 in Md., 1,645,000 in NJ, and 4,410,000 in Pa. If the estuary watershed were considered as a state, it would be the 13th most populous in the U.S. after New Jersey and Virginia and ahead of Washington and Massachusetts. The Delaware Estuary watershed occupies populated areas in Delaware (50% of land area and 72% of First State's population), New Jersey (26% of land area and 19% of Garden State's population), and Pennsylvania (7% of land area and 35% of Keystone State's population).

From 2000-2010, the population in the Delaware Estuary watershed grew by 5.1% or 325,000 people. The population increased by over 24% in Kent and Sussex counties, Del.; 12% in Gloucester Co., NJ and 14% in Chester Co., Pa. Philadelphia gained people for the first time in half a century. Cape May Co., NJ and Schuylkill Co., Pa. lost population since 2000.

In 2009, over 2,900,000 people worked in the watershed with 318,000 jobs in Del., 1,200 jobs in Md., 685,000 jobs in NJ, and 1,896,000 jobs in Pa. Ten watersheds flow from the Piedmont and Coastal Plain provinces to the tidal river and bay as depicted on the following watershed map.

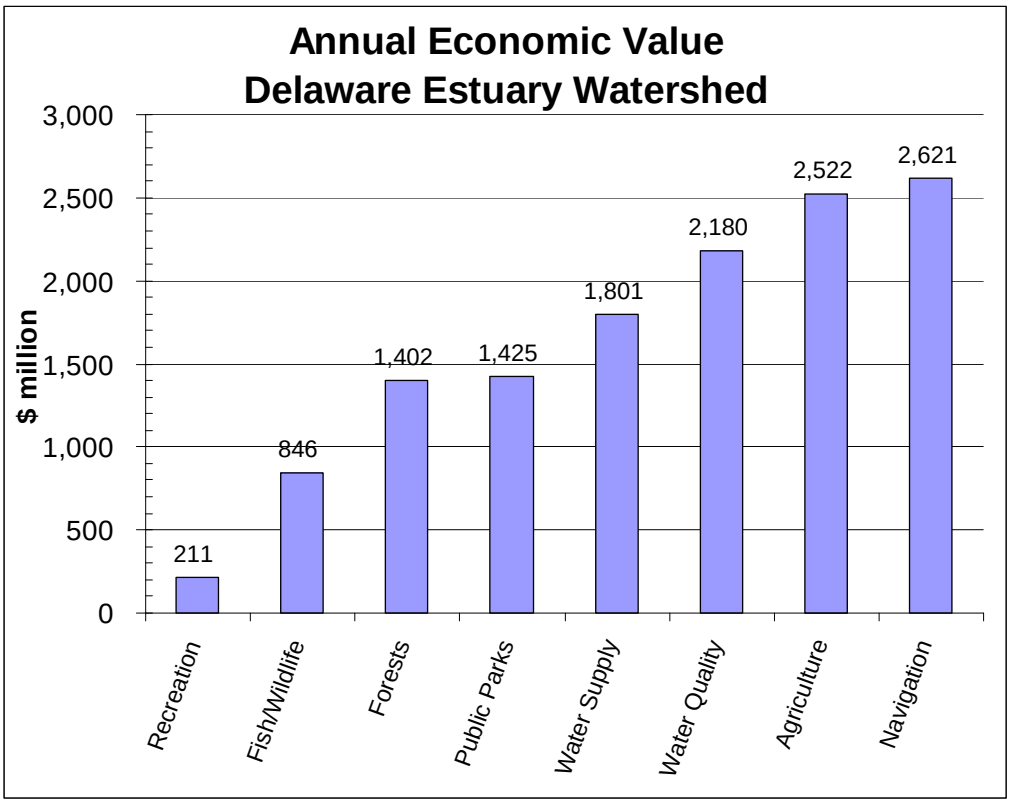

LV 2
UC 1
UC 2
SV 1
LV 3
LC 1
SV 2
SV 3
UE 1
LE 1
UE 2
LE 3
LE 2
DB 2
DB 1
Urban
Farmland
Forest
Forested FWW
Unforested FWW
Tidal Wetlands
Barren/Open Land
Open Water
Del. Estuary Basins
Land Cover in the Watersheds of the Delaware Estuary
Miles
0 3.75 7.5 15 22.5 30
Kilometers
0 4.5 9 18 27 36
Map produced by the University of Delaware, Water Resources Agency, August, 2010.

Annual Economic Value

The Delaware Estuary watershed contributes over $10 billion in annual market and non-market value. Market value is determined by the sale/purchase of watershed goods such as drinking water, fish, or hunting supplies. Nonmarket 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 totals are rounded down to avoid double counting (Table E1).

Table E1. Annual economic value of the Delaware Estuary watershed

Economic Value	**$ million**
Market Value	**> 8 billion**
Water Quality	
Water Treatment by Forests ($62/mgd)	17
Wastewater Treatment ($4.00/1000 gal)	1,490
Increased Property Value (+8% over 20 years)	13
Water Supply	
Drinking Water Supply ($4.78/1000 gal)	1,333
Irrigation Water Supply ($300/ac-ft)	30
Thermoelectric Power Water Supply ($44/ac-ft)	298
Industrial Water Supply ($200/ac-ft)	140
Fish/Wildlife	
Commercial Fish Landings ($0.60/lb)	34
Fishing (11-18 trips/angler, $17-$53/trip)	334
Hunting (16 trips/hunter, $16-50/trip)	171
Wildlife/Bird-watching (8-13 trips/yr, $15-$27/trip)	306
Agriculture	
Crop, poultry, livestock value ($2,300/ac)	2,522
Maritime Transportation	
Navigation ($15/ac-ft)	221
Port Activity	2,400
Non-Market Value	**>2 billion**
Recreation (Boating, Fishing, Swimming)	
Swimming ($13.40/trip)	9
Boating ($30/trip)	47
Fishing ($62.79/trip)	52
Wildlife/bird watching ($77.73/trip)	104
Water Quality	
Willing to Pay for Clean Water ($38/nonuser-$121/user)	660
Forests	
Carbon Storage ($827/ac)	981
Carbon Sequestration ($29/ac)	34
Air Pollution Removal ($266/ac)	316
Building Energy Savings ($56/ac)	66
Avoided Carbon Emissions ($3/ac)	4
Public Parks	
Health Benefits ($9,734/ac)	1,057
Community Cohesion ($2,383/ac)	259
Stormwater Benefit ($921/ac)	100
Air Pollution Control ($88/ac)	9



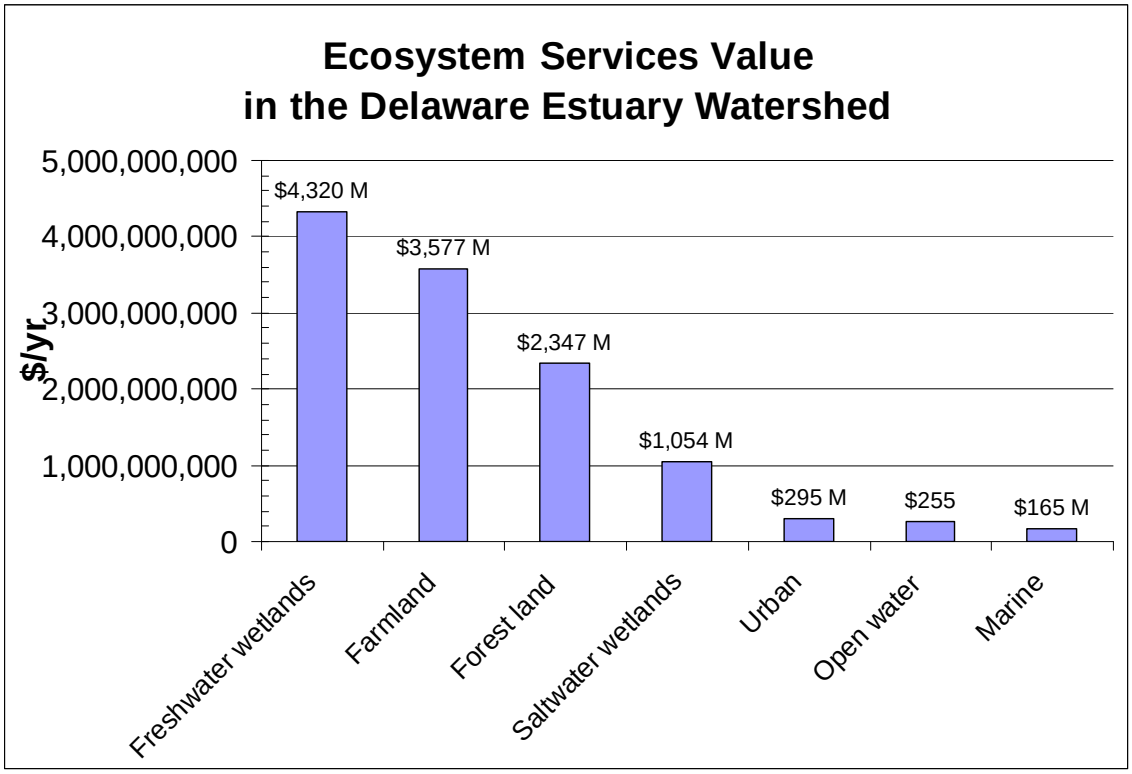
Ecosystem Services

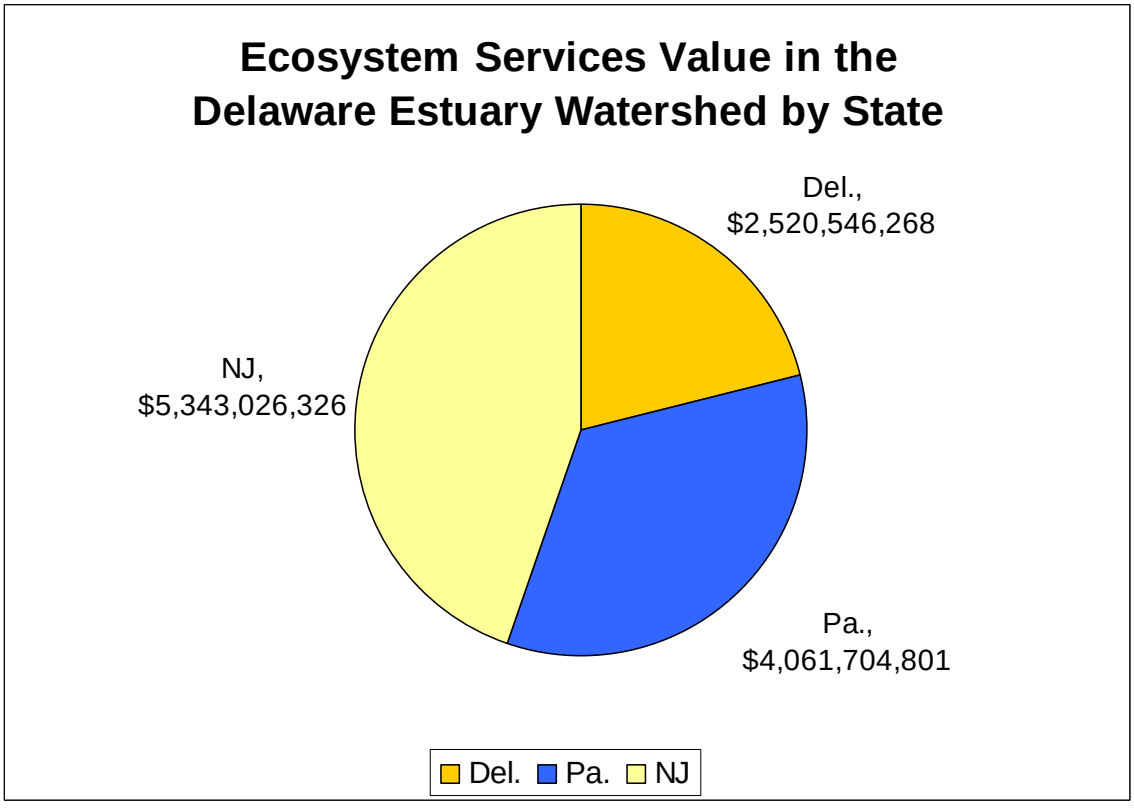
The Delaware Estuary watershed is rich in natural resources and habitat as measured by the economic value of ecosystem goods and services. Ecosystem goods are benefits provided by sale of watershed products such as drinking water and fish. Ecosystem services are economic benefits provided to society by nature such as water filtration, flood reduction, and carbon storage. The value of natural goods and services from ecosystems in the Delaware Estuary watershed is $12 billion ($2010) with net present value (NPV) of $392 billion using a discount rate of 3% over 100 years (Table E2). Ecosystem services by state include Delaware ($2.5 billion, NPV $81.9 billion), New Jersey ($5.3 billion, NPV 173.6 billion), Pennsylvania ($4.1 billion, NPV $132.0 billion).

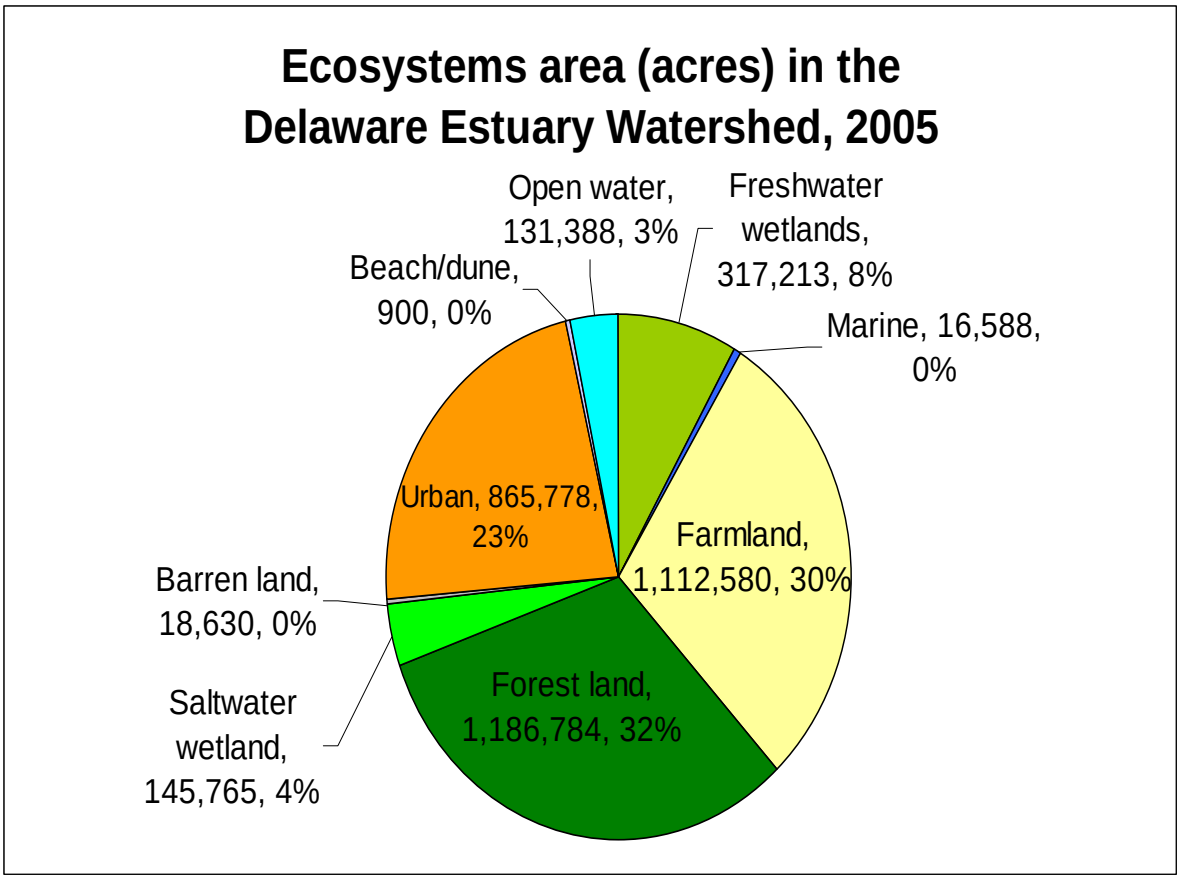
Table E2. Ecosystem goods and services value of the Delaware Estuary watershed

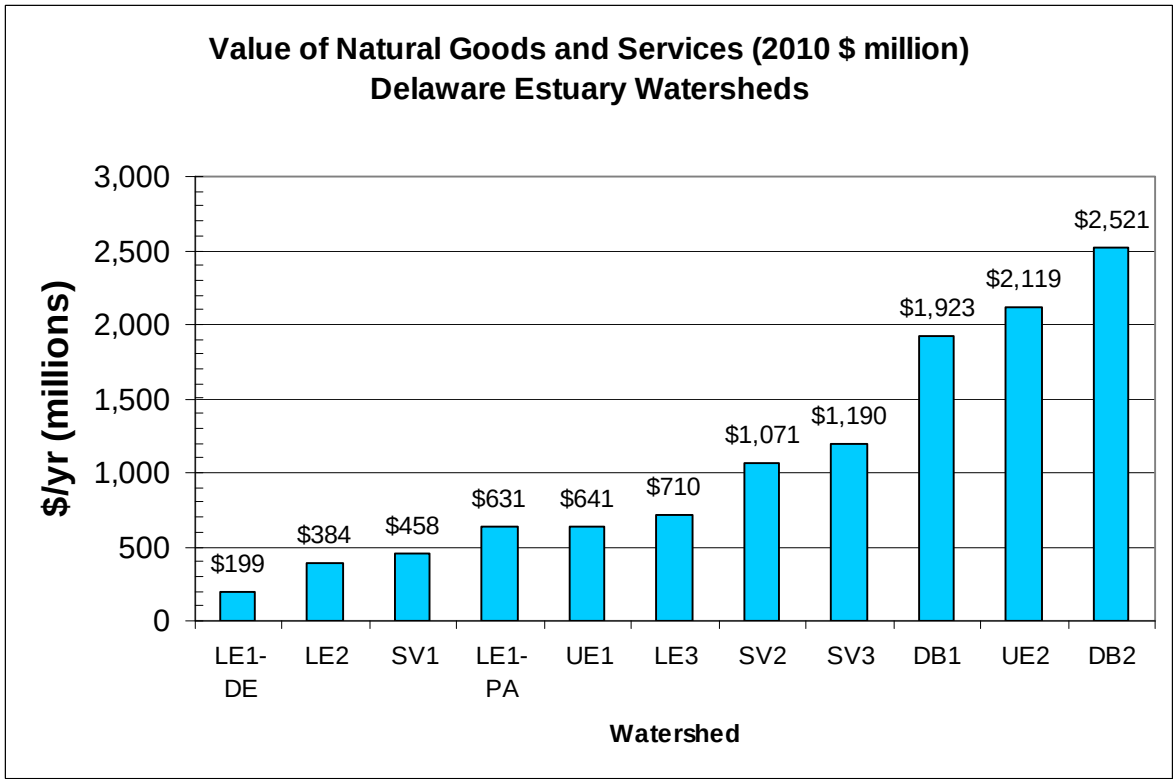
Ecosystem	Area (ac)	$/ac/yr 2010[1]	$/yr 2010	NPV $
Freshwater wetlands	317,213	13,621	4,320,647,087	140,421,030,319
Marine	16,588	10,006	165,982,947	5,394,445,767
Farmland	1,112,580	3,215[2]	3,577,486,604	116,268,314,632
Forest land	1,186,784	1,978	2,347,605,465	76,297,177,613
Saltwater wetland	145,765	7,235	1,054,617,851	34,275,080,170
Barren land	18,630	0	0	0
Urban	865,778	342	295,761,123	9,612,236,487
Beach/dune	900	48,644	43,758,633	1,422,155,566
Open water	131,388	1,946	255,655,983	8,308,819,443
Total	**3,795,626**		**12,061,000,000**	**391,999,000,000**

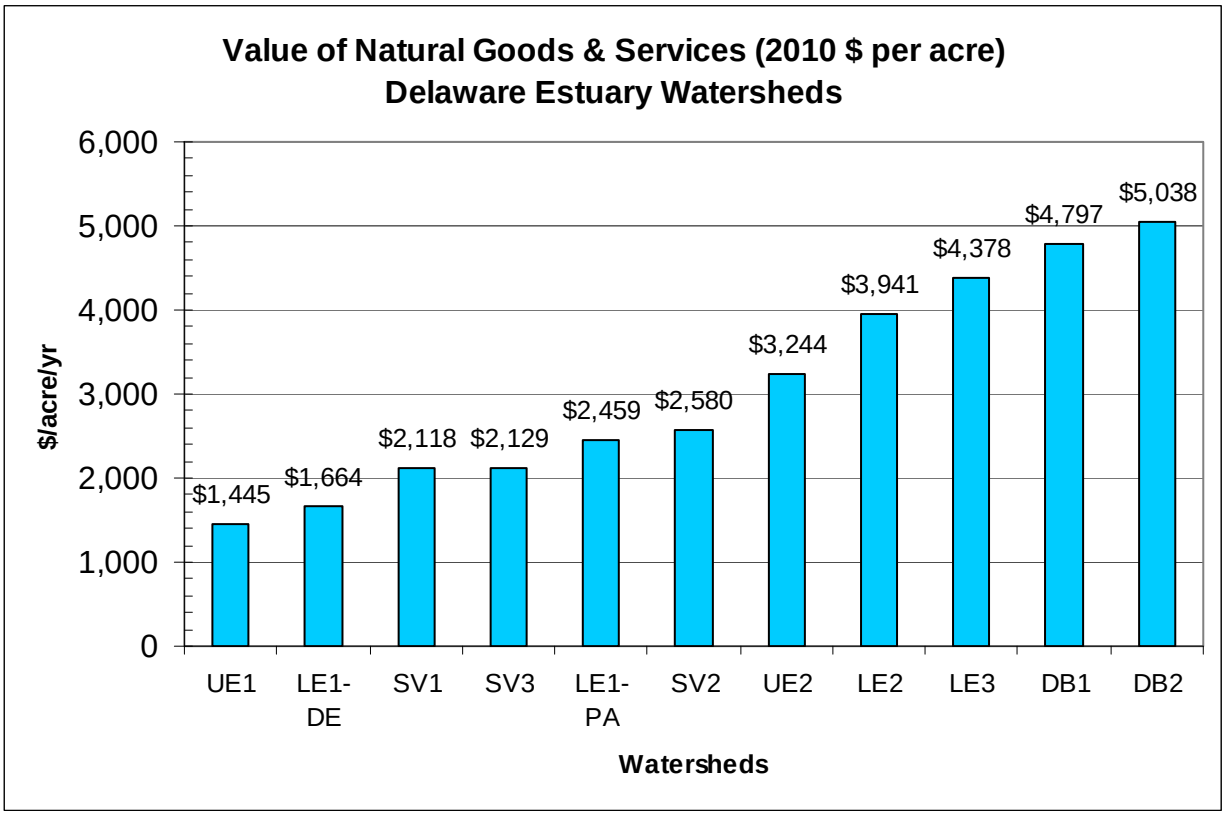
1. NJDEP 2004. 2. USDA 2009


Ecosystem Services Value
in the Delaware Estuary Watershed
$/yr
5,000,000,000
4,000,000,000
3,000,000,000
2,000,000,000
1,000,000,000
0
$4,320 M
$3,577 M
$2,347 M
$1,054 M
$295 M
$255
$165 M
Freshwater wetlands
Farmland
Forest land
Saltwater wetlands
Urban
Open water
Marine


Ecosystem Services Value in the
Delaware Estuary Watershed by State
Del.,
$2,520,546,268
NJ,
$5,343,026,326
Pa.,
$4,061,704,801
Del.
Pa.
NJ


Ecosystems area (acres) in the Delaware Estuary Watershed, 2005
Open water, 131,388, 3%
Freshwater wetlands, 317,213, 8%
Beach/dune, 900, 0%
Marine, 16,588, 0%
Urban, 865,778, 23%
Farmland, 1,112,580, 30%
Barren land, 18,630, 0%
Forest land, 1,186,784, 32%
Saltwater wetland, 145,765, 4%


Value of Natural Goods and Services (2010 $ million)
Delaware Estuary Watersheds
$/yr (millions)
3,000
2,500
2,000
1,500
1,000
500
0
$199
$384
$458
$631
$641
$710
$1,071
$1,190
$1,923
$2,119
$2,521
LE1-DE
LE2
SV1
LE1-PA
UE1
LE3
SV2
SV3
DB1
UE2
DB2
Watershed



Jobs and Wages

The Delaware Estuary watershed is a jobs engine that supports over 500,000 direct and indirect jobs with $10 billion in annual wages in the coastal, farm, ecotourism, water/wastewater, recreation, and port industries. Note total jobs and wages are rounded down to avoid double counting (Table E3).

Table E3. Jobs and wages related to the Delaware Estuary watershed

Sector	Jobs	Wages ($ million)	Data Source
Direct Basin Related	192,785	4,280	U.S. Bureau of Labor Statistics (2009)
Indirect Basin Related	231,342	3,420	U.S. Census Bureau (2009)
Coastal	44,658	947	National Coastal Economics Program (20090
Farm	28,276	1,159	USDA Census of Agriculture (2007)
Fishing/Hunting/Birding	24,713	812	U.S. Fish and Wildlife Service (2008)
Water Supply Utilities	2,290	127	UDWRA and DRBC (2010)
Wastewater Utilities	1,021	51	UDWRA and DRBC (2010)
Watershed Organizations	150	8	UDWRA and DRBC (2010)
Port Jobs	12,121	772	Economy League of Greater Phila. (2008)
Delaware Estuary watershed	**> 500,000**	**>$10 billion**	

Jobs directly associated with the Delaware Estuary watershed (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employ 192,785 people with $4.3 billion in

wages in Delaware (15,737 jobs, $340 million wages), New Jersey (52,007 jobs, $1.1 billion wages), and Pennsylvania (125,041 jobs, $2.8 billion wages).

Jobs indirectly related to the waters of the Delaware Estuary watershed (based on multipliers of 2.2 for jobs and 1.8 for salaries) employ 231,342 people with $3.4 billion in wages in Delaware (18,884 jobs, $270 million wages), New Jersey (62,408 jobs, $0.9 billion wages), and Pennsylvania (150,049 jobs, $2.2 billion in wages).

The National Coastal Economy Program (2009) reports coastal employment in the Delaware Estuary watershed provides 44,658 jobs earning $947 million in wages in Delaware (12,139 jobs, $214 million wages), New Jersey (4,423 jobs, $140 million wages), and Pennsylvania (28,096 jobs, $593 wages).

Over 12,800 farms employ 28,276 workers with $1.2 billion in salaries within the Delaware Estuary watershed including Delaware (3,289 farm jobs, $135 million wages), New Jersey (8,287 farm jobs, $340 million wages), and Pennsylvania (16,700 farm jobs, $685 million wages).

Fishing, hunting, bird watching, and wildlife recreation provides 24,713 jobs with $812 million in wages in the Delaware Estuary watershed including Delaware (4,092 jobs, $134 million wages), New Jersey (11,365 jobs, $373 million wages), and Pennsylvania (9,256 jobs, $304 million wages).

Public and private water utilities that withdraw drinking water from the Delaware Estuary watershed employ 2,290 people with wages of $127 million including Delaware (126 jobs, $7 million wages), New Jersey (509 jobs, $28 million wages), and Pennsylvania (1,654 jobs, $92 million wages).

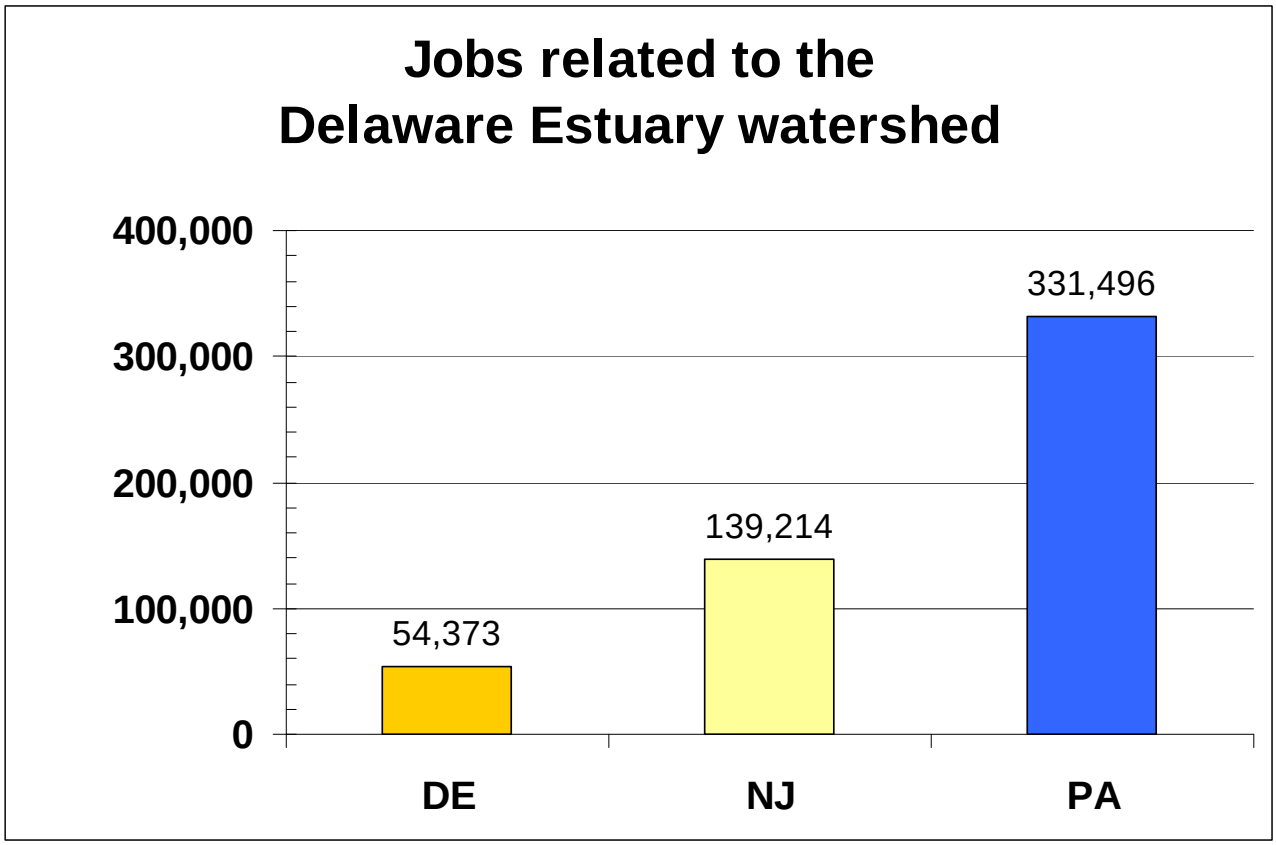
Wastewater agencies that treat and discharge wastewater to the Delaware Estuary watershed employ 1,021 people with wages of $51.1 million including Delaware (106 jobs, $5 million wages), New Jersey (215 jobs, $11 million wages), and Pennsylvania (700 jobs, $35 million wages).

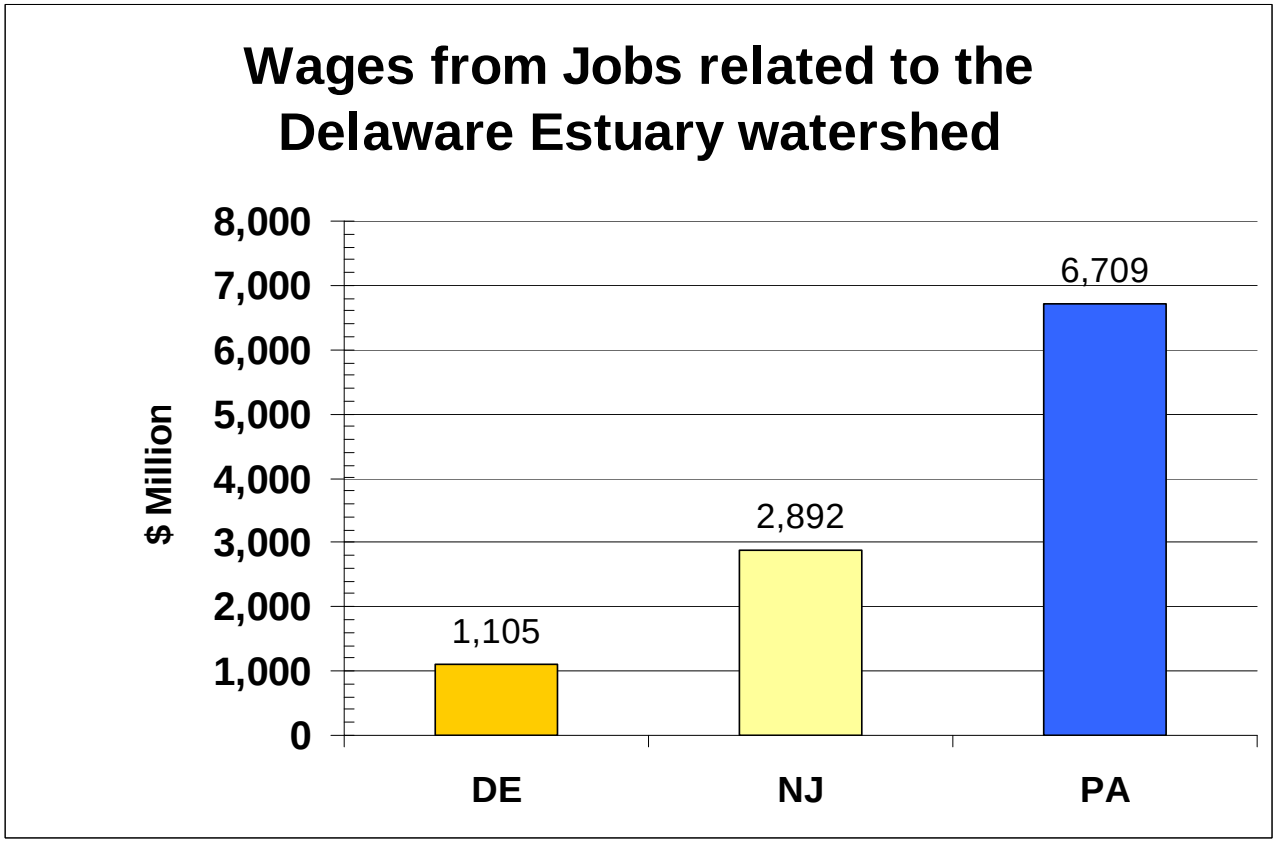
Ports along the Delaware River employ 4,056 workers who earn $326 million in wages and provide jobs that support an additional two jobs each in port activity and employee spending for a total of 12,121 port related jobs with $772 million in wages and $2.4 billion in annual economic output.

Close to 90 nonprofit watershed and environmental organizations employ at least 150 staff that work on programs to protect the land and water resources in the Delaware Estuary watershed.

Table E4. Jobs and wages in the Delaware Estuary watershed by state.

Sector	DE Jobs	NJ Jobs	PA Jobs	DE Wages ($M)	NJ Wages ($M)	PA Wages ($M)
Direct Basin Related	15,737	52,007	125,041	340	1,100	2,800
Indirect Basin Related	18,884	62,408	150,049	270	900	2,200
Coastal	12,139	4,423	28,096	214	140	593
Farm	3,289	8,287	16,700	135	340	685
Fishing/Hunting/Birding	4,092	11,365	9,256	134	373	304
Water Supply Utilities	126	509	1,654	7	28	92
Wastewater Utilities	106	215	700	5	11	35
Delaware Estuary watershed	**54,373**	**139,214**	**331,496**	**1,105**	**2,892**	**6,709**


Jobs related to the
Delaware Estuary watershed
400,000
300,000
200,000
100,000
0
54,373
139,214
331,496
DE
NJ
PA


Wages from Jobs related to the
Delaware Estuary watershed
$ Million
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1,105
2,892
6,709
DE
NJ
PA

1. Introduction

Objectives

This report summarizes the socioeconomic value of water, natural resources and ecosystems in the Delaware Estuary watershed in Delaware, New Jersey, and Pennsylvania estimated as:

1. Economic activity including market and nonmarket value of agriculture, water supply, fishing, hunting, recreation, boating, ecotourism, and navigation/port benefits in the watershed.

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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 the Delaware Estuary watershed.

These estimates demonstrate that the natural resources of the Delaware Estuary provide real and significant economic benefits to the tri-state region, and are worthy of investment to keep them healthy and productive. All were made by taking values from existing studies and applying them to the Delaware Estuary using ecological economics techniques described in this report.

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 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 indicates that the Delaware Estuary is an economic engine that contributes to our region's economy.**

It is also important to note that the estimates presented in this report are not comprehensive, nor are they meant to be used to compare/contrast different uses of the estuary for their value. Some values were not included in these estimates because the data to assess them is not readily available, or does not exist. For example, the full amount of economic activity and jobs associated with the many companies and industries that rely on waters of the Delaware Estuary 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 different activities vary greatly in how they were determined and applied to the Delaware Estuary making it difficult to accurately compare values across uses. Gathering more complex or tailored data on the Delaware Estuary would improve comparability of information across uses and make value estimates more comprehensive.

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 the Delaware Estuary. 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 Estuary and all of its benefits to the people of this region.

Previous Work

Two decades ago, researchers conducted a series of studies that indicated the Delaware Estuary was worth hundreds of millions if not billions of dollars. Latham and Stapleford (1990) from the University of Delaware estimated total contributions of Delaware Estuary activities within the State of Delaware accounted for 10,500 jobs with $222 million in annual wages, each direct estuary job created 2.2 indirect jobs, and the multiplier of direct/indirect wages was 1.8. The Greeley-Polhemus Group (1993) estimated the Delaware Estuary supported 123,000 jobs, $4.3 billion in wages, $24 billion in sales, $25 million in sport fishing non-market value, $1 million in commercial fish landings, and wetlands replacement values up to $638 million.

This report by the University of Delaware is designed to update economic analyses for the Delaware Estuary conducted 20 years ago and incorporate more recent valuation data from the emerging fields of ecological economics and ecosystem services.

The Value of a Watershed

Watersheds have significant economic value and restoration results in green jobs. The University of Maryland (1988) reported the Chesapeake Bay was worth $678 billion. The Chesapeake Blue Ribbon Panel (2003) concluded with inflation the present value of the bay exceeded $1 trillion.

The Brookings Institution (Austin et al. 2007) found restoration of the Great Lakes would cost $26 billion in present value and aggregate economic benefits would exceed $50 billion, a 2:1 benefit/cost ratio. Great Lakes restoration benefits include $6.5-11.8 billion in tourism, fishing, and recreation dollars; $12-19 billion increase in property values from contaminated sediment cleanup, and $50-125 million in reduced municipal water treatment costs. The Great Lakes Coalition (2010) concluded watershed restoration creates good paying jobs while restoring the environment (Table 1).

Completing the Comprehensive Everglades Restoration Plan (CERP) would result in $6 billion in benefits and 443,000 jobs over 50 years (McCormick 2010). The net present value of Everglades restoration benefits would be $46 billion from investments of $11.5 billion, a B/C ratio of 4:1.

Table 1. Jobs and salaries created by watershed restoration work (Great Lakes Coalition (2010) from U. S. Bureau of Labor Statistics)

Job	Mean Salary	Job	Mean Salary
Wetland scientist	$45,730	Fisheries Biologist	$60,670
Research scientist	$45,730	Archeologist	$57,230
Construction manager	$93,290	Operating Engineer	$44,180
Biologist	$69,430	Environmental Engr.	$80,750
Civil Engineer	$81,180	Hydrogeologist	$92,710
Chemist	$72,740	Environmental Planner	$64,680
Geologist	$58,000	Plumber/Pipefitter	$9,870
Helicopter Pilot	$90,000	Carpenter	$43,640
Info. Technology	$70,930	Electrician	$50,850
Biological technician	$41,140	Truck Driver	$39,260
Mechanics	$37,000	Concrete Workers	$39,410
Excavator	$38,540	Dredge Operator	$38,330
Landscape Architect	$65,910	Conservation Scientist	$61,180

An Economic Engine

What do Boeing, Sunoco, Campbell's Soup, DuPont, Wawa, Starbucks, Iron Hill Brewery, the Philadelphia Eagles, Salem Nuclear Power Plant, and the United States Navy have in common? They all depend on the waters of the Delaware Estuary watershed to sustain their business.

Most economists agree that water is an undervalued resource without a substitute in nature. The astronomer Copernicus and economist Adam Smith both considered the "diamond-water paradox". If water is more valuable to society than a precious gem, then why is water sold for a fraction of a penny per gallon for drinking water or not even valued at all as an ecological resource in the river or bay? Just as under-compensated police officers or teachers are more valuable to society than multimillion dollar movie stars, perhaps the value of water is just as marginalized. We tend to underprice water based on its marginal value for single uses (i.e. drinking water) and not consider the full value of water for all its myriad uses. This report attempts to quantify the highest multiobjective value of water *in toto* for its wide range of habitat, recreation, ecological, and industrial benefits in the Delaware Estuary watershed.

If hydrogen oxide is society's most valuable chemical, then the Delaware Estuary which holds 4.8 trillion gallons of water at low tide is the Delaware Valley's most invaluable asset. For over 400 years, the Delaware Estuary has been an economic engine ever since Henry Hudson discovered the bay off Cape May in August 1609 for the Dutch East India Company during his unsuccessful quest for an inner trade route to Asia.

When William Penn founded the City of Brotherly Love in 1681 seeking refuge from religious persecution in Europe, he also found a safe harbor between the Delaware and Schuylkill in a colony rich with lumber, fertile land, beaver pelts, and later coal and oil. By the 18th century, prosperous Philadelphia Quaker merchants established triangle trade routes to Europe and the Caribbean from their home port along the Delaware. By the American Revolution, Philadelphia was the largest city in the colonies and the 3rd largest port in the British Empire after London and Liverpool. In 1790 Ben Franklin, America's first environmentalist, was so concerned about pollution along the Delaware that he willed funds to build the first municipal water system in the U.S. at Philadelphia.

The economic engine kicked into high gear during the 19th century with hydropower and steam power during the Industrial Revolution. In 1802, the DuPont family searched up and down the Atlantic Seaboard and established gunpowder mills along the Brandywine falls above Wilmington as one of the first industries in the Delaware Valley. Delaware River ports grew when anthracite coal was discovered in the Lehigh Valley in 1792 and steam railroads were built in the 1830s. By the Gay Nineties, every Philadelphia wharf had railroad access and the advent of steam ships made for faster transatlantic shipping. In 1895, the Corps of Engineers dredged the Delaware River to 26 feet from the natural depth of 17 feet (Economy League 2008).

By the end of the 19th century, the Delaware Estuary supported the largest commercial American shad and sturgeon fishery along the Atlantic coast. The sturgeon was such a lucrative fish that boom town Caviar (Bayside) near Greenwich, New Jersey was founded to process the roe for worldwide export. By the 1880s, 1,400 sailing vessels harvested 22 million pounds of oysters from the Delaware Bay. In 1886, nationally famous hotels in Gloucester, N. J. served 10,000 planked shad dinners at events that resembled modern day blue crab feasts. In 1896 over 14 million pounds of shad were caught worth $400,000 ($10 million in 2008 dollars). In 1896, a fisheries report to the governor of Pennsylvania listed the catch of a 76-pound striped bass above Gloucester, New Jersey.

After the turn of the 20th century, Delaware River ports were a premier ship building industry and were known as the "Clyde of America" with ship building and repair production that rivaled its Scottish cousin. By 1912, Philadelphia and environs built and manufactured 5% of all goods in the United States. Export markets included coal, iron, cotton, leather, grain, lumber and tobacco, and gunpowder from Wilmington. By 1914, the Panama Canal opened access from the East Coast to Hawaii sugar cane fields and Philadelphia refined and shipped 500,000 tons of raw sugar or 1/6 of all sugar refined in the USA.

After the Delaware River ship channel was deepened to 41 feet in 1941, the port economy boomed during World War II as the Philadelphia Navy Yard employed 40,000 workers who built 53 ships and repaired over 500 vessels. After the war, the "Arsenal of America" manufacturing and export base declined due to decreased demand for Pennsylvania coal and decline of Lehigh Valley steel industries. In 1995, the Department of the Navy closed the Philadelphia Navy Yard and decommissioned the ghost fleet due to decreased ship building needs in the "New Navy."

By 1986, the Salem and Hope Creek nuclear power plants were built on Artificial Island in Salem County, New Jersey that pump over 3 billion gallons per day of cooling water from the estuary to provide 3,500 megawatts of electricity to the tri-state region. In 2010, over a billion gallons per day of drinking water and industrial process water were withdrawn from the rivers, streams, and aquifers in the Delaware Estuary watershed to sustain the region'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.

The Delaware Estuary is now at the center of the 5th largest metropolitan economy in the United States. The following report tabulates the substantial economic value and worth of this irreplaceable asset for over 6.5 million residents in Delaware, Pennsylvania, and New Jersey.

Governance

For the last fifty years, Federal, state, and local governments, nonprofits, and the private sector have focused efforts on restoring the Delaware Estuary. In 1961, JFK signed the Delaware River Basin Compact and appointed the Governors of Delaware, New Jersey, New York, and Pennsylvania as Commissioners of the first ever Federal-state watershed accord. In 1988, the Delaware Estuary was nominated by the Governors of Delaware, New Jersey, and Pennsylvania for the National Estuary Program per Section 320 of the Federal Clean Water Act. In 1996, the Delaware Estuary was designated by Congress as one of only 28 National Estuary Programs in the U.S. and is now the only tri-state estuary program in the nation. In 1996, the Partnership for the Delaware Estuary was established to implement a Comprehensive Conservation and Management Plan (CCMP). The PDE headquarters lie along the banks of the tidal Christina River in Wilmington, Delaware.

The Watershed

The Delaware Estuary watershed (Figure 1) occupies 5,947 sq mi in Delaware (16%), New Jersey (33%), Pennsylvania (51%), and a small sliver of Maryland. In 2010, 6,700,004 residents lived in the Delaware Estuary watershed including 642,438 people in Delaware (9%), 2,324 in Maryland, 1,645,500 in New Jersey (25%), and 4,409,742 in Pennsylvania (66%). Over 2,900,000 people work in the Delaware Estuary watershed with 317,997 jobs in Delaware (11%), 1,172 jobs in Maryland, 699,202 jobs in New Jersey (24%), and 1,909,699 jobs (65%) in Pennsylvania (Table 2).

Table 2. Land area, population, and employment in the Delaware Estuary watershed

State	Area (sq mi)	Population[1] 2010	Employment[2] 2009
Delaware	977	642,438	317,997
Maryland	8	2,324	1,172
New Jersey	1,943	1,645,500	699,202
Pennsylvania	3,019	4,409,742	1,909,699
Total	**5,947**	**6,700,004**	**2,928,070**

1. U.S. Census Bureau 2010. 2. U.S. Bureau of Labor Statistics 2009

Table 3 summarizes the area, population, and employment by state and county in the Delaware Estuary watershed. In Delaware, the estuary watershed covers 50% of the state's area yet includes 72% of the First State's population. The New Jersey portion of the watershed covers 26% of the state's area and includes 19% of the Garden State's population. The Pennsylvania part of the estuary watershed covers just 7% of the State yet includes 35% of the Keystone State's population.

Table 3. Land area, population, and employment by county in the Delaware Estuary watershed

State/county	Area (sq mi)	Population[1] 2010	Employment[2] 2009
Kent	393	107,684	50,450
New Castle	386	492,915	253,998
Sussex	199	41,839	13,549
Delaware	**977**	**642,438**	**317,997**
Cecil	8	2,324	1,172
Maryland	**8**	**2,324**	**1,172**
Burlington	488	362,309	188,186
Camden	118	429,876	169,356
Cape May	98	53,228	12,511
Cumberland	489	158,289	59,765
Gloucester	270	267,738	89,446
Mercer	98	259,483	143,767
Monmouth	18	24,620	9,385
Ocean	26	23,616	5,172
Salem	338	66,342	21,614
New Jersey	**1,943**	**1,645,500**	**699,202**
Berks	794	402,518	152,511
Bucks	345	542,555	206,963
Chester	603	437,911	216,995
Delaware	184	559,210	203,468
Lebanon	20	7,221	2,748
Lehigh	25	24,825	11,222
Montgomery	483	789,862	467,601
Philadelphia	135	1,558,613	621,014
Schuylkill	430	87,028	27,177
Pennsylvania	**3,019**	**4,409,742**	**1,909,699**
Total	**5,947**	**6,700,004**	**2,928,070**

1. U. S. Census Bureau 2010. 2. U. S. Bureau of Labor Statistics 2009.

Between 2000 and 2010, the population in the Delaware Estuary watershed population increased by 5.1% or 325,663 people (Table 4). Over the last decade, population increased by over 24% in Kent and Sussex counties, Del.; by 12% in Gloucester County, NJ; and 14% in Chester County, Pa. For the first time in half a century, the population of Philadelphia grew, increasing by 2.7%. Two counties lost population since 2000, Cape May, NJ (-4.4%) and Schuylkill County, Pa. (-2.1%).

The Delaware Estuary is the tidal portion of the Delaware River between the mouth of the bay at Cape Henlopen, Del. and the head of tide at Trenton. The Delaware Estuary watershed includes 10 subwatersheds that flow from the Piedmont and Coastal Plain physiographic provinces to the tidal river and bay (Figure 2).

Table 4. Population change in the Delaware Estuary watershed, 2000-2010 (U. S. Census)

State/county	Pop. 2000	Pop. 2010	Change	% change
Kent	85,680	107,684	22,004	25.7%
New Castle	459,829	492,915	33,086	7.2%
Sussex	33,716	41,839	8,123	24.1%
Delaware	**579,225**	**642,438**	**63,213**	**10.9%**
Cecil	1,976	2,324	348	17.6%
Maryland	**1,976**	**2,324**	**348**	**17.6%**
Burlington	348,729	362,309	13,580	3.9%
Camden	425,646	429,876	4,230	1.0%
Cape May	55,679	53,228	-2,451	-4.4%
Cumberland	146,442	158,289	11,847	8.1%
Gloucester	239,012	267,738	28,726	12.0%
Mercer	252,435	259,483	7,048	2.8%
Monmouth	23,465	24,620	1,155	4.9%
Ocean	20,887	23,616	2,729	13.1%
Salem	64,285	66,342	2,057	3.2%
New Jersey	**1,576,580**	**1,645,500**	**68,920**	**4.4%**
Berks	370,901	402,518	31,617	8.5%
Bucks	526,272	542,555	16,283	3.1%
Chester	383,443	437,911	54,468	14.2%
Delaware	551,410	559,210	7,800	1.4%
Lebanon	6,648	7,221	573	8.6%
Lehigh	22,485	24,825	2,340	10.4%
Montgomery	748,987	789,862	40,875	5.5%
Philadelphia	1,517,542	1,558,613	41,071	2.7%
Schuylkill	88,872	87,028	-1,844	-2.1%
Pennsylvania	**4,216,560**	**4,409,742**	**193,182**	**4.6%**
Total	**6,374,341**	**6,700,004**	**325,663**	**5.1%**

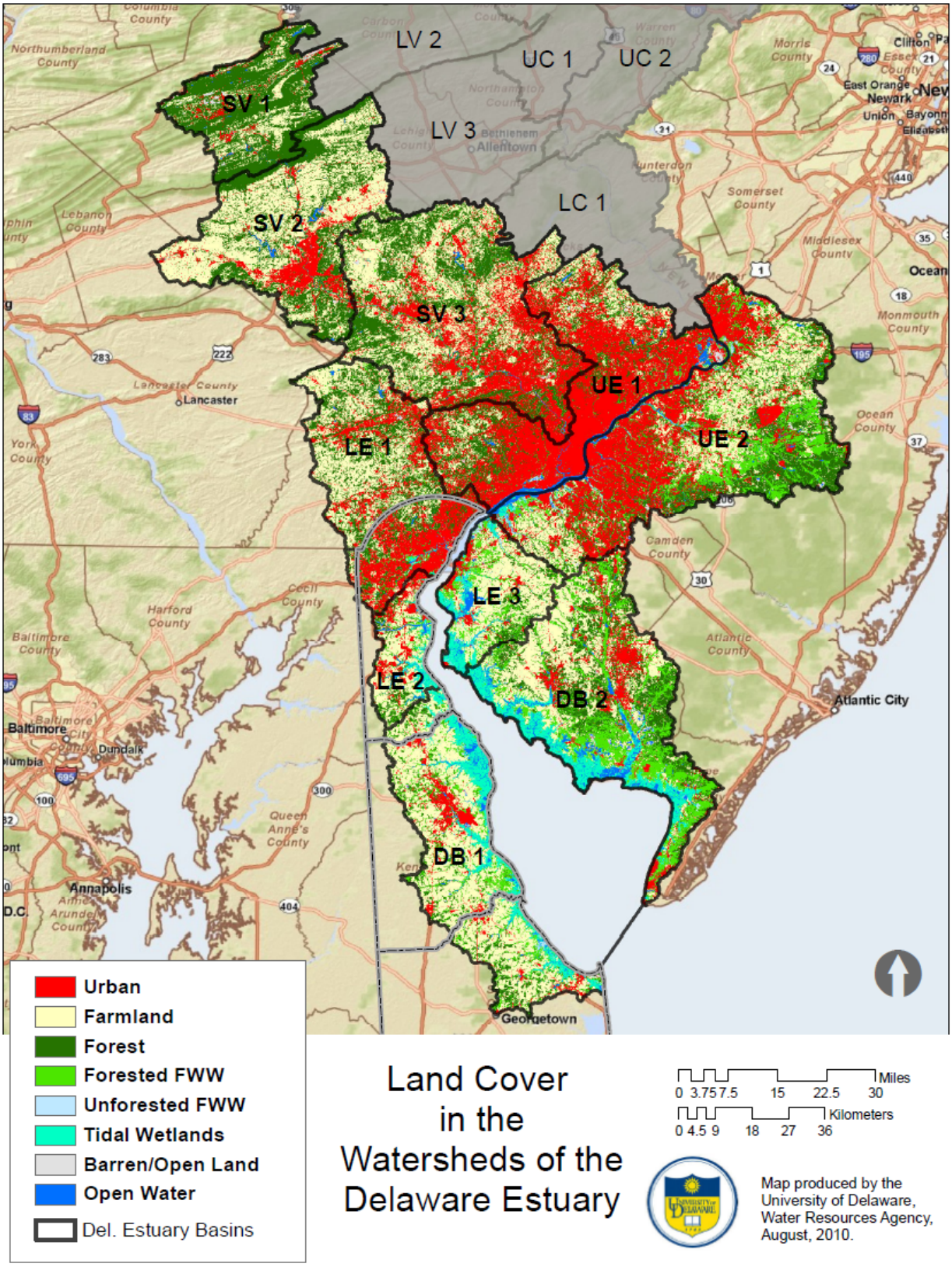


Figure 1. Land cover in the Delaware Estuary watershed (NOAA CSC 2006)

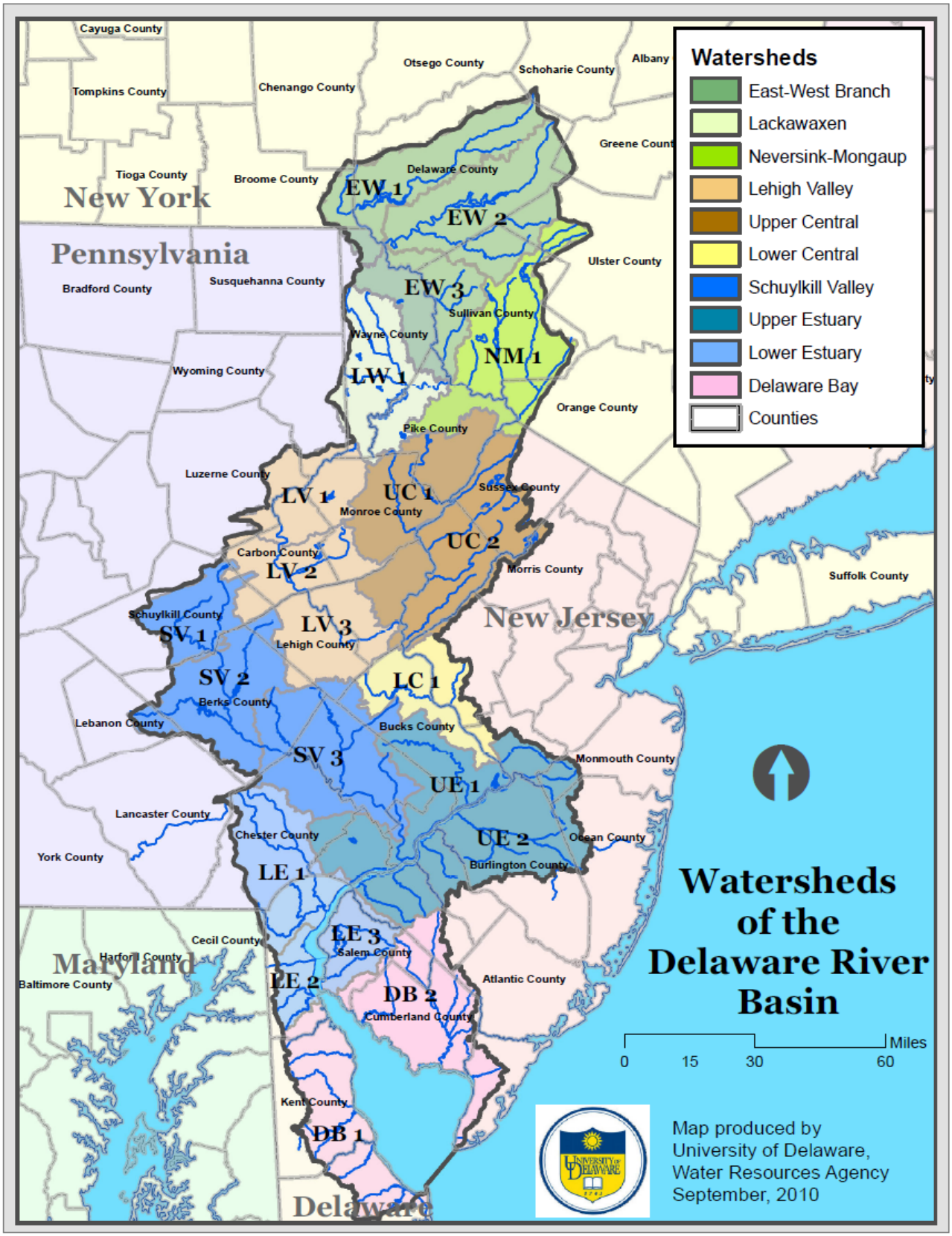


Figure 2. The Delaware River Basin (UDWRA 2010)

2. Methods

Valuation Techniques

The University of Delaware derived the economic value of the Delaware Estuary watershed in Delaware, New Jersey, and Pennsylvania from published studies and valuation methods including:

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

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

Net Factor Income by Enhancement of Income: Income may be increased by environmental restoration. Improved water quality can 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 hunting, fishing, and birding.

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

Contingent Valuation: Valuation by survey of individual preferences to preserve ecosystems. Residents 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 the Delaware Estuary watershed according to the following scope of work.

1. **Area of Interest:** The area of interest is defined as the watershed of the Delaware Estuary that flows into the tidal river and bay below the head of tide at Trenton. The UD 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 Delaware Estuary watershed including databases from the U. S. Census Bureau, U. S. Bureau of Labor Statistics, U. S. Department of Agriculture, U. S. Forest Service, and U. S. Fish and Wildlife Service.

3. Annual Economic Value: Estimate the direct (market) and indirect (nonmarket) economic value of agriculture, water quality, water supply, fishing, hunting, recreation, boating, ecotourism, and navigation in the watershed utilizing population, employment, industrial activity, and land use data. Total economic activity is the sum of direct and indirect use, option demand, and nonuse 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 (nonmarket) 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 bay. Nonuse (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 the Delaware Estuary watershed for habitat such as wetlands, forests, farmland, and open water. Ecosystem services (ecological services) are economic benefits provided to society by nature such as water filtration, flood reduction, and drinking water supply.

Using ArcGIS, map and tabulate ecosystem areas (acres) using 2006 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 ($/acre) data for ecosystem goods and services such as: (a) carbon sequestration, (b) flood control, (c) drinking water supply, (d) water quality filtration, (e) waste treatment and assimilation, (f) nutrient regulation, (g) fish and wildlife habitat, (h) recreation and aesthetics. Compute ecosystem services value by multiplying land use area (acres) by ecosystem value ($/ac).

Ecosystem services in the Delaware Estuary watershed 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 $ per acre values to Delaware Estuary land use areas. While primary research data from the watershed in question (the Delaware Estuary) 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 the Delaware Estuary watershed.

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 the Delaware Estuary watershed by North American Industry Classification System (NAICS) codes such as shipbuilding, marine transportation/ports, fisheries, recreation, minerals, trade, agriculture, and others. Total jobs and salaries were summarized for each county within the watershed based on population census block data. 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 summarizing (1) annual economic value of activities related to the Delaware Estuary watershed, (2) ecosystem goods and services (natural capital), and (3) jobs and wages directly and indirectly related to the Delaware Estuary watershed in $2010.

3. Economic Value

The value of the Delaware Estuary watershed from recreation, water quality, water supply, fishing, agriculture, forests and port benefits exceeds $10 billion (Table 5 and Figure 3).

It is important to note that the estimates presented here are not comprehensive, nor are they meant to be used to compare/contrast different uses of the estuary for their value. Some values were not included in these estimates because the data to assess them is not readily available, or does not exist. For example, the full amount of economic activity associated with the many companies and industries that rely on waters of the Delaware Estuary 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 different activities vary greatly in how they were determined and applied to the Delaware Estuary making it difficult to accurately compare values across uses. Gathering more complex or tailored data on the Delaware Estuary would improve comparability of information across uses and make value estimates more comprehensive.

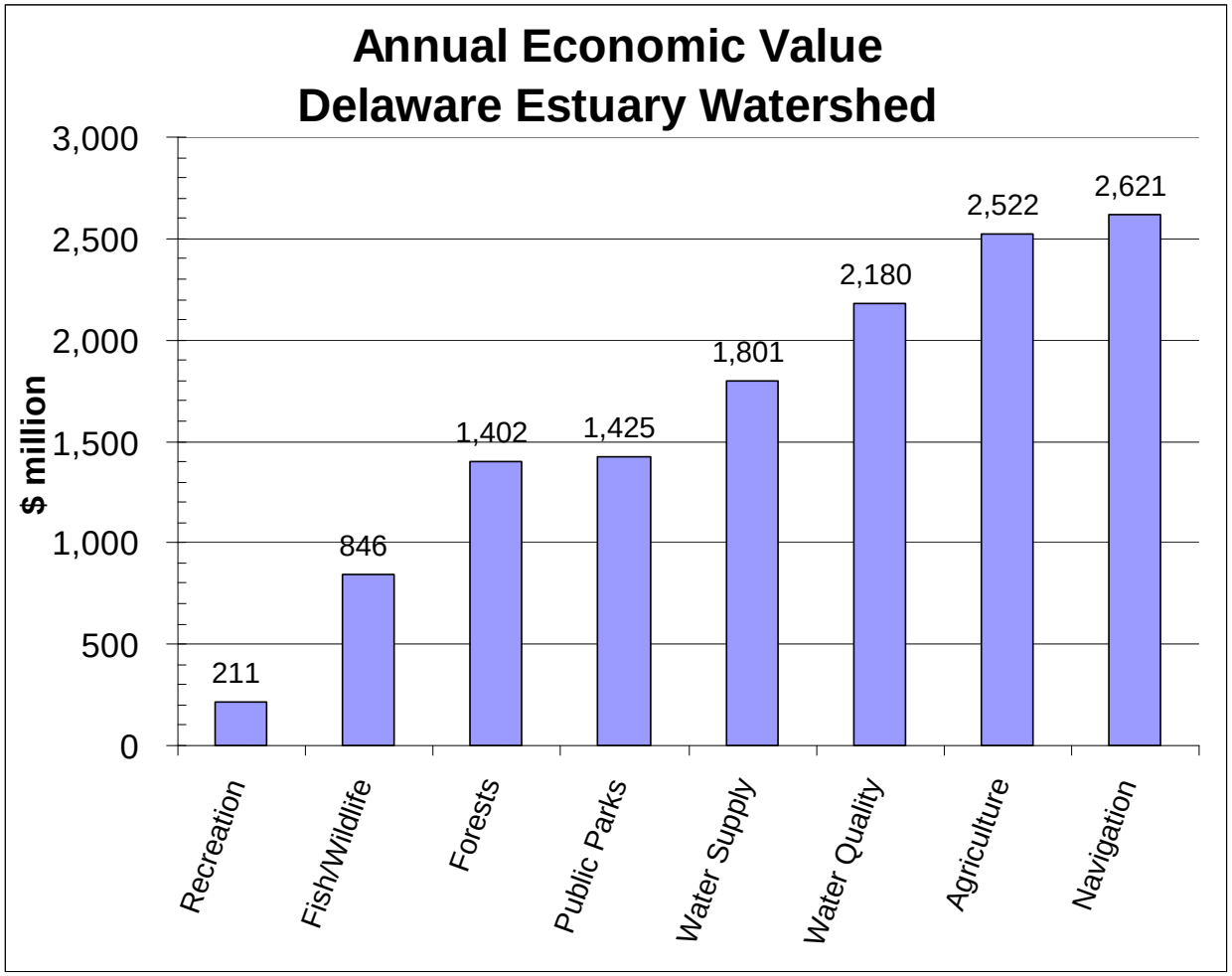


Figure 3. Annual economic value related to the Delaware Estuary watershed

Table 5. Annual economic value in the Delaware Estuary watershed

Activity	2010 ($ million)	Source
Recreation (Boating, Fishing, Swimming)		
Water Quality Based Recreation		
Swimming ($13.40/trip)	9	University of Rhode Island (2002)
Boating ($30/trip)	47	University of Rhode Island (2002)
Fishing ($62.79/trip)	52	University of Rhode Island (2002)
Wildlife/bird watching ($77.73/trip)	104	University of Rhode Island (2002)
Water Quality		
Willing to Pay for Clean Water ($38-$121/user)	660	University of Maryland (1989)
Water Treatment ($62/mgd)	17	Trust for Public Land, AWWA (2004)
Wastewater Treatment ($4.00/1000 gal)	1,490	DRBC and USEPA
Increased Property Value (+8% over 20 years)	13	EPA (1973), Brookings Institute (2010)
Water Supply		
Drinking Water Supply ($4.78/1000 gal)	1,333	UDWRA and DRBC (2010)
Irrigation Water Supply ($300/ac-ft)	30	Resources for the Future (1996), USDA (2007)
Thermoelectric Power Water Supply ($44/ac-ft)	298	EIA (2002), NETL (2009)
Industrial Water Supply ($200/ac-ft)	140	Resources for the Future (1996), DRBC (2010)
Fish/Wildlife		
Commercial Fish Landings ($0.60/lb)	34	NMFS, Nat'l. Ocean Econ. Program (2007)
Fishing (11-18 trips/angler, $17-$53/trip))	334	U. S. Fish and Wildlife Service (2006)
Hunting (16 trips/hunter, $16-50/trip)	171	U. S. Fish and Wildlife Service (2006)
Wildlife/Bird-watching (8-13 trip/yr, $15-$27/trip)	306	U. S. Fish and Wildlife Service (2006)
Agriculture		
Crop, poultry, livestock value ($2,300/ac)	2,522	USDA Census of Agriculture 2007 (2009)
Forests		
Carbon Storage ($827/ac)	628	U.S. Forest Service, Del. Ctr. Hort. (2008)
Carbon Sequestration ($29/ac)	34	U.S. Forest Service, Del. Ctr. Hort. (2008)
Air Pollution Removal ($266/ac)	316	U.S. Forest Service, Del. Ctr. Hort. (2008)
Building Energy Savings ($56/ac)	66	U.S. Forest Service, Del. Ctr. Hort. (2008)
Avoided Carbon Emissions ($3/ac)	4	U.S. Forest Service, Del. Ctr. Hort. (2008)
Public Parks		
Health Benefits ($9,734/ac)	1,057	Trust for Public Land
Community Cohesion ($2,383/ac)	259	Trust for Public Land
Stormwater Benefit ($921/ac)	100	Trust for Public Land
Air Pollution Control ($88/ac)	10	Trust for Public Land
Maritime Transportation		
Navigation ($15/ac-ft)	221	Resources for the Future (1996)
Port Activity	2,400	Economy League of Greater Phila. (2008)
Delaware Estuary watershed	**> $10 billion**	

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

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, New York at $8.59, $19.23, $40.25, and $49.83 per trip in $1995, respectively. Table 6 calculates water quality benefits to recreational users at $211 million per year in the Delaware Estuary watershed by transferring unit values from the Peconic Estuary, converting $1995 to $2010 at 3% per year and multiplying $2010 benefits by number of trips per year. Wildlife viewing/bird watching (49%) and fishing (24%) are the highest recreational benefits followed by boating (22%) and swimming (4%).

Table 6. Total annual value of recreational benefits in the Delaware Estuary watershed

Recreational Benefit	$1995 Consumer surplus/trip[1]	$2010 Consumer surplus/trip[2]	Trips/year to Del. Estuary	Annual Value	% of Benefit
Swimming	$8.59	$13.40	670,000[3]	$8,978,000	4%
Boating	$19.23	$30.00	1,568,473[4]	$47,054,190	22%
Fishing	$40.25	$62.79	824,249[4]	$51,754,595	24%
Wildlife/bird watching	$49.83	$77.73	3,336,440[5]	$103,700,000	49%
Total				**$211,486,785**	**100%**

1. Johnston et al. 2002. 2. $2010 transferred from $1995 at 3% per year. 3. 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. 5. USFWS 2006, wildlife/bird watching in watershed responsible for 427,500, 2,070,900, and 838,000 trips/year in Del., NJ, and Pa., respectively.

Water Quality

Willingness to Pay for Clean Water

Bockstael, McConnell, and Strand (1989) from the University of Maryland estimated annual public willingness to pay for moderate improvement in Chesapeake Bay water quality to be $10 to $100 million in 1984 dollars ($21.6 to $216 million in $2010 at 3% annually). The study found 43% of the respondents were users or visitors (boaters, fishermen) to the Chesapeake Bay and were willing to pay $121 per year to make the bay water quality "acceptable". About 57% of respondents were nonusers, those who do not visit or use the bay's resources but were willing to pay $38 per year to restore the bay. Transferring these values to the Delaware Estuary watershed (pop. 6,700,004) and using proportions of 10% users (visitors) to the estuary and 90% nonusers, aggregate willingness to pay to improve Delaware Estuary water quality is $660 million in $2010 or $99 per person.

Total willingness to pay for acceptable Delaware Estuary water quality = (0.10)(6,700,004)($121/yr) + (0.90)(6,700,004)($38/yr) = $310 million ($1984) or $660 million ($2010 at 3% annually).

Water Treatment

Based on avoided costs, the Trust for Public Land and American Water Works Association (2004) found for every 10% increase in forested watershed land, drinking water treatment and chemical costs are reduced by approximately 20% (Table 7). The public drinking water supply in the estuary watershed is 764 mgd. Forests cover 1,857 sq mi or 28% of the Delaware Estuary watershed. Loss

of all of the watershed forests would increase water treatment costs by $62 per mgd ($139 per mgd at 0% forested minus $77 per mgd a 28% forested). Increased water treatment costs due to loss of all Delaware Estuary watershed forests is estimated as $47,368 per day or $17,300,000 per year ($62/mgd x 764 mgd x 365 days/year.).

Table 7. Drinking water treatment and chemical costs based on percent of forested watershed (Trust for Public Land and AWWA 2004)

% of Watershed Forested	Water Treatment/ Chemical Costs (per mil gal)	% Change in Costs
0%	$139	21%
10%	$115	19%
20%	$93	20%
30%	$73	21%
40%	$58	21%
50%	$46	21%
60%	$37	19%

Increased Property Values

Several studies along rivers, estuaries, and coasts throughout the United States indicate that improved water quality can increase shoreline property values by 6% to 25% (Table 8). The EPA (1973) estimated that improved water quality can raise property values by up to 18% next to the water, 8% at 1000 feet from the water, 4% at 2000 feet from the water, and 1.5% at 3000 feet from the water. Leggett, et al. (2000) estimated that improved bacteria levels to meet state water quality standards along the western shore of the Chesapeake Bay in Maryland raised shoreline property values by 6%. The Brookings Institution (2007) projected that investments of $26 billion to restore the Great Lakes would increase shoreline property values by up to 10%. For this analysis, shoreline property values within 2000 feet of the waterways are estimated to increase by an average of 8% due to improved water quality in the Delaware Estuary.

Table 8. Increased property values resulting from improved water quality

Study	Watershed	Increased Property Value
EPA (1973)	San Diego Bay, CA Kanawha, OH Willamette R., OR	
Next to water		18%
1000 ft from water		8%
2000 ft from water		4%
3,000 ft from water		1.5%
Leggett, et al. (2000)	Chesapeake Bay	6%
Brookings Institution (2007)	Great Lakes	10%

Shoreline property values within 2000 feet of the water due to water quality improvements in the Delaware Estuary watershed will increase by $256 million (Table 9). The average riverfront property

value in Philadelphia is $92,000 per acre. Multiply this value by the area of property within a 2,000 feet corridor along the Delaware Estuary shore between the C&D Canal and head of tide at Trenton. Multiply by increased property value of 8% due to improved water quality in the Delaware Estuary. 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 the Delaware Estuary is estimated as $13 million.

Table 9. Increased shore property value due to improved water quality in the Delaware Estuary

State	Length of shoreline (ft)	Area 2000 ft of water (sf)	Area 2000 ft of water (ac)	Property Value @ $92,000/ac ($)	Increased Property Value @ 8% ($)
Delaware	114,048	228,096,000	5,236	481,745,455	38,539,636
New Jersey	357,456	714,912,000	16,412	1,509,915,152	120,793,212
Pennsylvania	285,648	571,296,000	13,115	1,206,593,939	96,527,515
Delaware Estuary	**757,152**	1,514,304,000	34,764	3,198,254,545	255,860,364

Wastewater Treatment

The Delaware Estuary watershed provides significant wastewater treatment and assimilation services. NPDES municipal wastewater dischargers possess Federal, state, and DRBC water quality permits to treat and discharge 1.02 billion gallons per day to the watershed or 106 mgd in Delaware, 215 mgd in New Jersey, and 700 mgd in Pennsylvania (Table 10). The average wastewater rate in the watershed is $4.00 per 1000 gal which for an average residence of 4 people (@ 50 gpcd) is a fee of $290 per year. The total market value based on treated wastewater rates in the Delaware Estuary watershed is $4.1 million per day or $1.5 billion per year.

Table 10. Value of NPDES wastewater discharges in the Delaware Estuary watershed

NPDES ID	Facility	Location	State	mgd	$/day	$/year
DE0020338	Kent Co. Levy Court WWTR	Frederica	DE	15.0		
DE0021512	Lewes City POTW	Lewes	DE	0.8		
DE0020320	Wilmington Wastewater Plant	Wilmington	DE	90.0		
Delaware			**DE**	**105.8**	**$423,200**	**$154,395,000**
NJ0027481	Beverly City Sewer Auth. STP	Beverly	NJ	1.0		
NJ0024678	Bordentown Sewerage Auth.	Bordentown	NJ	3.0		
NJ0024651	Cumberland Co. Utility Auth.	Bridgeton	NJ	7.0		
NJ0024660	Burlington City STP	Burlington	NJ	2.7		
NJ0021709	Burlington Twp. DPW	Burlington	NJ	1.6		
NJ0026182	Camden County MUA	Camden	NJ	80.0		
NJ0021601	Carneys Point Twp. Sewer Auth	Carneys Point	NJ	1.3		
NJ0024007	Cinnaminson Twp. Sewerage	Cinnaminson	NJ	2.0		
NJ0023701	Florence Twp. DPW Sewer Auth.	Florence	NJ	2.5		
NJ0026301	Hamilton Twp. DPW WWTP	Hamilton Twp.	NJ	16.0		
NJ0024759	Ewing Lawrence Sewer Auth.	Lawrenceville	NJ	16.0		
NJ0069167	Maple Shade Twp. Util. Authority	Maple Shade	NJ	3.4		
NJ0026832	Medford Twp. Sewer Auth. STP	Medford	NJ	1.8		
NJ0029467	Millville City Sewer Auth.	Millville	NJ	5.0		
NJ0024996	Moorestown Twp. Utilities Auth	Moorestown	NJ	3.5		
NJ0024015	Mount Holly Twp. MUA	Mount Holly	NJ	7.7		
NJ0024821	Pemberton Twp. MUA STP	Pemberton	NJ	2.5		
NJ0024023	Penns Grove Sewerage Auth.	Penns Grove	NJ	0.8		
NJ0021598	Pennsville Twp. Sewer Auth.	Pennsville	NJ	1.9		
NJ0024716	Phillipsburg Town STP	Phillipsburg	NJ	3.5		
NJ0022519	Riverside Twp. DPW	Riverside	NJ	1.0		
NJ0024856	Salem WWTP Facility	Salem	NJ	1.4		
NJ0024686	Gloucester Co. Util. Auth. STP	Thorofare	NJ	24.1		
NJ0020923	Trenton City DPW Sewer Auth.	Trenton	NJ	20.0		
NJ0023361	Willingboro Twp. MUA	Willingboro	NJ	5.2		
New Jersey			**NJ**	**214.9**	**$859,600**	**$313,754,000**
PA0026867	Abington Twp. STP	Abington	PA	3.9		
PA0021181	Bristol Borough Water and Sewer	Bristol	PA	1.2		
PA0027103	Delaware Co. Water Auth.	Chester	PA	44.0		
PA0026859	Coatesville WWTP	Coatesville	PA	3.8		
PA0026794	Conshohocken Borough Auth.	Conshohocken	PA	2.3		
PA0026531	Downingtown Regional WPCC	Downingtown	PA	7.1		
PA0026549	Borough of Doylestown WWTP	Doylestown	PA	28.5		
PA0029441	Upper Dublin Twp. MS4 UA	Ft. Washington	PA	1.1		
PA0051985	Horsham Twp. STP	Horsham	PA	1.0		
PA0024058	Kennett Square Borough WWTP	Kennett Square	PA	1.1		
PA0026298	Whitemarsh STP	Lafayette Hill	PA	2.0		
PA0026182	Lansdale Borough STP	Lansdale	PA	2.6		
PA0039004	Upper Gwynedd Towam. STP	Lansdale	PA	6.5		
PA0026468	Morrisville Mun. Auth. Water	Morrisville	PA	10.0		
PA0027421	Norristown Borough WWTP	Norristown	PA	9.8		
PA0020532	Upper Montgomery Joint Sewer	Pennsburg	PA	2.0		
PA0026689	Northeast WPCP	Philadelphia	PA	210.0		
PA0026662	Philadelphia Southeast POTW	Philadelphia	PA	112.0		
PA0026671	Southwest Water Pollution Cntrol	Philadelphia	PA	200.0		
PA0026549	Reading WWTP	Reading	PA	28.5		
PA0027031	Goose Creek STP	West Chester	PA	1.7		
PA0026018	West Chester Taylor Run STP	West Chester	PA	1.8		
PA0028584	West Goshen STP	West Chester	PA	6.0		
PA0023256	Upper Gwynedd Twp. WWTP	West Point	PA	5.7		
PA0025976	Upper Moreland Hatboro Sewer	Willow Grove	PA	7.2		
Pennsylvania			**PA**	**699.8**	**$2,799,200**	**$1,021,708,000**
Del. Estuary				**1,020.5**	**$4,082,000**	**$1.489,857,000**

Water Supply

Drinking Water Supply

The Delaware Estuary watershed covers just 0.2% of the continental U.S. yet supplies drinking water to 2% of the U.S. population. Table 11 provides a framework for measuring the economic benefits of groundwater reserve stock to generate ecosystem services (USEPA 1995).

Table 11. Groundwater services and effects (USEPA 2005)

Services	Effects
Drinking Water	Increase of decrease in availability of drinking water Change in human health or health risks
Water for Crop Irrigation	Change in value of crops or production costs Change in human health or health risks
Water for Livestock/Poultry	Change in Value of livestock products or production Change in human health or health risks

Rivers, creeks, and aquifers provide significant public drinking water supply (764 mgd) in the Delaware Estuary watershed with 70% from Pennsylvania (552 mgd), 20% from New Jersey (170 mgd), and almost 10% from Delaware (42 mgd) as depicted in Figure 4. Largest public water suppliers in the Delaware Estuary watershed include United Water Delaware and the City of Wilmington in Delaware; New Jersey American Water Co., City of Trenton, and City of Camden in New Jersey; and City of Philadelphia and Aqua Pennsylvania in Pennsylvania (Table 12).

The annual value of raw (untreated) public water supplies in the Delaware Estuary watershed (764 mgd) is $279 million. Water purveyors in Delaware estimate the value of raw water supply is $1.00/1000 gal from 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 $1.3 billion (Tables 13 and 14). The average value of treated drinking water based on rates set by public and private water purveyors in Delaware, New Jersey, Pennsylvania, and Maryland is $4.78 per 1000 gallons (Corrozi and Seymour 2008).

Table 12. Value of public drinking water supplies in the Delaware Estuary watershed by state

State	Withdrawal[1] (mgd)	Value/day untreated[2] ($1.00/1000 gal)	Value/year untreated ($1.00/1000 gal)	Value/year treated[3] ($4.78/1000 gal)
Delaware	42	$42,000	$ 15,330,000	$ 73,277,000
New Jersey	170	$170,000	$ 62,050,000	$296,599,000
Pennsylvania	552	$552,000	$201,480,000	$963,074,000
Delaware Estuary	**764**	**$764,000**	**$278,860,000**	**$1,332,950,000**

1. DRBC 2010. 2. UDWRA 2010. 3. Corrozi and Seymour 2008.

Table 13. Largest public water withdrawals in the Delaware Estuary watershed (DRBC 2010)

Water Purveyor	Withdrawal (mgd)
Delaware	
United Water Delaware	18.5
City of Wilmington	10.4
City of Dover	4.7
City of Newark	2.2
City of Milford	1.9
Lewes Board of Public Works	1.0
Tidewater Utilities	0.6
Dover Air Force Base	0.4
New Castle Mun. Services Comm.	0.4
Town of Smyrna	0.4
Harrington	0.4
Camden-Wyoming Water Authority	0.3
Town of Milton	0.2
Milford Boro Water Dept.	0.2
New Jersey	
NJ American Water Co.	39.4
City of Trenton	26.1
City of Camden	10.9
City of Vineland	8.3
Aqua New Jersey	6.3
Merchantville-Pennsauken Water	6.1
Washington Twp. MUA	4.8
Willingboro Twp. MUA	4.7
Mount Holly Water	4.5
City of Bridgeton	3.6
City of Wildwood	3.6
Evesham Twp. MUA	2.8
Millville City Water Dept.	2.6
Moorestown Twp.	2.5
Pennsylvania	
City of Philadelphia	287.8
Aqua Pennsylvania, Inc.	102.2
North Wales Water Authority	15.1
Bucks Co. Water and Sewer Auth.	15.0
Reading Area Water Authority	14.3
Bucks Co. Water and Sewer Auth.	13.8
Penna. American Water Co.	10.1
North Penn Water	8.6
Pennsylvania-American Water Co.	7.3
Schuylkill Co. Municipal. Authority	5.1
Pottstown Water Authority	4.6
Schuylkill Co. MUA	4.4
Phoenixville Municipal Waterworks	3.0

Table 14. Value of public drinking water supplies in the Delaware Estuary by watershed

Watershed	Withdrawal[1] (mgd)	Value/day untreated[2] ($1.00/1000 gal)	Value/year untreated ($1.00/1000 gal)	Value/year treated[3] ($4.78/1000 gal)
Schuylkill Valley	263	$263,000	$95,995,000	458,856,000
Upper Estuary	390	$390,000	$142,350,000	680,433,000
Lower Estuary	78	$78,000	$28,470,000	136,086,000
Delaware Bay	33	$33,000	$12,045,000	57,575,000
Delaware Estuary	**764**	**$764,000**	**$278,860,000**	**1,332,950,000**

1. DRBC 2010. 2. UDWRA 2010. 3. Corrozi and Seymour 2008.

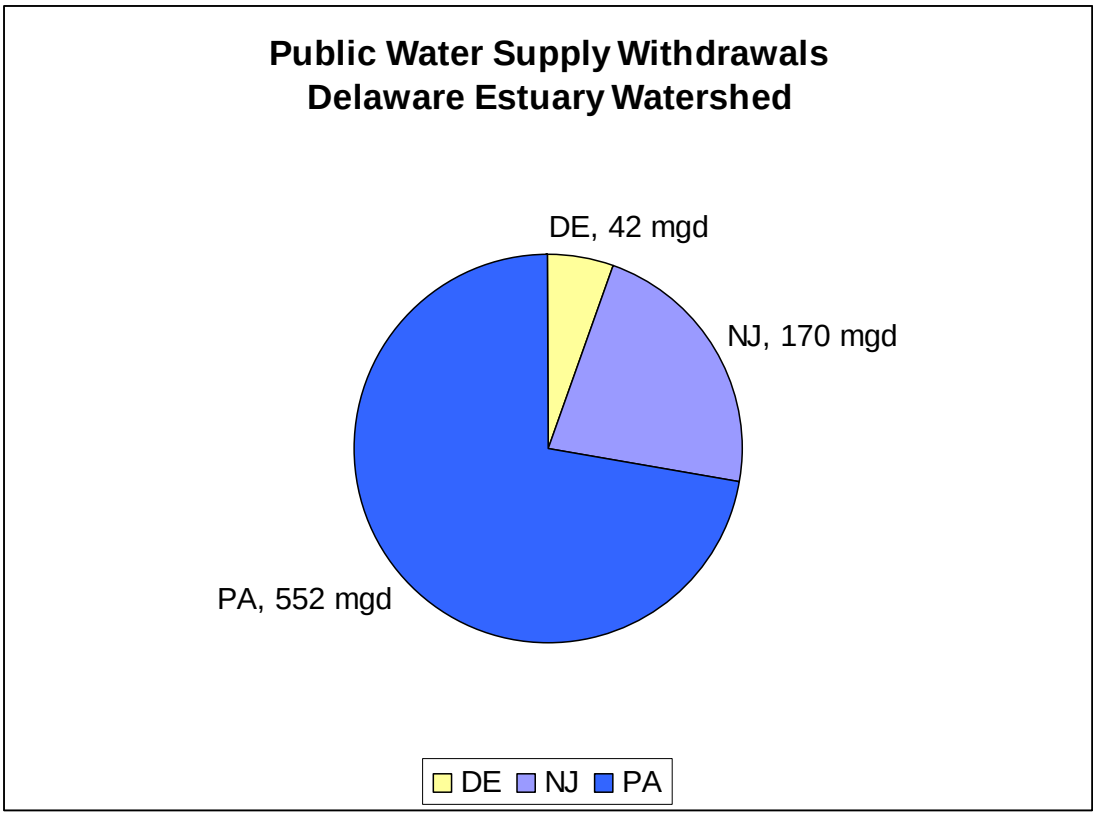


Figure 4. Public water supply withdrawals in the Delaware Estuary watershed (DRBC 2010)

Irrigation Water Supply

Resources for the Future in a study of the economic value of freshwater in the United States estimated the median market value of irrigation water withdrawals is $198/ac-ft in $1996 (Frederick et al. 1996) or $300/ac-ft ($0.92/1000 gal) in $2010 adjusting for 3% annually (Table 15). In 2007, over 188,309 acres of cropland were irrigated in the counties in the Delaware Estuary watershed (USDA 2007). Approximately 1,112,580 acres or 26% of the Delaware Estuary watershed is farm land, therefore, by proportion about 135,310 acres are irrigated in the watershed (Table 16). Annual irrigation water needs from June through September are 9 inches in the estuary watershed for corn, soybeans, and grain (2,600 gpd/acre or 417 mgd)). The total annual value of water demand to

irrigate 135,310 acres for agriculture, golf courses, and nurseries is $30.5 million or $13.8 million in Delaware, $14.8 million in New Jersey, and $1.9 million in Pennsylvania. The value of irrigation water demand = (9 in/12 in/ft) (135,310 ac) ($300/ac-ft) = $30,445,000/yr.

Table 15 Freshwater use values in the United States

Use	1996 Median[1] ($/ac-ft)	2010 Median[2] ($/ac-ft)	2010 Median ($/1000 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 at 3% annually.

Table 16. Value of agriculture irrigation in the Delaware Estuary watershed

County	Cropland by county[1] (ac)	Irrigation by county[1] (ac)	Farmland in estuary (ac)	Irrigated land in estuary (ac)	Value of irrigation[2] @ $300/ac-ft
New Castle	51,913	2,711			
Kent	146,536	29,066			
Sussex	234,324	72,785			
Delaware	**432,773**	**104,562**	**254,143**	**61,403**	**$13,816,000**
Burlington	85,790	12,620			
Camden	8,760	2,647			
Cape May	7,976	2,342			
Cumberland	69,489	18,357			
Gloucester	46,662	12,891			
Mercer	21,736	1,028			
Ocean	9,833	1,090			
Salem	96,530	18,001			
New Jersey	**346,776**	**68,976**	**330,114**	**65,662**	**$14,774,000**
Berks	170,760	1,260			
Bucks	58,012	1,421			
Chester	117,145	1,659			
Delaware	1,646	36			
Lancaster	326,648	5,366			
Lebanon	89,566	1,276			
Lehigh	72,737	1,189			
Montgomery	28,563	668			
Philadelphia	150	0			
Schuylkill	81,276	1,896			
Pennsylvania	**946,503**	**14,771**	**528,323**	**8,245**	**$1,855,000**
Total	**1,726,052**	**188,309**	**1,112,580**	**135,310**	**30,445,000**

1. Census of Agriculture 2007 (USDA 2009). 2. Frederick et al. 1996.

Thermoelectric Power Water Supply

Thermoelectric power plants which evaporate water during cooling produce over 89% of the energy in the U.S. The Delaware Estuary watershed provides 5,833 mgd of cooling water to run nuclear, coal, and gas-fired power plants that generate 11,578 megawatts of electricity. About 95% of cooling water returns to the river (nonconsumptive) and 5% evaporates (consumptive). The median $1996 economic value of thermoelectric power water withdrawals is $29/ac-ft ($0.09/1000 gal) with a range of $9 to $63/ac-ft (Frederick et al. 1996). Adjusting for 3% annually, the median $2010 value of thermoelectric plant withdrawals is $44 per ac-ft or $0.14/1000 gal. The annual value of power plant water withdrawals is nearly $300,000,000 or $409,000 in Del., $197,000,000 in NJ, and $101,000,000 in Pa. (Table 17). Table 18 lists power plant water withdrawals in the watershed from Energy Information Admin. (2002), National Energy Technology Lab (2009), and DRBC sources.

Table 17. Value of thermoelectric power withdrawals in the Delaware Estuary

Watershed	Withdrawal[1] (mgd)	$/day[2] ($0.14/1000 gal)	$/year ($0.14/1000 gal)
Schuylkill Valley	232	$32,480	$11,855,200
Upper Estuary	1,461	$204,540	$74,657,100
Lower Estuary	3,226	$451,640	$164,848,600
Delaware Bay	914	$127,960	$46,705,400
Delaware Estuary	**5,833**	**$816,620**	**$298,066,300**

1. DRBC 2010. 2. Frederick et al. 1996 adjusted to $2010 at 3% annually)

Table 18. Thermoelectric power withdrawals in the Delaware Estuary watershed

State/Power Plant	Type	Capacity (MW)	Withdrawal[1] (mgd)	Value/day[2] ($0.14/1000 gal)	Value/year ($0.14/1000 gal)
Delaware		**1,009**	**8**	**1,120**	**408,800**
Delmarva Delaware City		9		0	0
Conectiv Edgemoor	Coal/Gas	1,000	8	1,120	408,800
New Jersey		**4,838**	**3,848**	**538,720**	**196,632,800**
PSEG Salem 1 and 2	Nuclear	2,275	3,200	448,000	163,520,000
PSEG Hope Creek	Nuclear	1,268	67	9,380	3,423,700
Chambers Cogeneration Salem	Coal	285		0	0
Logan Generating	Coal	242	19	2,660	970,900
PSEG Mercer Trenton	Coal	768	562	78,680	28,718,200
Pennsylvania		**5,731**	**1,977**	**276,780**	**101,024,700**
PECO Chester	Coal	56		0	0
PECO Cromby	Coal	417	353	49,420	18,038,300
PECO Croyden	Coal	546		0	0
PECO Delaware (Phila.)	Coal	392	90	12,600	4,599,000
PECO Eddystone	Coal	1,448	1,470	205,800	75,117,000
PECO Fairless Hills	Coal	75		0	0
PECO Falls	Coal	64		0	0
PECO Limerick	Nuclear	2,230	42	5,880	2,146,200
PECO Moser	Coal	64		0	0
PECO Richmond (Phila.)	Coal	132		0	0
PECO Schuylkill (Phila.)	Oil	233	22	3,080	1,124,200
PECO Southwark (Phila.)	Coal	74		0	0
Del. Estuary watershed		**11,578**	**5,833**	**816,620**	**298,066,300**

1. EIA 2002, NETL 2009, DRBC 2010. Frederick et al. 1996 and adjusted to $2010 at 3% annually.

Industrial Water Supply

Industrial water withdrawals allocated by DRBC total 630 mgd in the Delaware Estuary watershed (Table 19). A study of the economic value of freshwater in the United States indicates the median market value of industrial withdrawals is $132/ac-ft in $1996 (Frederick et al. 1996) or $200/ac-ft ($0.61/1000 gal) in $2010 adjusting for 3% annually. The value of industrial withdrawals based on DRBC allocated supplies is $384,135 per day or $140,209,295 per year.

Table 19. Value of industrial water withdrawals in the Delaware Estuary by watershed

Watershed	Withdrawal [1] (mgd)	Value/day[2] ($0.61/1000 gal)	Value/year ($0.61/1000 gal)
Schuylkill Valley	40	$24,565	$8,966,164
Upper Estuary	132	80,703	29,456,676
Lower Estuary	446	271,849	99,225,009
Delaware Bay	12	7,018	2,561,445
Del. Estuary	**630**	**$384,135**	**$140,209,295**

1. DRBC 2010. 2. Frederick et al. 1996 adjusted to $2010 at 3% annually.

Fish/Wildlife

The annual value of commercial fish landings for Delaware Estuary species is $25.4 million in $2000 or $34 million in $2010 reported to the National Marine Fisheries Service and National Ocean Economics Program (2007). Table 20 ranks the most lucrative fisheries in $2010 as blue crab ($14.4 million/yr), summer flounder ($5.3 million/yr), Atlantic menhaden ($4.3 million/yr), Eastern oyster ($3.7 million/yr), striped bass ($2.3 million/yr), and American eel ($0.8 million/yr). Figure 5 and Table 21 show fish landings by weight/revenue for Delaware Estuary species.

Table 20. Value of fish landings in the Delaware Estuary0

Delaware Estuary Species[1]	Value ($2000)[2]	Value ($2010)[3]
Crab, Blue	$10,800,297	$14,472,398
Flounder, Summer	$3,999,988	$5,359,984
Menhaden, Atlantic	$3,200,359	$4,288,481
Oyster, Eastern	$2,721,300	$3,646,542
Bass, Striped	$1,717,372	$2,301,278
Eel, American	$625,511	$838,185
Herring, Atlantic	$563,083	$754,531
Bluefish	$508,128	$680,892
Whelk,Chan'd/Knob	$511,172	$684,970
Weakfish	$261,228	$350,046
Shad, American	$119,423	$160,027
Perch, White	$84,500	$113,230
Shellfish	$76,119	$101,999
Perch, Yellow	$71,847	$96,275
Snails (Conchs)	$59,016	$79,081
Crab, Horseshoe	$48,978	$65,631
Total	**$25,422,840**	**$34,066,606**

1. Dove and Nyman 1995. 2. NMFS and NOEP 2007. 3. adjusted to $2010 at 3% annually.

Table 21. Fish landings and landed value in the Delaware Estuary

	Delaware		New Jersey		Pennsylvania		Delaware Estuary	
Delaware Estuary Species[1]	**Pounds**	**Value ($2000)**	**Pounds**	**Value ($2000)**	**Pounds**	**Value ($2000)**	**Pounds[2]**	**Value[2] ($2000)**
Bass, Striped	188,671	$429,994	564,000	$1,287,000	211	$378	752,882	$1,717,372
Bluefish	19,565	$8,075	1,403,717	$500,053			1,423,282	$508,128
Carp. Common	3,764	$865			6,724	$26,805	10,488	$27,670
Catfish, Channel	6,922	$3,929					6,922	$3,929
Crab, Blue	3,799,820	$5,329,182	4,636,368	$5,471,115			8,436,188	$10,800,297
Crab, Horseshoe	229,602	$48,978					229,602	$48,978
Drum, Black	37,712	$21,867	1,518	$444			39,230	$22,311
Eel, American	139,648	$315,094	159,292	$310,417			298,940	$625,511
Flounder, Summer	5,464	$11,119	1,697,513	$3,988,869			1,702,977	$3,999,988
Herring, Blueback	1,434	$609					1,434	$609
Herring, Atlantic			6,039,473	$563,083			6,039,473	$563,083
Menhaden, Atlantic	85,080	$6,635	37,634,929	$3,193,724			37,720,009	$3,200,359
Oyster, Eastern	79,933	$490,465	444,227	$2,230,835			524,160	$2,721,300
Perch, White	55,973	$46,865	27,527	$29,654	4,560	$7,981	88,060	$84,500
Perch, Yellow					20,527	$71,847	20,527	$71,847
Shad, American	71,445	$42,408	58,981	$77,015			130,426	$119,423
Shellfish	30,130	$76,119					30,130	$76,119
Snails (Conchs)			30,250	$59,016			30,250	$59,016
Weakfish	24,604	$36,177	164,506	$225,051			189,110	$261,228
Whelk,Chan'd/Knob	277,217	$511,172					277,217	$511,172
Total	**5,056,984**	**$7,379,553**	**52,862,301**	**$17,936,276**	**32,022**	**$107,011**	**57,951,307**	**$25,422,840**

1. Dove and Nyman 1995. 2. NMFS and National Ocean Economics Program 2007.

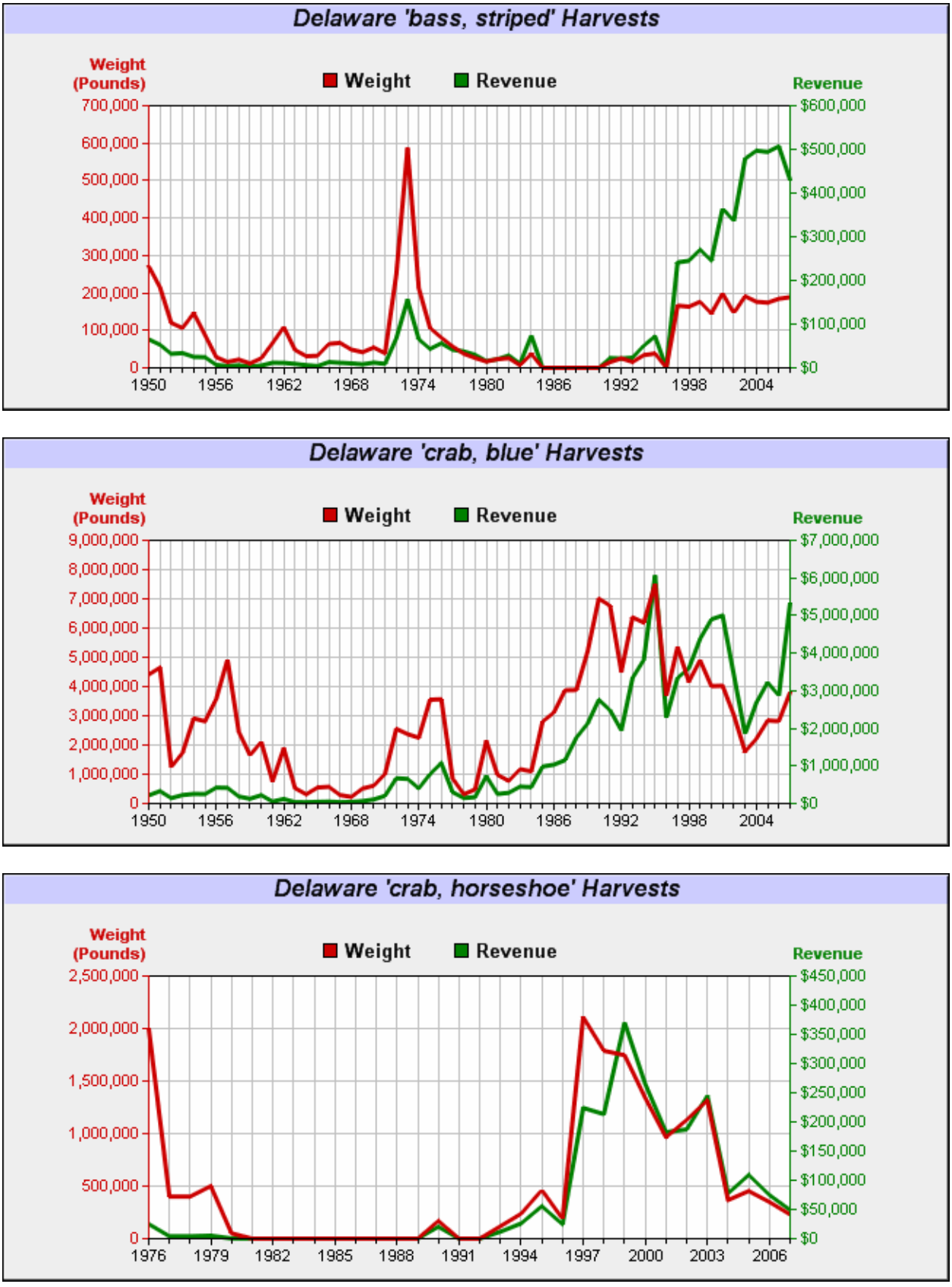


Figure 5. Fish landings in the Delaware Estuary (NMFS and NOEP 2007)

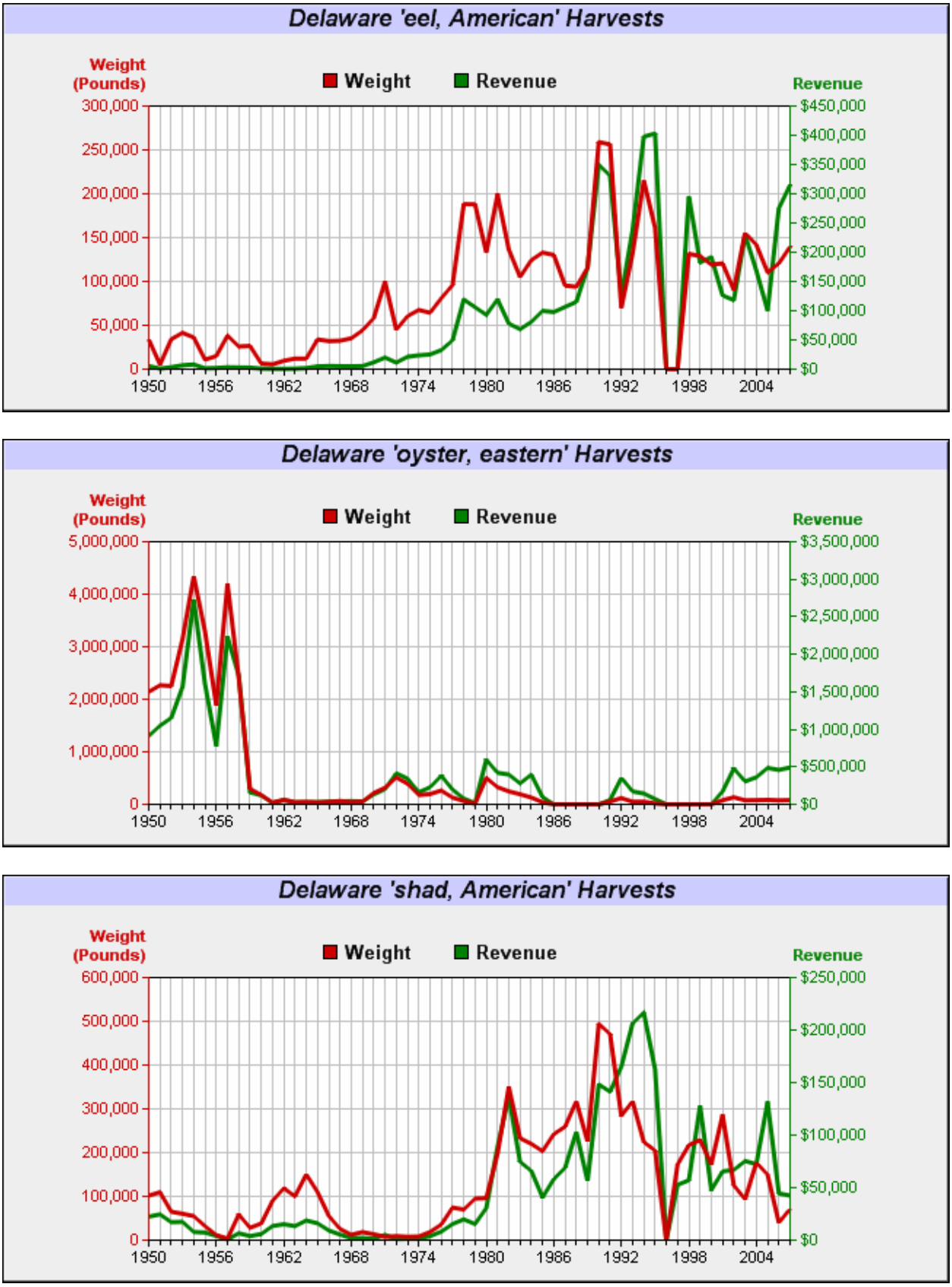


Figure 5. Fish landings in the Delaware Estuary, con't. (NMFS and NOEP 2007)

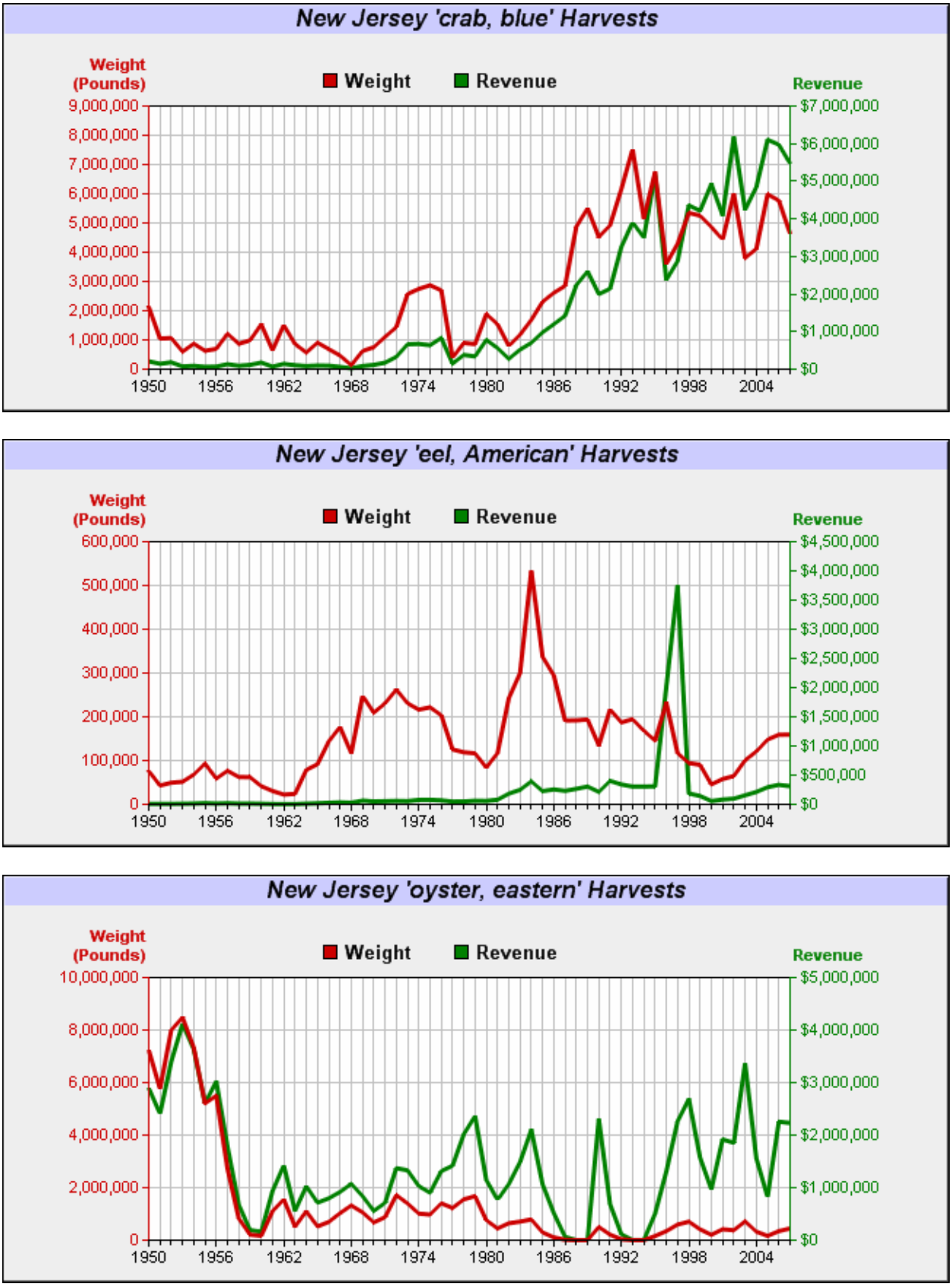


Figure 5. Fish landings in the Delaware Estuary, con't. (NMFS and NOEP 2007)

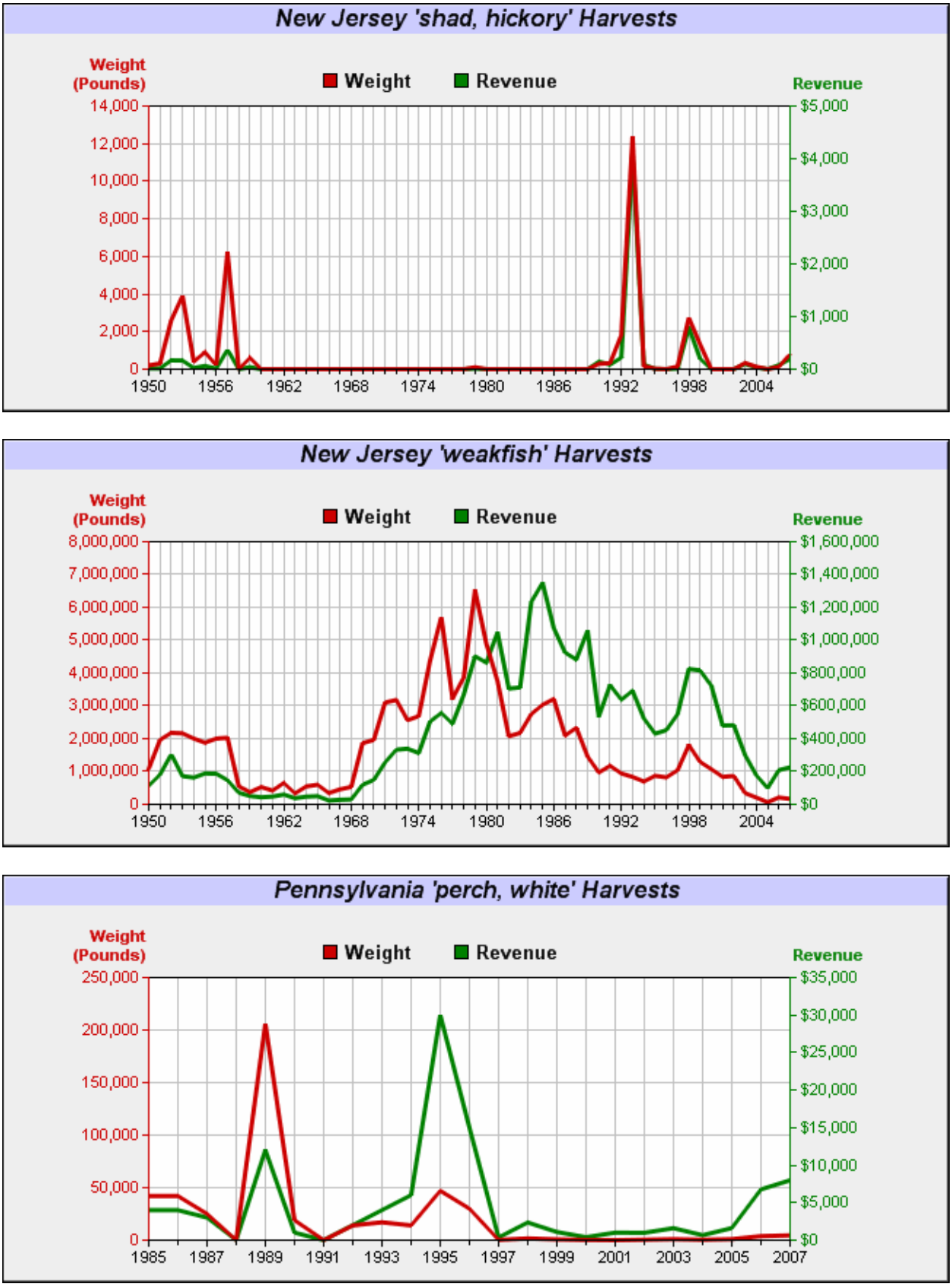


Figure 5. Fish landings in the Delaware Estuary, con't. (NMFS and NOEP 2007)

Fishing, Hunting, and Bird/Wild-life Watching

In Delaware, New Jersey, and Pennsylvania, the U. S. Fish and Wildlife Service (2008) estimated the annual economic value of recreational fishing, hunting, birding and wildlife-associated activities was $6.1 billion in $2006. 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 birding/wildlife recreation occurs on farms, forests, wetlands, and open water ecosystems such as the Prime Hook and Bombay Hook National Wildlife Refuges in Delaware, the Cape May National Wildlife Refuge and Pine Barrens National Reserve in New Jersey, state parks/forests in Pennsylvania and along Delaware River/Bay.

The Delaware Estuary watershed covers 50% of Delaware's land area, 26% of New Jersey's area, and 7% of Pennsylvania's area. Prorating for the ratio of estuary watershed to state land area, the estimated economic value of fishing, hunting, and wild-life associated recreation in the Delaware Estuary watershed is $812 million annually in $2006 or $134 million in Delaware, $373 million in New Jersey, and $304 million in Pennsylvania (Table 22).

Table 22. Value of fishing, hunting, and wildlife recreation in Delaware Estuary watershed

Recreation Activity	DE by state[1] ($M)	NJ by state[1] ($M)	PA by state[1] ($M)	DE in estuary[2] ($M)	NJ in estuary[2] ($M)	PA in estuary[2] ($M)	Del. Estuary ($M)
Fishing	**96.7**	**752.3**	**1,291.2**	**48.4**	**195.6**	**90.4**	**334.3**
Trip Related	48.5	471.2	298.6	24.3	122.5	20.9	167.7
Equipment/other	48.2	281.1	992.6	24.1	73.1	69.5	166.7
Hunting	**41.3**	**145.9**	**1,609.1**	**20.7**	**37.9**	**112.6**	**171.2**
Trip Related	13.6	72.6	274.2	6.8	18.9	19.2	44.9
Equipment/other	27.7	73.3	1,334.9	13.9	19.1	93.4	126.4
Wildlife/Birding	**130.8**	**537.4**	**1,442.6**	**65.4**	**139.7**	**101.0**	**306.1**
Trip Related	13.1	146.3	325.0	6.6	38.0	22.8	67.3
Equipment/other	117.7	391.1	1,117.6	58.9	101.7	78.2	238.8
Total	**268.8**	**1,435.6**	**4,342.9**	**134.4**	**373.3**	**304.0**	**811.7**

1. USFWS 2008, in $2006. 2. Prorated ratio of estuary watershed to state: Del. (50%), NJ (26%), Pa.(7%).

Agriculture

In the counties of the Delaware Estuary watershed, the USDA National Agricultural Statistics Service (2010) estimates the annual market value of agricultural products sold is $4.1 billion on 1,726,000 acres (2,697 sq mi) for crops such as corn, wheat, oats, barley, soybeans, potatoes, and vegetables, livestock, and poultry (Table 23). On 1,112,580 acres (1,738 sq mi) of cropland within the Delaware Estuary watershed, the prorated annual market value of agricultural products sold is $2.5 billion or $2,300 per acre. The Delaware Estuary watershed covers 5,931 sq mi or just 11% of the combined land areas of Delaware (1,953 sq mi), New Jersey (7,417 sq mi), and Pennsylvania (44,816 sq mi) yet accounts for $2.5 billion or 32% of total annual farm products sold in the three states (Table 23).

Table 23. Value of cropland and agriculture in the Delaware Estuary watershed

County	Farmland by county[1] (ac)	Cropland value by county[1] ($ million)	Cropland value by county ($/ac)	Farmland in estuary watershed[2] (ac)	Crop value in estuary watershed ($ million)
New Castle	51,913	45.7	880		
Kent	146,536	188.4	1,286		
Sussex	234,324	848.9	3,623		
Delaware	**432,773**	**$1,083.0**	**$2,502**	**254,143**	**636**
Burlington	85,790	86.3	1,006		
Camden	8,760	18.6	2,123		
Cape May	7,976	14.6	1,830		
Cumberland	69,489	156.9	2,258		
Gloucester	46,662	93.9	2,012		
Mercer	21,736	18.6	856		
Ocean	9,833	11.5	1,170		
Salem	96,530	80.0	829		
New Jersey	**346,776**	**$480.4**	**$1,385**	**330,114**	**458**
Berks	170,760	367.8	2,154		
Bucks	58,012	70.6	1,217		
Chester	117,145	553.3	4,723		
Delaware	1,646	9.4	5,711		
Lancaster	326,648	1,072.1	3,282		
Lebanon	89,566	257.1	2,871		
Lehigh	72,737	72.1	991		
Montgomery	28,563	30.0	1,050		
Philadelphia	150	0.5	3,333		
Schuylkill	81,276	124.7	1,534		
Pennsylvania	**946,503**	**$2,557.6**	**$2,702**	**528,323**	**1,428**
Total	**1,726,052**	**$4,121.0**	**$2,388**	**1,112,580**	**2,522**

1. Census of Agriculture 2007 (USDA 2009). 2. NOAA CSC 2006

Table 24. Farm products sold in the Delaware Estuary watershed

State	State area (sq mi)	Area in estuary watershed (sq mi)	Ratio area state/area watershed (%)	Farm products sold in state ($ million)	Farm products in watershed ($ million)	Products in state/ watershed (%)
Delaware	1,953	977	50%	$1,083	$ 635	59%
New Jersey	7,417	1,942	26%	$ 987	$ 457	46%
Pennsylvania	44,816	3,011	7%	$5,808	$1,428	25%
Total	**54,186**	**5,931**	**11%**	**$7,878**	**$2,520**	**32%**

Forests

The U. S. Forest Service and Delaware Center for Horticulture (Nowak et al. 2008) estimated 7,137 acres of forests in New Castle County provide environmental benefits such as carbon storage of $5.9 million ($827/ac), and air pollution removal of $1.9 million ($266/ac/yr). Applying these multipliers, 1,186,784 acres (1,854 sq mi) of forests in the Delaware Estuary watershed have benefits of carbon storage ($981 million), carbon sequestration ($34 million), air pollution removal ($316 million), and building energy savings ($66 million). In addition, forests in the Delaware Estuary watershed provide environmental benefits by regulating climate change, cooling, and air emissions control including 47 million tons of carbon storage capacity, 1.7 million tons of carbon sequestration, 47,471 tons of air pollution removal, 1166,150 tons of avoided carbon emissions capacity (Table 25 and 26).

Table 25. Economic and environmental benefits of forests in the Delaware Estuary watershed

Benefits	Forests New Castle County[1]		Forests Del. Estuary watershed[2]	
	Environ. (tons/ac)	Economic ($/ac)	Environ. (tons)	Economic ($)
Carbon storage	40	$827	47,471,360	$981,470,368
Carbon Sequestration	1.4	$29	1,661,498	$34,416,736
Air Pollution Removal	0.04	$266	47,471	$315,684,544
Building Energy Savings		$56		$66,459,904
Avoided Carbon Emissions	0.14	$3	166,150	$3,560,352

1. Nowak et al. 2008. 2. Computed for 1,186,784 acres of forests in Del. Estuary watershed

Table 26. Economic benefits of forests in the Delaware Estuary watershed by state

Forest Benefits	Delaware ($)	New Jersey ($)	Pennsylvania ($)	Del. Estuary ($)
Carbon Storage	78,850,902	274,788,584	627,830,709	981,470,195
Carbon Sequestration	2,765,026	9,635,875	22,015,829	34,416,730
Air Pollution Control	25,361,959	88,384,236	201,938,293	315,684,488
Energy Savings	5,339,360	18,607,208	42,513,325	66,459,893
Avoided Carbon Emissions	286,037	996,815	2,277,500	3,560,352

Public Parks

The Trust for Public Land (2009) found 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/ac).
- Community cohesion benefit from people socializing in the parks ($1,058,000 or $2,383/ac).
- Water pollution benefit from parks in treating stormwater ($409,000 or $921/ac).
- Air pollution mitigation value from tree and shrub absorption ($39,000 or $88/ac).

Assuming the data gathered for the City of Wilmington study is appropriate for value (benefits) transfer, public parks within the Delaware Estuary watershed provide the following annual economic benefits (Table 27):

- Health benefits from exercise in the parks ($1,056,601,092).
- Community cohesion benefit from people socializing in the parks ($258,668,626).
- Water pollution benefit from parks in treating stormwater ($99,972,222).
- Air pollution mitigation value from tree and shrub absorption ($9,552,178).

Table 27. Value of public parks in the Delaware Estuary watershed

State/county	Parks in watershed (ac)	Health Benefits ($9,734/ac)	Community Cohesion ($2,383/ac)	Stormwater Benefit ($921/ac)	Air Pollution ($88/ac)
Kent	4,587	44,646,735	10,930,056	4,224,332	403,628
New Castle	12,440	121,091,328	29,644,610	11,457,275	1,094,723
Sussex	1,389	13,525,327	3,311,162	1,279,723	122,275
Delaware[1]	**18,416[1]**	**179,263,390**	**43,885,829**	**16,961,330**	**1,620,626**
Burlington	7,970	77,577,441	18,991,888	7,340,130	701,337
Camden	2,985	29,052,307	7,112,353	2,748,837	262,647
Cape May	2,911	28,336,856	6,937,202	2,681,143	256,179
Cumberland	2,640	25,694,659	6,290,361	2,431,147	232,292
Gloucester	4,868	47,381,152	11,599,475	4,483,053	428,348
Mercer	8,283	80,629,463	19,739,060	7,628,902	728,929
Salem	2,144	20,872,042	5,109,726	1,974,846	188,693
New Jersey[2]	**31,800[2]**	**309,543,921**	**75,780,066**	**29,288,057**	**2,798,425**
Berks	3,979	38,730,881	9,481,784	3,664,592	350,146
Bucks	11,402	110,987,999	27,171,194	10,501,330	1,003,384
Chester	12,020	117,000,556	28,643,140	11,070,219	1,057,741
Delaware	6,274	61,066,383	14,949,783	5,777,906	552,069
Montgomery	14,138	137,620,541	33,691,160	13,021,216	1,244,155
Philadelphia	9,689	94,317,149	23,089,970	8,923,987	852,672
Schuylkill	829	8,070,273	1,975,700	763,583	72,959
Pennsylvania[3]	**58,331[3]**	**567,793,781**	**139,002,731**	**53,722,835**	**5,133,126**
Total	**108,547**	**1,056,601,092**	**258,668,626**	**99,972,222**	**9,552,178**

1. State, county, municipal park land in Delaware from county/local comprehensive plans.
2. County/municipal park land from NJ State Comprehensive Outdoor Recreation Plan (SCORP).
3. County/municipal parks in Pa. from DVRPC 2007 and Berks/Schuylkill comprehensive plans.

Maritime Transportation

Navigation

The 130-mile long Delaware River and Bay ship channel from Cape Henlopen to head of tide at Trenton has significant instream navigation use value. The water resource value that transports shipping is distinct from port activities described below. The Delaware River port includes Wilmington, Chester, Paulsboro, Camden, Philadelphia, and Trenton. The volume of the 720-sq mi Delaware Estuary at mean depth of 32 feet is 14.7 million ac-ft (4.8 trillion gallons). Frederick et al (1996) concluded the median instream navigation use value in the U.S. is $10/ac-ft in $1996 or $15/ac-ft in $2010 adjusting for 3% annually. The instream navigation use value of the Delaware Estuary from ocean to Trenton is $220.5 million.

Port Activity

For over 300 years since the time of William Penn, the Delaware River has been an economic engine that is now the largest freshwater port in the world. The Economy League of Greater Philadelphia (2008) reported the Delaware River ports from Wilmington to Philadelphia to Trenton:

- Are collectively the largest freshwater port in the world.
- Employ 4,056 workers who earn $326 million in wages.
- Provide port jobs that support two indirect jobs in port activity and employee spending to total 12,121 port jobs with $772 million in wages and $2.4 billion in annual economic output.
- Support 4,056 direct port jobs in cargo handling and warehousing with petroleum port jobs adding up to less than 10% of employment.
- Provides good jobs, the average salary of a port employee (with benefits) is over $80,000.
- Generate $81 million in tax revenues to Delaware, Pennsylvania, New Jersey (Table 28).
- Import 1/2 of the Nation's cocoa beans, 1/3 of the bananas, and 1/4 of all fruit and nuts.
- Rank 5th among ports in the USA in import cargo value and 20th in export value.
- Handle 16% of the container trade in the U.S. and 51% of container trade value nationwide.
- Load petroleum accounts for 65% of the port's imports while fruits and nuts account for 4%.

The Economy League reports that nearly 2,900 ships (8 per day) docked at Delaware River ports in 2006, up 10% from 1995. Most shipping traffic were tankers, containers, bulk, refrigerated (meat/fruits/vegetables) and auto transport vessels (Table 29).

Table 28. Tax revenues from Delaware River ports, 2005
(Economy League of Greater Philadelphia 2008)

Type	DE	NJ	PA	Total
Individual Income Tax	$2,538,803	$6,679,380	$13,102,579	$22,320,762
Sales and Use Tax		5,326,255	13,851,735	$19,177,990
Corporate Income Tax	888,055	1,988,447	3,632,195	$6,508,697
Selective Tax	1,075,499	2,674,104	7,807,469	$11,557,072
Other State Tax, License, Fees	2,536,226	1,597,420	5,199,444	$9,333,090
Total State and Local Tax	**7,038,582**	**18,266,605**	**55,974,357**	**$81,279,544**

Table 29. Delaware River port vessel calls, 1996-2000
(Economy League of Greater Philadelphia 2008)

Year	General	Container	Roll on	Refrg	Bulk	Tanker	Chem Gas	Auto	Passengr	Total
1995	304	368	84	333	405	812	138	110	16	2,570
2006	248	581	78	373	402	861	144	121	39	2,847
change	-56	213	-6	40	-3	49	6	11	23	277
% change	-18%	-58%	-7%	12%	-1%	6%	4%	10%	144%	11%

Top Delaware River exports (Table 30) are motor vehicles (31%) and petroleum products (12%). Top imports are petroleum (65%) and iron and steel (7%). Delaware River ports at Philadelphia, Chester, and Camden are the 6th, 35th, and 37th largest ports in the U.S. based on import value of goods and cargo (Table 31). Delaware River combined imports total $41 billion as the 5th largest port in the U.S. after Los Angeles, Newark (NJ), Houston, and Long Beach (CA) and ahead of

Seattle, Norfolk (VA), and Baltimore. Delaware River ports have combined exports of $6.4 billion as the 20th largest port in the U.S. after Oakland (CA) and Baltimore but ahead of Charleston (SC).

Table 30. Top exports and imports at Delaware River ports
(Economy League of Greater Philadelphia 2008)

Cargo	Exports	Imports
Motor Vehicles	31%	
Petroleum	12%	65%
Precious stones/Metals	7%	
Industrial Machinery	6%	2%
Plastics	6%	
Iron and Steel		7%
Fruits and Nuts		4%
Meat		3%

Table 31. Rank of Delaware River imports and exports in the United States, 2005
(Economy League of Greater Philadelphia 2008)

Imports Rank in U.S.	Port	Imports ($))
6	Philadelphia	$29,500,000,000
35	Chester	$5,700,000,000
37	Wilmington	$5,500,000,000
79	Paulsboro	$250,000,000
103	Camden	67,000,000
5	**Delaware R.**	**$41,017,000,000**
Exports Rank in U.S.	**Port**	**Exports ($)**
22	Philadelphia	$2,400,000,000
24	Wilmington	$2,200,000,000
32	Chester	$1,600,000,000
74	Camden, NJ	$150,000,000
84	Paulsboro, NJ	$89,000,000
20	**Delaware R.**	**$6,439,000,000**

4. Ecosystem Services

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

- 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 Univ. of Maryland and Nature Conservancy (2008)
- Economic value of ecosystem services in Massachusetts by the Audubon Society (2003).

Related Research

Ecosystem services include air filtration, water filtration, recycling nutrients, soil conservation, pollinating crops and plants, climate regulation, carbon sequestration, flood/stormwater control, and hydrologic cycle regulation. Ecological resources provide marketable goods and services such as timber, fish and wildlife recreation, hiking, and boating/kayaking. 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 32).

Table 32. Ecosystem services values for Cecil County (Weber 2007)

Ecosystem Service	Upland Forest ($/ac/yr)	Riparian Forest Wetlands ($/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**	**28,146**

The N.J. Dept. of Environmental Protection (2007) partnered with the University of Vermont and estimated the value of New Jersey's natural capital was $20 billion/year in $2004 with a net present value (NPV) of $681 billion based on a discount rate of 3% calculated in perpetuity. Net present

value 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. In New Jersey, farm products, fish, minerals, and water supply provide the most valuable ecosystem goods and soil regulation, water protection, habitat, recreation, waste treatment, and water supply provide the highest ecosystem services (Table 33).

Table 33. Ecosystem goods and services provided by New Jersey natural capital (NJDEP 2007)

Ecosystem	$ million/yr	%
Natural Goods	**$5,864**	**100%**
Farm products	3,676	63%
Commercial/recreational fish	958	16%
Minerals	587	10%
Raw Water	381	7%
Saw timber	147	3%
Fuelwood	95	2%
Game/fur animals	21	1%
Ecoservices	**$19,803**	**100%**
Nutrient cycling	5,074	26%
Disturbance regulation	3,383	17%
Water regulation	2,433	12%
Habitat	2,080	11%
Aesthetic/recreational	1,999	10%
Waste treatment	1,784	9%
Water supply	1,739	9%
Cultural//spiritual	778	4%
Gas/climate regulation	246	1%
Pollination	243	1%
Biological control	35	<1%
Soil formation	8	<1%

The Wilderness Society (Krieger 2001) concluded forest ecosystem services for climate regulation, water supply, water quality, and recreation benefits totaled $392/ac in $1994 (Table 34). A contingent value study by University of Rhode Island economists found natural resources values in the Peconic Estuary watershed in Suffolk County on Long Island New York ranged from $6,560/ac for wetlands to $9,979/ac for farmland in $1995 (Johnston et al. 2002). The University of Maryland studied the U.S. National Wildlife Refuge System and determined ecosystem values of freshwater wetlands and forests were $6,268/ac and $845/ac, respectively (Ingraham and Foster 2008). The Audubon Society found the economic value of ecosystems in Massachusetts ranged from $984/ac for forests to $15,452/ac for saltwater wetlands (Breunig 2003).

The USDA Census of Agriculture (2009) indicates the market value (natural goods) of crops, poultry, and livestock sold from 1,726,052 acres of farmland in counties in the Delaware Estuary watershed was $4.1 billion ($2,388/ac). Agricultural goods sold from 432,773 acres of watershed farmland in Del. was $1.1 billion ($2,502/ac). The market value of agriculture from 346,776 farm acres in NJ was $0.5 billion ($1,385/ac) and from 946,503 acres in Pa. was $2.6 billion ($2,702/ac).

Table 34. Forest ecosystem service values for U.S. temperate forests (Krieger 2001)

Ecosystem Good or Service	1994 Value ($/ac)	2010 Value[1] ($/ac)
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. $2010 computed at 3% annually.

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

Table 35. Comparison of ecosystem goods and services values from various studies

Ecosystem	Cecil Co. Md. 2006 ($/ac/yr)	NJDEP 2004 ($/ac/yr)	Wilderness Soc. 2001 ($/ac/yr)	Peconic Est. 1995 ($/ac/yr)	US Wildlife 2008 ($/ac/yr)	Mass Aud.2003 ($/ac/yr)	USDA[1] 2007 ($/ac/yr)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	2,388
Forest land	12,033	1,714	641		845	984	
Saltwater wetland	28,146	6,269		$6,560		12,580	
Undeveloped				$2,080			
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).

Delaware Estuary Watershed

The estimated value of ecosystem goods and services in the Delaware Estuary watershed is $12.1 billion ($2010) with a net present value (NPV) of $392 billion (Table 36). The ecosystems services

value of the Delaware Estuary watershed in Delaware, New Jersey, and Pennsylvania is $2.5 billion, $5.3 billion, and $4.1 billion, respectively, in $2010 (Figure 6). NPV is based on an annual discount rate of 3% over a perpetual life time (over 100 years).

The estimated value of Delaware Estuary natural goods (commodities for sale such as water supply, farm crops, fish, timber, and minerals) is $3.3 billion with NPV of $106 billion (Table 37). The estimated value of natural services (ecological benefits to society such as flood control by wetlands, water filtration by forests, and fishery habitat by beach and marine areas) is $8.8 billion with NPV of $286 billion (Table 42). Ecosystem services areas within the Delaware Estuary watershed are comprised of forests (32%), farmland (30%), freshwater wetlands (8%), saltwater wetlands (4%), and open water/marine (4%). Almost 23% of the Delaware Estuary watershed is urban (Figure 7).

Freshwater wetlands, farms, forests, and saltwater wetlands provide the highest total ecosystems goods and services values (Table 38 and Figure 8). Ecosystems that provide the highest natural good values are farmland ($2.7 billion or $2,388/ac/yr) followed by forest ($326 million or $275/ac), and freshwater wetlands ($85 million or $270/ac). Freshwater wetlands ($4.2 billion or $13,351/ac), forests ($2.0 billion or $1,703/ac) and saltwater wetlands ($1.0 billion or $7,076/ac) provide the highest natural ecosystem services values.

The DB2 Delaware Bay ($2.5 billion), UE2 New Jersey Coastal Plain ($2.1 billion), DB1 Delaware Bay ($1.9 billion), SV3 Schuylkill above Philadelphia ($1.2 billion), SV2 Schuylkill above Valley Forge ($1.1 billion), and LE3 Salem River ($710 million) watersheds provide the highest values of annual ecosystem services (Table 39 and Figure 9). Watersheds with high amounts (>75%) of forests and wetlands have the highest ecosystem services per acre and include the DB2 Delaware Bay ($5,038/ac), DB1 Delaware Bay ($4,797/ac), LE3 Salem River ($4,378/ac), LE2 C&D Canal ($3,941/ac), UE2 NJ Coastal Plain ($3,244), and SV2 Schuylkill abv. Valley Forge ($2,580/ac).

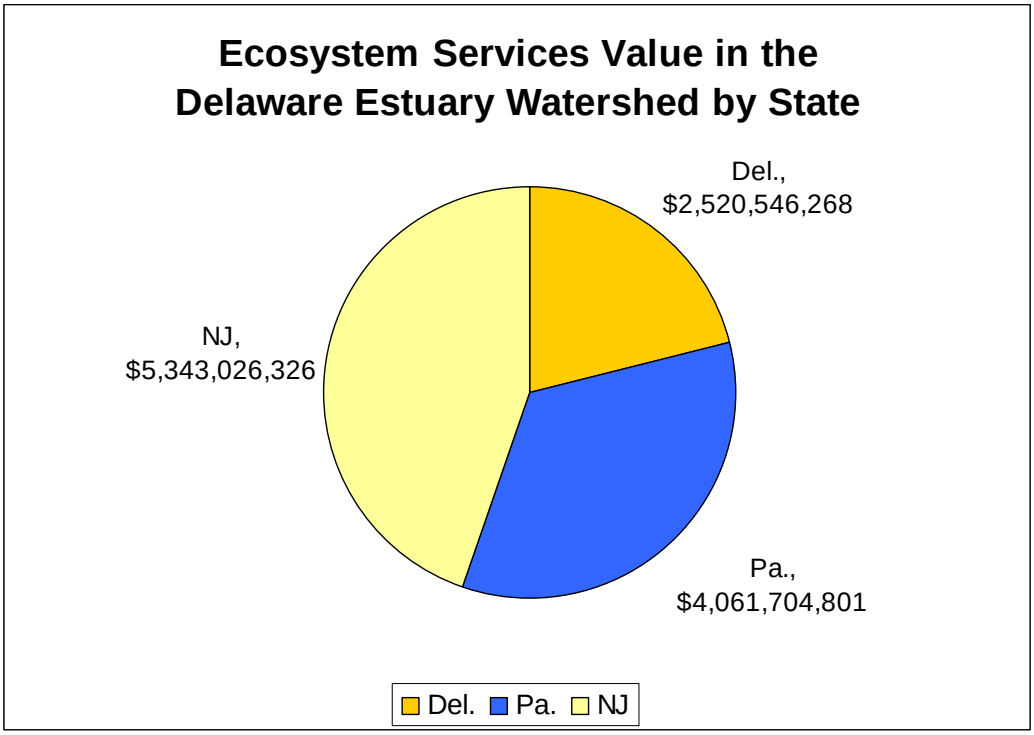


Figure 6. Ecosystem service value in the Delaware Estuary watershed by state

Table 36. Ecosystem goods and services value of the Delaware Estuary watershed

Ecosystem	Area (ac)	$/ac/yr 2010	PV 2010 $	NPV $
Del. Estuary watershed				
Freshwater wetlands	317,213	13,621	4,320,647,087	140,421,030,319
Marine	16,588	10,006	165,982,947	5,394,445,767
Farmland	1,112,580	3,215	3,577,486,604	116,268,314,632
Forest land	1,186,784	1,978	2,347,605,465	76,297,177,613
Saltwater wetland	145,765	7,235	1,054,617,851	34,275,080,170
Barren land	18,630	0	0	0
Urban	865,778	342	295,761,123	9,612,236,487
Beach/dune	900	48,644	43,758,633	1,422,155,566
Open water	131,388	1,946	255,655,983	8,308,819,443
Total ac	**3,795,626**		**12,061,515,692**	**391,999,259,997**
Delaware				
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	3,329	846,164,877	27,500,358,509
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
Total ac	**625,435**		**2,520,546,268**	**81,917,753,719**
New Jersey				
Freshwater wetlands	230,773	13,621	3,143,278,480	102,156,550,594
Marine	314	10,006	3,142,040	102,116,307
Farmland	330,114	2,212	730,372,720	23,737,113,392
Forest land	332,272	1,978	657,274,347	21,361,416,286
Saltwater wetland	83,563	7,235	604,583,594	19,648,966,813
Barren land	6,603	0	0	0
Urban	201,846	342	68,953,315	2,240,982,722
Beach/dune	499	48,644	24,253,858	788,250,378
Open water	57,132	1,946	111,167,973	3,612,959,116
Total ac	**1,243,115**		**5,343,026,326**	**173,648,355,608**
Pennsylvania				
Freshwater wetlands	28,049	13,621	382,051,245	12,416,665,469
Marine	0	10,006	0	0
Farmland	528,323	3,529	1,864,710,711	60,603,098,101
Forest land	759,167	1,978	1,501,725,484	48,806,078,236
Saltwater wetland	585	7,235	4,231,672	137,529,329
Barren land	9,723	0	0	0
Urban	540,884	342	184,773,031	6,005,123,491
Beach/dune	145	48,644	7,074,943	229,935,659
Open water	60,200	1,946	117,137,716	3,806,975,755
Total ac	**1,927,076**		**4,061,704,801**	**132,005,406,039**

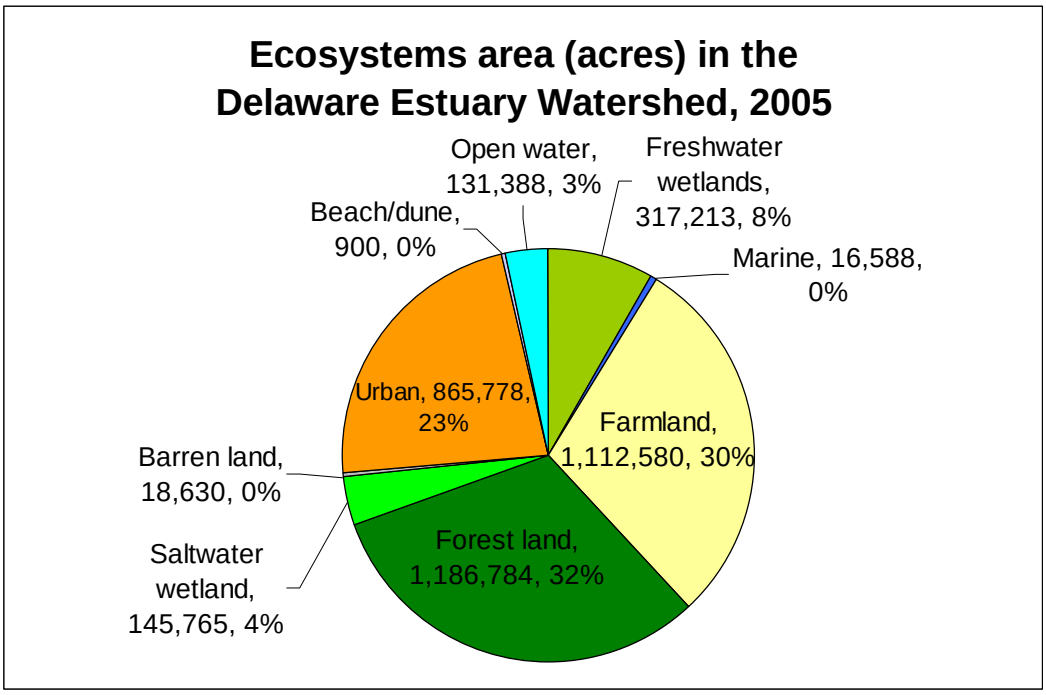


Figure 7. Ecosystem service areas within the Delaware Estuary watershed

Table 37. Ecosystem goods value of the Delaware Estuary watershed

Ecosystem/Goods	Area (ac)	2004 ($/ac/yr)	2004 ($/yr)	2010 ($/ac/yr)	2010 ($/yr 2010)	NPV ($)
Freshwater wetlands	317,213	234	74,227,760	270	85,666,109	2,784,148,542
Marine	16,588	1,125	18,661,829	1,298	21,537,580	699,971,336
Farmland	1,112,580			2,388	2,656,840,052	86,347,301,676
Forest land	1,186,784	238	282,454,542	275	325,980,222	10,594,357,218
Saltwater wetland	145,765	139	20,261,377	160	23,383,615	759,967,482
Barren land	18,630	0	0	0	0	0
Urban	865,778	13	11,255,118	15	12,989,509	422,159,035
Beach/dune	900	0	0	0	0	0
Open water	131,388	921	121,008,348	1,063	139,655,492	4,538,803,503
Total	**3,795,626**				**3,266,052,578**	**106,146,708,793**

Table 38. Ecosystem services value of the Delaware Estuary watershed

Ecosystem/Services	Area (ac)	2004 ($/ac/yr)	2004 ($/yr)	2010 ($/ac/yr)	2010 ($/yr)	NPV $
Freshwater wetlands	317,213	11,568	3,669,515,914	13,351	4,234,980,978	137,636,881,777
Marine	16,588	7,544	125,142,079	8,707	144,426,223	4,693,852,233
Farmland	1,112,580	717	797,719,563	827	920,646,552	29,921,012,956
Forest land	1,186,784	1,476	1,751,692,874	1,703	2,021,625,243	65,702,820,395
Saltwater wetland	145,765	6,131	893,687,073	7,076	1,031,402,464	33,520,580,080
Barren land	18,630	0	0	0	0	0
Urban	865,778	283	245,015,253	327	282,771,614	9,190,077,452
Beach/dune	900	42,149	37,915,873	48,644	43,758,633	1,422,155,566
Open water	131,388	765	100,511,820	883	116,000,490	3,770,015,939
Total	**3,795,626**				**8,795,612,197**	**285,857,396,399**

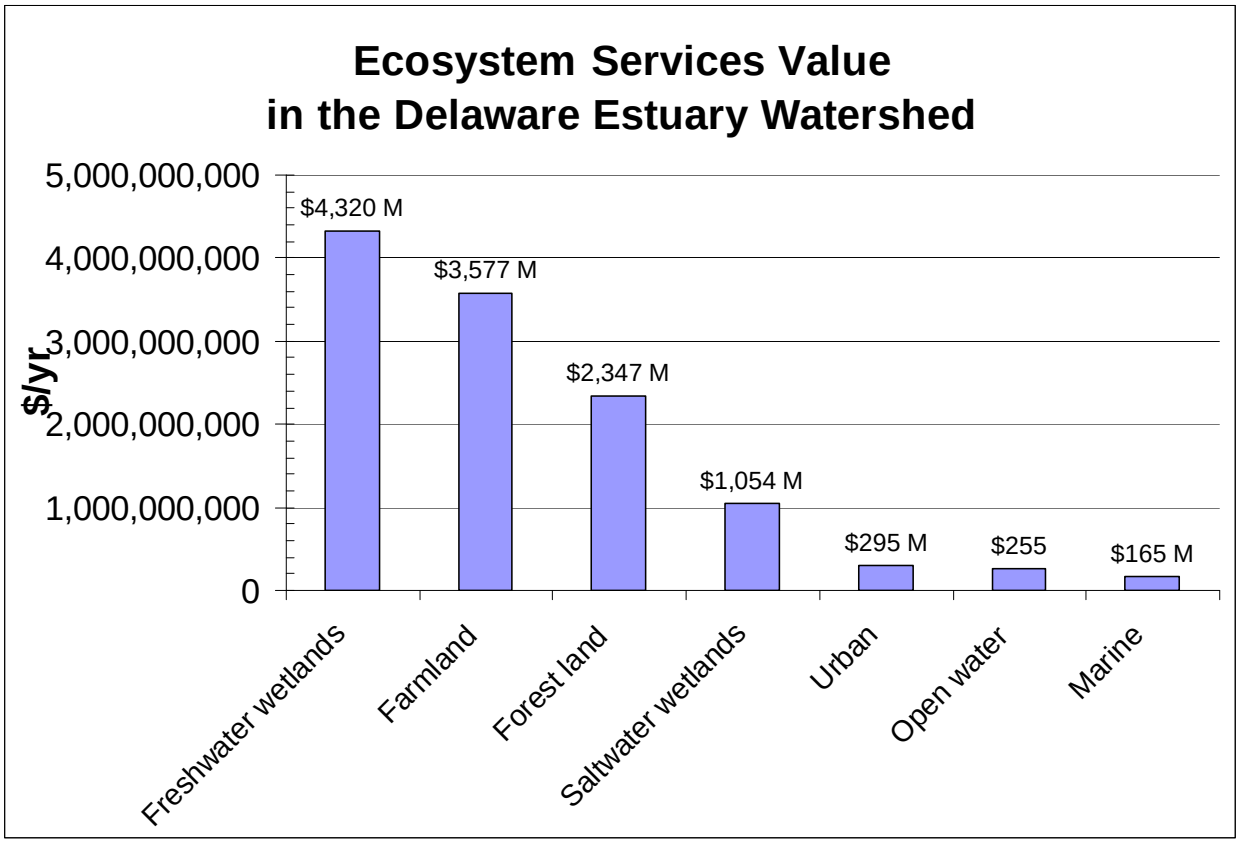
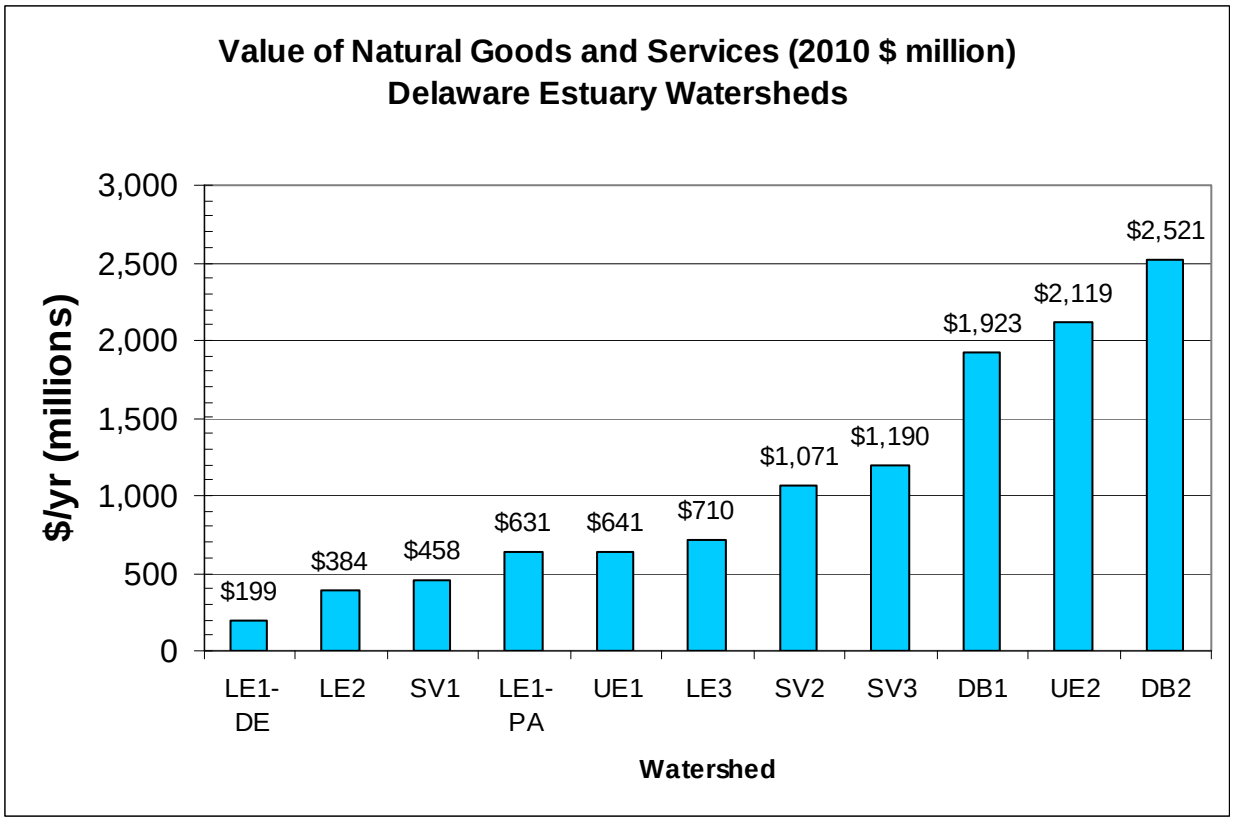
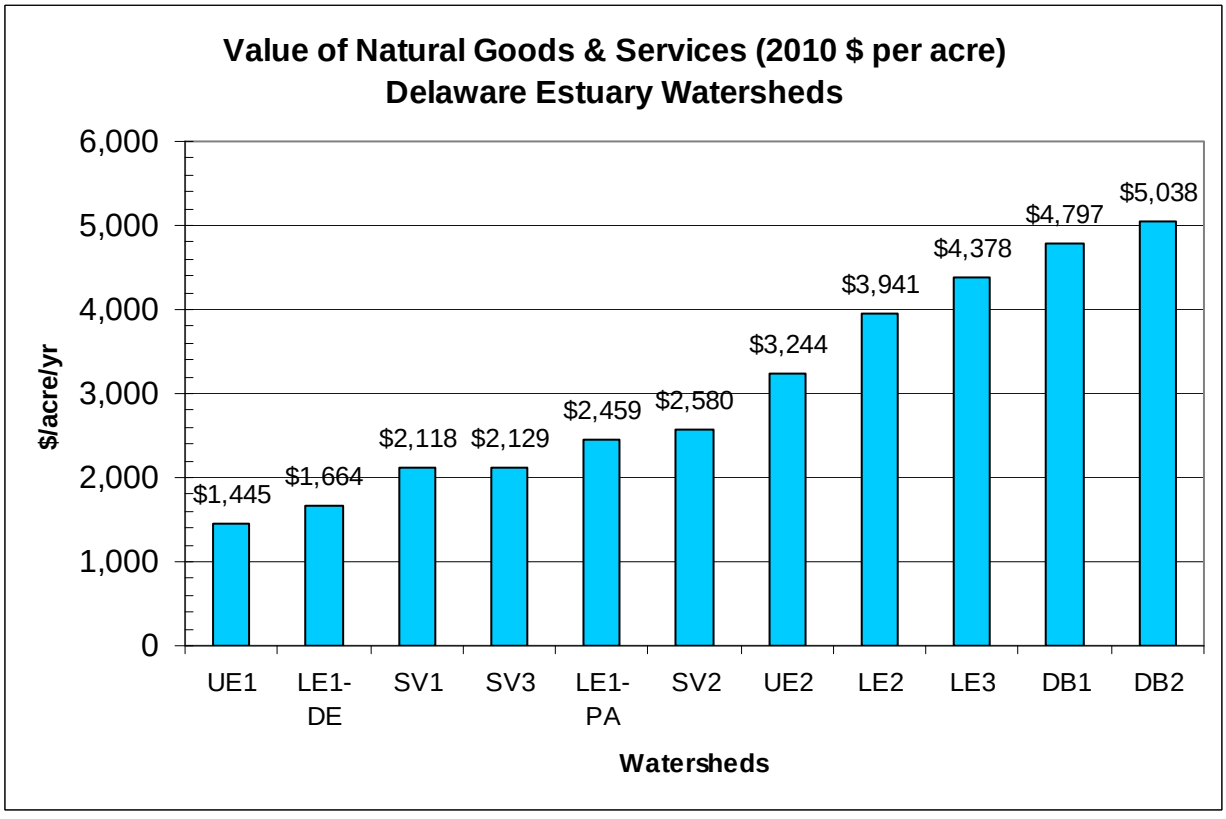


Figure 8. Ecosystem service value of habitat in the Delaware Estuary watershed

Table 39. Ecosystem goods and services value of watersheds in the Delaware Estuary watershed

Watershed	Area (sq mi)	2010 $/yr	2010 $/ac/yr
LE1 Brandywine/Christina	189	199,035,649	1,664
LE2 C&D Canal	154	384,011,292	3,941
DB1 Delaware Bay	634	1,922,732,778	4,797
Delaware	**977**		
UE2 New Jersey Coastal Plain	964	2,118,829,970	3,244
LE3 Salem River	240	710,403,036	4,378
DB2 Delaware Bay	738	2,521,208,766	5,038
New Jersey	**1943**		
SV1 Schuylkill above Reading	345	457,568,087	2,118
SV2 Schuylkill above Valley Forge	662	1,071,317,363	2,580
SV3 Schuylkill above Philadelphia	891	1,190,234,564	2,129
UE1 Penna Fall Line	706	641,100,447	1,445
LE1 Brandywine/Christina	409	630,949,322	2,459
Pennsylvania	**3011**		
Delaware Estuary watershed	**5,931**	**$12,061,515,692**	**$3,178**





9. Value of natural goods and services in Delaware Estuary watersheds

Ecosystem services in the Delaware Estuary watershed using NJDEP and USDA farm good values are worth $12.1 billion or $392.0 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 NJDEP values, ecosystems services in the Delaware Estuary watershed would be $5.7 billion or NPV = $184 billion (Table 40). If higher per acre estimates from other studies were used, the value of ecosystems in the Delaware Estuary would be $44.0 billion or NPV = $1.4 trillion (Table 41).

Estimate	**PV $B**	**NPV $B**
Low	5.7	184
NJDEP	12.1	392
High	44.0	1,400

Table 40. Low range estimate of ecosystem goods/services in the Delaware Estuary watershed

Ecosystem	Area (ac)	$/ac/yr	PV $	NPV $
Freshwater wetlands	317,213	6,268[5]	1,988,288,879	64,619,388,565
Marine	16,588	8,670[2]	143,820,496	4,674,166,116
Farmland	1,112,580	1,387[6]	1,543,147,886	50,152,306,292
Forest land	1,186,784	641[3]	760,728,410	24,723,673,310
Saltwater wetland	145,765	6,269[2]	913,802,685	29,698,587,269
Barren land	18,630	0	0	0
Urban	865,778	296[2]	256,270,371	8,328,787,059
Beach/dune	900	42,149[2]	37,915,873	1,232,265,862
Open water	131,388	217[5]	28,511,196	926,613,870
Total	**3,795,626**		**5,672,485,795**	**184,355,788,343**

Table 41. High range estimate of ecosystem goods/services in the Delaware Estuary watershed

Ecosystem	Area (ac)	$/ac/yr	PV $	NPV $
Freshwater wetlands	317,213	43,685[1]	13,857,434,537	450,366,622,440
Marine	16,588	8,670[2]	143,820,496	4,674,166,116
Farmland	1,112,580	9,979[4]	11,102,431,690	360,829,029,912
Forest land	1,186,784	12,033[1]	14,280,569,348	464,118,503,801
Saltwater wetland	145,765	28,146[1]	4,102,710,221	133,338,082,193
Barren land	18,630	0	0	0
Urban	865,778	296[2]	256,270,371	8,328,787,059
Beach/dune	900	42,149[2]	37,915,873	1,232,265,862
Open water	131,388	1,686[2]	221,520,168	7,199,405,460
Total	**3,795,626**		**44,002,672,703**	**1,430,086,862,843**

1. Cecil Co., Md. 2006. 2. NJDEP 2004. 3. Wilderness Society 2001. 4. Peconic Estuary 1995. 5. U. S. Nat'l. Wildlife Refuge 2008. 6. Mass Audubon Society 2003.

5. Jobs and Wages

The Delaware Estuary watershed is a jobs engine with water resources and habitat that supports over 500,000 direct and indirect jobs with $10 billion in annual wages in the coastal, farm, ecotourism, water/wastewater, recreation, and port industries (Table 42).

Table 42. Jobs and wages directly and indirectly related to the Delaware Estuary watershed

Sector	Jobs	Wages ($ million)	Data Source
Direct Estuary Related	192,785	4,280	U.S. Bureau of Labor Statistics (2009)
Indirect Estuary Related	231,342	3,420	U.S. Census Bureau (2009)
Coastal	44,658	947	National Coastal Econ. Program (2009)
Farm	28,276	1,159	USDA Census of Agriculture (2007)
Fishing/Hunting/Birding	24,713	812	U.S. Fish and Wildlife Service (2008)
Water Supply Utilities	2,290	127	UDWRA and DRBC (2010)
Wastewater Utilities	1,021	51	UDWRA and DRBC (2010)
Watershed Organizations	150	8	UDWRA and DRBC (2010)
Port Jobs	12,121	772	Economy League of Greater Phila. (2008)
Delaware Estuary watershed	**> 500,000**	**>$10 billion**	

Jobs and wages in the Delaware Estuary watershed were obtained from U. S. Bureau of Labor Statistics (2009) and U. S. Census Bureau (2009) data bases as summarized in Tables 43-45. Note the NAICS data base does not include jobs for certain known water-related industries, such as commercial fishing and boat building, and the column are left blank. Hence, the number of estuary-related jobs is likely undercounted. Delaware Estuary-related jobs are tabulated for four scenarios:

1. Jobs in Delaware Estuary counties including portions of counties outside the watershed.
2. Jobs in counties within the Delaware Estuary watershed determined by NAICS code (formerly SIC code) and then grouped by census tract.
3. Direct Delaware Estuary-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 state and county within the watershed boundary.
4. 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 job funds 1.2 indirect jobs and a dollar in direct wages funds $0.80 in indirect wages.

U. S. Bureau of Labor Statistics (2009) indicates there were 3,220,901 jobs in Delaware Estuary watershed counties (including areas just outside watershed) with wages of $163.7 billion including:

- Delaware (394,918 jobs, $18.8 billion in wages)
- New Jersey (836,735 jobs, $40.9 billion in wages)
- Pennsylvania (1,989,248 jobs, $104.0 billion in wages)

The Delaware Estuary watershed contained 2,898,106 jobs earning $149.0 billion in wages including:

- Delaware (317,997 jobs, $15.9 billion in wages)
- New Jersey (684,645 jobs, $33.2 billion in wages)
- Pennsylvania (1,895,464 jobs, $99.9 billion in wages)

Jobs directly associated with the Delaware Estuary watershed (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employed 192,785 people with $4.3 billion in wages including:

- Delaware (15,737 jobs, $340 million in wages)
- New Jersey (52,007 jobs, $1.1 billion in wages)
- Pennsylvania (125,041 jobs, $2.8 billion in wages)

Jobs indirectly related to the Delaware Estuary watershed (based on multipliers of 2.2 for jobs and 1.8 for salaries) employed 231,342 people with $3.4 billion in wages including:

- Delaware (18,884 jobs, $270 million in wages)
- New Jersey (62,408 jobs, $910 million in wages)
- Pennsylvania (150,049 jobs, $2.2 billion in wages)

Table 43. Delaware Estuary watershed jobs and wages, 2009

State/County	(1) County Jobs	(2) Estuary Jobs	(3) Direct Jobs	(4) Indirect Jobs	(1) County Wages $ billion	(2) Estuary Wages $ billion	(3) Direct Wages $ billion	(4) Indirect Wages $ billion
Delaware	**394,918**	**317,997**	**15,737**	**18,884**	**18.8**	**15.9**	**0.34**	**0.27**
Kent	60,145	50,450			2.2	1.9		
New Castle	266,134	253,998			14.3	13.6		
Sussex	68,639	13,549			2.3	0.5		
New Jersey	**836,735**	**684,645**	**52,007**	**62,408**	**40.9**	**33.2**	**1.14**	**0.91**
Burlington	194,944	188,186			9.4	9.1		
Camden	196,160	169,356			9.2	7.9		
Cape May	40,857	12,511			1.4	0.4		
Cumberland	59,892	59,765			2.5	2.5		
Gloucester	99,392	89,446			4.1	3.7		
Mercer	223,876	143,767			13.3	8.5		
Salem	21,614	21,614			1.1	1.1		
Pennsylvania	**1,989,248**	**1,895,464**	**125,041**	**150,049**	**104**	**99.9**	**2.8**	**2.24**
Berks	160,684	152,159			6.6	6.2		
Bucks	249,559	206,704			11.1	9.2		
Chester	235,763	217,042			13.7	12.6		
Delaware	203,468	203,468			9.8	9.8		
Montgomery	467,768	467,571			27	27		
Philadelphia	622,304	621,120			34.1	34		
Schuylkill	49,702	27,400			1.7	0.9		
Delaware Estuary watershed	**3,220,901**	**2,898,106**	**192,785**	**231,342**	**163.7**	**149**	**4.28**	**3.42**

Jobs and wages: (1) in Delaware Estuary counties, (2) in the Delaware Estuary watershed, (3) direct estuary related, and (4) indirect estuary related, in 2009.

Table 44. Direct estuary related jobs within the Delaware Estuary watershed by state, 2009

Sector	Industry	1997 NAICS Code	DE Jobs	DE Wages (x$1,000)	NJ Jobs	NJ Wages (x$1,000)	PA Jobs	PA Wages (x$1,000)
Construction	Marine Related	237120			81	4,532	923	58,999
	Water and Sewer	23711	529	21,838	1,520	99,955	3,083	208,417
	Construction	237990	126	5,678	318	19,547	306	16,427
Living Resources	Fish Hatcheries	112511						
	Aquaculture	112512						
	Fishing	11411			0	0		
	Finfish Fishing	114111			111	5,591		
	Shellfish Fishing	114112			28	995		
	Seafood Markets	445220	39	1,447	81	1,550	283	6,348
	Seafood Process.	31171			97	6,734		
	Comm. Fisheries		0	0	0	0	0	0
Minerals	Sand & Gravel	212321			166	8,109		
		212322	0	0	81	3,865		
	Oil & Gas	541360	16	752			39	3,802
Ship/Boat Building	Boat Bldg. Repair	336612						
	Shipbuilding		0	0	0	0	0	0
Tourism/Recreation	Recreation	487990			52	1,184		
		611620	64	513	305	5,301	675	12,270
		532292			50	774		
	Amusement	713990	250	4,102	832	14,503	1,503	25,136
	Boat Dealers	441222	198	7,489	157	5,945		
	Restaurants	722110	3,714	173,787	20,582	332,081	55,089	907,378
		722211	6,797	4,102	14,697	190,314	31,766	422,438
		722212	265	3,876	312	4,717	1,138	18,281
		722213	942	13,509	2,388	32,495	7,628	119,695
	Hotels & Lodging	721110	650	11,673	2,323	52,310	6,965	243,253
		721191			92	1,583		
	Marinas	713930			202	6,410		
	RV Park/Camps	721211	105	3,611	339	11,894	39	494
	Scenic Tours	487210	18	393	34	738		
	Sporting Good	339920			20	787	16	960
	Zoos, Aquaria	712130					55	1,959
		712190			58	3,411	466	28,459
Transportation	NavigationShipping	488330	39	2,856	0	0	44	2,585
	Marine Cargo	488320	954	34,378	1,823	71,222	904	43,155
	Search/Navigation	334511					672	58,785
	Warehousing	493110	313	13,739	2,396	95,952	8,477	336,427
		493120			361	14,120	337	14,571
	Ports		0	0	0	0	0	0
	Dredging/Disposal		0	0	0	0	0	0
Environmental	Environ. Organiz.	813312	83	2,976	37	1,804	595	21,367
	Environ. Consult.	54162	205	10,745	726	54,723	1,421	90,104
Water/Wastewater	Water/Sewage	2213	267	20,004	122	5,856	180	11,219
	Waste Managment	562	146	6,028	1,530	74,498	2,200	107,389
	Septic Tank	562991	17	644	86	3,873	237	9,059
Total			**15,737**	**344,140**	**52,007**	**1,137,373**	**125,041**	**2,766,392**

Table 45. Direct estuary related and indirect jobs within the Delaware Estuary watershed, 2009

Sector	Industry	1997 NAICS Codes	Direct Jobs	Direct Wages (x$1,000)	Indirect Jobs[1]	Indirect Wages[2] (x$1,000)
Construction	Marine Related	237120	1,004	63,531	1,205	50,825
	Water and Sewer	23711	5,132	330,210	6,158	264,168
	Construction	237990	750	41,652	900	33,322
Living Resources	Aquaculture	112512	0	0	0	0
	Finfish Fishing	114111	111	5,591	133	4,473
	Shellfish Fishing	114112	28	995	34	796
	Seafood Markets	445220	403	9,345	484	7,476
	Seafood Process.	31171	97	6,734	116	5,387
	Comm. Fisheries		0	0	0	0
Minerals	Sand & Gravel	212321	166	8,109	199	6,487
		212322	81	3,865	97	3,092
	Oil & Gas	541360	55	4,554	66	3,643
Ship/Boat Building	Boat Bldg. Repair	336612	0	0	0	0
	Shipbuilding		0	0	0	0
Tourism/Recreation	Recreation	487990	52	1,184	62	947
		611620	1,044	18,084	1,253	14,467
		532292	50	774	60	619
	Amusement	713990	2,585	43,741	3,102	34,993
	Boat Dealers	441222	355	13,434	426	10,747
	Restaurants	722110	79,385	1,413,246	95,262	1,130,597
		722211	53,260	616,854	63,912	493,483
		722212	1,715	26,874	2,058	21,499
		722213	10,958	165,699	13,150	132,559
	Hotels & Lodging	721110	9,938	307,236	11,926	245,789
		721191	92	1,583	110	1,266
	Marinas	713930	202	6,410	242	5,128
	RV Park/Camps	721211	483	15,999	580	12,799
	Scenic Tours	487210	52	1,131	62	905
	Sporting Good	339920	36	1,747	43	1,398
	Zoos, Aquaria	712130	55	1,959	66	1,567
		712190	524	31,870	629	25,496
Transportation	NavigationShipping	488330	83	5,441	100	4,353
	Marine Cargo	488320	3,681	148,755	4,417	119,004
	Search/Navigation	334511	672	58,785	806	47,028
	Warehousing	493110	11,186	446,118	13,423	356,894
		493120	698	28,691	838	22,953
	Ports		0	0	0	0
	Dredging/Disposal		0	0	0	0
Environmental	Environ. Organiz.	813312	715	26,147	858	20,918
	Environ. Consult.	54162	2,352	155,572	2,822	124,458
Water/Wastewater	Water/Sewage	2213	569	37,079	683	29,663
	Waste Managment	562	3,876	187,915	4,651	150,332
	Septic Tank	562991	340	13,576	408	10,861
Total			**192,785**	**4,247,905**	**231,342**	**3,398,324**

1. Direct jobs are directly related to the Delaware Estuary. 2. Indirect jobs/wages 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 Program

The National Ocean Economic Program (2009) published a report that summarized the coastal economy in the United States that includes 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), counties in the Delaware Estuary watershed contributed 44,658 coastal jobs with $947 million in annual wages. Jobs and salaries in the portions of the states within the Delaware Estuary watershed were calculated by totaling employment in counties within the watershed from the NOEP 2009 report and dividing by total employment in the counties reviewed in the NOEP 2009 report. Table 46 summarizes coastal employment and wages in the Delaware Estuary watershed by multiplying county-wide values from the NOEP 2009 report by 80% for Delaware, 5% for New Jersey and 86% for Pennsylvania.

Table 46. Coastal employment and wages within the Delaware Estuary watershed (NOEP 2009)

Sector	Jobs	Wages ($ million)
Delaware	**12,139**	**$214**
Marine Construction		
Living Resources	354	$8
Offshore Minerals		
Tourism & Recreation	10,398	$151
Marine Transportation	1,744	$53
Ship and Boat Building		
New Jersey	**4,423**	**$140**
Marine Construction		
Living Resources		
Offshore Minerals		
Tourism & Recreation	2,939	
Marine Transportation		
Ship and Boat Building		
Pennsylvania	**28,096**	**$593**
Marine Construction		
Living Resources		
Offshore Minerals		
Tourism & Recreation	**20,093**	
Marine Transportation		
Ship and Boat Building		
Del. Estuary watershed	**44,658**	**$947**
Marine Construction		
Living Resources	354	$8
Offshore Minerals		
Tourism & Recreation	33,430	$151
Marine Transportation	1,744	$53
Ship and Boat Building		

Farm Jobs

The USDA (2007) reported there were 20,102 farms in the counties of the Delaware Estuary watershed which based on proportion of farmland means approximately 12,853 farms within the estuary watershed (0.64 x 20,102). The USDA estimates farms employ about 2.2 full time equivalent jobs per farm. Therefore, farming and agricultural conservation accounts for at least 28,276 jobs in the Delaware Estuary watershed with $1.2 billion in wages at an average farm salary of $41,000 (Table 47).

Table 47. Farm jobs in the Delaware Estuary watershed

County	Farmland in county[1] (ac)	Farmland/ watershed (ac)	%	Farms in County[1]	Farms in watershed	Farm jobs/ watershed[2]	Farm Wages[3] ($)
New Castle	51,913			825			
Kent	146,536			347			
Sussex	234,324			1,374			
Delaware	**432,773**	**254,143**	**59%**	**2,546**	**1,495**	**3,289**	**134,859,930**
Burlington	85,790			922			
Camden	8,760			225			
Cape May	7,976			201			
Cumberland	69,489			615			
Gloucester	46,662			669			
Mercer	21,736			311			
Ocean	9,833			255			
Salem	96,530			759			
New Jersey	**346,776**	**330,114**	**95%**	**3,957**	**3,767**	**8,287**	**339,771,931**
Berks	170,760			1,980			
Bucks	58,012			934			
Chester	117,145			1,733			
Delaware	1,646			79			
Lancaster	326,648			5,462			
Lebanon	89,566			1,193			
Lehigh	72,737			516			
Montgomery	28,563			719			
Philadelphia	150			17			
Schuylkill	81,276			966			
Pennsylvania	**946,503**	**528,323**	**56%**	**13,599**	**7,591**	**16,700**	**684,685,348**
Total	**1,726,052**	**1,112,580**	**64%**	**20,102**	**12,853**	**28,276**	**1,159,317,209**

1. USDA 2007 Census of Agriculture (2009). 2. @ 2.2 jobs per farm. 3. @ $41,000 salary per farm job.

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. If fishing, hunting, and bird/wildlife associated recreation in the Delaware

Estuary watershed accounts for $812 million in annual economic activity ($2006), then ecotourism accounts for 24,713 jobs (Table 48). While this estimate of ecotourism jobs is not exact, it provides a reasonable estimate of the jobs provided by fishing, hunting, and bird/wildlife associated recreation in the Delaware Estuary watershed.

Table 48. Jobs from fishing, hunting, and wildlife recreation in the Delaware Estuary watershed

Recreation Activity	DE in estuary[1] ($ million)	NJ in estuary[1] ($ million)	PA in estuary[1] ($ million)	Estuary watershed ($ million)
Fishing	48	199	90	334
Hunting	21	38	113	171
Wildlife/Bird-watching	65	140	101	306
Total	134	373	304	812
	DE Jobs[2]	**NJ Jobs[2]**	**PA Jobs[2]**	**Estuary Jobs[2]**
Fishing	1,472	5,956	2,752	10,180
Hunting	629	1,155	3,430	5,213
Wildlife/Bird-watching	1,991	4,254	3,075	9,320
Total	4,092	11,365	9,256	24,713

1. USFWS 2006 and prorated by ratio of estuary watershed to state area: Del. (50%), NJ (26%), and Pa. (7%).
2. Jobs estimated at $32,843 average salary.

Water Utility Jobs

Close to 250 public and private water utilities withdraw up to 764 mgd of drinking water from surface water and groundwater supplies in the Delaware Estuary watershed. 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 the Delaware Estuary watershed is 2,290 with annual wages of $127 million (Table 49).

Wastewater Utility Jobs

Over 50 wastewater utilities discharge over 1 billion gallons per day of treated wastewater to the Delaware Estuary watershed. These wastewater utilities employ 1,021 employees who earn $51 million in wages annually (Table 50).

Table 49. Largest public water withdrawals in the Delaware Estuary watershed (DRBC 2010)

Water Purveyor	Jobs	Salaries
Delaware	**126**	**$6,999,252**
United Water Delaware	55	$3,067,697
City of Wilmington	31	$1,727,970
City of Dover	14	$787,450
City of Newark	7	$369,407
City of Milford	6	$312,746
Lewes Board of Public Works	3	$162,200
Tidewater Utilities	2	$105,881
Dover Air Force Base	1	$73,556
New Castle Mun. Services Comm.	1	$68,142
Town of Smyrna	1	$61,907
Harrington	1	$60,286
Camden-Wyoming Water Authority	1	$51,000
Town of Milton	1	$28,581
Other	8	$416,038
New Jersey	**509**	**$28,184,219**
NJ American Water Co.	118	$6,543,488
City of Trenton	78	$4,338,049
City of Camden	33	$1,810,857
City of Vineland	25	$1,383,842
Aqua New Jersey	19	$1,055,000
Merchantville-Pennsauken Water	18	$1,006,097
Washington Twp. MUA	14	$796,358
Willingboro Twp. MUA	14	$772,909
Mount Holly Water	13	$744,757
City of Bridgeton	11	$603,778
City of Wildwood	11	$596,720
Evesham Twp. MUA	8	$468,456
Millville City Water Dept.	8	$423,203
Other	152	$8,435,517
Pennsylvania	**1,654**	**$91,675,458**
City of Philadelphia	863	$47,832,620
Aqua Pennsylvania, Inc.	307	$16,984,999
North Wales Water Authoriity	45	$2,508,043
Bucks Co. Water and Sewer Auth.	45	$2,490,992
Reading Area Water Authority	43	$2,378,003
Bucks Co. Water and Sewer Auth.	41	$2,291,878
Penna. American Water Co.	30	$1,678,582
North Penn Water	26	$1,428,225
Pennsylvania-American Water Co.	22	$1,207,000
Schuylkill Co. Municipal. Authority	15	$856,662
Pottstown Water Authority	14	$771,197
Schuylkill Co. MUA	13	$724,040
Phoenixville Municipal Waterworks	9	$500,940
Other	221	$12,236,387
Delaware Estuary watershed	**2,290**	**$126,858,929**

Table 50. Jobs at NPDES wastewater utilities in the Delaware Estuary watershed

NPDES ID	Facility	Location	State	Jobs	Salaries
DE0020338	Kent Co. Levy Court WWTR	Frederica	DE	15.0	795,000
DE0021512	Lewes City POTW	Lewes	DE	1	40,000
DE0020320	Wilmington Wastewater Plant	Wilmington	DE	90	4,500,000
Delaware			**DE**	**106**	**5,335,000**
NJ0027481	Beverly City Sewer Auth. STP	Beverly	NJ	1	50,000
NJ0024678	Bordentown Sewerage Auth.	Bordentown	NJ	3	150,000
NJ0024651	Cumberland Co. Utility Auth.	Bridgeton	NJ	7	350,000
NJ0024660	Burlington City STP	Burlington	NJ	3	135,000
NJ0021709	Burlington Twp. DPW	Burlington	NJ	2	80,000
NJ0026182	Camden County MUA	Camden	NJ	80	4,000,000
NJ0021601	Carneys Point Twp. Sewer Auth	Carneys Point	NJ	1	65,000
NJ0024007	Cinnaminson Sewerage Auth.	Cinnaminson	NJ	2	100,000
NJ0023701	Florence Twp. Sewer Auth.	Florence	NJ	3	125,000
NJ0026301	Hamilton Twp. DPW WWTP	Hamilton.	NJ	16	800,000
NJ0024759	Ewing Lawrence Sewer Auth.	Lawrenceville	NJ	16	800,000
NJ0069167	Maple Shade Util, Authority	Maple Shade	NJ	3	170,000
NJ0026832	Medford Twp. Sewer Auth. STP	Medford	NJ	2	90,000
NJ0029467	Millville City Sewer Auth.	Millville	NJ	5	250,000
NJ0024996	Moorestown Twp. Utilities Auth	Moorestown	NJ	4	175,000
NJ0024015	Mount Holly Twp. MUA	Mount Holly	NJ	8	385,000
NJ0024821	Pemberton Twp. MUA STP	Pemberton	NJ	3	125,000
NJ0024023	Penns Grove Sewerage Auth.	Penns Grove	NJ	1	40,000
NJ0021598	Pennsville Twp. Sewer Auth.	Pennsville	NJ	2	95,000
NJ0024716	Phillipsburg Town STP	Phillipsburg	NJ	4	175,000
NJ0022519	Riverside Twp. DPW	Riverside	NJ	1	50,000
NJ0024856	Salem WWTP Facility	Salem	NJ	1	70,000
NJ0024686	Gloucester Co. Util. Auth. STP	Thorofare	NJ	24	1,205,000
NJ0020923	Trenton City DPW Sewer Auth.	Trenton	NJ	20	1,000,000
NJ0023361	Willingboro Twp. MUA	Willingboro	NJ	5	260,000
New Jersey			**NJ**	**215**	**10,745,000**
PA0026867	Abington Twp. STP	Abington	PA	4	195,000
PA0021181	Bristol Borough Water/Sewer	Bristol	PA	1	60,000
PA0027103	Delaware Co. Reg. Water Auth.	Chester	PA	44	2,200,000
PA0026859	Coatesville WWTP	Coatesville	PA	4	190,000
PA0026794	Conshohocken Borough Auth.	Conshohocken	PA	2	115,000
PA0026531	Downingtown Regional WPCC	Downingtown	PA	7	355,000
PA0026549	Borough of Doylestown WWTP	Doylestown	PA	29	1,425,000
PA0029441	Upper Dublin Twp. MS4 UA	Ft.Washington	PA	1	55,000
PA0051985	Horsham Twp. STP	Horsham	PA	1	50,000
PA0024058	Kennett Square Borough WWTP	Kennett Sq.	PA	1	55,000
PA0026298	Whitemarsh STP	Lafayette Hill	PA	2	100,000
PA0026182	Lansdale Borough STP	Lansdale	PA	3	130,000
PA0039004	Upper Gwynedd Towam. STP	Lansdale	PA	7	325,000
PA0026468	Morrisville Mun. Auth. Water	Morrisville	PA	10	500,000
PA0027421	Norristown Borough WWTP	Norristown	PA	10	490,000
PA0020532	Upper Montgomery Joint Sewer	Pennsburg	PA	2	100,000
PA0026689	Northeast WPCP	Philadelphia	PA	210	10,500,000
PA0026662	Philadelphia Southeast POTW	Philadelphia	PA	112	5,600,000
PA0026671	SW Water Pollution Control	Philadelphia	PA	200	10,000,000
PA0026549	Reading WWTP	Reading	PA	29	1,425,000

PA0027031	Goose Creek STP	West Chester	PA	2	85,000
PA0026018	West Chester Taylor Run STP	West Chester	PA	2	90,000
PA0028584	West Goshen STP	West Chester	PA	6	300,000
PA0023256	Upper Gwynedd Twp. WWTP	West Point	PA	6	285,000
PA0025976	Upper Moreland Hatboro Sewer	Willow Grove	PA	7	360,000
Pennsylvania			**PA**	**700**	**34,990,000**
Del. Estuary				**1021**	**51,070,000**

1. DRBC and USEPA.

Watershed Jobs

Close to 90 nonprofit watershed and environmental organizations employ at least 150 staff to work on programs to protect the land and waters that flow to the Delaware Estuary (Table 51).

Table 51. Watershed organization jobs in the Delaware Estuary watershed

Watershed Organization	Town	State	Jobs	Salaries
Christina Conservancy, Inc.	Wilmington	DE	1	48,000
Coalition for Natural Stream Valleys	Newark	DE		
Delaware Audubon Society	Wilmington	DE	1	48,000
Delaware Nature Society's Stream Watch	Hockessin	DE	20	960,000
Fairfield Watershed Association	Newark	DE		
Friends of Bombay Hook	Smyrna	DE	1	48,000
Friends of White Clay Creek State Park	Newark	DE	1	48,000
Naamans Creek Watershed Association	Arden	DE		
Nature Conservancy of Delaware	Wilmington	DE	2	96,000
Partnership for the Delaware Estuary, Inc.	Wilmington	DE	10	480,000
Save Wetlands and Bays	Millsboro	DE		
St. Jones River Greenway Commission	Magnolia	DE		
St. Jones River Watershed Association	Dover	DE	1	48,000
Waterfront Watch of Wilmington	Wilmington	DE	1	48,000
White Clay Creek Watershed Mgmt. Committee	Newark	DE	1	48,000
Delaware			**39**	**1,872,000**
Cape May County Watershed Area 16	Cape May Ct. Hse.	NJ	1	48,000
Citizens United to Protect the Maurice River	Millville	NJ	1	48,000
Cooper River Watershed Association	Haddonfield	NJ		
Crafts Creek Spring Hill Brook Watershed	Bordentown	NJ		
Crosswicks Creek Watershed Association	Yardville	NJ	1	48,000
Crosswicks-Doctors Creeks Watershed Association	New Egypt	NJ	1	48,000
Delaware River Greenway Partnership	Burlington	NJ	1	48,000
Friends Hamilton-Trenton-Bordentown Marsh	Robbinsville	NJ		
Mantua/Woodbury Creeks Watershed Association	Glassboro	NJ	1	48,000
Newton Creek Watershed Association	Collingswood	NJ	1	48,000
Oldmans Creek Watershed Association.	Mullica Hill	NJ	1	48,000
Pinelands Preservation Alliance	Southampton	NJ	1	48,000
Pinelands Watershed Alliance	Tuckerton	NJ	1	48,000
Pompeston Creek Watershed Association	Cinnaminson	NJ	1	48,000
Raccoon Creek Watershed Association, Inc.	Mullica Hill	NJ	1	48,000
Rancocas Conservancy	Vincentown	NJ	2	96,000
Salem County Watershed Task Force	Woodstown	NJ		
South Jersey Land and Water Trust	Glassboro	NJ	2	96,000
Upper Maurice River Watershed Association	Franklinville	NJ	1	48,000
New Jersey			**17**	**816,000**
Berks County Conservancy	Reading	PA	5	240,000

Brandywine Valley Association	West Chester	PA	8	384,000
Chester Creek Watershed Association	Glen Mills	PA		
Chester-Ridley-Crum Watersheds Association	Media	PA	5	240,000
Cooks Creek Watershed Association	Springtown	PA	1	48,000
Crum Creek Watershed Partnership	Swarthmoore	PA	1	48,000
Darby Cobbs Watershed Partnership	Philadelphia	PA	1	48,000
Darby Creek Valley Association	Drexel Hill	PA	1	48,000
Delaware Riverkeeper Network	Bristol	PA	13	624,000
French and Pickering Creeks Conservation Trust	Valley Forge	PA	7	336,000
Friends of Cobbs Creek Park	Philadelphia	PA	1	48,000
Friends of Crum Creek	Philadelphia	PA	1	48,000
Friends of Lake Afton	Yardley	PA	1	48,000
Friends of Mingo Creek	Royersford	PA	1	48,000
Friends of Poquessing Watershed, Inc.	Philadelphia	PA	1	48,000
Friends of Tacony Creek Park	Philadelphia	PA	1	48,000
Friends of the Manayunk Canal	Philadelphia	PA	1	48,000
Friends of the Pennypack Park	Philadelphia	PA	1	48,000
Friends of the Wissahickon	Philadelphia	PA	1	48,000
Greater Pottstown Watershed Alliance	Pottstown	PA		
Green Valleys Association	Pottstown	PA	3	144,000
Hay Creek Watershed Association	Geigertown	PA	1	48,000
Little Schuylkill Conservation Club	Delano	PA		
Lower Merion Conservancy	Gladwyne	PA	6	288,000
Maiden Creek Watershed Association	Kempton	PA		
Mid-Atlantic Council of Watershed Associations	West Chester	PA		
Middle Anthracite Watershed Association	Sybertsville	PA	1	48,000
Mill Creek Council, Inc.	Philadelphia	PA	1	48,000
Neshaminy Creek Watershed Association	Rushland	PA	1	48,000
North Branch Watershed Association	Doylestown	PA	1	48,000
Pennsylvania Organization Watersheds and Rivers	Harrisburg	PA	3	144,000
Pennypack Ecological Restoration Trust	Huntington Valley	PA	8	384,000
Pennypack Watershed Partnership	Philadelphia	PA	1	48,000
Perkiomen Watershed Conservancy	Schwenksville	PA	4	192,000
Poquessing Watershed Partnership	Philadelphia	PA		
Schuylkill Action Network	Philadelphia	PA	2	96,000
Schuylkill Canal Association	Oaks	PA	1	48,000
Schuylkill Headwaters Association	Pottsville	PA	2	96,000
Schuylkill River Greenway Association	Pottstown	PA		
Southampton Watershed Association	Southampton	PA		
Springton Lake/Crum Creek Conservancy	Newtown Square	PA		
Stony Creek Watershed Committee	Norristown	PA		
Swarthmore College's Watershed Projects	Swarthmore	PA	1	48,000
Tookany/Tacony - Frankford Watershed Partner.	Philadelphia	PA		
Water Resources Association Delaware River Basin	Exton	PA	1	48,000
White Clay Watershed Association	Landenberg	PA	1	48,000
Wissahickon Restoration Volunteers	Philadelphia	PA	1	48,000
Wissahickon Valley Watershed Association	Ambler	PA	1	48,000
Wissahickon Watershed Partnership	Philadelphia	PA	1	48,000
Red Clay Valley Association	West Chester	PA	1	48,000
Upper Perkiomen Watershed Coalition	Palm	PA	1	48,000
Pennsylvania			**94**	**4,512,000**
Delaware Estuary Watershed			**150**	**7,200,000**

Port Activity

The Economy League of Greater Philadelphia (2008) reported that Delaware River ports from Wilmington to Philadelphia to Trenton:

- Employ 4,056 workers who earn $326 million in wages and generate $1.3 billion in economic output annually (Table 52).
- Provide port jobs that support an additional two jobs each in port activity and employee spending for a total of 12,121 port related jobs with $772 million in wages and $2.4 billion in annual economic output.
- Most of the 4,056 direct port jobs are in cargo handling and warehousing with petroleum port jobs adding up to less than 10% of employment.
- Provide good jobs, the average salary of a port employee (with benefits) is over $80,000.

Table 52. Delaware River port jobs
(Economy League of Greater Philadelphia 2008)

Employment Type	Jobs
Direct	**4056**
Cargo Handling	1,911
Warehousing	987
Federal Government	553
Construction	318
State/Local Government	152
Security	99
Wholesale	36
Indirect (Industry)	**4,655**
Induced (Worker Spending)	**3,410**
Total	**12,121**

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Appendix A
Employment Codes by Industry, 2009
(U. S. Bureau of Labor Statistics)

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		
	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
			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