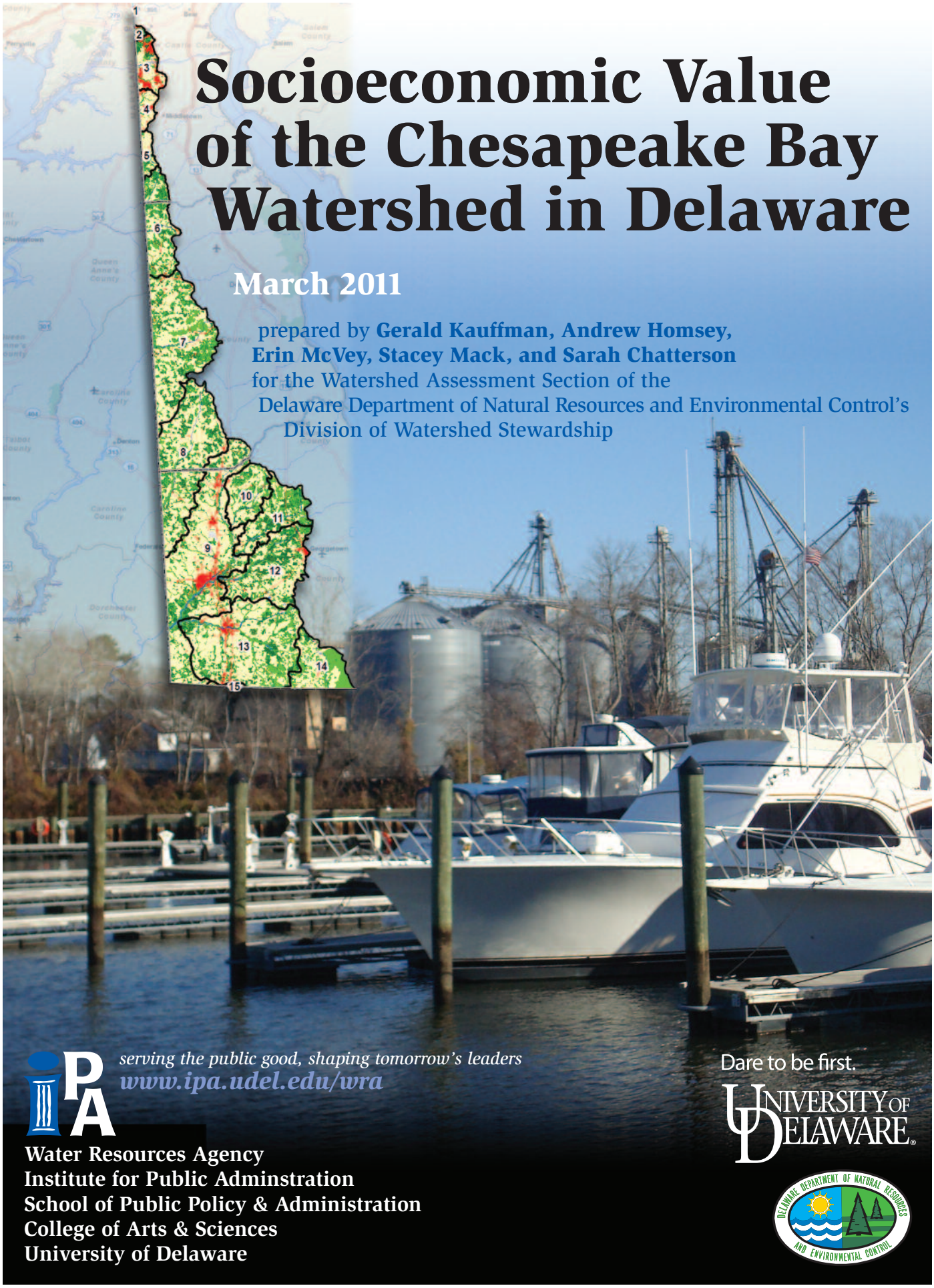

Socioeconomic Value of the Chesapeake Bay Watershed in Delaware

March 2011

prepared by **Gerald Kauffman, Andrew Homsey, Erin McVey, Stacey Mack, and Sarah Chatterson**
for the Watershed Assessment Section of the
Delaware Department of Natural Resources and Environmental Control's
Division of Watershed Stewardship

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Water Resources Agency
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DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

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Preface

President Barack Obama has described the Chesapeake Bay as a "National Treasure," and its 64,000-square-mile watershed, which occupies portions of six states plus Washington, D.C., has an economic value that some say is in excess of a trillion dollars. We are pleased to partner with the Delaware Department of Natural Resources and Environmental Control to deliver this report—"Socioeconomic Value of the Chesapeake Bay Watershed in Delaware." While just one percent of the watershed is in Delaware, the Chesapeake Bay watershed covers 35 percent of the state's land mass.

The natural resources in the watershed—farms, forest, wetlands, streams, and aquifers—provide significant economic value to Delaware's economy, especially in the agricultural, tourism, and construction-job sectors. Restoration of the Chesapeake Bay watershed promises to provide hundreds of green jobs in agricultural conservation and stormwater management. In Delaware, this report demonstrates that restoration of the Chesapeake Bay watershed can promote economic development while cleaning up the nation's largest and most valuable estuary.

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

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Abstract

The Chesapeake Bay watershed in Delaware (1) contributes over $2 billion in annual economic activity from benefits associated with water quality, water supply, ecotourism, recreation, agriculture, forest, open space, and navigation, (2) provides annual ecosystem value of natural goods and services of $3.4 billion (in 2010 dollars) with a net present value (NPV) of $109.6 billion over a perpetual lifetime, and (3) is directly/indirectly responsible for 47,000 jobs with $1.2 billion in annual salaries.

Delaware occupies 702 square miles or just about 1% of the 64,000-sq-mi Chesapeake Bay watershed, while the Chesapeake Bay watershed covers about 35% of Delaware's land area (1,953 square miles). Almost 140,000 residents—16% of the First State's total population of 885,000—live in Delaware portion of the watershed. More than 41,800 people—11% of Delaware's total employment—work in the Delaware portion of the watershed.

Economic activity in the Delaware portion of the Chesapeake Bay watershed exceeds $2 billion annually from water quality, water supply, ecotourism, recreation, agriculture, forests, open space, and navigation benefits. These benefits include Clean Water Act Restoration ($1,550,543), water-quality recreation ($101,629,897), Chesapeake Bay restoration ($22,200,000), increased property value due to improved water quality ($392,735,030), water treatment by forests ($550,000), wastewater treatment ($29,054,000), septic-system assimilation ($16,099,500), drinking water supply ($50,453,374), irrigation water supply ($11,295,000), hunting/fishing/bird and wildlife watching ($108,900,000), agriculture ($522,000,000), forest carbon storage ($854,600,000), carbon sequestration ($2,960,000), air-pollution removal ($27,210,000), building-energy savings ($5,730,000), avoided carbon emissions ($310,000), public park health benefits ($188,537,846), community-cohesion benefit ($46,156,327), water-pollution control ($17,838,849), air-pollution mitigation ($1,704,472), and instream navigation ($570,000).

The estimated value of natural goods and services provided by ecosystems in the Chesapeake Bay watershed in Delaware is $3.4 billion (2010) with a net present value of $109.6 billion based on an annual discount rate of 3% over a perpetual lifetime (over 100 years). Natural goods are commodities that can be sold, such as water supply, farm crops, fish, timber, and minerals. Natural services are ecological benefits to society, such as flood control by wetlands, water filtration by forests, and fishery habitat by wetlands. Ecosystem services areas within the Chesapeake Bay watershed in Delaware comprise habitats, such as farmland (55%), forests (23%), and freshwater wetlands (18%).

Ecosystems with the highest natural-goods values are farmland ($600 million or $2,446 acres/year), forest ($28 million or $275 acres/year), and freshwater wetlands ($22 million or $270 acres/year). Highest natural ecosystem services values are provided by forests ($1.4 billion or $13,887/acre), freshwater wetlands ($1.1 billion or $13,351/acre), and farmland ($203 million or $827/acre). The Nanticoke River ($786 million), Broad Creek ($557 million), and Choptank River ($490 million) watersheds provide the highest values of annual ecosystem services. Watersheds with the highest per acre ecosystem services include Elk Creek ($11,209/acre), Gravelly Branch ($9,559/acre), Pocomoke ($8,750/acre), and Chester River ($8,704/acre), as these systems are rich in forests and wetlands (over 75%).

Jobs in New Castle, Kent, and Sussex Counties within the Chesapeake Bay watershed in Delaware total 41,824, representing wages of $1.2 billion annually. Jobs pertaining to activities directly/indirectly associated with the Chesapeake Bay watershed (such as farming, fishing, hunting, recreation, tourism) total 12,800, representing annual wages of $310 million. Ecotourism such as fishing, hunting, and bird/wildlife-associated recreation, accounts for 3,319 jobs in the Delaware portion of the Chesapeake Bay watershed. Farming and agricultural-habitat conservation accounts for at least 2,500 jobs in the Delaware portion of the Chesapeake Bay watershed. Delaware's Chesapeake Bay Watershed Implementation Plan has the potential to fund more than 200 green jobs annually.

1. Executive Summary

1. Ecosystems and habitat in the Delaware portion of the Chesapeake Bay watershed:

   - Contribute over $2 billion in annual economic activity from water quality, water supply, ecotourism, recreation, agriculture, forest, open space, and navigation benefits.
   - Provide an annual value of ecosystem natural goods and services of at least $3.4 billion (2010) with a net present value (NPV) of $109.6 billion over a perpetual lifetime.
   - Directly/indirectly account for more than 12,800 jobs, representing $310 million in annual salaries.

2. Delaware occupies 702 square miles or just 1% of the 64,000-sq-mi Chesapeake Bay watershed, while the Chesapeake watershed covers about 35% of Delaware's land area (1,953 sq. mi.). Almost 140,000 residents—16% of the First State's total population of 885,000—live in the Delaware portion of the watershed. More than 41,800 people—11% of Delaware's total employment—work in the Delaware portion of the watershed.

3. In the Chesapeake watershed, Delaware is a headwaters state, from which the Sassafras, Chester, Choptank, and Nanticoke Rivers flow west through Maryland's Eastern Shore to the bay.

4. Economic activity in Delaware portion in the Chesapeake Bay exceeds $2 billion annually from water quality, water supply, ecotourism, recreation, agriculture, forest, open space, and navigation benefits:

Water Quality	
Clean Water Act Restoration	$ 1,550,543
Water-Quality Recreation	$101,629,897
Chesapeake Bay Restoration	$ 22,200,000
Increased Property Value	$392,735,030
Water/Wastewater Treatment	
Water Treatment by Forests	$ 550,000
Wastewater Treatment	$ 29,054,000
Septic-System Assimilation	$ 16,099,500
Water Supply	
Drinking Water	$ 50,453,374
Irrigation	$ 11,295,000
Hunting/Fishing/Wildlife Watching	$108,900,000
Agriculture	$522,000,000
Forests	
Carbon Storage	$854,600,000
Carbon Sequestration	$ 2,960,000
Air-Pollution Removal	$ 27,210,000
Building-Energy Savings	$ 5,730,000
Avoided Carbon Emissions	$ 310,000
Public Parks	
Health Benefits	$188,537,846
Community-Cohesion Benefit	$ 46,156,327
Water-Pollution Control	$ 17,838,849

Air-Pollution Mitigation	$ 1,704,472
Port/Navigation	
Instream Navigation	$ 570,000
Port of Baltimore via C&D Canal	$4.3 billion (exports)

5. The value of natural goods and services provided by ecosystems in the Chesapeake Bay watershed in Delaware is $3.4 billion (2010) with a net present value of $109.6 billion based on an annual discount rate of 3% over a perpetual lifetime (over 100 years). Forests, freshwater wetlands, and farms provide the highest ecosystems values (Table ES1). Natural goods are commodities to be sold such as water supply, farm crops, fish, timber, and minerals. Natural services are ecological benefits to society, such as flood control by wetlands, water filtration by forests, and fishery habitat by streams.

Table ES1. Ecosystem goods/services in the Delaware portion of the Chesapeake Bay watershed

Ecosystem	Area (ac)	$/ac/yr 2010	$/yr 2010	NPV $
Freshwater wetlands	81,130	13,621	1,105,045,825	35,913,989,309
Marine	233	10,005	2,327,334	75,638,340
Farmland	245,509	3,273	803,557,787	26,115,628,085
Forest land	102,306	14,162	1,448,848,947	47,087,590,792
Saltwater wetland	353	7,236	2,557,110	83,106,069
Barren land	844	0	0	0
Urban	17,019	342	5,813,781	188,947,882
Open freshwater	1,780	1,946	3,462,694	112,537,541
Total	**449,174**		**3,371,613,478**	**109,577,438,019**

6. Ecosystem services areas within the Chesapeake Bay watershed in Delaware include farmland (55%), forests (23%), and freshwater wetlands (18%). Only 4% of the watershed in Delaware is urban.

7. Ecosystems that provided the highest natural goods values are farmland ($600 million or $2,446/acre/year), followed by forest ($28 million or $275/acre/year) and freshwater wetlands ($22 million or $270/acre/year). The highest natural ecosystem services values are provided by forests ($1.4 billion or $13,887/acre), freshwater wetlands ($1.1 billion or $13,351/acre), and farmland ($203 million or $827/acre).

8. The Nanticoke ($786 million), Broad Creek ($557 million), and Choptank ($490 million) watersheds provide the highest values of ecosystem services. Watersheds with the highest per acre ecosystem services include Elk Creek ($11,209/acre), Gravelly Branch ($9,559/acre), Pocomoke River ($8750/acre), and Chester River ($8,704/acre), as these systems are rich in forests and wetlands (over 75%).

9. Jobs in New Castle, Kent, and Sussex Counties in the Chesapeake Bay watershed in Delaware total 41,823, representing wages of $1.2 billion annually. Jobs pertaining to farming, fishing, hunting, recreation, tourism directly associated with the bay and its tributaries total 12,800, representing annual wages of $310 million indirectly.

10. Ecotourism such as fishing, hunting, and bird/wildlife-associated recreation accounts for 3,319 jobs in the Delaware portion of the Chesapeake Bay watershed.

11. Agriculture and land conservation provides 2,566 jobs in Delaware in the Chesapeake Bay watershed.

12. Delaware's Chesapeake Bay Watershed Implementation Plan has the potential to fund more than 200 green jobs annually.

2. Introduction

Objectives

This report summarizes the socioeconomic value of natural resources and ecosystems in the Chesapeake Bay watershed in Delaware by tabulating:

- Economic activity, including market use and non-use value of agriculture, water supply, fishing, hunting, recreation, boating, ecotourism, and aesthetic benefits in the watershed.
- Natural capital or ecosystem services value of natural goods and services provided by habitat such as wetlands, forests, farms and open water.
- Jobs and wages associated with the study area.

Chesapeake Bay TMDL

On December 29, 2010, the U.S. Environmental Protection Agency established a pollution diet to restore clean water in the Chesapeake Bay by reducing nitrogen, phosphorus, and sediment loads in the watershed from Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. On November 29, 2010, DNREC submitted Delaware's Phase I Chesapeake Watershed Implementation Plan to EPA (DNREC, 2010). Delaware's WIP was prepared by an interagency workgroup representing DNREC, Delaware Department of Agriculture, Department of Transportation, Office of State Planning Coordination, County Conservation Districts, U.S. Department of Agriculture, U.S. Geological Survey, and stakeholders from the farming and development communities.

On September 1, 2010, the six Chesapeake Bay states and District of Columbia submitted draft WIPs to EPA as part of a federal-state partnership to restore the bay by 2025, with 60 percent of the work to be completed by 2017. On September 24, 2010, EPA announced Chesapeake Bay watershed TMDL limits for nitrogen, phosphorus, and sediment for the watershed states. On July 1, 2010, EPA announced draft TMDL allocations for nitrogen and phosphorus to meet water-quality standards in the Chesapeake Bay and tributaries. In May 2009, President Barack Obama issued an Executive Order that recognizes the Chesapeake Bay as a "National Treasure" and called for a renewed effort by EPA and the bay states to restore the nation's largest estuary.

The Value of a Watershed

Studies for the Chesapeake Bay, Great Lakes, and Florida Everglades conclude that (1) watersheds have significant economic value and (2) restoration can result in green jobs and favorable cost-benefit investment ratios. The Chesapeake Bay Watershed Blue Ribbon Finance Panel (2004) concluded the bay was worth over a trillion dollars. Recreational boating in Maryland was measured at $2 billion per year. Fishing activities in Pennsylvania resulted in $4.7 billion a year in expenditures and generated 43,000 jobs in outfitting, guiding, and lodging. The University of Maryland (1988) reported that the Chesapeake Bay was worth $678 billion.

The Brookings Institution (Austin et al., 2007) found that restoration of the Great Lakes would cost $26 billion in present value and aggregate economic benefits would exceed $50 billion (2:1 B/C ratio). Great Lakes benefits include $6.5–11.8 billion in tourism, fishing, and recreation dollars, $12–19 billion increase in property values from contaminated sediment cleanup, $50–125 million in reduced municipal water-treatment costs, and $30 billion in short-time-multiplier benefits. The Great Lakes Coalition (2010) concluded that investment in watershed restoration creates good paying jobs and leads to economic

benefits while restoring the environment (Table 1). The Everglades Foundation estimated that the Comprehensive Everglades Restoration Plan (CERP) would result in $6 billion in benefits and 443,000 jobs over 50 years (McCormick et al., 2010). Net present value of Everglades' restoration benefits would be $46 billion, resulting from investments of $11.5 billion or a benefit-to-cost ratio of 4:1.

Table 1. Jobs and salaries created by watershed restoration work

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 Engineer	$80,750
Toxicologist	$70,000	Hydrogeologist	$92,710
Chemist	$72,740	Environmental Planner	$64,680
Geologist	$58,000	Plumber/Pipefitter	$69,870
Helicopter Pilot	$90,000	Carpenter	$43,640
Information Technology	$70,930	Electrician	$50,850
Admin. Staff	$32,990	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
Civil Engineer	$81,180	Biological technician	$41,140
General Laborer	$33,190	Pile Drive Operator	$51,410

Source: Great Lakes Coalition (2010) from U. S. Bureau of Labor Statistics

An Economic Engine

What do Perdue, DuPont, Red Lion Foods, Delaware State Fairgrounds, Wawa, Starbucks, C&D Ship Canal, and the nation's most lucrative lima bean farms in Sussex County have in common? They all depend on the waters of the Chesapeake Bay watershed in Delaware to sustain their businesses.

Most economists agree that water is an undervalued resource, yet it is a key driver of the economy and is an essential part of the gross domestic product (GDP) of any government. The astronomer Copernicus and economist Adam Smith (of the invincible hand of the economy fame) 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 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) and not consider its full value for all its myriad uses.

This report quantifies the multi-objective value of water *in toto* for a wide range of habitat, recreation, and ecological benefits in the Chesapeake Bay watershed in Delaware. If dihydrogen oxide is society's most valuable chemical, then the Chesapeake Bay, which holds eight trillion gallons of it, is one of our nation's most invaluable economic assets. The Chesapeake Bay has been an economic engine ever since Captain John Smith sailed up the Nanticoke River into present day Delaware in 1608 in search of gold and beaver pelts. In 2010, millions of gallons per day of drinking water and irrigation were withdrawn from the creeks and aquifers in the Chesapeake Bay watershed to sustain the domestic, commercial, and

agricultural economy. The watershed's rivers, wetlands, forests, and farms support a multi-billion-dollar tourism, recreation, and hunting/fishing/birding economy. The Chesapeake Bay watershed in Delaware is situated between the 5th (greater Philadelphia) and 9th (greater Washington, D.C.) largest metropolitan economies in the United States. The following report tabulates the substantial economic value of this irreplaceable asset.

The Watershed

Delaware occupies 702 square miles or just about 1% of the 64,000-sq-mi Chesapeake Bay watershed, while the Chesapeake watershed covers about 35% of Delaware's 1,953-sq-mi land area (Figure 1). Almost 140,000 residents—16% of the First State's total population of 885,000—live in the Delaware portion of the watershed. More than 41,800 people—11% of Delaware's total employment—work in the Delaware portion of the watershed (Table 2). In the Chesapeake Bay watershed, Delaware is a headwaters state, from which the Sassafras, Chester, Choptank, and Nanticoke Rivers flow west through Maryland's Eastern Shore to the bay (Table 3 and Figure 2).

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

Jurisdiction	Area (sq mi)	Population[1]	Employment[2]
New Castle County		31,503	6,630
Kent County		35,726	8,595
Sussex County		71,460	26,598
Total	**702**	**138,689**	**41,823**

1. Delaware Population Consortium, 2010. 2. U.S. Bureau of Labor Statistics, 2009.

Table 3. Watersheds in the Chesapeake Bay watershed in Delaware

Watershed	Area (sq mi)	Portion
Elk Creek	1	0.1%
Perch Creek	2	0.3%
C&D Canal West	17	2.5%
Bohemia Creek	9	1.2%
Sassafras River	8	1.1%
Chester River	40	5.6%
Choptank River	97	13.8%
Marshyhope Creek	96	13.7%
Nanticoke River	144	20.5%
Gum Branch	30	4.3%
Gravelly Branch	38	5.5%
Deep Creek	63	9.0%
Broad Creek	120	17.0%
Wicomico River	2	0.3%
Pocomoke River	35	4.9%
Total	**702**	**100.0%**

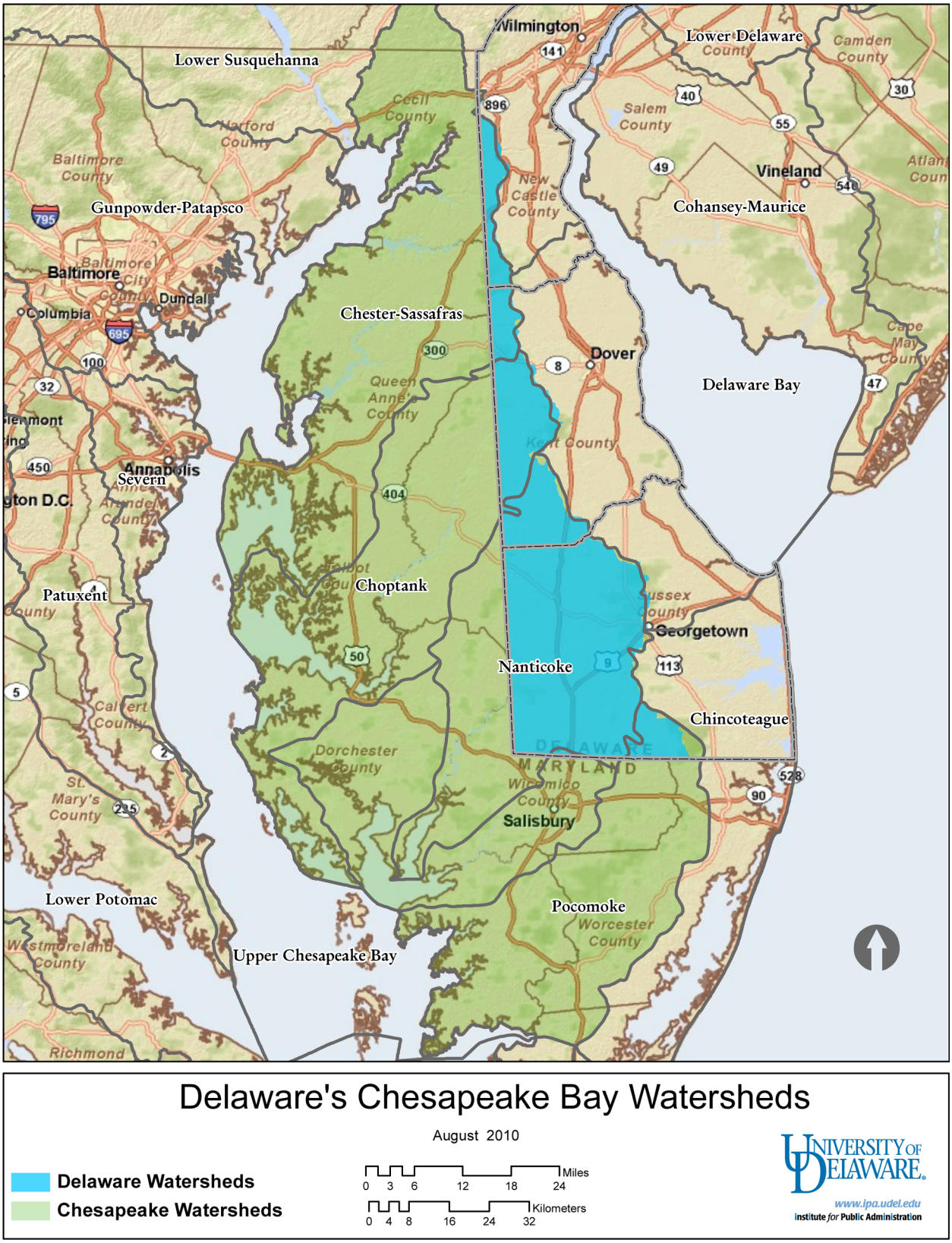


Figure 1. Delaware portion of the Chesapeake Bay watershed (WRA, 2010)

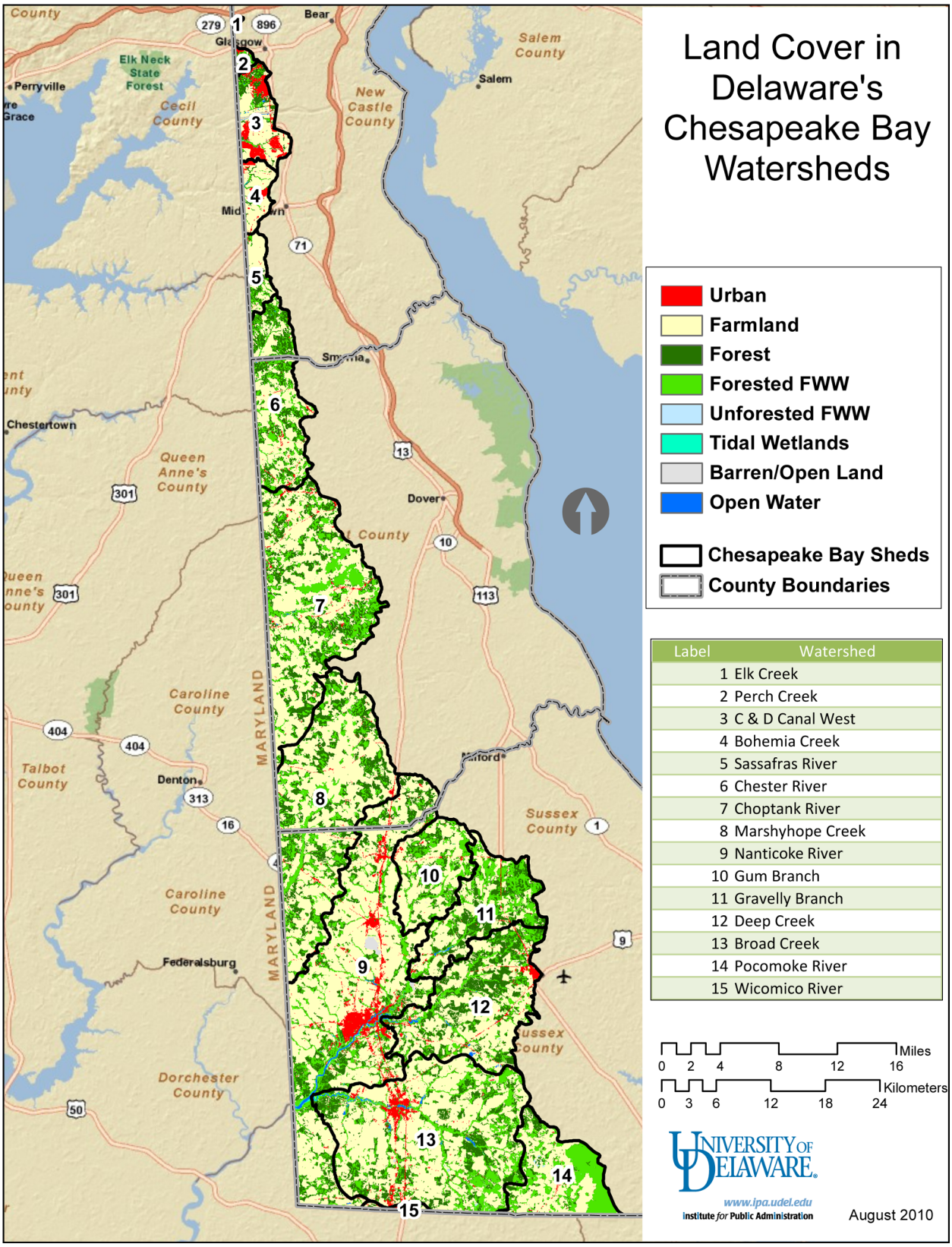


Figure 2. Land cover of Delaware watersheds in the Chesapeake Bay watershed (NOAA Coastal Services Center, 2006, and mapped by WRA, 2010)

3. Methods

Ecological goods and services include (1) direct market goods or services such as drinking water, transport, power, pollution treatment, irrigation, and recreation and (2) non-market goods or services such as biodiversity, ecosystems, plant and animal habitat, and aesthetic value.

Valuation Techniques

The socioeconomic value of the Chesapeake Bay watershed in Delaware was derived from published studies in the literature that employed the following economic valuation methods.

Avoided Cost: Society sustains costs if certain ecosystems were not present. For instance the loss of wetlands may increase flood damage.

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

Net Factor Income by Habitat Enhancement: Improved water quality is known to enhance fishing, hunting, and crabbing industries.

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

Hedonic-Pricing Process: People will pay more for property values that may be higher along bay and river coastlines.

Contingent Valuation: Valuation by survey of individual preferences to preserve ecosystems. People may be willing to pay more for preserved and improved bay water quality.

Scope of Work

The Water Resources Agency (WRA) estimated the socioeconomic value of the Chesapeake Bay watershed in Delaware according to the following scope of work.

1. **Define and map area of interest:** The area of interest is the 702-sq.-mi. watershed of the Chesapeake Bay within westerly New Castle, Kent, and Sussex Counties in Delaware. WRA developed GIS map layers of population census blocks, watershed boundaries, and land use/land cover to perform the analysis.

2. **Literature review:** Gather socioeconomic data from published literature and Internet resources for the Chesapeake Bay watershed from U.S. Census Bureau, Bureau of Labor Statistics, Department of Agriculture, Forest Service, Fish and Wildlife Service, and Delaware Department of Labor.

3. **Economic activity:** Estimate the market/non-market value of agriculture, water quality, water supply, fishing, hunting, recreation, boating, ecotourism, and aesthetic benefits in the Chesapeake Bay watershed in Delaware. Total economic activity is calculated by adding up direct and indirect use, option demand, and non-use values. Direct use values are realized from natural resources, such as withdrawals from aquifers for drinking water, boating, recreation, and commercial fishing. Indirect values are economic benefits provided by ecosystems, such as water filtration by forests and flood control and habitat protection from wetlands. Option demand is a willingness by the public to pay to

maintain or enhance benefits from water quality or scenic value of the water resource. Non-use values are derived 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 watershed for habitat, such as wetlands, forests, farmland, and open water. Ecosystem services (ecological services) are provided by nature and represent benefits such as water filtration, flood reduction, and drinking water supply.

   Using WRA's GIS system, define ecosystem areas within each county and watershed in the Chesapeake Bay watershed in Delaware using 2006 NOAA CSC land cover data merged into the following classifications: (a) freshwater wetlands, (b) marine, (c) farmland, (d), forest, (e) barren, (f) saltwater wetland, (g) urban, (h) beach/dune, (i) open freshwater, and (j) riparian buffer.

   Review research studies and gather relevant value ($/acre) data for following ecosystem services: (a) carbon sequestration, (b) flood control, (c) drinking-water supply, (d) water-quality filtration, (e) waste treatment and assimilation, (f) nutrient regulation, (g) fish and wildlife habitat, (h) recreation and aesthetics. Ecosystem services were estimated using value (benefit) transfer, where published data and literature are reviewed and applied in the context of the resource in question. Value transfer is used to estimate ecosystem goods and services for the Delaware portion of the Chesapeake Bay watershed.

   Compute ecosystem services value by multiplying land use area (acres) by ecosystem value ($/acre). The value transfer techniques employed here involve selecting data from published literature from another watershed or study area and applying the $/acre values to land-use areas computed by GIS in Delaware. While primary research data from the watershed in question (the Chesapeake Bay) 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 has previously been deemed zero. Future economic valuation survey research is recommended to develop primary ecosystem services values for the Chesapeake Bay watershed and in Delaware.

5. **Jobs and salaries:** Obtain job and salary data from the Delaware Department of Labor, U.S. Bureau of Labor Statistics, and U.S. Census Bureau. Calculate the number of direct/indirect jobs in the Chesapeake Bay watershed in Delaware organized by North American Industry Classification System (NAICS) codes such as shipbuilding, marine transportation/ports, fisheries (shellfish, finfish), recreation, minerals, trade, agriculture, water/sewer construction, and others. Total jobs and salaries were summarized for each of the three counties in Delaware and then prorated for the Delaware portion of the Chesapeake Bay watershed based on population census-block data from the U.S. Census Bureau. The NAICS data were supplemented with farm jobs data estimated from the USDA Agricultural Statistics Bureau and U.S. Fish and Wildlife Service ecotourism data.

6. **Report:** Prepare a report and GIS mapping that summarizes the direct and indirect economic values of goods and services provided by the Chesapeake Bay watershed in Delaware updated to 2010 levels.

4. Economic Activity

The value of the Chesapeake Bay watershed in Delaware from market and non-market goods and services exceeds $2 billion annually (Table 4).

Table 4. Annual economic value of the Chesapeake Bay watershed in Delaware

Activity	Value ($2010/year)	Source
Water Quality		
Clean Water Act Restoration	$1,550,543	University of Delaware (2003)
Water Quality–based Recreation	$101,629,897	University of Rhode Island (2002)
Chesapeake Bay Restoration	$22,200,000	University of Maryland (1989)
Increased Property Value	392,735,030	Leggett et al. (2000), EPA (1973), Brookings Institute (2007)
Water/Wastewater Treatment		
Water Treatment by Forests	$550,000	Trust for Public Land and AWWA (2004)
Wastewater Treatment	$29,054,000	DNREC (2010)
Septic-System Assimilation	$16,099,500	DNREC (2010)
Water Supply		
Drinking Water	$50,453,374	WRA, DNREC (2010)
Irrigation	$11,295,000	DNREC, USDA (2007), Resources for the Future (1996)
Ecotourism		
Hunting, Fishing, Bird/Wildlife Watching	$108,900,000	U.S. Fish and Wildlife Service (2006)
Agriculture		
Cropland/Livestock/Poultry	$522,000,000	USDA (2010)
Forests		
Carbon Storage	$854,600,000	U.S. Forest Service (2008)
Carbon Sequestration	$2,960,000	U.S. Forest Service (2008)
Air-Pollution Removal	$27,210,000	U.S. Forest Service (2008)
Building-Energy Savings	$5,730,000	U.S. Forest Service (2008)
Avoided Carbon Emissions	$310,000	U.S. Forest Service (2008)
Public Parks		
Health Benefits from Exercise	$188,537,846	Trust for Public Land (2009)
Community-Cohesion Benefit	$46,156,327	Trust for Public Land (2009)
Water-Pollution Benefit	$17,838,849	Trust for Public Land (2009)
Air-Pollution Mitigation	$1,704,472	Trust for Public Land (2009)
Navigation/Ports		
Instream Navigation Value	$570,000	Resources for the Future (1996)
Port of Baltimore via C&D Canal in Delaware	Imports $7.8B Exports $4.3B	Maryland Port Authority (2010) U.S. Army Corps of Engineers
Total	**> $2 billion/yr**	

Water Quality

Clean Water Act Restoration

Parsons, Helm, and Bondelid (2003) from the University of Delaware measured the economic benefits to recreational users due to Clean Water Act improvements in the northeastern states and found annual per person benefits were $0.47 for viewing, $0.62 for boating, $2.40 for fishing, and $5.59 for swimming. Table 5 summarizes water-quality benefits of $1.5 million per year or $11.17 per person for recreational users in the Chesapeake Bay watershed by adjusting 2003 values to 2010 figures, based on an annual discount rate of 3% and then multiplying those numbers by the bay watershed population in Delaware. Swimming (62%) and fishing (26%) are the highest valued recreational benefits, followed by boating (7%) and viewing (2%).

Table 5. Clean Water Act benefits in the Chesapeake Bay watershed in Delaware

Recreational Benefit	2003[1] (per person)	2010[2] (per person)	Chesapeake Pop. in Del.	Total Benefit	Benefit Portion
Viewing	$0.47	$0.58	138,689	$80,440	5%
Boating	$0.62	$0.76	138,689	$105,404	7%
Fishing	$2.40	$2.95	138,689	$409,133	26%
Swimming	$5.59	$6.88	138,689	$954,180	62%
Total	**$9.08**	**$11.17**	**138,689**	**$1,550,543**	**100%**

1. Parsons et al., 2003. 2. 2010 estimates, adjusted at 3% annually.

Water Quality–based Recreation

Using travel cost demand methods, Johnston et al. (2002) from the University of Rhode Island computed the consumer surplus (economic use value per person) for recreation in the Peconic Estuary watershed on Long Island, N.Y. In 1995 swimming, boating, fishing, and wildlife viewing values were $8.59, $19.23, $40.25, and $49.83 per trip, respectively. Table 6 summarizes water quality benefits to recreational users in the Chesapeake Bay watershed in Delaware by using 1995 values from the Peconic Estuary, adjusting them to 2010 dollars at 3% annually, and multiplying those numbers by trips per year.

Table 6. Annual value of recreational benefits in Chesapeake Bay watershed in Delaware

Recreational Benefit	1995 Consumer surplus/trip[1]	2010 Consumer surplus/trip[2]	Trips/year Chesapeake Watershed	Annual Value	Benefit Portion
Swimming	$8.59	$13.40	13,870[3]	$185,858	0.2%
Boating	$19.23	$30.00	32,620[4]	$978,600	1%
Fishing	$40.25	$62.79	612,150[5]	$38,436,899	38%
Wildlife/bird watching	$49.83	$77.73	798,000[6]	$62,028,540	61%
Total				**$101,629,897**	**100%**

1. Johnston et al., 2002.
2. 2010 values adjusted from 1995 data at annual rate of 3%.
3. 10% of population of 138,689 swims = 13,870 trips.
4. 16.8% of population are boaters @ 1.4 trips/person/year = 32,620 trips (NOEP, 2009).
5. 159,000 anglers in Delaware or 55,650 anglers in bay watershed @ 11 trips/yr = 612,150 trips (USFWS, 2008).
6. 285,000 wildlife/bird watchers in Delaware or 99,750 participants in bay watershed @ 8 trips/year = 798,000 trips (USFWS, 2008).

Chesapeake Bay Restoration

Bockstael, McConnell, and Strand (1989) from the University of Maryland estimated the public's annual willingness to pay for a moderate improvement in Chesapeake Bay water quality to range from $10 to $100 million in 1984 ($21.6 to $216 million in 2010, adjusted at 3% annually). The study found that 43 percent of the respondents were users (boaters, fishermen) of the Chesapeake Bay and were willing to pay $121 per year to make the bay water quality "acceptable." Fifty-seven percent of respondents were non-users, those who did not visit or use the bay's resources but were willing to pay $38 per year to restore the bay. Using similar proportions of users/non-users and given the population is 138,689, aggregate willingness to pay to make water quality acceptable for the public within the Chesapeake Bay watershed in Delaware = (0.43) (138,689) ($121/yr) + (0.57) (138,689) ($38/yr) = $10.2 million (1984) = $22.2 million (2010).

Increased Property Value

Several studies along rivers, estuaries, and coasts in the U.S. indicate improved water quality can increase shoreline property values by 6% to 25% (Table 7). The EPA (1973) estimated that improved water quality can raise property values by up to 18% next to the water, 8% at 1,000 feet from the water, 4% at 2,000 feet from the water, and 2% at 3,000 feet from the water. Leggett et al. (2000) estimated improved bacterial levels to meet state water quality standards along the western shore of the Chesapeake Bay in Maryland could raise property values by 6%. The Brookings Institute (2007) projected that investments of $26 billion to restore the Great Lakes would increase shoreline property values by 10%.

Table 7. Increased property values resulting from improved water quality

Study	Watershed	Increased Value
EPA (1973)	San Diego Bay, Calif.	
- Next to water	Kanawha, Ohio	18%
- 1,000 ft. from water	Willamette River, Ore.	8%
- 2,000 ft. from water		4%
Leggett et al. (2000)	Chesapeake Bay	6%
Brookings Institute (2007)	Great Lakes	10%

Property values within 1,000 feet of the shore may increase by 8% due to improved water quality in the Chesapeake Bay watershed. If the median property value in rural Delaware is $34,000 per acre, then properties within a 1,000-ft corridor along 596 miles of streams in the Chesapeake Bay watershed in Delaware have an estimated value of $4.9 billion. Property values within 1,000 feet of the water would increase by 8% or $393 million due to water-quality improvements in the bay watershed (Table 8).

Table 8. Added property value from improved water quality in Chesapeake Bay watershed in Delaware

Stream	Length[1] (mi)	Length (ft)	Area (acres) within 1,000 ft	Value @ $34,000/ac	Increased Value @ 8%
Broad Creek	83.4	440,352	20,218	$687,418,182	$54,993,455
Choptank River	148.9	786,192	36,097	$1,227,296,970	$98,183,758
Cypress Branch	8.5	44,880	2,061	$70,060,606	$5,604,848
Elk River	2.8	14,784	679	$23,078,788	$1,846,303
Gravelly Run	14.8	78,144	3,588	$121,987,879	$9,759,030
Marshyhope Creek	69.0	364,320	16,727	$568,727,273	$45,498,182
Nanticoke River	229.1	1,209,648	55,539	$1,888,339,394	$151,067,152
Pocomoke River	20.8	109,824	5,042	$171,442,424	$13,715,394
Sassafras River	2.9	15,312	703	$23,903,030	$1,912,242
Sewell Branch	15.4	81,312	3,733	$126,933,333	$10,154,667
Total	**595.6**	**3,144,768**	**144,388**	**$4,909,187,879**	**$392,735,030**

1. DNREC Sec. 303d Report, 2010.

Water/Wastewater Treatment

Water Treatment

The Trust for Public Land and American Water Works Association (2004) found for every 10 percent increase in forested watershed land, drinking-water treatment and chemical costs are reduced by approximately 20 percent (Table 9). If the public drinking-water supply is 28.9 million gallons per day (mgd) and forests cover 160 square miles or 23 percent of the Delaware portion of the Chesapeake Bay watershed, then loss of these forests would increase drinking water–treatment costs by $52 per mgd ($139 per mgd @ 0% forested minus $87 per mgd @ 23% forested) or $1,503 per day = $550,000 per year.

Table 9. Drinking water treatment and chemical costs based on percent of forested watershed

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

Source: Trust for Public Land and AWWA, 2004

Wastewater Treatment

Surface water and groundwater in the Chesapeake Bay watershed in Delaware provides wastewater-treatment, -discharge, and -assimilation services. NPDES wastewater discharges to surface waters in the watershed total 19.9 mgd. The average wastewater rate in the watershed is $4.00 per 1,000 gallons, which for an average residence of three people at 50 gallons per capita per day (gpcd) is a fee of $219 per year. The total value of treated wastewater from NPDES dischargers in the watershed is $79,600 per day or $29,054,000 per year (Table 10).

Table 10. Value of NPDES wastewater discharges in Chesapeake Bay watershed in Delaware

NPDES ID	Facility	Flow[1] (mgd)	Value $4.00/1,000 gallons ($/day)	Wastewater Value ($/year)
DE0020249	Bridgeville WWTP	0.8	3,200	1,168,000
DE0020125	Laurel WWTP	0.7	2,800	1,022,000
DE0020265	Seaford WWTP	2.0	8,000	2,920,000
DE0000035	Invista	16.4	65,600	23,944,000
Delaware		**19.9**	**79,600**	**29,054,000**

1. DNREC, 2010.

Septic-System Assimilation

The groundwater table provides valuable wastewater assimilation services for 32,199 septic systems in the Delaware portion of the Chesapeake Bay watershed in 2010 (DNREC, 2010). Assuming per capita wastewater flow is 50 gpcd and three persons per dwelling unit (150 gpd/du), the septic-system wastewater flow is projected to be 4.8 mgd. The average annual cost of a septic system is $500, assuming installation cost of $15,000 amortized over 30 years at 5% interest and annual O&M costs of $350 for pumping and cleanout. The property value investment of 32,199 septic systems in the watershed in Delaware is $16.1 million (Table 11).

Table 11. Value of septic systems in the Chesapeake Bay watershed in Delaware

County	Septic Systems[1]	Flow @ 150 gpd/du (gpd)	Value @ $500/system ($)
New Castle	3,713	556,950	1,856,500
Kent	4,652	697,800	2,326,000
Sussex	23,834	3,575,100	11,917,000
Total	32,199	4,829,850	16,099,500

1. DNREC, 2010.

Water Supply

Sole source aquifers in the Delaware portion of the Chesapeake Bay watershed provide water supplies for drinking water and irrigation purposes. Table 12 provides a framework for measuring the economic benefits of groundwater reserve stock to generate ecosystem services (USEPA, 1995).

Table 12. Groundwater services and effects

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

Source: USEPA, 2005

Drinking Water

The annual value of raw (untreated) groundwater for drinking water in the Delaware portion of the Chesapeake Bay watershed (28.9 mgd) is $10.5 million. When treated and delivered to customers, the value is $50.4 million (Table 13). Water purveyors in Delaware estimate the value of raw water supply is $1.00/1,000 gallons according to cost of services studies for rate setting by the Public Service Commission. The average value of treated drinking water based on rates set by public and private water purveyors in Delaware is $4.78/1,000 gallons (Corrozi and Seymour, 2008).

Table 13. Value of drinking water supply in Delaware portion of Chesapeake Bay watershed

Watershed	PWS[1]	Capacity (gpm)	Capacity (gpd)	Value/day untreated ($1/1,000 gal)	Value/year untreated ($1/1,000 gal)	Value/year treated ($4.78/1,000 gal)
Choptank River	C	230	331,200	331	120,888	577,845
	NTNC	225	324,000	324	118,260	565,283
	TNC	0	0	0	0	0
	Subtotal	455	655,200	655	239,148	1,143,127
Marshyhope Creek	C	20	28,800	29	10,512	50,247
	NTNC	50	72,000	72	26,280	125,618
	Subtotal	70	100,800	101	36,792	175,866
Nanticoke River	C	8,580	12,355,200	12,355	4,509,648	21,556,117
	NTNC	4,695	6,760,800	6,761	2,467,692	11,795,568
	TNC	140	201,600	202	73,584	351,732
	Subtotal	13,415	19,317,600	19,318	7,050,924	33,703,417
Gum Branch	NTNC	60	86,400	86	31,536	150,742
	Subtotal	60	86,400	86	31,536	150,742
Gravelly Branch	C	0	0	0	0	0
	NTNC	20	28,800	29	10,512	50,247
	TNC	0	0	0	0	0
	Subtotal	20	28,800	29	10,512	50,247
Deep Creek	C	1,650	2,376,000	2,376	867,240	4,145,407
	NTNC	105	151,200	151	55,188	263,799
	TNC	35	50,400	50	18,396	87,933
	Subtotal	1,790	2,577,600	2,578	940,824	4,497,139
Broad Creek	C	4,250	6,120,000	6,120	2,233,800	10,677,564
	NTNC	22	31,680	32	11,563	55,272
	Subtotal	4,272	6,151,680	6,152	2,245,363	10,732,836
Total		**20,082**	**28,918,080**	**28,918**	**10,555,099**	**50,453,374**

1. PWS = public water system, C = community system, NTNC = non-transient non-community system, TNC = transient non-community system.

Irrigation

In a study of the economic value of freshwater in the United States, Resources for the Future estimated the median value of irrigation water withdrawals is $198/acre-ft in $1996 (Frederick, VandenBerg, and Hansen 1996) or $300/acre-ft ($0.92/1,000 gal) in 2010, adjusted at 3% annually (Table 14).

Table 14. Freshwater values in the United States by use

Use	2006[1] ($/ac-ft)	2010[2] ($/ac-ft)	2010 ($/1,000 gal)
Navigation	10	15	0.02
Irrigation	198	300	0.92
Industrial Process	132	200	0.61
Thermoelectric Power	29	44	0.14

1. Frederick, VandenBerg, and Hansen, 1996. 2. 2010 estimates, adjusted at 3% annually.

In Delaware 104,562 acres of farmland were irrigated (USDA, 2007). About 48 percent of Delaware farmland is in the Chesapeake Bay watershed, and 50,200 acres are irrigated. If irrigation needs from June through September are nine inches and the value of irrigation water is $300 per acre-ft, annual value of water supply (102 mgd) to irrigate 50,200 acres for agriculture, golf courses, and nurseries is $11.3 million. Value of irrigation water supply = (9 in/12 in/ft) (50,200 acres) ($300/acre-ft) = $11,295,000.

Ecotourism (Hunting, Fishing, Birding/Wildlife Viewing)

In Delaware, the U.S. Fish and Wildlife Service (2008) estimated the annual economic value of fishing, hunting, and birding/wildlife-associated recreation as $269 million in 2006 (or $302 million in 2010, adjusted at 3% annually). Trip-related expenditures are food and lodging, transportation, and hunting, fishing, and wildlife-watching equipment. Most fishing, hunting, and birding/wildlife-oriented recreation occurs on farm, forest, wetlands, and open-water ecosystems and state parks, forests, and wildlife areas, such as Blackbird State Forest in New Castle County, Taber State Forest in Kent County, and Trap Pond State Park in Sussex County. Adjusting to 2010 figures and then prorating for the ratio of bay watershed to total state land area (702 sq mi/1953 sq mi = 36%), the economic value of fishing, hunting, and wildlife-associated recreation in Delaware in the Chesapeake Bay watershed is $109 million annually (Table 15).

Table 15. Value of fishing, hunting, wildlife recreation in Delaware in the Chesapeake Bay watershed

Recreation Activity	State of Delaware[1] 2006 ($M)	State of Delaware[2] 2010 ($M)	Chesapeake Bay[3] 2010 ($M)
Fishing	**96.7**	**108.8**	**39.2**
Trip Related	48.5	54.6	19.7
Equipment/other	48.2	54.2	19.5
Hunting	**41.3**	**46.5**	**16.7**
Trip-related	13.6	15.3	5.5
Equipment/other	27.7	31.2	11.2
Wildlife/Bird-watching	**130.8**	**147.2**	**53.0**
Trip Related	13.1	14.7	5.3
Equipment/other	117.7	132.5	47.7
Total	**268.8**	**302.5**	**108.9**

1. USFWS, 2008.
2. 2010 estimates, adjusted at 3% annually.
3. Prorated based on ratio of Chesapeake Bay watershed to state land area (702 sq mi/1953 sq mi = 36%).

Agriculture

In Delaware, the USDA National Agricultural Statistics Service (2010) estimated the real estate value of farms is $8,100 per acre and the cropland value is $2,120 per acre. The annual market value of agricultural products sold in Delaware is $1.083 billion on 510,253 acres (797 square miles) for crops (corn, wheat, oats, barley, soybeans, potatoes, and vegetables), livestock, and poultry. On 245,509 acres (384 square miles) of farmland in the Chesapeake Bay watershed in Delaware, the prorated annual market value of agricultural products sold is $522 billion. The Chesapeake Bay watershed covers just about 35 percent of Delaware's land area yet accounts for nearly half of farm products sold in the state.

Forests

The U.S. Forest Service and Delaware Center for Horticulture (Nowak et al., 2008) estimated that 7,137 acres of forests in New Castle County have carbon-storage value of $5.9 million ($827/acre), and air-pollution-removal value of $1.9 million ($266/acre/year). Applying these multipliers, 102,306 acres of forests in the Delaware portion of the Chesapeake Bay watershed have a carbon-storage value of $854 million and air-pollution-removal value of $27 million. Forests in the Chesapeake Bay watershed in Delaware provide environmental benefits by regulating climate change, cooling, and air emissions including four million tons of carbon-storage capacity, 143,000 tons of carbon sequestration, 4,000 tons of air-pollution removal, 14,000 tons of avoided-carbon-emissions capacity (Table 16).

Table 16. Benefits of forests in the Delaware portion of the Chesapeake Bay watershed

Forest Benefit	New Castle County[1]		Chesapeake Watershed in Delaware[2]	
	Environmental (tons/ac)	Economic ($/ac)	Environmental (tons)	Economic ($)
Carbon storage	40	827	4,092,240	854,607,062
Carbon Sequestration	1.4	29	143,228	2,966,874
Air-Pollution Removal	0.04	266	4,092	27,213,396
Building-Energy Savings		56	0	5,729,136
Avoided Carbon Emissions	0.14	3	14,323	306,918
Structural Value		170,000	0	17.4 billion

1. Nowak et al., 2008. 2. Computed for 102,306 acres of forests.

Public Parks

The Trust for Public Land (2009) found that the 444-acre City of Wilmington park system provides annual economic savings to the public from direct-use value ($94,155/acre), health benefits ($9,734/acre), community-cohesion benefits ($2,383/acre), stormwater benefits ($921/acre), and air-pollution-mitigation value ($88/acre). Parks in the Delaware portion of the Chesapeake Bay watershed cover 19,369 acres and include Blackbird State Forest in New Castle County, Taber State Forest in Kent County, and Trap Pond State Park and Nanticoke River Preserve in Sussex County. Using data from the Wilmington study, parks in the Chesapeake Bay watershed in Delaware provide the following economic benefits (Table 17).

- Health benefits from exercise in the parks ($189 million).
- Community-cohesion benefit from people socializing in the parks ($46 million).
- Water-pollution benefit from parks in treating stormwater ($18 million).
- Air-pollution-mitigation value from tree and shrub absorption ($1.7 million).

Table 17. Value of public parks in the Chesapeake Bay watershed in Delaware

Parks	Parks in watershed (ac)	Direct-Use Value[1] ($94,155/ac)	Health Benefits[1] ($9,734/ac)	Community Cohesion[1] ($2,383/ac)	Stormwater Benefit[1] ($921/ac)	Air Pollution[1] ($88/ac)
Kent	**1,296**	**122,024,880**	**12,615,264**	**3,088,368**	**1,193,616**	**114,048**
State Forest	1,273	119,859,315	12,391,382	3,033,559	1,172,433	112,024
Local	23	2,165,565	223,882	54,809	21,183	2,024
New Castle	**5,018**	**472,469,790**	**48,845,212**	**11,957,894**	**4,621,578**	**441,584**
State Forest	4,800	451,944,000	46,723,200	11,438,400	4,420,800	422,400
County	203	19,113,465	1,976,002	483,749	186,963	17,864
Local	15	1,412,325	146,010	35,745	13,815	1,320
Sussex	**13,055**	**1,229,193,525**	**127,077,370**	**31,110,065**	**12,023,655**	**1,148,840**
State Forest	9,500	894,472,500	92,473,000	22,638,500	8,749,500	836,000
State Park	3,300	310,711,500	32,122,200	7,863,900	3,039,300	290,400
Local	255	24,009,525	2,482,170	607,665	234,855	22,440
Delaware	**19,369**	**1,823,688,195**	**188,537,846**	**46,156,327**	**17,838,849**	**1,704,472**

1. Trust for Public Land, 2009.

Navigation/Ports

The Chesapeake and Delaware (C&D) Canal and Nanticoke River provide instream navigation–use value. The 35-ft-deep C&D Canal in the Delaware part of the Chesapeake Bay watershed holds 10,000 acre-ft or 3.2 billion gallons of water. The volume of the Nanticoke River in Delaware is 28,000 acre-ft or 9.1 billion gallons. A study of the economic value of freshwater in the United States included estimates of the median value of instream navigation uses at $10/acre-ft in 1996 (Frederick, VandenBerg, and Hansen, 1996), or $15/acre-ft in 2010, adjusted at 3% annually. Therefore, the instream navigation–use value of the C&D Canal and Nanticoke River in the Delaware portion of the Chesapeake Bay watershed is $570,000.

The 35-ft-deep C&D Canal is a valuable commercial resource that flows through the Chesapeake Bay watershed in Delaware and carries 40 percent of all ship traffic to/from the Port of Baltimore. The C&D Canal trims almost 300 miles for ships that would otherwise sail to Baltimore up the Chesapeake Bay from the Atlantic Ocean. Normally, 6 to 35 ships sail through the C&D Canal per day.

The Port of Baltimore is responsible for 16,700 direct jobs, $3.7 billion in wages, and almost $400 million in state and local tax revenues (Maryland Port Administration, 2010). Of 360 U.S. ports, Baltimore is No. 1 in forest product, gypsum, and sugar imports and No. 2 in automobile exports. In 2009, the Port of Baltimore was 11th among all U.S. port districts with $10.8 billion in exports after Seattle (9th) and San Francisco (10th). Baltimore was 12th in the U.S. with $19.4 billion in imports after Norfolk (10th) and Port Arthur, Tex. (11th).

If 40 percent of all Baltimore shipping traffic sails through the C&D Canal, then 40 percent of the economic activity generated by the port can be indirectly attributed to this avenue of commerce that cuts through the Chesapeake Bay watershed in Delaware (Table 18).

Table 18. Economic activity generated by the Port of Baltimore through the C&D Canal

Activity	Port of Baltimore[1]	C&D Canal[2]
Jobs	16,700	6,700
Wages	$3.7 billion	$1.5 billion
Imports	$19.4 billion	$7.8 billion
Exports	$10.8 billion	$4.3 billion

1. Maryland Port Administration, 2010.
2. 40% of shipping to/from Port of Baltimore navigates through the C&D Canal in Delaware.

5. Ecosystem Services

Data from the following studies were used to estimate the value of ecosystem services for the Chesapeake Bay watershed in Delaware.

- Cecil County Green Infrastructure Plan by the Conservation Fund, Annapolis, Md.
- New Jersey Department of Environmental Protection with the University of Vermont
- Ecosystem services value of forests by the Wilderness Society
- Ecosystem services value of Peconic Estuary watershed by University of Rhode Island.
- U.S. National Wildlife Refuge System by University of Maryland and Nature Conservancy
- Economic value of ecosystem services in Massachusetts by the Audubon Society.

Other Studies

Ecosystem services include air filtration, water filtration, recycling nutrients, soil conservation, pollination of crops and plants, climate regulation, carbon sequestration, flood and stormwater control, and hydrologic-cycle regulation (Table 19). These ecological resources provide marketable goods and services, such as timber, fish and wildlife recreation, hiking, and boating/kayaking. A Cecil County, Md., study found the largest ecosystem services values result from stormwater/flood control, water supply, and clean water functions (Weber, 2007).

Table 19. Ecosystem services values for Cecil County, Maryland (Weber, 2007)

Ecosystem Service	Upland Forest ($/ac/yr)	Riparian Forests/ Wetlands ($/ac/yr)	Nonriparian Wetlands ($/ac/yr)	Tidal Marsh ($/ac/yr)
Carbon sequestration	31	65	65	65
Clean air	191	191	191	
Soil and peat formation	17	946	450	1,351
Stormwater/flood control	679	32,000	32,000	1,430
Water supply	8,630	8,630	8,630	
Clean water	1,100	1,925	1,100	11,000
Erosion/sediment control	151	3,418	151	12,700
Water temperature regulation		4,450		
Pest control	50	50	50	
Pollination	75	75	75	
Wood products	142			
Recreation, fish, wildlife habitat	486	534	534	544
Community-services savings	439	439	439	439
Increase in property values	42	42		
Total	**12,033**	**52,765**	**43,685**	**28,146**

Source: Weber, 2007

The New Jersey Department of Environmental Protection (2007) partnered with the University of Vermont and estimated the value of New Jersey's natural capital was $20 billion/year plus or minus $9 billion/year in 2004 with a net present value of $681 billion, based on a discount rate of 3% calculated in perpetuity (over 100 years in the future). Natural capital is the sum of goods (commodities like water,

crops, and timber that can be sold) and services (functions like flood control, water filtration, and wildlife/fisheries habitat) provided by watershed ecosystems such as wetlands, forests, farms, and open water. In addition to these direct benefits, ecosystems also provide indirect benefits such as ecotourism by hunters, fishermen, boaters, and hikers who spend money to visit natural sites and realize value from improved water quality and habitat. Table 20 summarizes total ecosystem goods and services in New Jersey. Farm products, fish, minerals, and water supply provide the most ecosystem goods; nutrient cycling, soil disturbance regulation, water regulation, habitat, aesthetic/recreational, waste treatment, and water supply provide the highest ecosystem services.

Table 20. Ecosystem goods and services provided by New Jersey natural capital

Ecosystem	$ million/yr	Portion
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%
Ecosystem Services	**$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%

Source: NJDEP, 2007

An analysis for the Wilderness Society (Krieger, 2001) concluded that forest ecosystem services values for climate regulation, water supply, water quality, and recreation benefits totaled $392/acre in 1994 or $631/acre in 2010, adjusted at 3% annually (Table 21).

Table 21. Forest ecosystem services values for U.S. temperate forests (Krieger, 2001)

Ecosystem Good or Service	1994 Value[1] ($/ac)	2010 Value[2] ($/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. Krieger, 2001. 2. 2010 estimates, adjusted at 3% annually.

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, N.Y., ranged from $6,560/acre for wetlands to $9,979/acre 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 are $6,268/acre and $845/acre, respectively (Ingraham and Foster, 2008). The Audubon Society found that the economic value of ecosystems in Massachusetts ranged from $984/acre for forests to $15,452/acre for saltwater wetlands (Breunig, 2003).

According to the 2007 USDA Census of Agriculture (2009), the total market value of agricultural crops sold from 510,253 acres of farmland in Delaware was $1,083 billion ($210.6 million in crops and $872.4 million in poultry and livestock). With 245,509 acres of farmland, the prorated value of agricultural crops sold in the Delaware portion of the Chesapeake Bay watershed was $520 million or $2,119 per acre.

Table 22 compares ecosystem services values ($/acre) from other studies. Data from the NJDEP/University of Vermont study are used for value transfer, since the Chesapeake Bay watershed in Delaware is similar to New Jersey habitat and the two adjacent states share a similar climate (humid continental) at 40 degrees north in latitude, similar physiographic provinces (Coastal Plain), and similar aquifers, soils, and ecosystems. Cecil County, Md., is in the Chesapeake Bay watershed and has higher ecosystem values on a per acre basis for forests and wetlands than the other studies. The NJDEP ecosystem services estimates ($/acre) are lower than Cecil County values for wetlands and forests and MassAudubon values for wetlands but higher than Wilderness Society values for forests and U.S. National Wildlife Refuge values for freshwater wetlands and forests. Values for 2010 were estimated from figures from previous studies, adjusting at 3% annually. Net present values were calculated based on an annual discount rate of 3% in perpetuity (over 100 years in the future).

Table 22. Comparison of ecosystem service value studies

Ecosystem	Cecil Co. Maryland 2006 ($/ac/ yr)	New Jersey DEP 2004 ($/ac/ yr)	Wilderness Society 2001 ($/ac/yr)	Peconic Estuary 1995 ($/ac/ yr)	U.S. Wildlife Refuge 2008 ($/ac/ yr)	Mass Audubon 2003 ($/ac/ yr)	USDA Census[1] (2007) ($/ac/ yr)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	2,119[1]
Forest land	12,033	1,714	641		845	984	
Saltwater wetland	28,146	6,269		6,560		12,580	
Undeveloped				2,080			
Urban		296					
Beach/dune		42,149					
Open freshwater		1,686			217	983	
Riparian buffer	52,765	3,500					
Shellfish areas				4,555			

1. Value of ecosystem goods only as measured by agricultural crops, livestock, and poultry sold.

Chesapeake Bay Watershed in Delaware

The estimated 2010 value of natural goods and services provided by ecosystems in the Chesapeake Bay watershed in Delaware (702 square miles or 449,174 acres) is $3.4 billion with a net present value (NPV) of $109.6 billion (Table 23). NPV is based on an annual discount rate of 3% over a perpetual lifetime (over 100 years). Natural goods are commodities that can be sold, such as water supply, farm crops, fish, timber, and minerals. Natural services are ecological benefits to society, such as flood control by wetlands, water filtration by forests, and fishery habitat by beach and marine areas. Ecosystem services areas within the Chesapeake Bay watershed in Delaware comprise farmland (55%), forests (23%), and freshwater wetlands (18%). Only 4% of the bay watershed in Delaware is urban/suburban (Figure 3).

Forests, freshwater wetlands, and farms provide the highest total ecosystems goods and services values (Figure 4). Ecosystems that provide the highest natural goods values are farmland ($600 million or $2,446/acre/year), followed by forest ($28 million or $275/acre/year) and freshwater wetlands ($22 million or $270/acre/year). The highest natural ecosystem services values are provided by forests ($1.4 billion or $13,887/acre) followed by freshwater wetlands ($1.1 billion or $13,351/acre), and farmland ($203 million or $827/acre).

The Nanticoke River ($786 million), Broad Creek ($557 million), and Choptank River ($490 million) watersheds provide the highest values of annual ecosystem services (Figure 5). Watersheds with the highest value of annual ecosystem services per acre include the Elk Creek ($11,209/acre), Gravelly Branch ($9,559/acre), Pocomoke River ($8,750/acre), and Chester River ($8,704/acre), as these systems are rich in forests and wetlands (over 75%).

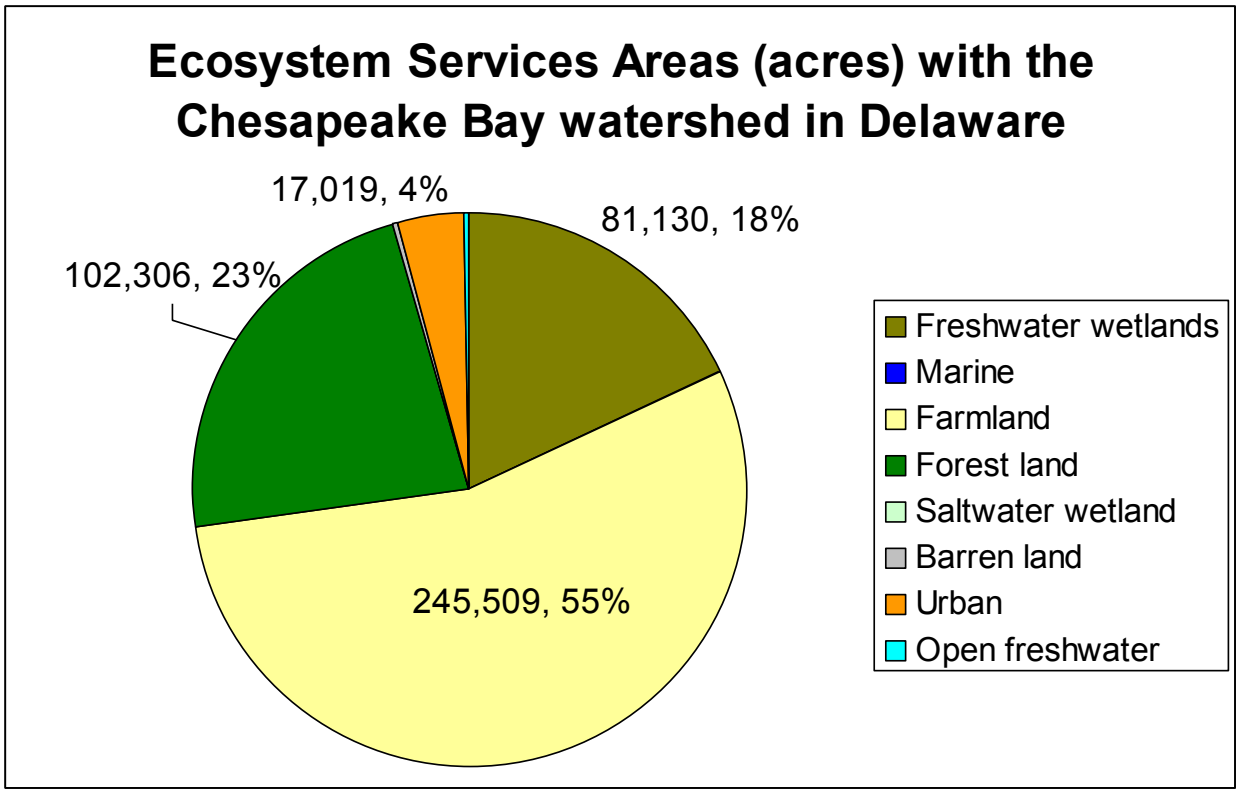
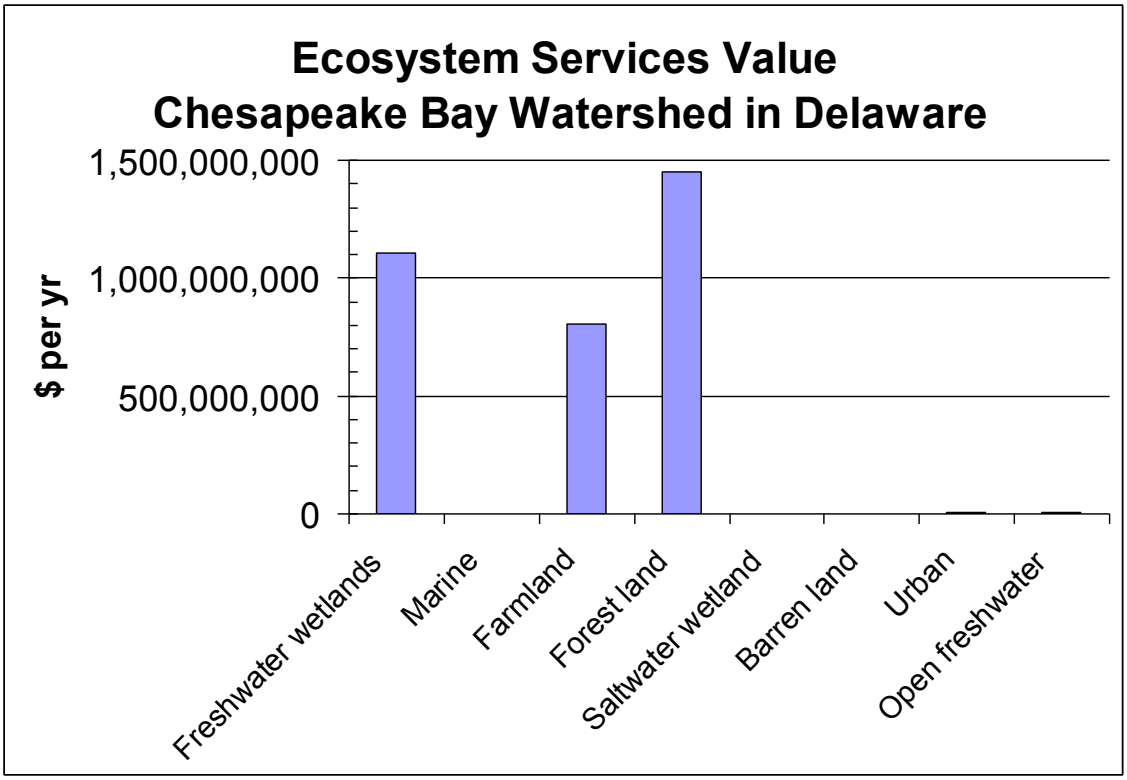


Figure 3. Ecosystem service areas within the Chesapeake Bay watershed in Delaware

Table 23. Ecosystem services in the Chesapeake Bay watershed in Delaware

			Natural Goods			
Ecosystem	**Area (ac)**	**$/ac/yr 2004**	**$/yr 2004**	**$/ac/yr 2010**	**$/yr 2010**	**NPV $**
Freshwater wetlands	81,130	234	18,984,442	270	21,909,907	712,071,979
Marine	233	1,125	261,697	1,298	302,024	9,815,796
Farmland	245,509	2,119	520,234,508	2,446	600,401,605	19,513,052,155
Forest land	102,306	238	24,348,792	275	28,100,892	913,279,000
Saltwater wetland	353	139	49,120	160	56,689	1,842,383
Barren land	844	0	0	0	0	0
Urban	17,019	13	221,242	15	255,335	8,298,387
Open freshwater	1,780	921	1,638,979	1,063	1,891,543	61,475,134
Total	**449,174**		**565,738,780**		**652,917,995**	**21,219,834,834**
			Natural Services			
Ecosystem	**Area (ac)**	**$/ac/yr 2004**	**$/yr 2004**	**$/ac/yr 2010**	**$/yr 2010**	**NPV $**
Freshwater wetlands	81,130	11,568	938,512,949	13,351	1,083,135,918	35,201,917,330
Marine	233	7,544	1,754,885	8,707	2,025,309	65,822,545
Farmland	245,509	717	176,030,270	827	203,156,182	6,602,575,930
Forest land	102,306	12,033	1,231,046,285	13,887	1,420,748,055	46,174,311,792
Saltwater wetland	353	6,131	2,166,559	7,076	2,500,421	81,263,686
Barren land	844	0	0	0	0	0
Urban	17,019	283	4,816,269	327	5,558,446	180,649,496
Open freshwater	1,780	765	1,361,367	883	1,571,151	51,062,407
Total	**449,174**		**2,355,688,583**		**2,718,695,483**	**88,357,603,185**
			Natural Goods and Services			
Ecosystem	**Area (ac)**	**$/ac/yr 2004**	**$/yr 2004**	**$/ac/yr 2010**	**$/yr 2010**	**NPV $**
Freshwater wetlands	81,130	11,802	957,497,392	13,621	1,105,045,825	35,913,989,309
Marine	233	8,669	2,016,582	10,005	2,327,334	75,638,340
Farmland	245,509	2,836	696,264,778	3,273	803,557,787	26,115,628,085
Forest land	102,306	12,271	1,255,395,077	14,162	1,448,848,947	47,087,590,792
Saltwater wetland	353	6,270	2,215,678	7,236	2,557,110	83,106,069
Barren land	844	0	0	0	0	0
Urban	17,019	296	5,037,511	342	5,813,781	188,947,882
Open freshwater	1,780	1,686	3,000,346	1,946	3,462,694	112,537,541
Total	**449,174**		**2,921,427,364**		**3,371,613,478**	**109,577,438,019**



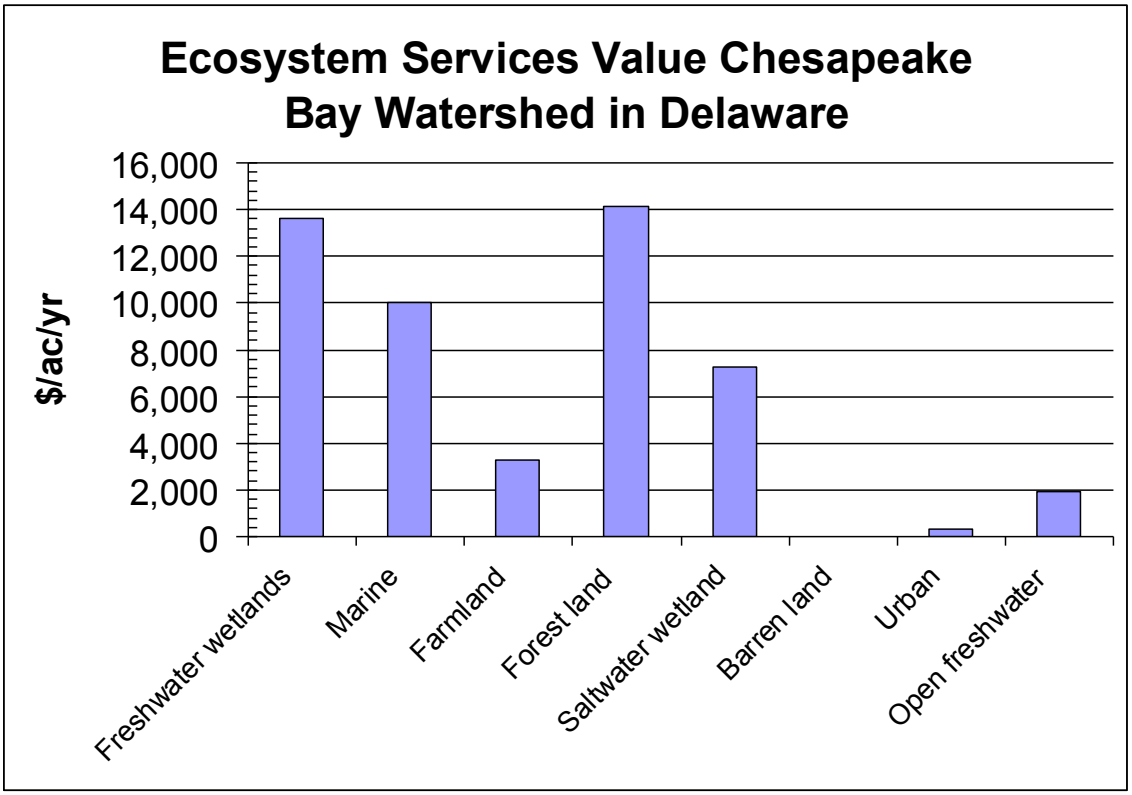
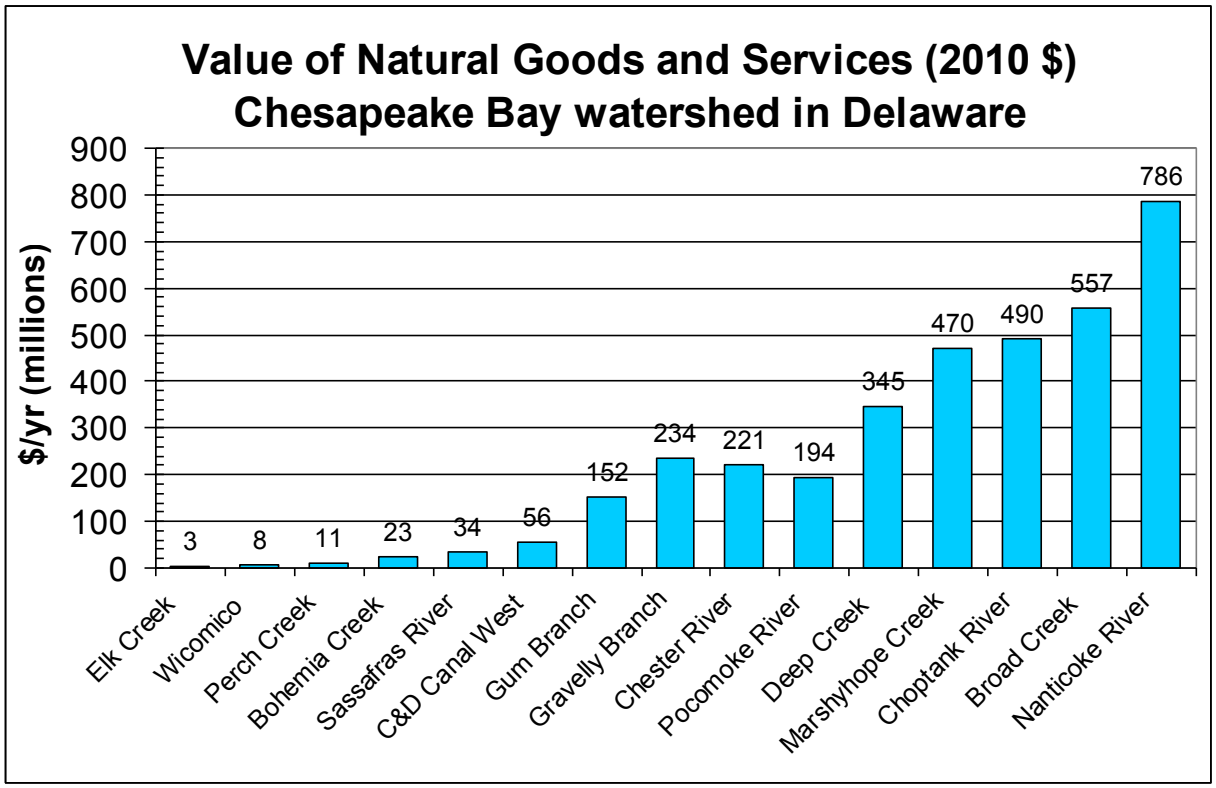


Figure 4. Estimated 2010 ecosystem services values in the Chesapeake Bay watershed in Delaware



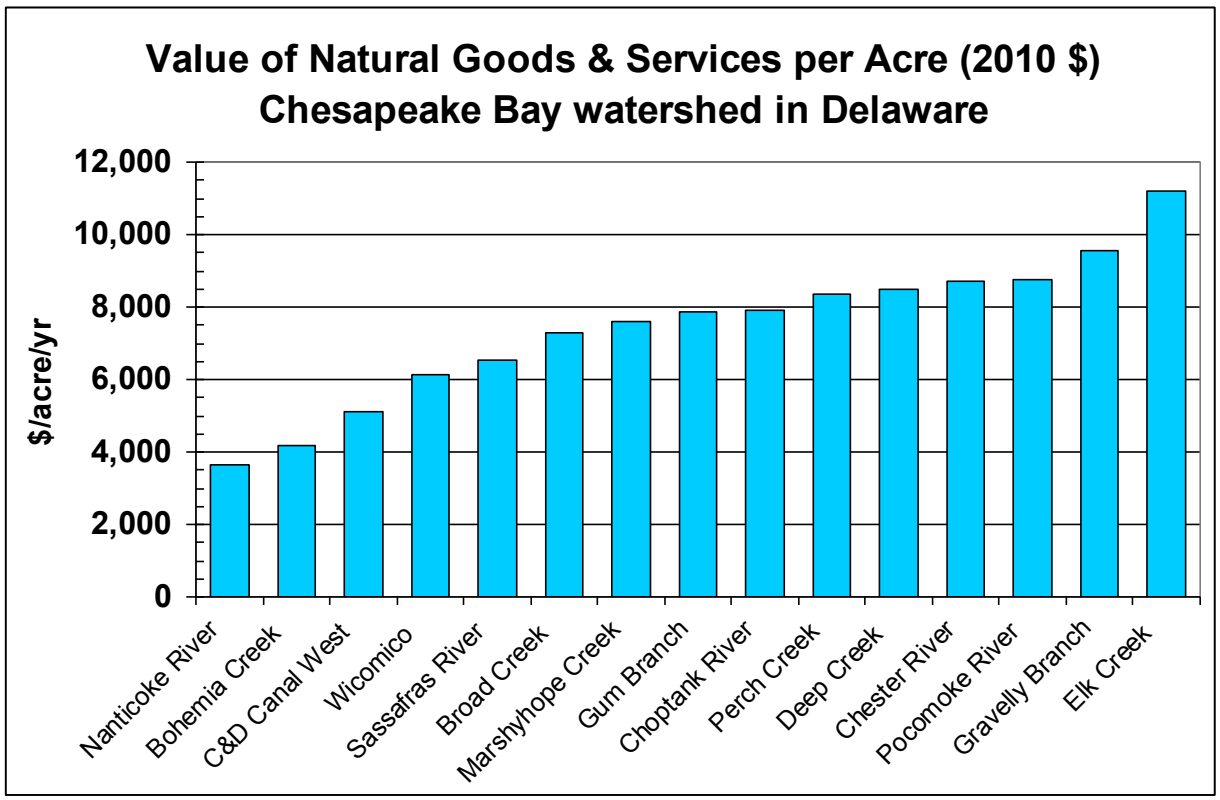


Figure 5. Estimated 2010 value of natural goods and services in the Chesapeake Bay watershed in Delaware

Estimates of ecosystem services in the Chesapeake Bay watershed in Delaware using the NJDEP/University of Vermont values ($3.4 billion in $2010 or NPV of $109.6 billion) are conservative and in the middle of the range compared to values from other studies. If lower per acre estimates of ecosystem services value from other studies were used instead of the NJDEP values, the total value of natural resources in the Chesapeake Bay watershed in Delaware would be $924 million or NPV = $30 billion (Table 24). If higher per acre estimates of ecosystem services value from other studies were used, the total value of natural resources in the Chesapeake Bay watershed in Delaware would be $7.3 billion or NPV = $236 billion (Table 25).

Estimate	PV ($B)	NPV ($B)
Low	0.9	30
NJDEP	3.4	110
High	7.3	236

Table 24. Low range of ecosystem services in the Chesapeake Bay watershed in Delaware

Ecosystem	Area (ac)	$/ac/yr	PV $	NPV $
Freshwater wetlands	81,130	6,268[5]	508,523,441	16,527,011,836
Marine	233	8,670[2]	2,016,815	65,546,484
Farmland	245,509	1,387[6]	340,521,596	11,066,951,872
Forest land	102,306	641[3]	65,578,049	2,131,286,606
Saltwater wetland	353	6,269[2]	2,215,325	71,998,058
Barren land	844	0	0	0
Urban	17,019	296[2]	5,037,511	163,719,097
Open water	1,780	217[5]	386,166	12,550,381
Total	**449,174**		**924,278,903**	**30,039,064,333**

Table 25. High range of ecosystem services in the Chesapeake Bay watershed in Delaware

Ecosystem	Area (ac)	$/ac/yr	PV $	NPV $
Freshwater wetlands	81,130	43,685[1]	3,544,168,239	115,185,467,780
Marine	233	8,670[2]	20,168,614	655,479,956
Farmland	245,509	9,979[4]	2,449,938,722	79,623,008,459
Forest land	102,306	12,033[1]	1,231,046,285	40,009,004,254
Saltwater wetland	353	28,146[1]	9,946,169	323,250,493
Barren land	844	0	0	0
Urban	17,019	296[2]	5,037,511	163,719,097
Open water	1,780	1,686[2]	3,000,346	97,511,252
Total	**449,174**		**7,263,305,886**	**236,057,441,292**

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

6. Jobs and Salaries

Watershed Jobs

According to the U.S. Bureau of Labor Statistics, U.S. Census Bureau, and Delaware Department of Labor, 41,823 people were employed with $1.2 billion in wages in 2009 in New Castle, Kent, and Sussex Counties within the Chesapeake Bay watershed in Delaware (Table 26).

Table 26. Jobs and salaries in the Chesapeake Bay watershed in Delaware in 2009

Socioeconomic Activity Area	Jobs	Salaries (billion)
State of Delaware	**380,603**	**$10.4**
New Castle County	249,869	$6.9
Kent County	60,974	$1.5
Sussex County	69,760	$2.0
Chesapeake Bay watershed in Delaware	**41,825**	**$1.2**
New Castle County	6,630	$0.2
Kent County	8,595	$0.2
Sussex County	26,598	$0.8
Directly/indirectly associated with Chesapeake Bay watershed	**12,809**	**$0.31**

Chesapeake Bay watershed jobs and salaries were obtained from the U.S. Department of Labor Bureau of Labor Statistics (2009) and U.S. Census Bureau for the following scenarios.

1. The entire state of Delaware.
2. Total jobs in each county within the Chesapeake Bay watershed determined from NAICS industry code (formerly SIC code) data and then grouped by census tract.
3. Direct and indirect bay watershed–related jobs determined for each NAICS code. Indirect jobs and salaries were estimated by a multiplier of 2.2 applied to direct jobs and 1.8 applied to direct wages provided by purchases of goods and services from firms that recognize the interlinked regional economy (Latham and Stapleford, 1987).

The Chesapeake Bay watershed in Delaware supports over 12,800 direct and indirect jobs with $308 million in annual wages in the farm, ecotourism, water/wastewater, recreation, seafood, and environmental industries (Tables 27 and 28).

Table 27. Jobs and wages related to the Chesapeake Bay watershed in Delaware

Sector	Jobs	Wages ($million)	Data Source
Direct Bay Watershed Related	3,147	68.8	U.S. Bureau of Labor Statistics, 2009
Indirect Bay Watershed Related	3,777	55.1	U.S. Census Bureau, 2009
Farm	2,566	75.0	USDA Census of Agriculture, 2007
Fishing/Hunting/Birding	3,319	109.0	U.S. Fish and Wildlife Service, 2008
Total	**12,809**	**308.0**	

Table 28. Direct/indirect jobs related to the Chesapeake Bay watershed in Delaware, 2009

Sector	Industry	1997 NAICS Code	Direct Jobs[1]	Direct Wages[1] (x$1,000)	Indirect Jobs[2]	Indirect Wages[2] (x$1,000)
Construction	Marine Related	237120				
	Water and Sewer	23711	106	4,368		
	Construction	237990	25	1,136		
Living Resources	Fish Hatcheries	112511				
	Aquaculture	112512				
	Fishing	11411				
	Finfish Fishing	114111				
	Shellfish Fishing	114112				
	Seafood Markets	445220	8	289		
	Seafood Process.	31171				
	Comm. Fisheries					
Minerals	Sand & Gravel	212321				
		212322				
	Oil & Gas	541360	3	150		
Ship/Boat Building	Boat Bldg. Repair	336612				
	Shipbuilding					
Tourism/Recreation	Recreation	487990				
		611620	13	103		
		532292				
	Amusement	713990	50	820		
	Boat Dealers	441222	40	1,498		
	Restaurants	722110	743	34,757		
		722211	1,359	820		
		722212	53	775		
		722213	188	2,702		
	Hotels & Lodging	721110	130	2,335		
		721191				
	Marinas	713930				
	RV Park/Camps	721211	21	722		
	Scenic Tours	487210	4	79		
	Sporting Good	339920				
	Zoos, Aquaria	712130				
		712190				
Transportation	Navigation/Shipping	488330	8	571		
	Marine Cargo	488320	191	6,876		
	Search/Navigation	334511				
	Warehousing	493110	63	2,748		
		493120				
	Ports					
	Dredging/Disposal					
Environmental	Environ. Organizations	813312	17	595		
	Environ. Consulting	54162	41	2,149		
Water/Wastewater	Water/Sewage	2213	53	4,001		
	Waste Management	562	29	1,206		
	Septic Tank	562991	3	129		
Total			**3,147**	**68,828**	**3,777**	**55,062**

1. Direct jobs are those directly related to the Chesapeake Bay watershed in Delaware. 2. Indirect jobs and wages are derived from purchases of goods and services by direct jobs earners calculated by multipliers of 2.2 for jobs and 1.8 for wages.

Ecotourism Jobs

The 2007 NJDEP study estimates the average annual salary per ecotourism job is $32,843, using figures from the 2001 U.S. Fish and Wildlife Service report (2003) on fishing, hunting, and wildlife-associated recreation. If fishing, hunting, and bird/wildlife-associated recreation in the Delaware portion of the Chesapeake Bay watershed accounts for $109 million in annual economic activity (2010), then ecotourism accounts for about 3,319 jobs.

Farm Jobs

In 2007 there were 2,546 farms in Delaware or approximately 1,222 farms in the Delaware portion of the Chesapeake Bay watershed. The USDA estimates farms employ about 2.1 full-time-equivalent jobs per farm; therefore, farming and agricultural habitat conservation account for about 2,566 Delaware jobs in the bay watershed.

Chesapeake Bay WIP Jobs

The Chesapeake Bay Watershed Implementation Plan (WIP) is designed to fund green jobs in Delaware. Investment in watershed-restoration jobs can stimulate the local economy in much the same way that public works, transportation, and highway projects inject money to the region. Table 29 lists jobs and salaries in science, construction, and engineering funded by watershed restoration work.

Table 29. Jobs and salaries created by watershed restoration work

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 Engineer	$80,750
Toxicologist	$70,000	Hydrogeologist	$92,710
Chemist	$72,740	Environmental Planner	$64,680
Geologist	$58,000	Plumber/Pipefitter	$79,870
Helicopter Pilot	$90,000	Carpenter	$43,640
Information Technology	$70,930	Electrician	$50,850
Administrative Staff	$32,990	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
Civil Engineer	$81,180	Biological technician	$41,140
General Laborer	$33,190	Pile Driver Operator	$51,410

Source: Great Lakes Coalition, 2010, from U.S. Bureau of Labor Statistics

The University of Virginia (Rephann, 2010) estimated implementation of the Virginia Agricultural BMP Tributary Action Strategy for the Chesapeake Bay would inject $940.1 million into the state economy and fund 11,171 direct and indirect jobs in agriculture, forestry, construction, retail trade, scientific services, and waste-management services (Table 30). The Virginia Tributary Strategy calls for implementation of agricultural best management practices (BMP), such as forest buffers ($545/acre), wetland restoration ($889/acre), tree planting ($1,284/acre), and cover crops ($97/acre).

Table 30. Economic impact of Virginia agriculture BMP for Chesapeake Bay restoration

Profession	Output ($million)	Jobs
Agriculture, forestry, fishing	71.76	2,089
Mining	0.32	1
Utilities	3.25	3
Construction	172.08	1,565
Manufacturing	14.01	48
Wholesale trade	10.83	53
Transportation and warehousing	17.60	157
Retail trade	44.68	605
Information	11.23	37
Finance and insurance	14.02	59
Real estate and rental	30.78	117
Scientific and technical	83.91	509
Company management	6.32	25
Waste services	320.52	6,088
Education services	1.23	20
Health and social services	6.53	76
Arts, entertainment, recreation	1.54	38
Accommodation and food services	7.11	119
Other services	9.56	105
Government and other	112.79	36
Total	**940.07**	**11,751**

Source: Rephann, 2010

Talberth et al. (2010), from the World Resources Institute, estimated that a Chesapeake Bay nutrient-trading program could provide annual cash flows to a typical 200-acre Maryland farm ranging from $13,291 in the Potomac River Basin to $15,033 in the lower Eastern Shore Basin. In fiscal year 2008, the USDA Natural Resources Conservation Service authorized $27 million and Maryland authorized $14 million ($41 million total) to implement best management practices (BMP) on Maryland farms. If 80% of BMP-implementation costs are due to labor costs at a mean salary of $45,000 and 20% are from materials, maintenance, and land-rental costs, then the $41 million investment from federal and state sources in Maryland funded approximately 730 jobs in 2008.

Implementation of the Chesapeake Bay total maximum daily load (TMDL) in Delaware has the potential to fund hundreds of watershed-restoration jobs over the next 15 years. Delaware's Phase I Chesapeake Bay WIP estimates that $33 million in cost-share funds ($2.2 million/yr) will be needed to achieve nutrient TMDL goals by 2025 (DNREC, 2010). The Delaware 2011 milestones to reduce nitrogen and phosphorus loads to the Chesapeake Bay are estimated to cost $9.7 million per year (Table 31). If 80% of BMP-implementation costs are due to labor costs at a mean salary of $45,000 and 20% are from materials, maintenance, and land rental costs, then the $9.7 million investment will fund 215 jobs by 2011. Appendix G of the Delaware Chesapeake Bay WIP indicates that implementation of agriculture BMP will cost $4.8 million per year, which will fund 107 jobs (Table 32).

Table 31. BMP costs to achieve Delaware Chesapeake Bay watershed 2011 milestones

Best Management Practice	Coverage (ac or tons)	Cost ($/unit/yr)	Annual Cost ($)
Cover Crops (ac)	18,600	$97	$1,804,200
Forest Buffers (ac)	2,700	545	$1,471,500
Wetland Restoration (ac)	420	889	$373,380
Tree Planting (ac)	200	1,285	$257,000
Poultry-Litter Transport (tons)	55,100	60	$3,306,000
Nutrient Management (ac)	177,000	14	$2,478,000
Total			**$9,690,080**

Source: Delaware Chesapeake Bay WIP, 2010

Table 32. BMP costs for Chesapeake Bay watershed restoration in Delaware

Best Management Practice	Coverage (ac or unit)	Cost ($/ac/yr)	Annual Cost
Cover Crop –Traditional (ac)	3,320	30	$99,600
Cover Crop – Commodity (ac)	7,913	50	$395,650
Conservation Tillage (ac)	6,000	13	$78,000
No-Till Conservation (ac)	1,000	40	$40,000
Precision Agriculture (ac)	20,637	30	$619,110
Poultry-Area Pads (each)	45	4,661	$209,745
Swine-Waste Structures (each)	3	25,000	$75,000
Equine-Waste Structures (each)	1	15,000	$15,000
Dairy-Waste Structures (each)	2	60,000	$120,000
Water Control Structures (each)	1	5,000	$5,000
Stream Fencing (ac)	35	284	$9,940
Manure Relocation (tons)	4,000	4.32	$17,280
Poultry-Waste Structures (each)	88	27,005	$2,376,440
Runoff-Control Systems (each)	8	10,500	$84,000
Poultry Composters (each)	95		$0
Grass Buffers (ac)	71	300	$21,300
Forest Buffers (ac)	225	425	$95,625
Wetland Restoration (ac)	30	1,702	$51,060
Tree Planting (ac)	3	400	$1,200
Grassland (ac)	5	300	$1,500
Natural Filters (ac)	50	300	$15,000
Vegetative Environmental Buffers (each)	10	4,000	$40,000
Tax-Ditch Restoration	6,000	75	$450,000
Total			**$4,820,450**

Source: Delaware Chesapeake Bay WIP, 2010

Table 33. Delaware employment by industry, 2009

Industry			NAICS Code
Agriculture, Forestry, Fishing and Hunting			11
	Crop Production		111
	Animal Production		112
		Aquaculture	1125
	Forestry and Logging		113
	Fishing, Hunting and Trapping		114
		Fishing	1141
	Support Activities for Agriculture and Forestry		115
Mining, Quarrying, and Oil and Gas Extraction			21
	Oil and Gas Extraction		211
	Mining (except Oil and Gas)		212
		Nonmetallic Mineral Mining and Quarrying	2123
	Support Activities for Mining		213
Utilities			22
	Utilities		221
		Electric Power Generation, Transmission and Distribution	2211
		Natural Gas Distribution	2212
		Water, Sewage and Other Systems	2213
Construction			23
	Construction of Buildings		236
		Residential Building Construction	2361
		Nonresidential Building Construction	2362
	Heavy and Civil Engineering Construction		237
		Land Subdivision	2372
		Highway, Street, and Bridge Construction	2373
		Other Heavy and Civil Engineering Construction	2379
	Specialty Trade Contractors		238
Manufacturing			31
	Food Manufacturing		311
		Seafood Product Preparation and Packaging	3117
	Beverage and Tobacco Product Manufacturing		312
	Textile Mills		313
	Textile Product Mills		314
	Apparel Manufacturing		315
		Apparel Knitting Mills	3151
	Leather and Allied Product Manufacturing		316
	Wood Product Manufacturing		321
	Paper Manufacturing		322
	Petroleum and Coal Products Manufacturing		324
	Chemical Manufacturing		325
		Basic Chemical Manufacturing	3251
		Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	3252
		Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	3253
		Pharmaceutical and Medicine Manufacturing	3254
		Paint, Coating, and Adhesive Manufacturing	3255

		Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256
		Other Chemical Product and Preparation Manufacturing	3259
	Plastics and Rubber Products Manufacturing		326
	Nonmetallic Mineral Product Manufacturing		327
		Cement and Concrete Product Manufacturing	3273
		Lime and Gypsum Product Manufacturing	3274
		Other Nonmetallic Mineral Product Manufacturing	3279
	Primary Metal Manufacturing		331
	Fabricated Metal Product Manufacturing		332
	Machinery Manufacturing		333
	Computer and Electronic Product Manufacturing		334
		Computer and Peripheral Equipment Manufacturing	3341
		Communications Equipment Manufacturing	3342
		Audio and Video Equipment Manufacturing	3343
		Semiconductor and Other Electronic Component Manufacturing	3344
		Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	3345
		Manufacturing and Reproducing Magnetic and Optical Media	3346
	Electrical Equipment, Appliance, and Component Manufacturing		335
	Transportation Equipment Manufacturing		336
		Motor Vehicle Manufacturing	3361
		Motor Vehicle Body and Trailer Manufacturing	3362
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Source: U.S. Bureau of Labor Statistics

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