Attachment 5

Socioeconomic Value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania

The Delaware River Basin, an economic engine for over 400 years

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Executive Summary

What do the Guggenheim Museum, New York Yankees, Boeing, Sunoco, Campbell's Soup, DuPont, Wawa, Starbucks, Iron Hill Brewery, Philadelphia Phillies, Camelback Ski Area, Pt. Pleasant Canoe Livery, Salem Nuclear Power Plant, and United States Navy all have in common? They all depend on the waters of the Delaware River Basin to sustain their businesses.

The Delaware River Basin is an economic engine that supplies drinking water to the 1st (New York City) and 7th (Philadelphia) largest metropolitan economies in the United States and supports the largest freshwater port in the world. The Delaware Basin's water supplies, natural resources, and ecosystems in Delaware, New Jersey, New York, Pennsylvania and a small sliver of Maryland:

- Contribute $25 billion in annual economic activity from recreation, water quality, water supply, hunting/fishing, ecotourism, forest, agriculture, open space, potential Marcellus Shale natural gas, and port benefits.

- Provide ecosystem goods and services (natural capital) of $21 billion per year in 2010 dollars with net present value (NPV) of $683 billion discounted over 100 years.

- Are directly/indirectly responsible for 600,000 jobs with $10 billion in annual wages.

The Basin

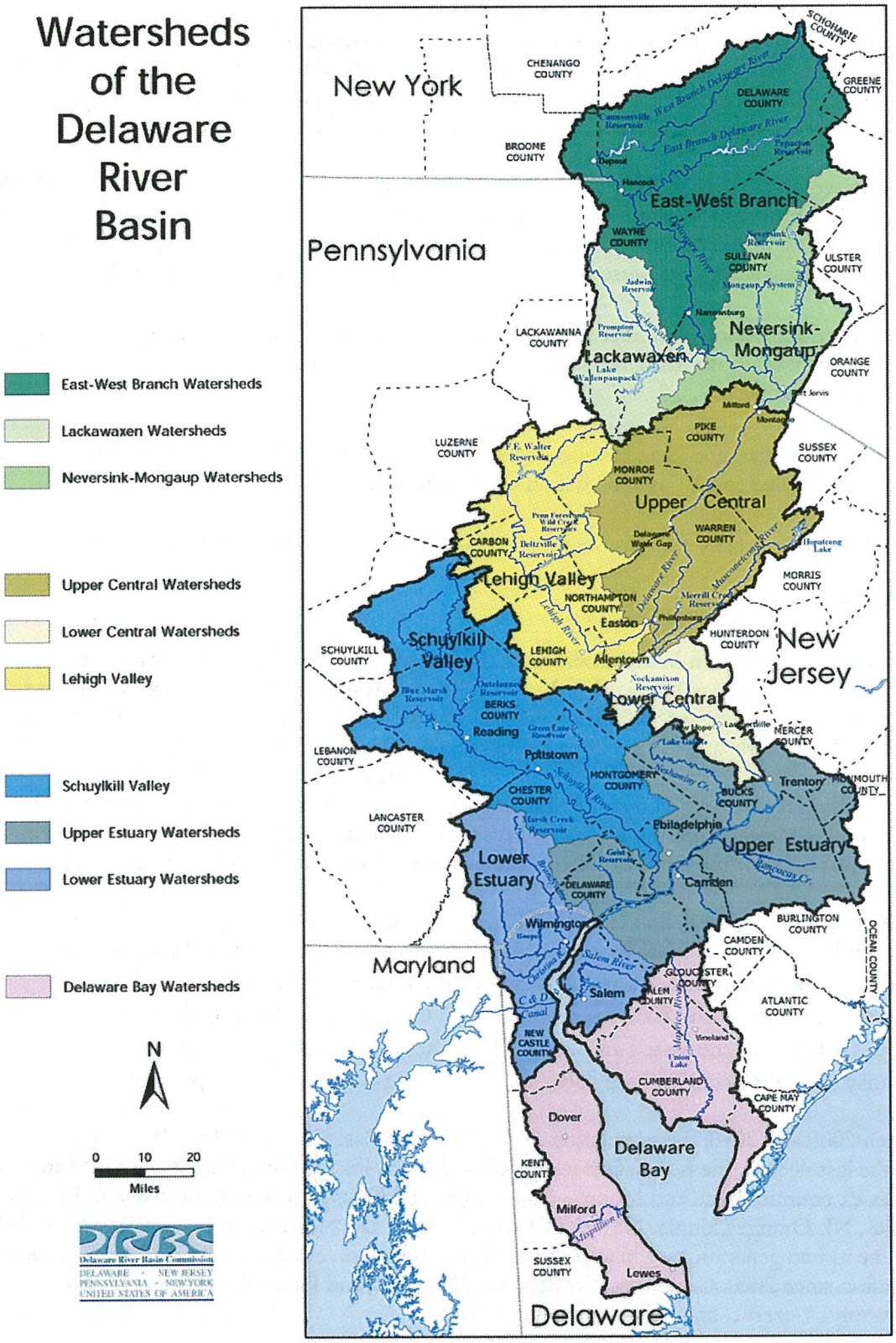
The Delaware River Basin occupies almost 13,000 sq mi (not including the river and bay) in Delaware, Maryland, New Jersey, New York, and Pennsylvania. In 2010, over 8.2 million residents lived in the basin including 654,000 people in Delaware, 2,300 in Maryland, 1,964,000 in New Jersey, 131,000 in New York, and 5,469,000 in Pennsylvania. Nearly 3,500,000 people work in the basin with 316,000 jobs in Delaware, 823,000 jobs in New Jersey, 70,000 jobs in New York, and 2,271,000 jobs in Pennsylvania. An additional 8 million people in New York City and northern New Jersey receive drinking water from the Delaware River via interbasin transfers. The Delaware Basin occupies just 0.4% of the continental U.S. yet supplies drinking water to 5% of the U.S. population.

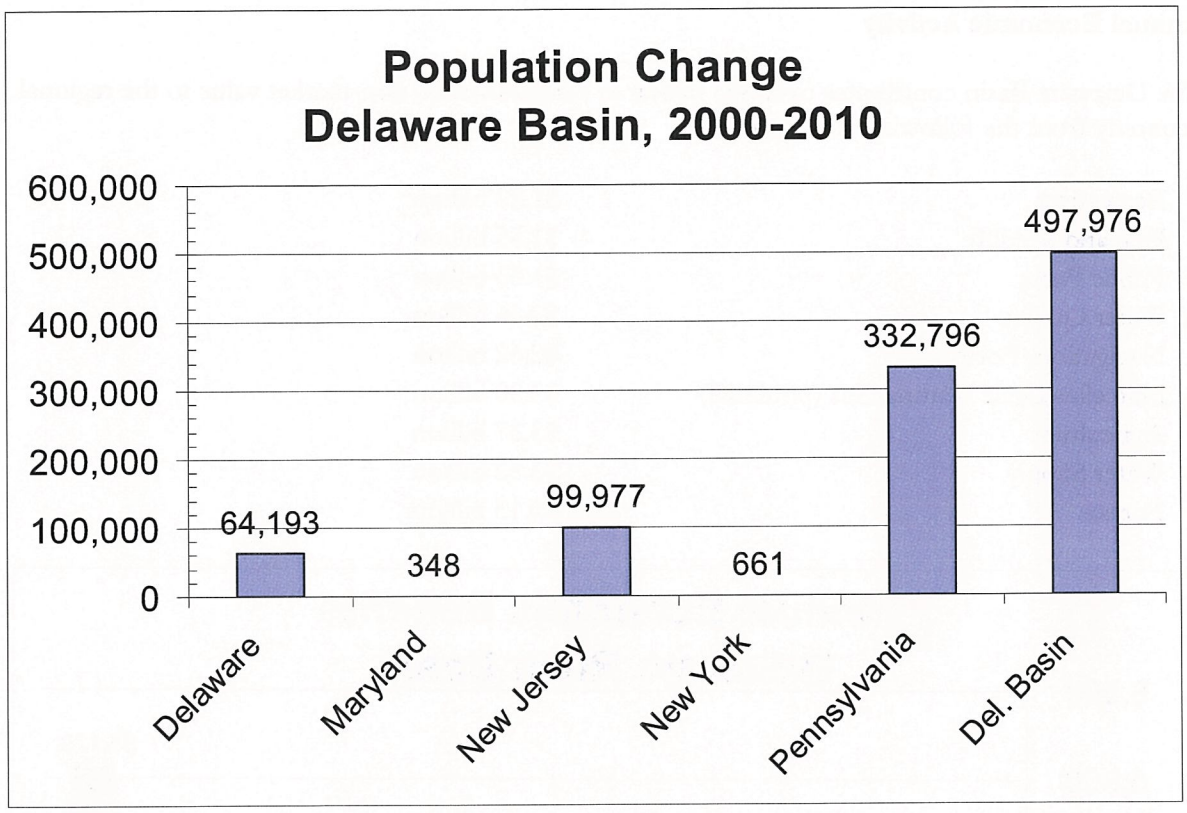
The Delaware Basin population exceeds 8.2 million which if counted together would be the 12th most populous state after New Jersey but ahead of Virginia. The Delaware Basin occupies:

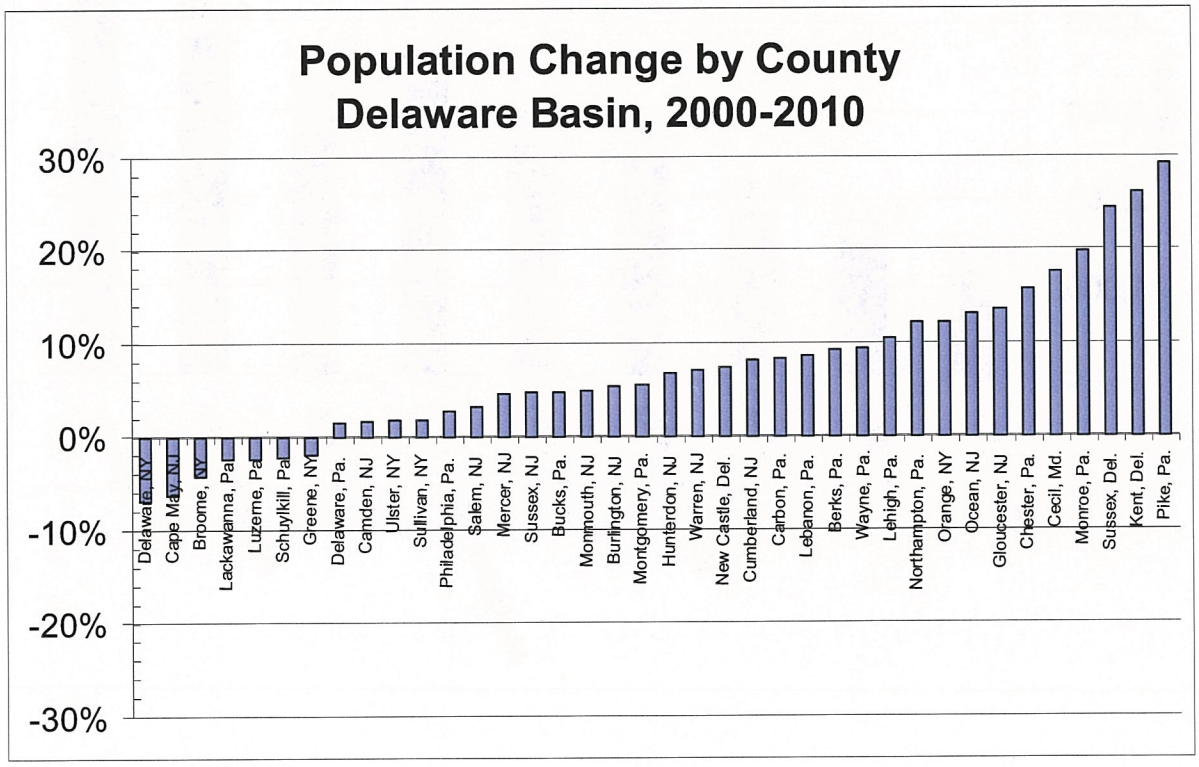
- Delaware (50% of the State's area and 74% of the First State's population)
- New Jersey (40% of the State's area and 22% of the Garden State's population)
- New York (5% of the State's area and 0.7% of the Empire State's population)
- Pennsylvania (14% of the State's area and 43% of the Keystone State's population.

Between 2000 and 2010, the population in the Delaware Basin increased by 6.1% or 472,066 people. Over the last decade, the population increased by 30% in Pike County, Pa.; by over 20% in Kent and Sussex counties, Del. and Monroe County, Pa.; and by over 10% in Gloucester and Ocean counties, NJ, Orange County, NY, and Chester, Lehigh, and Northampton counties, Pa. For the first time in two generations, Philadelphia gained population. Several counties in the basin lost population since 2000: Cape May, NJ; Broome, Delaware, and Greene counties, NY; and Lackawanna, Luzerne, and Schuylkill counties, Pa.

Watersheds of the Delaware River Basin




Population Change
Delaware Basin, 2000-2010
600,000
500,000
400,000
300,000
200,000
100,000
0
64,193
348
99,977
661
332,796
497,976
Delaware
Maryland
New Jersey
New York
Pennsylvania
Del. Basin


Population Change by County
Delaware Basin, 2000-2010
30%
20%
10%
0%
-10%
-20%
-30%
Delaware, NY
Cape May, NJ
Broome, NY
Lackawanna, Pa.
Luzerne, Pa.
Schuylkill, Pa.
Greene, NY
Delaware, Pa.
Camden, NJ
Ulster, NY
Sullivan, NY
Philadelphia, Pa.
Salem, NJ
Mercer, NJ
Sussex, NJ
Bucks, Pa.
Monmouth, NJ
Burlington, NJ
Montgomery, Pa.
Hunterdon, NJ
Warren, NJ
New Castle, Del.
Cumberland, NJ
Carbon, Pa.
Lebanon, Pa.
Berks, Pa.
Wayne, Pa.
Lehigh, Pa.
Northampton, Pa.
Orange, NY
Ocean, NJ
Gloucester, NJ
Chester, Pa.
Cecil, Md.
Monroe, Pa.
Sussex, Del.
Kent, Del.
Pike, Pa.

Annual Economic Activity

The Delaware Basin contributes over $25 billion in annual market/non-market value to the regional economy from the following activities:

- Recreation $1.22 billion
- Fish and Wildlife $1.55 billion
- Public Parks $1.83 billion
- Water Quality $2.46 billion
- Navigation/Ports $2.62 billion
- Marcellus Shale Natural Gas (potential) $3.30 billion
- Agriculture $3.37 billion
- Water Supply $3.82 billion
- Forests $5.13 billion

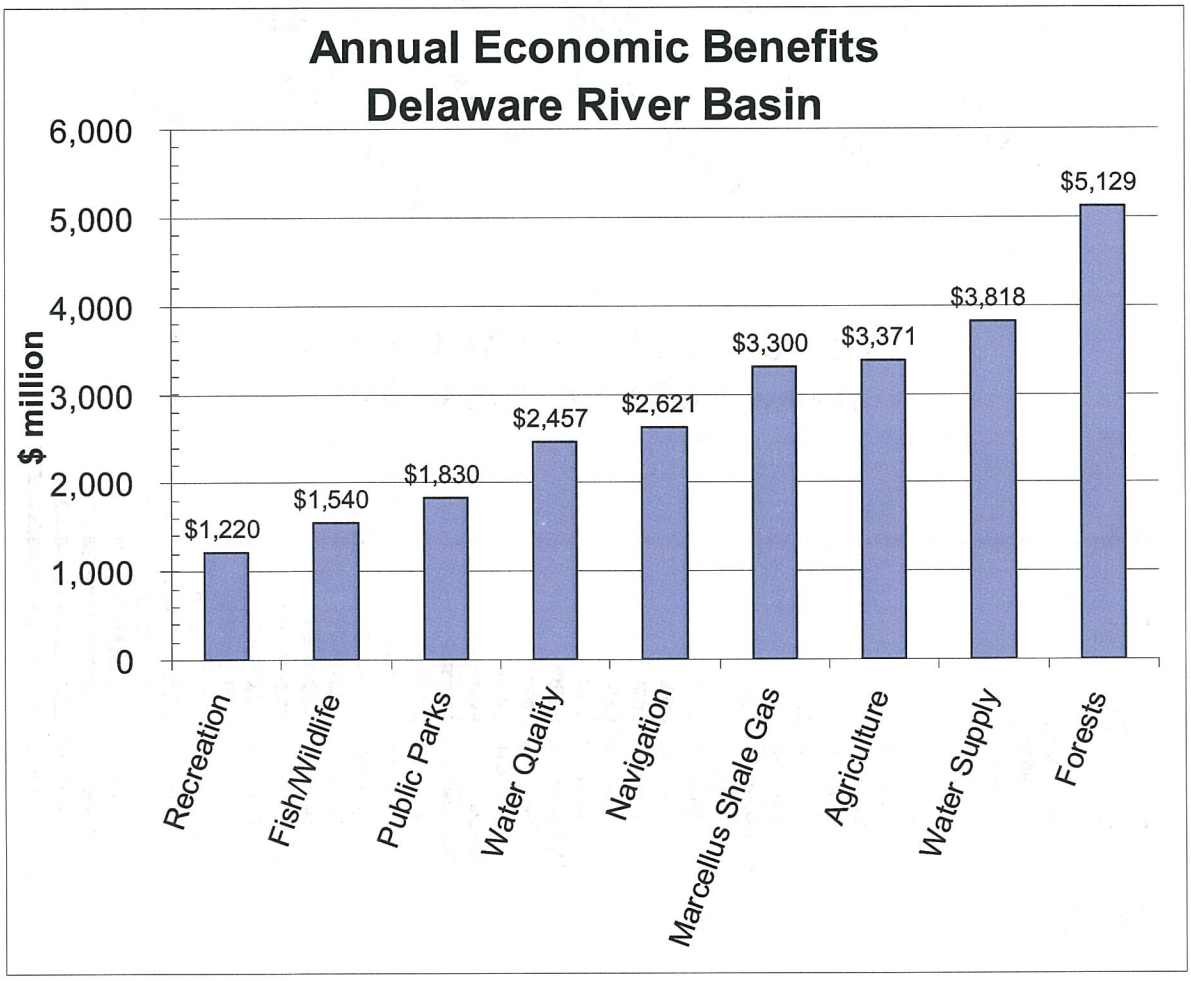


Table E1. Annual economic value supported by the Delaware River Basin.

Market Value	2010 ($ million)	Sources
Recreation (Boating, Fishing, Swimming)		
Skiing (1.9 million ski-days @ $45/day)	325	Penna Ski Areas Association (2010
Paddling-based Recreation (620,860 paddlers)	362	Outdoor Industry Association (2006)
Del. Water Gap River Recreation (267,000 visits)	41	U.S. Forest Service, Nat'l Park Service (1990)
Canoe/Kayak/Rafting (225,000 visits)	9	Canoe and Kayak Liveries (2010)
Powerboating (232,000 boat registrations)	395	National Marine Manufacturers Assoc. (2010)
Water Quality		
Water Treatment by Forests ($96/mgd)	63	Trust for Public Land, AWWA (2004)
Wastewater Treatment ($4.00/1000 gal)	1,722	DRBC and USEPA
Increased Property Value (+8%, 2000 ft of river)	13	EPA (1973), Brookings Institute (2010)
Water Supply		
Drinking Water Supply ($4.78/1000 gal)	3,145	UDWRA and DRBC (2010)
Reservoir Storage ($0.394/1000 gal)	145	UDWRA and DRBC (2010)
Irrigation Water Supply ($300/ac-ft)	32	Resources for Future (1996), USDA (2007)
Thermoelectric Power Water Supply ($44/ac-ft)	297	EIA (2002), NETL (2009)
Industrial Water Supply ($200/ac-ft)	179	Resources for Future (1996), DRBC (2010)
Hydropower Water Supply ($32/ac-ft)	20	Resources for 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, $53/trip)	576	U. S. Fish and Wildlife Service (2001)
Hunting (16 trips/hunter, $50/trip)	340	U. S. Fish and Wildlife Service (2001)
Wildlife/Bird-watching (8-13 trips/yr, $27/trip)	561	U. S. Fish and Wildlife Service (2001)
Shad Fishing (63,000 trips, $102/trip)	6	Pennsylvania Fish & Boat Comm. (2011)
Wild Trout Fishing	29	Sportfishing Assn./Trout Unlimited (1998)
Agriculture		
Crop, poultry, livestock value ($1,180/ac)	3,371	USDA Census of Agriculture 2007 (2009)
Public Parks		
Del. Water Gap Natl. Rec. Area (4.9 million visits)	100	U.S. National Park Service (2002)
Marcellus Shale		
Natural Gas (potential)	3,300	USGS (2011), EIA (2011)
Maritime Transportation		
Navigation ($15/ac-ft)	220	Resources for the Future (1996)
Port Activity	2,400	Economy League of Greater Phila. (2008)
Delaware Basin Market Value	**≈ $17.7 billion**	
Non-Market Value		
Recreation (Boating, Fishing, Swimming)		
Clean Water Act Restoration		
Viewing/Aesthetics ($0.58/person)	5	University of Delaware (2003)
Boating ($0.76/person)	6	University of Delaware (2003)
Fishing ($2.95/person)	24	University of Delaware (2003)
Swimming ($6.88/person)	57	University of Delaware (2003)
Water Quality		
WTP for Clean Water ($38/nonuser-$121/user)	659	University of Maryland (1989)
Forests		
Carbon Storage ($827/ac)	3,592	U.S. Forest Service, Del. Center Hort. (2008)
Carbon Sequestration ($29/ac)	126	U.S. Forest Service, Del. Center Hort. (2008)
Air Pollution Removal ($266/ac)	1,155	U.S. Forest Service, Del. Center Hort. (2008)
Building Energy Savings ($56/ac)	243	U.S. Forest Service, Del. Center Hort. (2008)
Avoided Carbon Emissions ($3/ac)	13	U.S. Forest Service, Del. Center Hort. (2008)
Public Parks		
Health Benefits ($9,734/ac)	1,283	Trust for Public Land (2009)
Community Cohesion ($2,383/ac)	314	Trust for Public Land (2009)
Stormwater Benefit ($921/ac)	121	Trust for Public Land (2009)
Air Pollution ($88/ac)	12	Trust for Public Land (2009)
Delaware Basin Non-Market Value	**≈ $7.6 billion**	

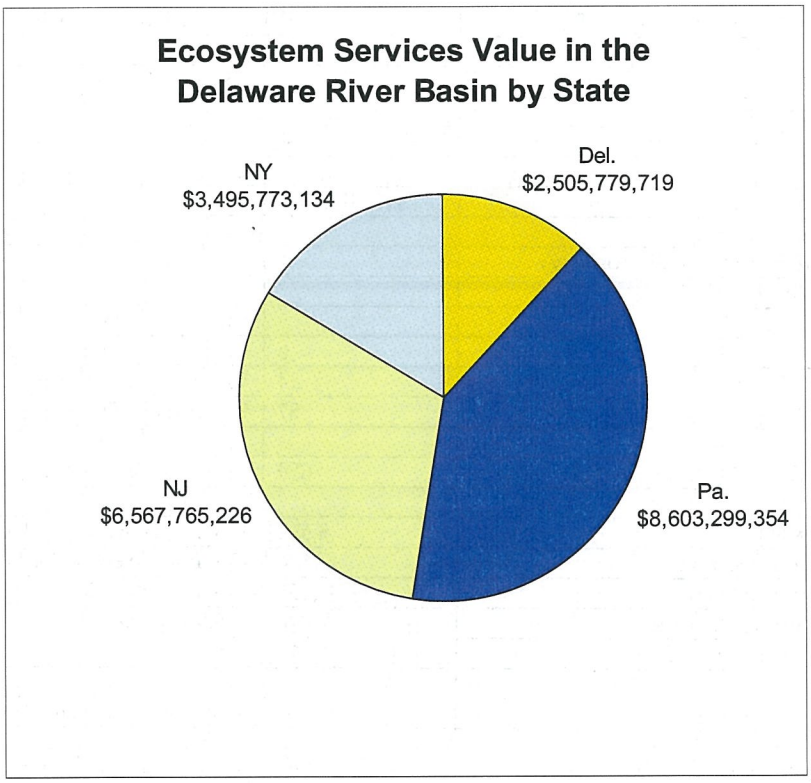
Ecosystem Services

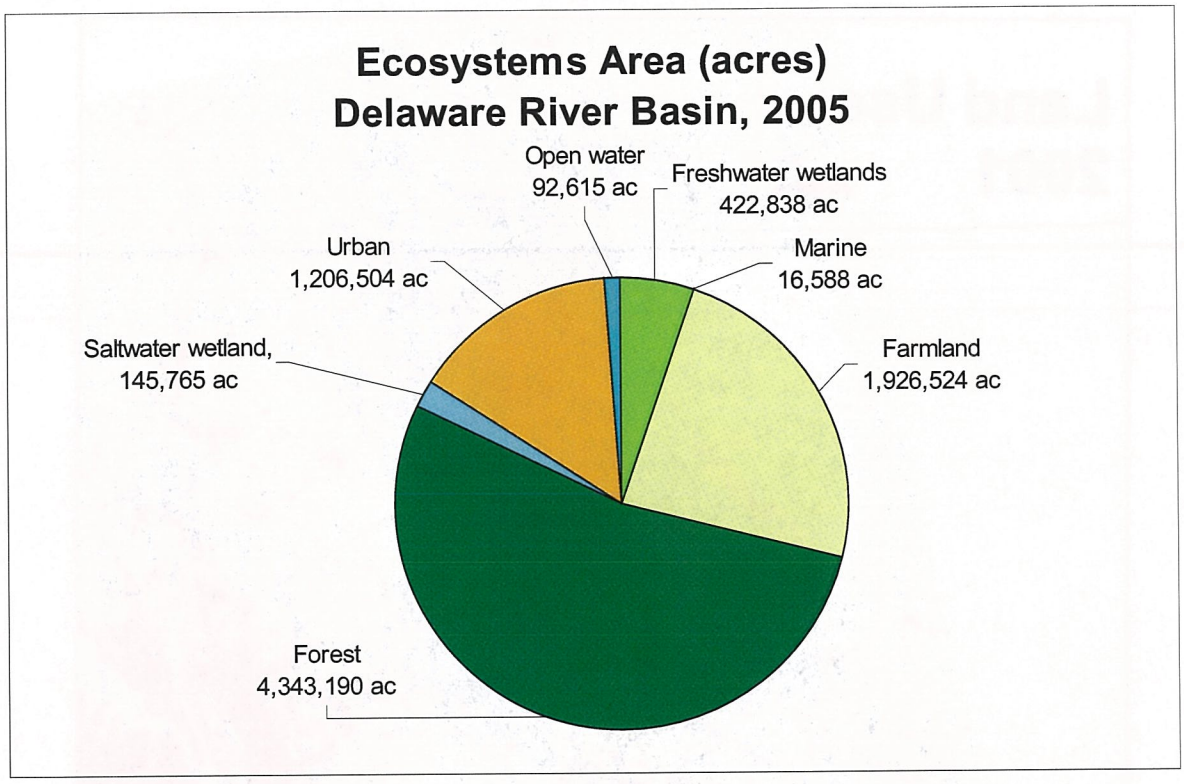
The value of natural goods and services from ecosystems in the Delaware Basin is $21 billion ($2010) with net present value (NPV) of $683 billion using a discount of 3% over 100 years. The contributions of ecosystem services by state include:

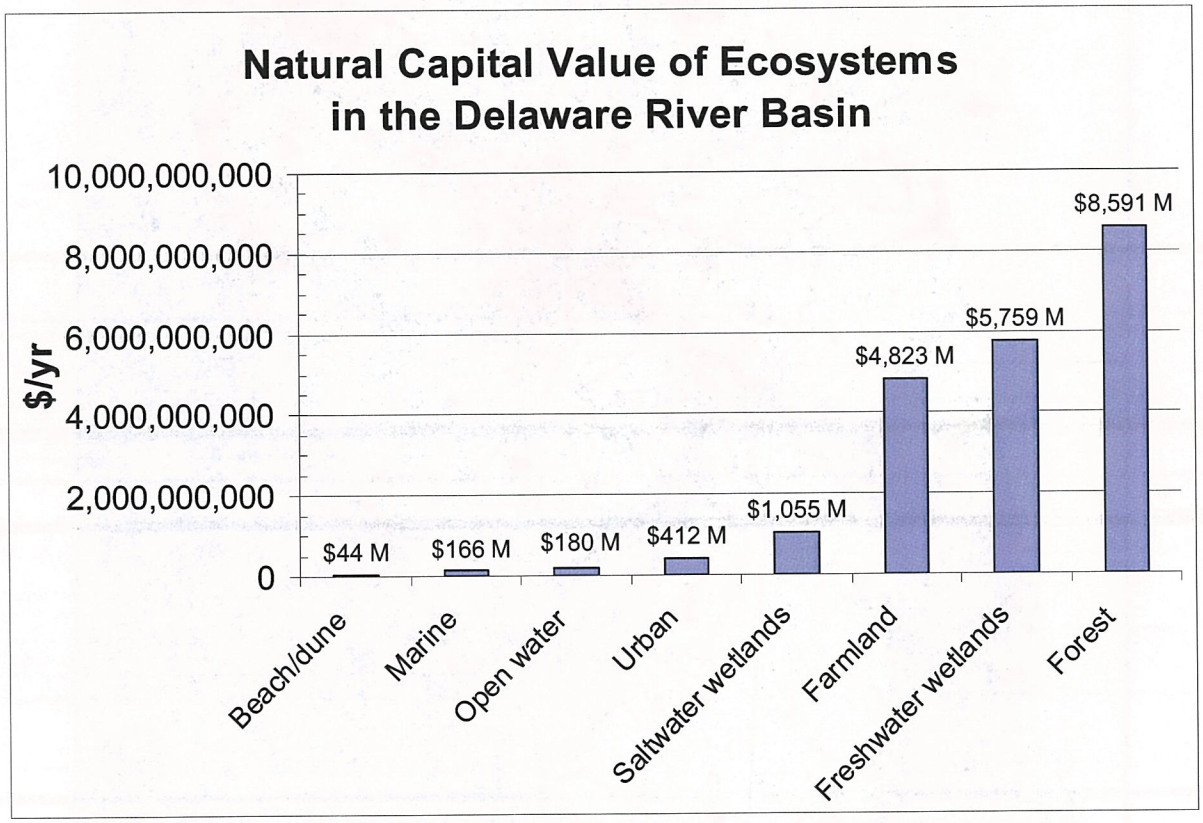
- Delaware ($2.5 billion, NPV $81.4 billion)
- New Jersey ($6.6 billion, NPV $213.4 billion)
- New York ($3.5 billion, NPV $113.6 billion)
- Pennsylvania ($8.6 billion, NPV $279.6 billion)

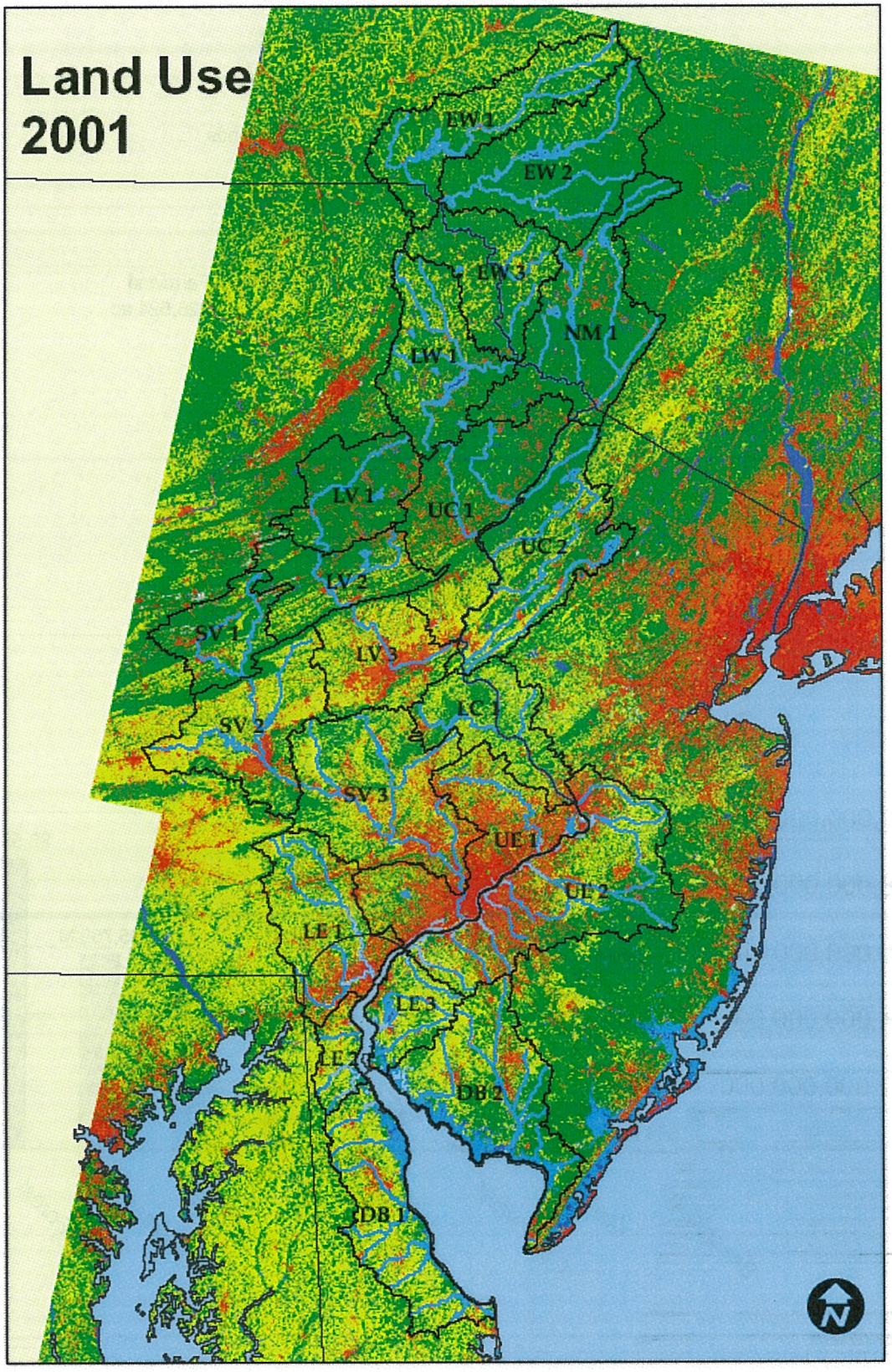
Table E2. Ecosystem goods and services provided by the Delaware River Basin

Ecosystem	Area (ac)	$/ac/yr 2010	$/yr 2010	NPV $
Freshwater wetlands	422,838	13,621	5,759,329,048	187,178,194,067
Marine	16,588	10,006	165,982,947	5,394,445,767
Farmland	1,926,524	2,503	4,823,030,404	156,748,488,136
Forest land	4,343,190	1,978	8,591,367,360	279,219,439,184
Saltwater wetland	145,765	7,235	1,054,617,851	34,275,080,170
Urban	1,206,504	342	412,157,579	13,395,121,322
Beach/dune	900	48,644	43,758,633	1,422,155,566
Open water	92,615	1,946	180,210,703	5,856,847,857
Total	**8,154,924**		**$21,030,454,525**	**$683,489,772,069**




Ecosystems Area (acres)
Delaware River Basin, 2005
Open water
92,615 ac
Freshwater wetlands
422,838 ac
Urban
1,206,504 ac
Marine
16,588 ac
Saltwater wetland,
145,765 ac
Farmland
1,926,524 ac
Forest
4,343,190 ac


Natural Capital Value of Ecosystems
in the Delaware River Basin
$/yr
10,000,000,000
8,000,000,000
6,000,000,000
4,000,000,000
2,000,000,000
0
$44 M
$166 M
$180 M
$412 M
$1,055 M
$4,823 M
$5,759 M
$8,591 M
Beach/dune
Marine
Open water
Urban
Saltwater wetlands
Farmland
Freshwater wetlands
Forest


Land Use
2001
EW 1
EW 2
EW 3
NM 1
LW 1
LV 1
UC 1
UC 2
LV 2
SV 1
LV 3
LC 1
SV 2
SV 3
UE 1
UE 2
LE 1
LE 3
LE 2
DB 2
DB 1
N

Jobs and Wages

The Delaware River Basin is a jobs engine that supports 600,000 direct/indirect jobs with $10 billion in annual wages in the coastal, farm, ecotourism, water/wastewater, ports, and recreation industries.

Table E3. Jobs and wages directly and indirectly supported by the Delaware River Basin

Sector	Jobs	Wages ($ million)	Source
Direct Basin Related	240,621	4,900	U.S. Bureau of Labor Statistics, 2009
Indirect Basin Related	288,745	4,000	U.S. Census Bureau, 2009
Coastal	44,658	947	National Coastal Economics Program, 2009
Farm	45,865	1,376	USDA Census of Agriculture, 2007
Fishing/Hunting/Birding	44,941	1,476	U.S. Fish and Wildlife Service, 2008
Water Supply Utilities	8,750	485	UDWRA and DRBC, 2010
Wastewater Utilities	1,298	61	UDWRA and DRBC, 2010
Watershed Organizations	201	10	UDWRA and DRBC, 2010
Ski Area Jobs	1,753	88	Penna. Ski Areas Association
Paddling-based Recreation	4,226		Outdoor Industry Association (2006
River Recreation	448	9	U. S. Forest Service/Nat'l. Park Service, 1990
Canoe/Kayak/Rafting	225		Canoe Liveries and UDWRA, 2010
Wild Trout Fishing	350	4	Maharaj, McGurrin, and Carpenter, 1998
Del. Water Gap Nat'l. Rec. Area	7,563	101	Stynes and Sun, 2002
Port Jobs	12,121	772	Economy League of Greater Phila., 2008
Delaware Basin Total	**> 600,000**	**>$10 billion**	

Within the Delaware Basin are 3,480,483 jobs earning $172.6 billion in wages including:

- Delaware (316,014 jobs earning $16.5 billion in wages)
- New Jersey (823,294 jobs, $38.1 billion in wages)
- New York (69,858 jobs earning $2.5 billion in wages)
- Pennsylvania (2,271,317 jobs earning $115.5 billion in wages)

Jobs directly associated with the Delaware River Basin (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employ 240,621 with $4.9 billion in wages including:

- Delaware (15,737 jobs earning $340 million in wages)
- New Jersey (62,349 jobs earning $1.3 billion in wages)
- New York (32,171 jobs earning $550 million in wages)
- Pennsylvania (130,364 jobs earning $2.8 billion in wages)

Jobs indirectly related to the waters of the Delaware Basin (based on multipliers of 2.2 for jobs and 1.8 for salaries) employ 288,745 people with $4.0 billion in wages including:

- Delaware (18,884 jobs earning $270 million in wages)
- New Jersey (74,819 jobs earning $1.0 billion in wages)
- New York (38,605 jobs earning $400 million in wages)
- Pennsylvania (156,437 jobs earning $2.2 billion in wages)

According to the National Coastal Economy Report (2009), coastal employment sectors within the Delaware River Basin are responsible for 44,658 jobs earning $947 million in wages with contributions of $1.8 billion toward the GDP including:

- Delaware (12,139 jobs, $214 million in wages, $392 million toward the GDP)
- New Jersey (4,423 jobs, $140 million in wages, $235 million toward the GDP).
- Pennsylvania (28,096 jobs, $593 million in wages, $1.2 billion toward the GDP.

Over 21,800 farms provide 45,865 jobs with $1.9 billion in wages in the Delaware Basin including:

- Delaware (3,140 farm jobs earning $129 million in wages)
- New Jersey (14,305 farm jobs earning $587 million in wages)
- New York (2,410 farm jobs earning $99 million in wages)
- Pennsylvania (26,010 farm jobs earning $1.1 billion in wages)

Fishing, hunting, and bird watching/wildlife associated recreation employ 44,941 jobs with $1.5 billion in wages in the Delaware Basin including:

- Delaware (4,080 jobs earning $134 million in wages)
- New Jersey (17,477 jobs earning $574 million in wages)
- New York (4,872 jobs earning $160 million in wages)
- Pennsylvania (18,512 jobs earning $608 million in wages)
-

Public and private water utilities that withdraw drinking water from the Delaware River Basin employ 8,750 people with wages of $485 million including:

- Delaware (141 jobs earning $7.8 million in wages)
- New Jersey (823 jobs earning $46 million in wages)
- New York (5,600 jobs earning $310 million in wages)
- Pennsylvania (2,186 jobs earning $121 million in wages)

Wastewater utilities that treat and discharge wastewater to the Delaware River Basin employ 1,298 people with wages of $61 million including:

- Delaware (108 jobs earning $5 million in wages)
- New Jersey (257 jobs earning $12 million in wages)
- New York (20 jobs earning $1 million in wages)
- Pennsylvania (913 jobs earning $43 million in wages)

Over 100 nonprofit watershed and environmental organizations employ at least 200 staff who earn at least $9.5 million in wages to restore the watersheds in the Delaware River Basin.

In the Pocono Mountains of Pennsylvania, 9 ski resorts support 1,753 direct jobs in the Delaware Basin from aggregate annual revenues of $87,655,063 from 1,908,228 skier visits.

Paddling-based recreation in the Delaware Basin is responsible for 620,860 participants and 4,226 jobs according to data prorated from the Outdoor Industry Association (2006).

The U. S. Forest Service and U.S. National Park Service estimated river recreation along the Upper Delaware River and Delaware Water Gap was responsible for 448 jobs with wages of $8.8 million in $1986.

The 37 canoe/kayak liveries along the Delaware, Lehigh, and Schuylkill, and Brandywine Rivers have earnings of $9 million per year and employ 225 people to lease watercraft to 225,000 visitors.

Along the Beaverkill, East Branch, West Branch, and upper main stem of the Delaware River in New York, wild trout fishing provides for 350 jobs with $3.6 million in wages.

The Delaware Water Gap National Recreation Area recorded 4,867,272 recreation visits in 2001 that generated $106 million in sales and 7,563 direct/indirect jobs with $100 million in wages.

Delaware River ports from Wilmington to Philadelphia to Trenton are collectively the 5th largest port in the U.S. based on imports and the 20 largest U.S. port based on exports. These ports:

- Employ 4,056 workers who earn $326 million in wages.
- 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.
- 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
- Provides good jobs, the average salary of a port employee (with benefits) is over $80,000.

1. Introduction

Objectives

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

- Economic activity including market use and nonuse value of water supply, fishing, hunting, recreation, boating, ecotourism, agriculture, and navigation/port benefits in the basin.

- 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 directly and indirectly associated with the Delaware River Basin.

Two decades ago, researchers conducted a series of studies that indicated the Delaware River and Bay 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 (the tidal river and bay) 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 is designed to update economic analyses for the Delaware River and Bay 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

Studies for the Chesapeake Bay, Great Lakes, and Florida Everglades conclude that watersheds have significant economic value and restoration can result in green jobs and favorable cost-benefit investment ratios. The University of Maryland reported in 1988 that the Chesapeake Bay was worth $678 billion and the Chesapeake Blue Ribbon Panel (2003) reported with inflation the present value of the bay would exceed $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 (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 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 2010). Net present

value of the Everglades's 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 (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
Toxicologist	$70,000	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
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

An Economic Engine

What do the Guggenheim Museum, Boeing, Sunoco, Campbell's Soup, DuPont, Wawa, Starbucks, Iron Hill Brewery, Philadelphia Philadelphia Phillies, New York Yankees, Camelback Ski Area, Pt. Pleasant Canoe Livery, Salem Nuclear Power Plant, and the United States Navy have in common? They all depend on the waters of the Delaware River Basin to sustain their businesses.

Most economists agree that water is an undervalued resource. The astronomer Copernicus and 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 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 River Basin.

If water is society's most valuable chemical, then the Delaware River with a mean annual flow of 2.7 trillion gallons per year at Trenton is the Delaware Valley's (and by aqueduct Manhattan Island's) most invaluable economic asset. For 400 years, the Delaware River has been an economic engine ever since Henry Hudson discovered the bay off Cape May in August 1609 for commerce and 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 the Schuylkill in a colony rich with lumber, fertile land, beaver pelts, and in later centuries coal and oil reserves. By the 18th century frugal yet prosperous Philadelphia Quaker merchants established triangle trade route connections to Europe and the Caribbean from their home port along the Delaware. During 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 in the river that he willed funds to build the first municipal water system in the United States at Philadelphia to tap the Delaware and Schuylkill for drinking water.

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 falls of the Brandywine River 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 River 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 with a value of $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, NJ.

At the turn of the 20th century, Delaware River ports supported a premier ship building industry. By the First World War the Delaware was 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 United States.

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."

During the 19th Century, the Delaware Water Gap along the Blue Mountain near Stroudsburg, Pa. was a resort that grew with the railroads from Philadelphia and New York City. In 1965, Congress authorized the National Park Service to form the Delaware Water Gap National Recreation Area that now receives 5 million visits per year, the 8th most visited unit in the National Park System.

In 1931 and amended in 1954, the U. S. Supreme Court issued a decree authorizing New York City to divert 800 mgd of water from three Catskill Mountain reservoirs in the Delaware Basin to the Hudson River Basin. The Delaware River delivers over half the drinking water to New York City.

By 1986, the Salem and Hope Creek nuclear power plants were built on Artificial Island in Salem County, New Jersey that pump 3 billion gallons per day of cooling water to provide 3,500 megawatts of electricity to the tri-state region. In 2010, a billion gallons per day of drinking water and industrial process water were withdrawn from streams and aquifers in the Delaware Basin to sustain the region's jobs and domestic, commercial, and industrial economy. The river, bay, beaches, wetlands, and forests support a billion dollar tourism, recreation, and hunting/fishing/birding economy.

After the turn of the 21st Century, new horizontal drilling and hydraulic fracturing technology kicked off the Marcellus Shale natural gas drilling boom in a 50,000 square mile basin stretching from Kentucky to Pennsylvania and New York. The Marcellus Shale occupies about 36% or 4700 square miles under the upper Delaware Basin. A 2011 USGS report indicates 7 trillion cubic feet of natural gas may be recoverable under the Delaware Basin, a potential multi-billion dollar natural resource.

The Delaware River Basin supplies drinking water to the 1st (New York City) and 5th (Philadelphia) largest metropolitan economies in the United States. The following report tabulates the substantial economic value and worth of this irreplaceable asset for over 8 million residents in Delaware, New Jersey, New York, and Pennsylvania who live in the basin and an additional 8 million people in New York City and northern New Jersey who receive drinking water from the Delaware River.

Governance

For the last fifty years, Federal, state, and local governments, nonprofits, and the private sector have focused efforts on restoring the Delaware River Basin. In 1961, JFK signed the Delaware River Basin Compact that appointed the Governors of Delaware, New Jersey, New York, and Pennsylvania as Commissioners as the first ever Federal-state watershed accord. In 1968 a full four years before the Clean Water Act was passed by Congress, the DRBC issued waste load allocations to reduce pollutant discharges from over 80 wastewater treatment plants. 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 United States and is now the only tri-state estuary program in the nation. In 1996, the nonprofit Partnership for the Delaware Estuary was established to implement a Comprehensive Conservation and Management Plan (CCMP). In 2011, the DRBC celebrates the 50th anniversary of its founding by JFK, Congress, and the Governors of Delaware, New Jersey, New York, and Pennsylvania.

The Watershed

The Delaware River Basin (Figure 1 and Table 2) occupies 12,769 sq mi (not including the river and bay) in Delaware (8%), New Jersey (23%), New York (20%), and Pennsylvania (49%). In 2010, 8,255,013 residents lived in the basin including 643,418 people in Delaware (9%), 2,324 in Maryland, 1,951,047 in New Jersey (24%), 124,969 in New York (2%), and 5,533,254 in Pennsylvania (66%). In 2009, nearly 3,500,000 people worked in the Delaware Basin with 316,014 jobs in Delaware (9%), 1,172 jobs in Maryland, 823,294 jobs in New Jersey (24%), 69,858 jobs in New York (2%), and 2,271,317 jobs in Pennsylvania (65%).

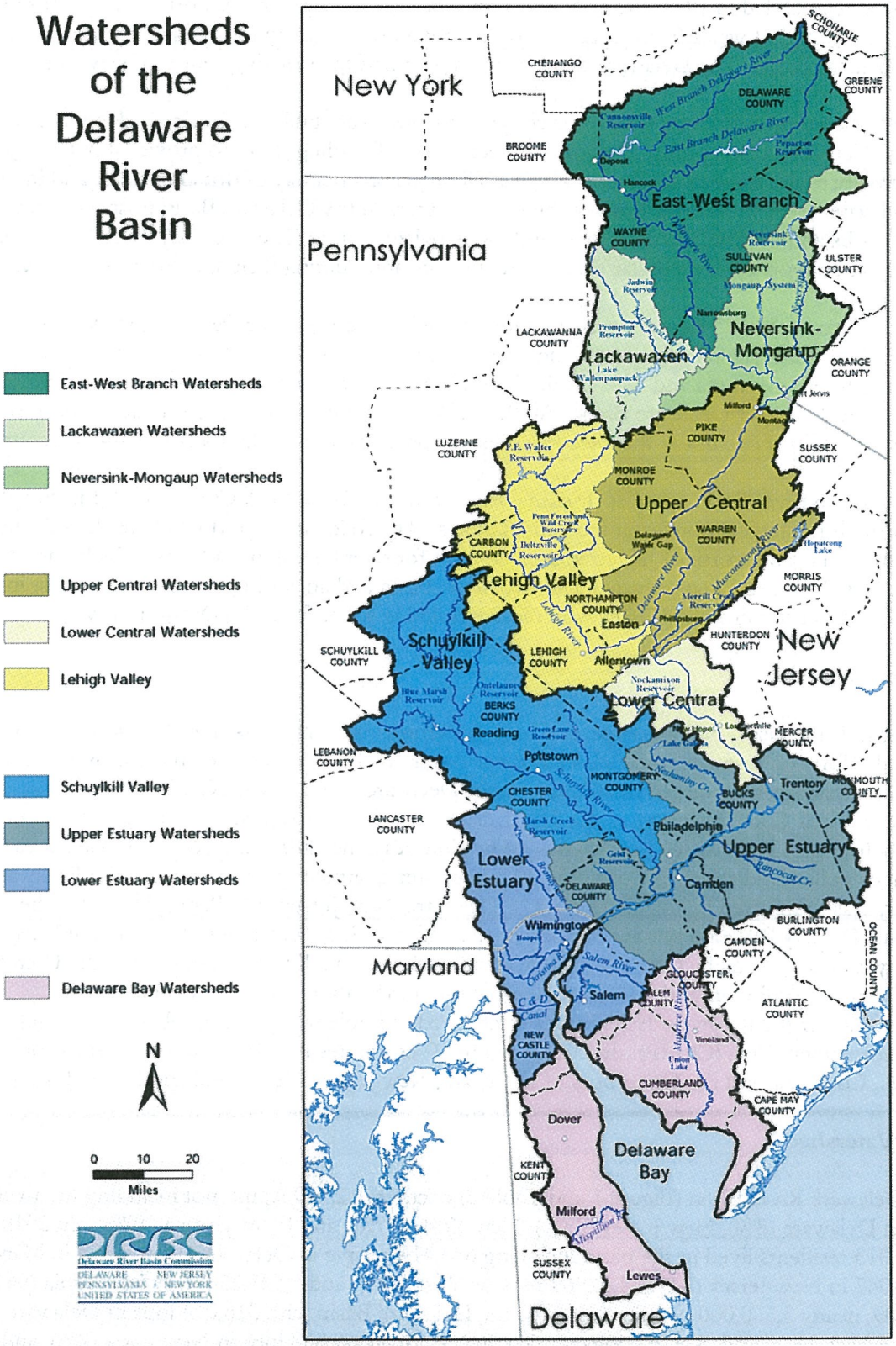


Figure 1. The Delaware River Basin. (DRBC)

Table 2. Land area, population, and employment in the Delaware River Basin

State	Area (sq mi)	Population[1] 2010	Employment[2] 2009
Delaware	965	643,418	316,014
Maryland	8	2,324	1,172
New Jersey	2,961	1,951,047	823,294
New York	2,555	124,969	69,858
Pennsylvania	6,280	5,533,254	2,271,317
Total	12,769	8,255,013	3,481,655

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

Table 3 summarizes the area, population, and employment by state and county in the Delaware Basin. In Delaware, the basin covers 50% of the land area yet includes 74% of the First State's population. The New Jersey portion of the basin covers 40% of the State's land area and includes 22% of the Garden State's population. New York State covers 5% of the State's land area and the basin includes 0.7% of the Empire State's population. The Pennsylvania part of the basin covers just 14% of the State's area yet includes 43% of the Keystone State's population.

The population of the Delaware Basin now exceeds 8.2 million which if considered as a single jurisdiction, it would be the 12th most populous state in the U.S. after North Carolina and New Jersey but ahead of Virginia and Massachusetts. Between 2000 and 2010, the population in the Delaware Basin increased by 6.1% or 472,066 people (Table 4 and Figure 2). Over the last decade, population increased by 30% in Pike County, Pa.; by over 20% in Kent and Sussex counties, Del. and Monroe County, Pa.; and by over 10% in Gloucester and Ocean counties, NJ, Orange County, NY, and Chester, Lehigh, and Northampton counties, Pa (Figure 3). For the first time in twp generations, Philadelphia gained population. Several counties in the basin lost population since 2000: Cape May, NJ; Broome, Delaware, and Greene counties, NY; and Lackawanna, Luzerne, and Schuylkill counties, Pa.

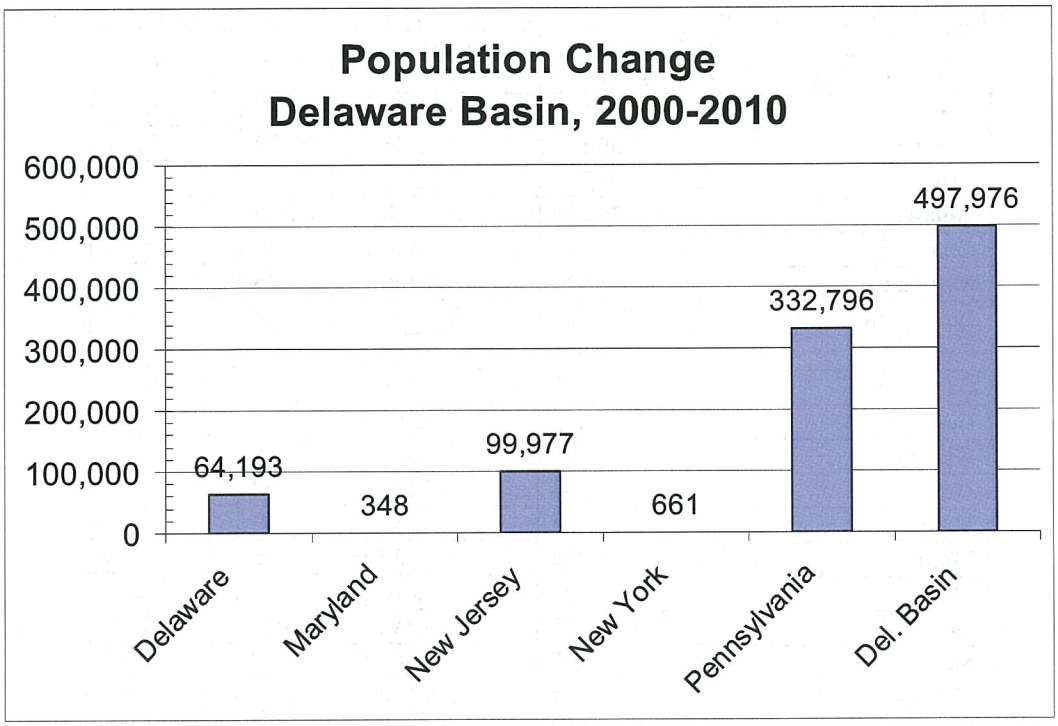
Table 3. Land area, population, and employment by county in the Delaware River Basin

State/county	Area 2005[1] (sq mi)	Population[2] 2010	Employment[3] 2009
Kent	389	108,025	50,412
New Castle	381	493,428	252,534
Sussex	195	41,965	13,068
Delaware	**965**	**643,418**	**316,014**
Cecil	8	2,324	1,172
Maryland	**8**	**2,324**	**1,172**
Burlington	495	367,157	187,758
Camden	123	432,315	169,909
Cape May	104	52,209	14,545
Cumberland	490	158,289	61,868
Gloucester	279	271,332	89,183
Hunterdon	215	65,132	23,650
Mercer	180	287,685	178,320
Monmouth	20	24,620	9,864
Ocean	30	23,616	7,495
Salem	347	66,342	21,900
Sussex	320	92,689	23,302
Warren	358	109,662	35,500
New Jersey	**2,961**	**1,951,047**	**823,294**
Broome	85	15,038	11,292
Delaware	1,295	26,111	14,240
Greene	25	1,207	572
Orange	65	19,887	10,456
Sullivan	940	47,563	25,511
Ulster	145	15,162	7,787
New York	**2,555**	**124,969**	**69,858**
Berks	777	407,843	150,665
Bucks	607	626,280	244,453
Carbon	381	63,640	16,730
Chester	616	491,070	212,996
Delaware	184	559,776	201,208
Lackawanna	25	11,335	4,830
Lebanon	20	7,221	2,750
Lehigh	347	344,571	166,932
Luzerne	50	17,491	8,074
Monroe	609	166,209	56,025
Montgomery	483	789,862	453,771
Northampton	374	299,646	96,536
Philadelphia	135	1,558,613	619,396
Pike	547	59,859	9,874
Schuylkill	420	79,358	27,077
Wayne	705	50,480	14,114
Pennsylvania	**6,280**	**5,533,254**	**2,271,317**
Delaware Basin	**12,761**	**8,255,013**	**3,481,655**

1. NOAA CSC 2005. 2. U. S. Census Bureau 2010. 3. U. S. Bureau of Labor Statistics 2009.

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

State/ County	Population 2000	Population 2010	Change	%
Kent	85,680	108,025	22,345	26.1%
New Castle	459,829	493,428	33,599	7.3%
Sussex	33,716	41,965	8,249	24.5%
Delaware	**579,225**	**643,418**	**64,193**	**11.1%**
Cecil	1,976	2,324	348	17.6%
Maryland	**1,976**	**2,324**	**348**	**17.6%**
Burlington	348,729	367,157	18,428	5.3%
Camden	425,646	432,315	6,669	1.6%
Cape May	55,679	52,209	-3,470	-6.2%
Cumberland	146,442	158,289	11,847	8.1%
Gloucester	239,012	271,332	32,320	13.5%
Hunterdon	60,995	65,132	4,137	6.8%
Mercer	274,945	287,685	12,740	4.6%
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%
Sussex	88,547	92,689	4,142	4.7%
Warren	102,438	109,662	7,224	7.1%
New Jersey	**1,851,070**	**1,951,047**	**99,977**	**5.9%**
Broome	15,713	15,038	-675	-4.3%
Delaware	28,030	26,111	-1,919	-6.8%
Greene	1,231	1,207	-24	-1.9%
Orange	17,722	19,887	2,165	12.2%
Sullivan	46,712	47,563	851	1.8%
Ulster	14,900	15,162	262	1.8%
New York	**124,308**	**124,969**	**661**	**0.5%**
Berks	373,638	407,843	34,205	9.2%
Bucks	597,632	626,280	28,648	4.8%
Carbon	58,795	63,640	4,845	8.2%
Chester	424,241	491,070	66,829	15.8%
Delaware	551,976	559,776	7,800	1.4%
Lackawanna	11,617	11,335	-282	-2.4%
Lebanon	6,648	7,221	573	8.6%
Lehigh	312,090	344,571	32,481	10.4%
Luzerne	17,916	17,491	-425	-2.4%
Monroe	138,690	166,209	27,519	19.8%
Montgomery	748,987	789,862	40,875	5.5%
Northampton	267,077	299,646	32,569	12.2%
Philadelphia	1,517,542	1,558,613	41,071	2.7%
Pike	46,303	59,859	13,556	29.3%
Schuylkill	81,159	79,358	-1,801	-2.2%
Wayne	46,147	50,480	4,333	9.4%
Pennsylvania	**5,200,458**	**5,533,254**	**332,796**	**6.2%**
Delaware Basin	**7,757,037**	**8,255,013**	**497,976**	**6.4%**



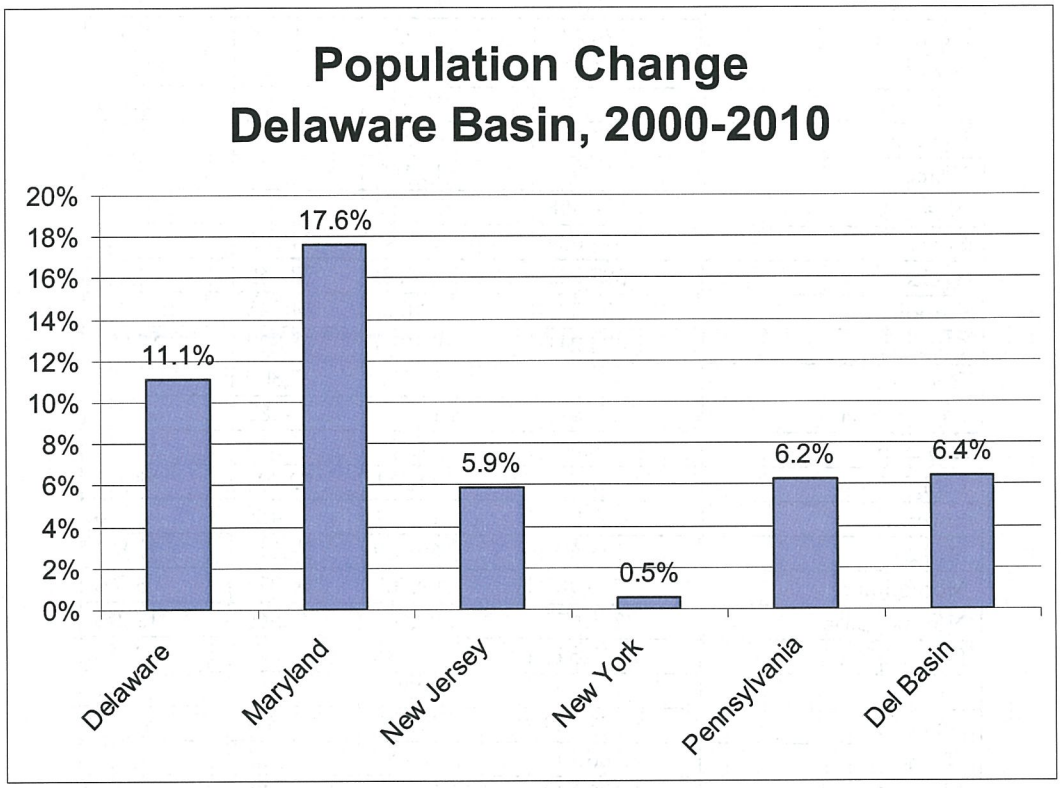
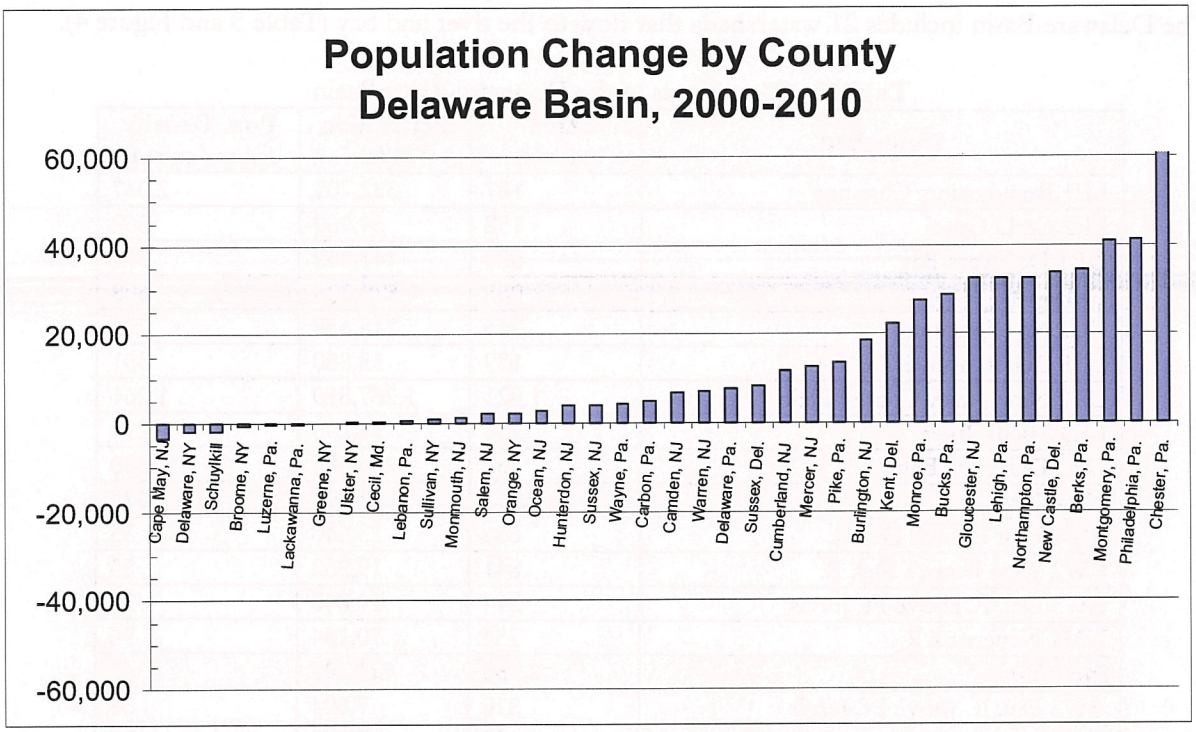


Figure 2. Population change in the Delaware River Basin, 2000-2010 (U.S. Census)



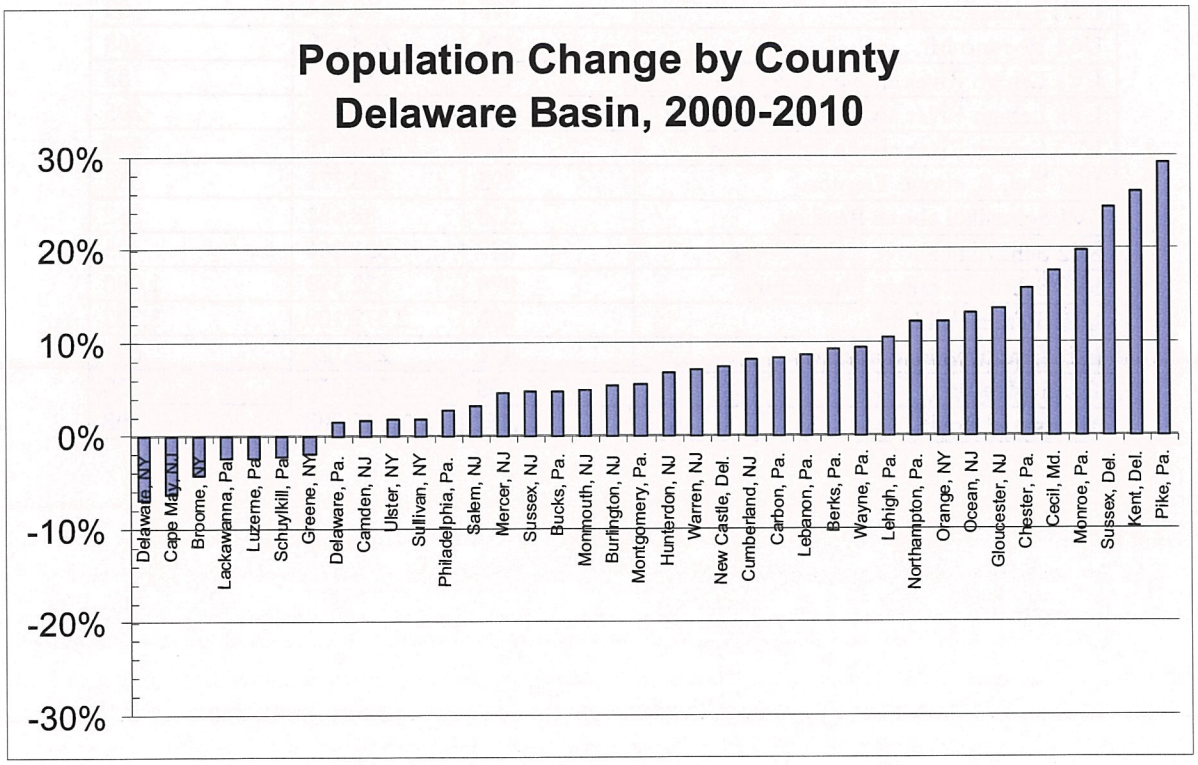


Figure 3. Population change in Delaware River Basin counties, 2000-2010 (U.S. Census)

The Delaware Basin includes 21 watersheds that flow to the river and bay (Table 5 and Figure 4).

Table 5. Watersheds in the Delaware River Basin

Watershed	Area (sq mi)	Population 2000	Pop. Density (pop./sq mi)
LE1 Brandywine/Christina	187	382,703	2,047
LE2 C&D Canal	152	54,960	362
DB1 Delaware Bay	626	141,562	226
Delaware	**965**	**579,225**	**600**
UC2 NJ Highlands	745	218,638	293
LC1 Del. R. above Trenton	159	55,880	351
UE2 New Jersey Coastal Plain	1,021	1,287,810	1,261
LE3 Salem River	254	54,290	214
DB2 Delaware Bay	782	234,480	300
New Jersey	**2,961**	**1,851,098**	**625**
EW1 East Branch Del. R.	666	23,040	35
EW2 West Branch Del. R.	841	19,263	23
EW3 Del. R. above Pt. Jervis	314	11,840	38
NM1 Neversink R.	734	70,164	96
New York	**2,555**	**124,307**	**49**
EW3 Del. R. above Pt. Jervis	210	7,894	38
NM1 Neversink R.	82	7,796	95
LW1 Lackawaxen R.	598	49,734	83
UC1 Pocono Mt.	779	208,478	268
LV1 Lehigh River above Lehighton	451	37,622	83
LV2 Lehigh River above Jim Thorpe	430	88,349	205
LV3 Lehigh River above Bethlehem	480	478,278	996
LC1 Del. R. above Trenton	295	103,771	352
SV1 Schuylkill above Reading	338	88,681	262
SV2 Schuylkill above Valley Forge	649	321,066	495
SV3 Schuylkill above Philadelphia	874	952,560	1,090
UE1 Penna Fall Line	693	2,579,100	3,722
LE1 Brandywine/Christina	401	277,129	691
Pennsylvania	**6,280**	**5,200,458**	**828**
Delaware Basin	**12,761**	**7,755,088**	**608**

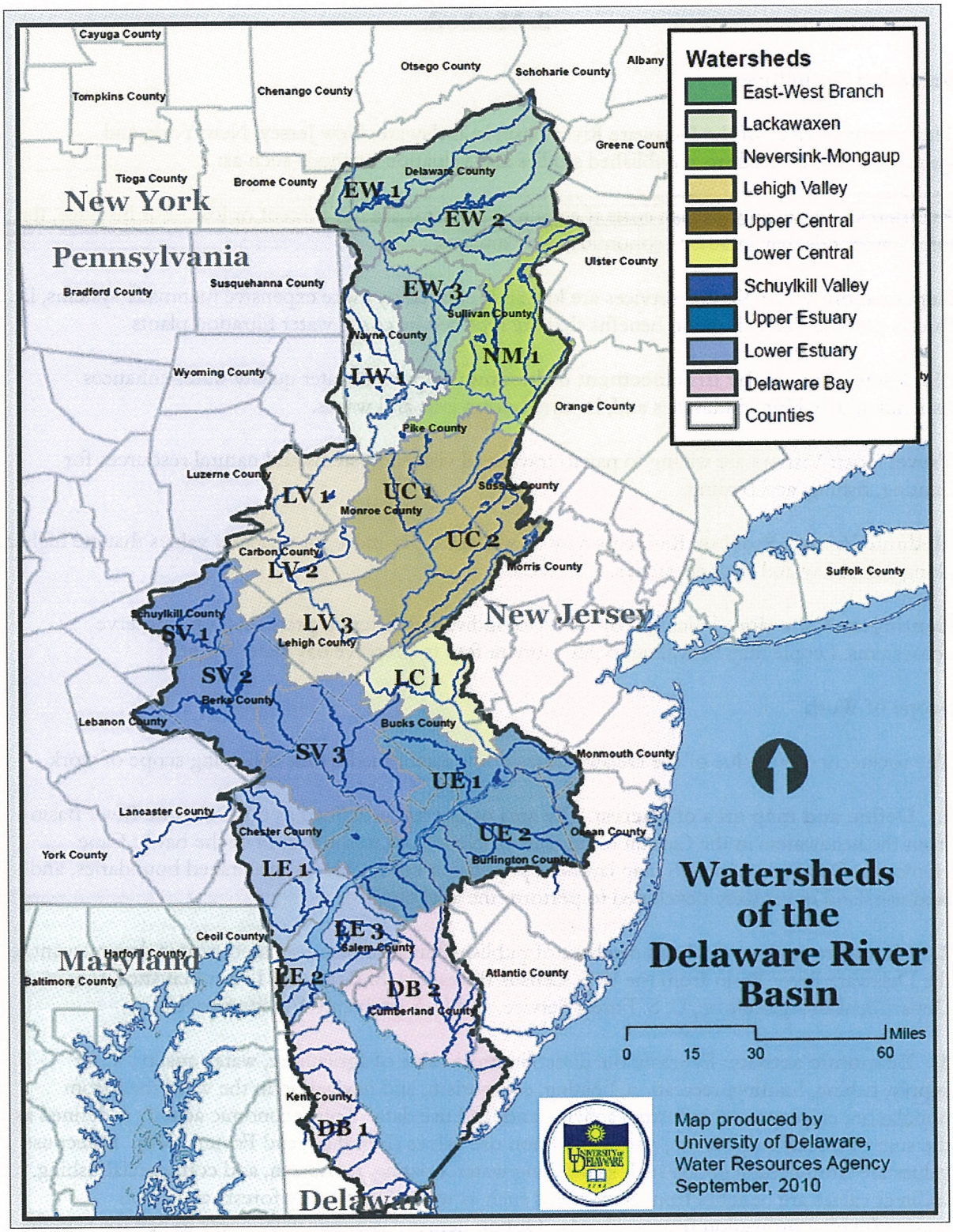


Figure 4. Watersheds in the Delaware River Basin (UDWRA 2010)

2. Methods

Valuation Techniques

The economic value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania is derived from published studies and valuation methods such as:

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

Replacement Cost: Natural services are lost and replaced by more expensive manmade systems, i.e. forests provide water filtration benefits that are replaced by costly water filtration plants.

Net Factor Income by Enhancement of Income: Improved water quality water enhances fisheries and crabbing industries and, in turn, boosts jobs and wages.

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

Hedonic Pricing Process: Residents may be willing to pay more for property values that are higher along scenic bay and river coastlines.

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

Scope of Work

The socioeconomic value of the Delaware Basin was established by the following scope of work.

1. **Define and map area of interest:** The area of interest is defined as the Delaware River Basin from the headwaters in the Catskill Mountains of New York to the mouth of the bay at Cape Henlopen, Delaware. ArcGIS map layers of population census blocks, watershed boundaries, and land use/land cover were developed to perform the analysis.

2. **Literature review:** Gather a database of published literature and socioeconomic data relevant to the Delaware River Basin 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. **Economic activity:** Estimate the direct/indirect value of agriculture, water quality, water supply, fishing, hunting, recreation, boating, ecotourism, and navigation in the watershed from population, employment, industrial activity, and land use data. Total economic activity is defined as the sum of direct/indirect use, option, and non use values (Ingraham and Foster 2008). Direct use values are from natural goods such as drinking water, boating, recreation, and commercial fishing. Indirect 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 accrue to 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. Prepare GIS based data sets and mapping. Ecosystem services (ecological services) are provided by nature and represent benefits such as water filtration, flood reduction, and drinking water supply.

Using GIS, define ecosystem areas using 2006 NOAA Coastal Services Center 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, (i) Open freshwater, and (j) Riparian buffer.

Search research studies and gather value ($/acre) data for 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 (benefits) 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 River Basin.

Compute ecosystem services value by multiplying land use area (acres) by ecosystem value ($/ac). The value transfer techniques employed here involves selecting data from published literature from another watershed or study area and applying the $ per ac values to land use areas computed by GIS. While primary research data from the watershed in question (the Delaware Basin) is preferable and is used 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 survey research is recommended to develop primary ecosystem service values for the Delaware Basin in particular.

4. Jobs and salaries: Obtain employment and wage data from the U. S. Department of Labor, U. S. Census Bureau, and National Ocean Economics Program. Calculate direct/indirect jobs in the Delaware Basin 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.

5. Report: Prepare a report and GIS mapping summarizing the direct and indirect economic values of goods and services provided by the Delaware River Basin updated to 2010 dollars.

3. Annual Economic Activity

Estimated annual economic value of the Delaware River Basin from recreation, fish and wildlife, public parks, water quality, navigation/ports, potential Marcellus Shale natural gas, agriculture, water supply, and forest activities is over $25 billion (Table 6 and Figure 5).

- Recreation $1.22 billion
- Fish and Wildlife $1.55 billion
- Public Parks $1.83 billion
- Water Quality $2.46 billion
- Navigation/Ports $2.62 billion
- Marcellus Shale Natural Gas (potential) $3.30 billion
- Agriculture $3.37 billion
- Water Supply $3.82 billion
- Forests $5.13 billion

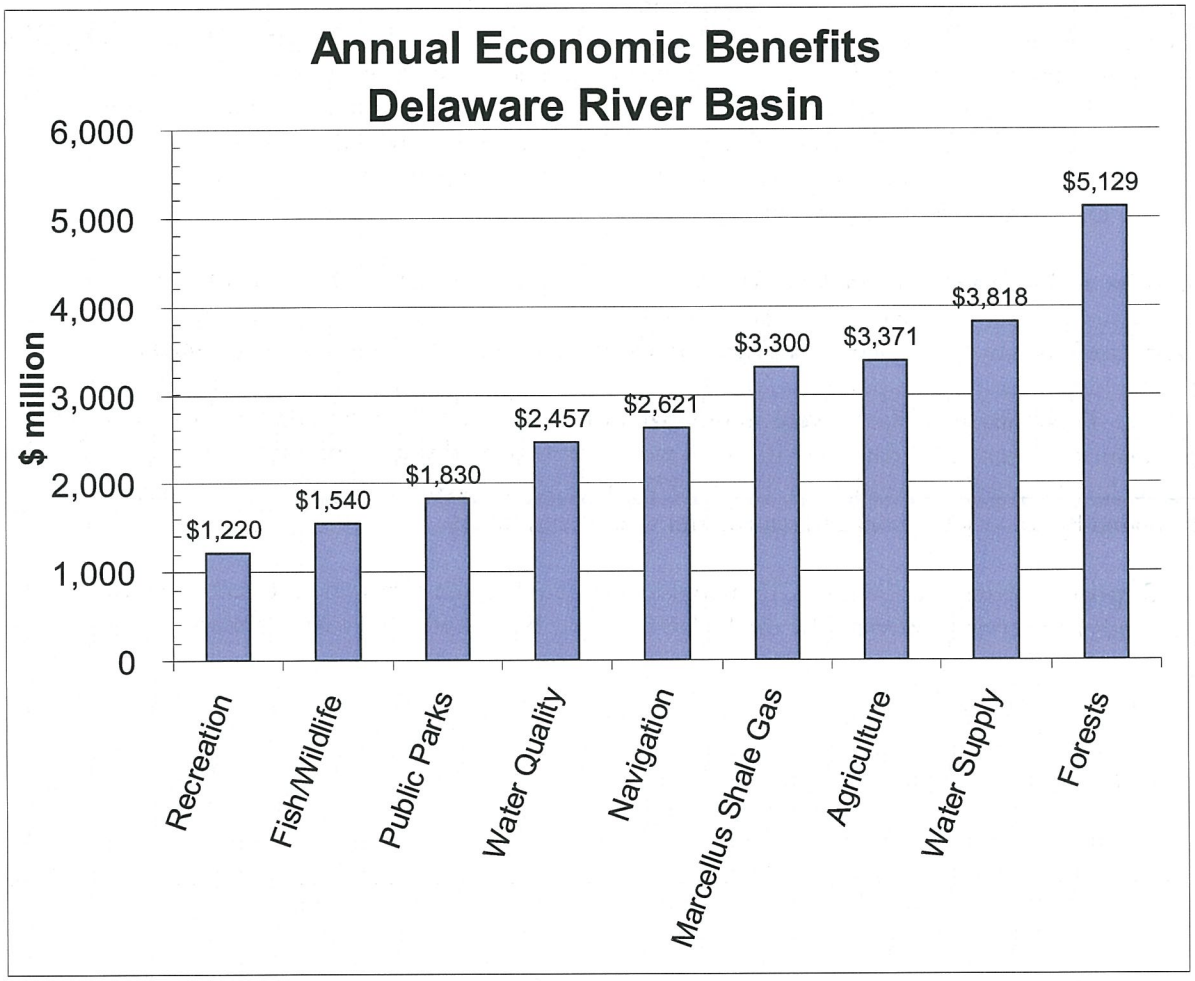


Figure 5. Annual economic activity related to the Delaware River Basin

Table 6. Annual economic activity in the Delaware River Basin, 2010

Activity	2010 ($ million)	Value Transfer Sources
Recreation (Boating, Fishing, Swimming)		
Clean Water Act Restoration		
Viewing/Aesthetics ($0.58/person)	5	University of Delaware (2003)
Boating ($0.76/person)	6	University of Delaware (2003)
Fishing ($2.95/person)	24	University of Delaware (2003)
Swimming ($6.88/person)	57	University of Delaware (2003)
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)
Skiing (1.9 million ski-days @$45/day)	325	Pennsylvania Ski Areas Association (2010)
Paddling-based Recreation (620,860 paddlers)	362	Outdoor Industry Association(2006)
Del. Water Gap River Recreation (267,000 visitors)	41	U.S. Forest Service, U.S. Nat'l Park Service (1990)
Canoe/Kayak/Rafting (225,000 visits)	9	Canoe and Kayak Liveries (2010)
Powerboating (232,000 boat registrations)	395	National Marine Manufacturers Association (2010)
Water Quality		
Willing to Pay for Clean Water ($38-$121/user)	659	University of Maryland (1989)
Water Treatment by Forests ($96/mgd)	63	Trust for Public Land, AWWA (2004)
Wastewater Treatment ($4.00/1000 gal)	1,722	DRBC and USEPA
Increased Property Value (+8%)	13	EPA (1973), Brookings Institute (2010)
Water Supply		
Drinking Water Supply ($4.78/1000 gal)	3,145	UDWRA and DRBC (2010)
Reservoir Storage ($0.394/1000 gal)	145	UDWRA and DRBC (2010)
Irrigation Water Supply ($300/ac-ft)	32	Resources for the Future (1996), USDA (2007)
Thermoelectric Power Water Supply ($44/ac-ft)	297	EIA (2002), NETL (2009)
Industrial Water Supply ($200/ac-ft)	179	Resources for the Future (1996), DRBC (2010)
Hydropower Water Supply ($32/ac-ft)	20	Resources for the Future (1996), DRBC (2010)
Fish/Wildlife		
Commercial Fish Landings ($0.60/lb)	34	NMFS, Nat'l. Ocean Economics Program (2007)
Fishing (11-18 trips/angler, $17-$53/trip))	576	U. S. Fish and Wildlife Service (2001)
Hunting (16 trips/hunter, $16-50/trip)	340	U. S. Fish and Wildlife Service (2001)
Wildlife/Bird-watching (8-13 trip/yr, $15-$27/trip)	561	U. S. Fish and Wildlife Service (2001)
Shad Fishing (63,000 trips, $102/trip)	6	Pennsylvania Fish and Boat Commission (2011)
Wild Trout Fishing	29	Amer. Sportfishing Assn./Trout Unlimited (1998)
Agriculture		
Crop, poultry, livestock value ($1,180/ac)	3,371	USDA Census of Agriculture 2007 (2009)
Forests		
Carbon Storage ($827/ac)	3,592	U.S. Forest Service, Del. Ctr. Horticulture (2008)
Carbon Sequestration ($29/ac)	126	U.S. Forest Service
Air Pollution Removal ($266/ac)	1,155	U.S. Forest Service
Building Energy Savings ($56/ac)	243	U.S. Forest Service
Avoided Carbon Emissions ($3/ac)	13	U.S. Forest Service
Public Parks		
Health Benefits ($9,734/ac)	1,283	Trust for Public Land
Community Cohesion ($2,383/ac)	314	Trust for Public Land
Stormwater Benefit ($921/ac)	121	Trust for Public Land
Air Pollution ($88/ac)	12	Trust for Public Land
Del. Water Gap Natl. Rec. Area (4.9 million visits)	100	U.S. National Park Service (2002)
Marcellus Shale		
Natural Gas (7.3 trillion cf @ $11.21/1000 cf)	3,300	USGS (2011), EIA (2011)
Maritime Transportation		
Navigation ($15/ac-ft)	220	Resources for the Future (1996)
Port Activity	2,400	Economy League of Greater Philadelphia (2008)
Delaware River Basin	**≈$25 billion**	

Recreation

Clean Water Act Restoration

Parsons, Helm, and Bondelid (2003) from the University of Delaware measured the economic benefits of water quality improvements to recreational users in the northeastern states and found annual per person benefits for improvements due to the Clean Water Act ranged from $0.47 for viewing, $0.62 for boating, $2.40 for fishing, to $5.59 for swimming. Table 7 summarizes total water quality benefits to recreational users in the Delaware River Basin by transferring the benefits in $2003 to $2010 assuming an annual rate of 3% and then multiplying the $2010 benefits by the basin population. Total 2010 recreation benefits due to Clean Water Act water quality improvements in the Delaware Basin are $92 million per year or $11.17 per person. Swimming (62%) and fishing (26%) are the highest valued recreational benefits followed by boating (7%) and viewing (5%).

Table 7. Water quality benefits from Clean Water Act improvements in the Delaware River Basin

Recreational Benefit	$2003[1] (per person)	$2010[2] (per person)	Del. Basin Pop. 2010	Benefit/yr	% of Benefit
Viewing	$0.47	$0.58	8,255,013	$4,787,908	5%
Boating	$0.62	$0.76	8,255,013	$6,273,810	7%
Fishing	$2.40	$2.95	8,255,013	$24,352,288	26%
Swimming	$5.59	$6.88	8,255,013	$56,794,489	62%
Total	**$9.08**	**$11.17**	**8,255,013**	**$92,208,495**	**100%**

1. Parsons et al. 2003. 2. $2010 transferred from $2003 at annual rate of 3%.

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 swimming, boating, recreational fishing, and bird watching/wildlife viewing in the Peconic Estuary watershed on Long Island, New York. Swimming, boating, fishing, and wildlife viewing were valued at $8.59, $19.23, $40.25, and $49.83 per trip in $1995, respectively. Table 8 summarizes water quality benefits to recreational users of $211 million per year in the Delaware Basin (estuary only) by transferring unit values from the Peconic Estuary, converting $1995 to $2010 by an annual rate of 3%, and multiplying $2010 benefits by trips per year.

Table 8. Total annual value of recreational benefits in the Delaware River Basin

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%. 3. 10% of Delaware Estuary population swims. 4. NOEP 2009 for boating (16.8% of pop. and 1.4 trips/p./yr) and fishing (10.3% of pop. and 1.2 trips/p./yr). 5. USFWS 2006 wildlife/bird watching (Del. 427,500, NJ 2,070,900, & Pa. 838,000 trips/yr).

Skiing

In the Pocono Mountains of Pennsylvania, nine ski areas draw approximately 1 mgd from Delaware Basin water supplies for snowmaking on 1,005 skiable acres. The Pennsylvania Ski Areas Association (2009) estimated the economic value at 23 ski resorts statewide was $832,000,000. Prorating from PSAA statewide estimates, the economic value for 9 resorts in the Delaware Basin is $325,000,000. The nine ski resorts in the Delaware Basin have aggregate annual revenues of $87,655,063 from 1,908,228 skier visits based on a mid-week lift ticket rate of $45/day (Table 9).

Table 9. Revenues from ski resorts in the Delaware River Basin

Ski Resort	Ski Area (ac)	Annual Ski Visits	Lift Ticket ($/day)	Revenue ($)
Elk Mountain	235	446,203	$48	$21,417,722
Ski Big Bear	26	49,367	42	2,073,418
Ski Shawnee	125	237,342	43	10,205,696
Alpine Mountain	60	113,924	37	4,215,190
Camelback	160	303,797	48	14,582,278
Jack Frost	100	189,873	44	8,354,430
Big Boulder	55	104,430	44	4,594,937
Blue Mountain	158	300,000	49	14,700,000
Bear Creek	86	163,291	46	7,511,392
Total	**1,005**	**1,908,228**	**$45**	**$87,655,063**

Paddling-based Recreation

Canoeing, kayaking, and rafting are key drivers to the local economy along the Brandywine, Lehigh, Schuylkill, and middle/upper Delaware rivers in the Delaware Basin (Van Rossum, Carluccio, and Blankinship 2010). In the Mid-Atlantic census division (NY, NJ, PA), the Outdoor Industry Association (2006) estimates paddling-based recreation is practiced by 11% of the population and is responsible for 3,356,000 participants, $356 million in gear retail sales, $1.6 billion in trip related sales, and 22,844 jobs. Given the Delaware Basin is the home of 7,611,595 people in NJ, NY, and Pa. or 22% of New Jersey's population (1,951,047), 0.7% of New York State's population, (124,969), and 43% of Pennsylvania's population (5,533,254) or 18.5% of the three state's total population of 40,800,000 people, then prorated paddling-based recreation in the basin is responsible for 620,860 participants, $96 million in gear retail sales, $296 million in trip sales, and 4,226 jobs (Table 10).

Table 10. Economic value of paddling-based recreation in the Delaware River Basin

Paddling Based Recreation	States of NJ, NY, PA[1]	Del. Basin NJ, NY, PA[2]
Population	40,800,000	7,563,762
Participants	3,356,000	620,860
Gear retail sales	$356 million	$66 million
Trip related sales	$1.600 billion	$296 million
Total Sales	$1.956 billion	$362 million
Jobs	22,844	4,226

1. Outdoor Industry Association 2006. 2. Prorated by 18.5% given 40,800,000 people live in NJ, NY, and PA and 7,611,595 people live in these states in the Delaware Basin.

River Recreation

Cordel et al. (1990) from the U. S. Forest Service and U.S. National Park Service estimated river recreation along the Upper Delaware River and Delaware Water Gap was responsible for $13.3 million and $6.9 million in total economic output, respectively, in $1986 (Table 11). Adjusting for 3% annually, river recreation economic output along the Upper Delaware River and Delaware Water Gap is roughly $27.1 million and $14.1 million, respectively, or $41.2 million total in $2010.

Table 11. Economic impacts of river recreation along Upper Delaware and Delaware Water Gap

River	Participants	Jobs	Wages ($1986)	Economic Output ($1986)	Wages ($2010)	Economic Output ($2010)
Upper Delaware	232,000	292	5,582,800	13,351,000	11,408,000	$27,100,000
Del. Water Gap	135,400	156	3,246,300	6,929,000	6,633,743	$14,100,000
Total	**367,400**	**448**	**8,829,100**	**20,280,000**	**18,041,743**	**41,200,000**

1. Cordel et al. 1990. 2. Adjusted to $2010 at 3% annually.

Canoe/Kayak/Rafting

Thirty seven (37) canoe and kayak liveries along the Delaware, Lehigh, and Schuylkill, and Brandywine Rivers lease watercraft to approximately 225,000 visitors with earnings of $9 million per year assuming a daily rental fee of $40 per person (Table 12).

Table 12. Annual revenue from canoe and kayak liveries in the Delaware River Basin

Canoe/Kayak Livery	Address	Daily Rate ($)	Annual Visitors	Revenue ($)
Delaware River				
Adventure Sports Canoe/Raft	Marshalls Creek, PA	$40	9,000	$360,000
Bucks County River Country	Point Pleasant, PA	$40	13,500	$540,000
Catskill Mountain Canoe Rentals	Hankins, NY	$40	7,000	$280,000
Cedar Rapids Kayak/Canoe	Barryville, NY	$40	5,000	$200,000
Chamberlain Canoes Inc	Minisink Hills, PA	$40	5,000	$200,000
Delaware River Rafting/Canoeing	Delaware, NJ	$40	9,000	$360,000
Delaware River Tubing	Frenchtown, NJ	$40	7,000	$280,000
Driftstone on the Delaware	Mount Bethel, PA	$40	5,000	$200,000
GreenWave Paddling	Yardville, New Jersey	$40	3,000	$120,000
Indian Head Canoes & Rafts	Barryville, NY	$40	5,000	$200,000
Jerrys Three River Canoes	Pond Eddy, NY	$40	4,000	$160,000
Kayak East	East Stroudsburg, PA	$40	4,000	$160,000
Kittatinny Canoes, Inc.	Dingmanns Ferry, PA	$40	4,000	$160,000
Landers River Trips	Narrowsburg, NY	$40	15,000	$600,000
Lazy River Outpost	Phillipsburg, NJ	$40	4,000	$160,000
Pack Shack Adventures Inc	Delaware Water Gap, PA	$40	5,000	$200,000
Paint Island Canoe & Kayak	Bordentown, NJ	$40	4,000	$160,000
Portland Outfitters	Portland, PA	$40	5,000	$200,000
River Country	Point Pleasant, PA	$40	9,000	$360,000
Shawnee Canoe Trips	Shawnee on Delaware, PA	$40	12,000	$480,000
Silver Canoe Rentals	Port Jervis, NY	$40	4,000	$160,000
Upper Delaware Campgrounds	Callicoon, NY	$40	5,000	$200,000
Whitewater Willies Canoe Rentals	Pond Eddy, NY	$40	4,000	$160,000
Wild & Scenic River Tours/Rentals	Barryville, NY	$40	5,000	$200,000
Lehigh River				$0
Jim Thorpe River Adventures	Jim Thorpe, PA	$40	9,000	$360,000
Lehigh Rafting Rentals Inc	White Haven, PA	$40	9,000	$360,000
Lehigh River Bait and Bow	Allentown, PA	$40	3,000	$120,000
Northeast PA Kayak School	Lehighton, PA	$40	3,000	$120,000
Pocono Whitewater	Jim Thorpe, PA	$40	8,000	$320,000
Whitewater Challengers, Inc.	White Haven, PA	$40	9,000	$360,000
Whitewater Rafting Adventures Inc.	Nesquehoning, PA	$40	6,000	$240,000
Schuylkill				$0
Schuylkill River Outfitters	Birdsboro, PA	$40	4,500	$180,000
Brandywine River				$0
Brandywine Outfitters	Coatesville, PA	$40	3,000	$120,000
Northbrook Canoe	West Chester, PA	$40	9,000	$360,000
Wilderrness Canoe Trips	Wilmington, DE	$40	9,000	$360,000
Total			**225,000**	**9,000,000**

Powerboating

The National Marine Manufacturers Association (2010) announced that New York, Delaware, Pennsylvania, and New Jersey ranked 3rd, 7th, 17th, and 23rd in the U.S. respectively in total expenditures for new powerboats, outboard engines, boat trailers, and accessories. Table 13 summarizes powerboat expenditures by state and then prorated by percent population of each state within the Delaware Basin. Powerboat expenditures due to boating within the waters of the Delaware Basin are estimated at about $395 million/year

Table 13. Recreational powerboat expenditures in the Delaware River Basin (NMMA 2010)

State	Rank Expenditures	Total Powerboat Expenditures ($)	% Pop. of State in Basin	Del. Basin Powerboat Expenditures ($)
Delaware	7	343,743,963	74%	254,370,533
New Jersey	23	183,044,985	22%	40,269,897
New York	3	401,353,400	0.70%	2,809,474
Pennsylvania	17	226,281,490	43%	97,301,041
Total		**1,154,423,838**		**394,750,944**

New York, Pennsylvania, New Jersey, and Delaware are ranked 7th, 13th, 28th, and 40th in number of recreational boat registrations in 2009. The four states combined had just over $1 million boat registrations in 2009 with 232,000 registrations for boating in the Delaware River Basin (Table 14).

Table 14. Recreational boat registrations in the Delaware River Basin (NMMA 2010)

State	Rank Registrations	Total Boat Registrations	% Pop. of State in Basin	Del. Basin Boat Registrations
Delaware	40	61,523	0.74	45,527
New Jersey	28	173,994	0.22	38,279
New York	7	479,161	0.007	3,354
Pennsylvania	13	337,747	0.43	145,231
Total		**1,052,425**		**232,391**

Water Quality

Willingness to Pay for Clean Water

Bockstael, McConnell, and Strand (1989) from the University of Maryland estimated public annual willingness to pay for a moderate improvements in water quality of the Chesapeake Bay 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 estuary watershed portion of the Delaware Basin

(pop. 6,700,000) and using proportions of 10% users or visitors to the estuary and 90% nonusers, aggregate willingness to pay to make the Delaware Estuary water quality acceptable to the public is $658 million in $2010 or $99 per person.

Total willingness to pay for acceptable Delaware Estuary water quality
= (0.10)(6,700,000)($121/yr) + (0.90)(6,700,000)($38/yr)
= $310 million ($1984) = $659 million ($2010 at 3% annually).

Water Treatment

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 15). The public drinking water supply is 1,803 mgd and forests cover 6,786 sq mi or 53% of the Delaware River Basin. Loss of these forests would increase drinking water treatment costs by $96 per mil gal ($139 per mil gal @ 0% forested minus $43 per mil gal @ 53% forested) or $173,088 per day for 1,803 mgd = $63,177,120 per year.

Table 15. 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%

Wastewater Treatment

The waters of the Delaware Basin provide significant wastewater treatment, discharge, and assimilation services. In accordance with Federal Clean Water Act, DRBC, and state water quality regulations, NPDES municipal wastewater dischargers hold permits to discharge up to 1,180 million gallons per day to the Delaware River Basin or 106 mgd in Delaware, 218 mgd in New Jersey, 7 mgd in New York, and 849 mgd in Pennsylvania (Table 16). The average wastewater rate in the basin is $4.00 per 1000 gal. The fee for an average residence of 4 people @ 50 gpcd is $290 per year. The value of treated wastewater in the Delaware Basin is $4.7 million per day or $1.7 billion per year.

Table 16. Value of NPDES wastewater treatment discharges in the Delaware River Basin

NPDES ID	Facility	Location	State	Flow[1] (mgd)	Value[2] ($/day)	Wastewater Value ($/year)
DE0020338	Kent Co. Levy Court WWTR	Frederica	DE	15.0	60000	21900000
DE0021512	Lewes City POTW	Lewes	DE	0.8	3,200	1,168,000
DE0020320	Wilmington Wastewater Plant	Wilmington	DE	90.0	360,000	131,400,000
Delaware			**DE**	**105.8**	**423,200**	**154,468,000**

NJ0027481	Beverly City Sewer Auth. STP	Beverly	NJ	1.0	4,000	1,460,000
NJ0024678	Bordentown Sewerage Auth.	Bordentown	NJ	3.0	12,000	4,380,000
NJ0024651	Cumberland Co. Auth. WWTP	Bridgeton	NJ	7.0	28,000	10,220,000
NJ0024660	Burlington City STP	Burlington	NJ	2.7	10,800	3,942,000
NJ0021709	Burlington Twp. DPW	Burlington	NJ	1.6	6,400	2,336,000
NJ0026182	Camden County MUA	Camden	NJ	80.0	320,000	116,800,000
NJ0021601	Carneys Point Twp. WWTP	Carneys Point	NJ	1.3	5,200	1,898,000
NJ0024007	Cinnaminson Sewerage Auth.	Cinnaminson	NJ	2.0	8,000	2,920,000
NJ0023701	Florence Twp. DPW Sewer Auth.	Florence	NJ	2.5	10,000	3,650,000
NJ0026301	Hamilton Twp. DPW	Hamilton Twp.	NJ	16.0	64,000	23,360,000
NJ0020915	Lambertville City Sewer Auth.	Lambertville	NJ	1.5	6,000	2,190,000
NJ0024759	Ewing Lawrence Sewer WWTP	Lawrenceville	NJ	16.0	64,000	23,360,000
NJ0069167	Maple Shade Twp. Util, Authority	Maple Shade	NJ	3.4	13,600	4,964,000
NJ0026832	Medford Twp. Sewer Auth. STP	Medford	NJ	1.8	7,200	2,628,000
NJ0029467	Millville City Sewer Auth.	Millville	NJ	5.0	20,000	7,300,000
NJ0024996	Moorestown Twp. WWTP	Moorestown	NJ	3.5	14,000	5,110,000
NJ0024015	Mount Holly Twp. MUA	Mount Holly	NJ	7.7	30,800	11,242,000
NJ0020184	Newton Town DPW	Newton	NJ	1.4	5,600	2,044,000
NJ0024821	Pemberton Twp. MUA STP	Pemberton	NJ	2.5	10,000	3,650,000
NJ0024023	Penns Grove Sewerage Auth.	Penns Grove	NJ	0.8	3,200	1,168,000
NJ0021598	Pennsville Twp. Sewer Auth.	Pennsville	NJ	1.9	7,600	2,774,000
NJ0024716	Phillipsburg Town STP	Phillipsburg	NJ	3.5	14,000	5,110,000
NJ0022519	Riverside Twp. DPW	Riverside	NJ	1.0	4,000	1,460,000
NJ0024856	Salem WWTP Facility	Salem	NJ	1.4	5,600	2,044,000
NJ0024686	Gloucester Co. Util. Auth. STP	Thorofare	NJ	24.1	96,400	35,186,000
NJ0020923	Trenton City DPW Sewer Auth.	Trenton	NJ	20.0	80,000	29,200,000
NJ0023361	Willingboro Twp. MUA	Willingboro	NJ	5.2	20,800	7,592,000
New Jersey				**217.8**	**871,200**	**317,988,000**
NY0020265	Delhi WWTP	Delhi	NY	0.8	3,200	1,168,000
NY0030074	Liberty WWTF	Liberty	NY	1.6	6,400	2,336,000
NY0022454	Monticello STP	Monticello	NY	3.1	12,400	4,526,000
NY0029271	Sidney WWTP	Sidney	NY	1.7	6,800	2,482,000
New York				**7.2**	**28,800**	**10,512,000**
PA0026867	Abington Twp. STP	Abington	PA	3.9	15,600	5,694,000
PA0026000	Allentown City WWTP	Allentown	PA	40.0	160,000	58,400,000
PA0026042	Bethlehem City STP	Bethlehem	PA	90.0	360,000	131,400,000
PA0021181	Bristol Borough Water and Sewer	Bristol	PA	1.2	4,800	1,752,000
PA0027103	Delaware Co. Reg. Water Auth.	Chester	PA	44.0	176,000	64,240,000
PA0026859	Coatesville WWTP	Coatesville	PA	3.8	15,200	5,548,000
PA0026794	Conshohocken Borough Auth.	Conshohocken	PA	2.3	9,200	3,358,000
PA0026531	Downingtown Regional WPCC	Downingtown	PA	7.1	28,400	10,366,000
PA0026549	Borough of Doylestown WWTP	Doylestown	PA	28.5	114,000	41,610,000
PA0027235	Easton Area Joint Auth. WWTP	Easton, PA	PA	10.0	40,000	14,600,000
PA0029441	Upper Dublin Twp. MS4 UA	Ft. Washington	PA	1.1	4,400	1,606,000
PA0051985	Horsham Twp. STP	Horsham	PA	1.0	4,000	1,460,000
PA0024058	Kennett Square Borough WWTP	Kennett Square	PA	1.1	4,400	1,606,000
PA0026298	Whitemarsh STP	Lafayette Hill	PA	2.0	8,000	2,920,000
PA0026182	Lansdale Borough STP	Lansdale	PA	2.6	10,400	3,796,000
PA0039004	U. Gwynedd/Towamencin STP	Lansdale	PA	6.5	26,000	9,490,000
PA0026468	Morrisville Municipal Authority	Morrisville	PA	10.0	40,000	14,600,000
PA0027421	Norristown Borough WWTP	Norristown	PA	9.8	39,200	14,308,000
PA0020532	Upper Montgomery Joint Sewer	Pennsburg	PA	2.0	8,000	2,920,000

PA0026689	Northeast WPCP	Philadelphia	PA	210.0	840,000	306,600,000
PA0026662	Philadelphia Southeast POTW	Philadelphia	PA	112.0	448,000	163,520,000
PA0026671	SW Water Pollution Control	Philadelphia	PA	200.0	800,000	292,000,000
PA0020460	Quakertown WWTP	Quakertown	PA	4.3	17,200	6,278,000
PA0026549	Reading WWTP	Reading	PA	28.5	114,000	41,610,000
PA0020168	East Stroudsburg Filtration Plant	Stroudsburg	PA	2.3	9,200	3,358,000
PA0029289	Stroudsburg STP	Stroudsburg	PA	2.5	10,000	3,650,000
PA0027031	Goose Creek STP	West Chester	PA	1.7	6,800	2,482,000
PA0026018	West Chester Taylor Run STP	West Chester	PA	1.8	7,200	2,628,000
PA0028584	West Goshen STP	West Chester	PA	6.0	24,000	8,760,000
PA0023256	Upper Gwynedd Twp. WWTP	West Point	PA	5.7	22,800	8,322,000
PA0025976	Upper Moreland Hatboro Sewer	Willow Grove	PA	7.2	28,800	10,512,000
Pennsylvania			**PA**	**848.9**	**3,395,600**	**1,239,394,000**
Delaware Basin			**Basin**	**1,179.7**	**4,718,800**	**1,722,362,000**

1. DRBC and USEPA. 2. Value at @ $4.00/1000 gal

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 17). 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.

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 18). 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 17. Increased property values resulting from improved water quality

Study	Watershed	Increased 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%

Table 18. Increased shore property value due to improved water quality in the Delaware Basin

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

Water Supply

Drinking Water Supply

The Delaware Basin covers just 0.4% of the continental United States (12,769 sq mi/3,000,000 sq mi) yet supplies drinking water to 5% of the U.S. population (16,000,000/309,000,000 people). Delaware Basin aquifers and streams supply drinking water to over 8 million people within the basin to cities like Wilmington, Philadelphia, Allentown, Camden, and Trenton, NJ. Through interbasin transfers, the Delaware Basin also supplies drinking water to an additional 8 million people who live outside the basin by allocated diversions through the New York City Catskill Reservoir system (800 mgd) and the Delaware & Raritan Canal in New Jersey (100 mgd). Table 19 summarizes the economic benefits of groundwater reserve stock to generate ecosystem services (USEPA 1995).

Table 19. 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

The Delaware Basin provides significant public drinking water supplies (1,804 mgd) with 44% in NY (800 mgd), 38% from Pa. (679 mgd), 16% from NJ (284 mgd), and 2% from Del. (40 mgd), Figure 6. The largest public water supply allocations in the Delaware Basin include United Water Delaware and Wilmington in Del.; Delaware & Raritan Canal diversion, New Jersey American, Trenton, and Camden in NJ; New York City, and Philadelphia and Aqua Pennsylvania in Pa. (Table 20). Figure 7 depicts public water supply service areas in the Delaware River Basin.

The annual value of raw (untreated) public water supply allocations in the Delaware Basin (1,803 mgd) is $658 million. When treated and delivered to customers the annual value of drinking water supplies is $3.14 billion (Table 21). Water purveyors in Delaware estimate the value of raw water supply is $1.00/1000 gallons according to cost of services studies for rate setting by the Public Service Commission. In FY13, the New Jersey Water Supply Authority plans to sell raw water supplies from the Manasquan Reservoir system for $1.02/1000 gallons (NJWSA 2011). The average value of treated drinking water based on rates set by public/private water purveyors in Del., NJ, Pa., and Md. is $4.78/1000 gallon (Corrozi and Seymour 2008).

Table 20. Public water supply allocations in the Delaware River Basin (DRBC 2010)

Water Purveyor	Supply (mgd)	Water Purveyor	Supply (mgd)	Water Purveyor	Supply (mgd)
Delaware	**40.10**				
United Water Del.	18.46	Harrington	0.36	Frederica Perkiomen	0.05
Wilmington	10.40	Camden-Wyoming	0.31		
Dover	4.74	Milton	0.17		
Newark	2.22	Milford	0.17		
Lewes BPW	0.98	Georgetown	0.13		
Tidewater Utilities	0.64	Frederica	0.08		
Dover AFB	0.44	Felton	0.08		
New Castle MSC	0.41	Delaware State Fair	0.05		
Smyrna	0.37	Magnolia	0.05		
New Jersey	**284.19**				
Del. & Raritan Canal	100.00	Hackettstown MUS	2.57	Medford Twp.	1.29
NJ American Western	39.37	Millville Water Dept	2.55	NJ American Oxford	1.20
Trenton	26.10	Moorestown	2.51	Florence Twp.	1.17
Camden	10.89	Bordentown	2.21	Salem City	1.12
Vineland	8.33	Burlington Twp.	2.00	Mantua Twp.	1.04
Merchant.-Pennsauken	6.05	Mt. Laurel	1.96	Pennsville Twp.	1.04
Washington Twp.	4.79	Glassboro	1.95	Pemberton Twp.	1.01
Willingboro MUA	4.65	Collingswood	1.93	Gloucester City	0.95
NJ American Mt. Holly	4.48	Maple Shade	1.64	Lower Twp MUA	0.95
Bridgeton	3.63	West Deptford	1.57	Sparta Twp.	0.94
Wildwood	3.59	Woodbury	1.55	Audubon Twp.	0.91
Aqua NJ Phillipsburg	3.46	Burlington City	1.47	Haddon Twp.	0.90
Aqua NJ Hamilton Sq.	3.39	Pennsgrove	1.42	Bellmawr Twp.	0.86
Aqua NJ Blackwood	2.96	Deptford Twp.	1.38	Haddonfield	0.82
Evesham MUA	2.82	Nesqehoning Boro	1.30	Greenwich Twp	0.82
				Misc. Water Purveyors	16.65
New York State	**800.03**				
New York City	800.00				
Pennsylvania	**679.30**				
Philadelphia	287.77	Easton Suburb.Water	4.47	Falls Twp.	2.66
Aqua PA Main System	102.18	Schuylkill Co. Auth.	4.36	Northampton Bucks	2.55
Forest Park	20.16	Muhlenberg Twp.	4.31	Warminster Twp.	2.54
Bethlehem	15.69	Lehigh County	4.22	Horsham Water/Sewer	2.30
Allentown	15.46	PA American Nazareth	4.13	Newtown Artesian	2.24
North Wales Water	15.09	Hazelton	4.12	Milford	1.88
Bucks Co. Water	14.99	PA Amer. Coatesville	4.07	Tamaqua MWA	1.87
Reading Area Auth.	14.31	Allentown City	4.02	Lehighton MWA	1.77
Bucks County SW	13.79	Northampton Boro.	3.74	Ambler Boro	1.75
PA Amer. Norristown	10.10	East Stroudsburg	3.69	Brodhead Cr. Auth.	1.73
Lower Bucks County	8.66	PA American Yardley	3.20	South Whitehall Twp.	1.71
North Penn Water	8.59	Phoenixville	3.01	Emmaus Munic. Water	1.49
Easton	7.13	Morrisville	2.89	Warrington Twp.	1.45
Schuylkill Co. Auth.	5.15	PA American Home	2.88	Wyomissing Boro	1.44
Pottstown Water Auth.	4.64	PA American Penn	2.76	Schuylkill Haven Boro.	1.42
				Misc. Water Purveyors	50.93

Table 21. Value of public drinking water supply allocations in the Delaware River Basin

State	Withdrawal (mgd)	Value/day untreated ($1.00/1000 gal)	Value/year untreated ($1.00/1000 gal)	Value/year treated ($4.78/1000 gal)
Delaware	40	40,000	14,600,000	69,788,000
New Jersey	284	284,000	103,660,000	495,494,800
New York	800	800,000	292,000,000	1,395,760,000
Pennsylvania	679	679,000	247,835,000	1,184,651,300
Delaware Basin	**1,803**	**1,803,000**	**658,095,000**	**3,145,694,100**

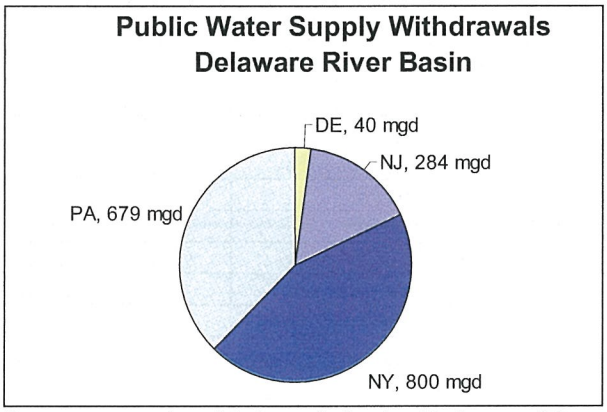


Figure 6. Public water supply withdrawals in the Delaware River Basin (DRBC)

Reservoir Storage

Almost 369 billion gallons of water is stored in reservoirs for interstate flow management and drinking water supply in the Delaware Basin (Table 22). The New Jersey Water Supply Authority operates a reservoir system and Delaware & Raritan Canal diversion from the Delaware River to New Jersey. The NJWSA delivers untreated water to public water purveyors from the Raritan River reservoir system at an estimated market price of $0.394/1,000 gallons (NJWSA 2011). Given the raw water value of drinking water before treatment) is $0.394/1000 gallons, the annual value of reservoir storage for flow management purposes in the Delaware Basin is $145 million.

Table 22. Economic value of reservoir storage in the Delaware River Basin

Reservoir	Storage (BG)	Value ($0.394/1000 gal)
Pepacton	140	55,160,000
Cannonsville	96	37,824,000
Neversink	35	13,790,000
Mongaup	15	5,910,000
Merrill Creek	16	6,304,000
Hoopes	2	788,000
Marsh Creek	4	1,576,000
Blue Marsh	6	2,561,000
Beltzville	13	5,122,000
F. E. Walter	11	4,334,000
L.Waullenpaupack	30	11,820,000
Total	**368**	**145,189,000**

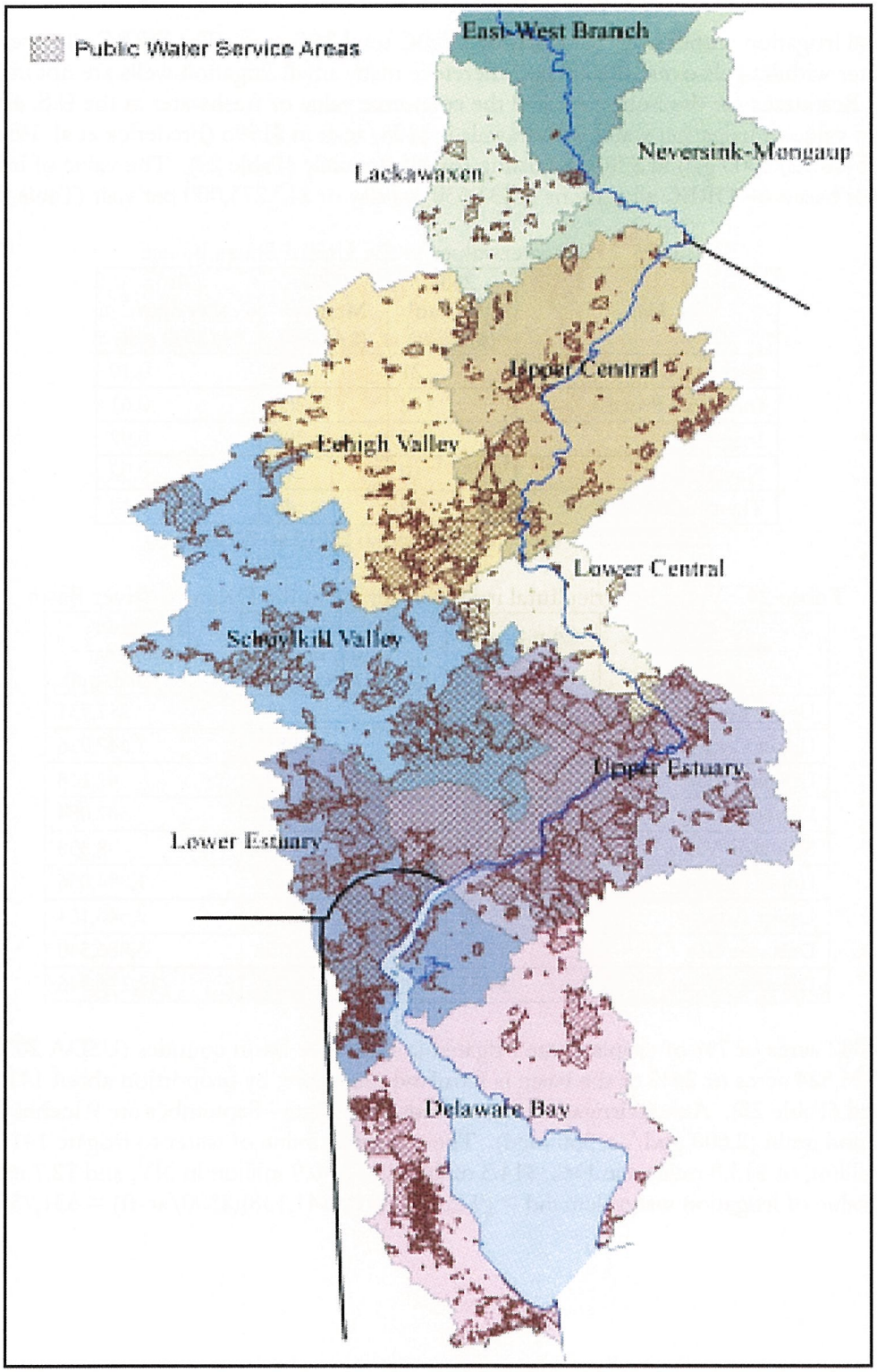


Figure 7. Public water supply service areas in the Delaware River Basin (DRBC 2011)

Irrigation Water Supply

Agricultural irrigation withdrawals allocated by DRBC total 36.5 mgd. The DRBC allocates groundwater withdrawals over 100,000 gpd therefore many small irrigation wells are not included in this total. Resources for the Future studied the economic value of freshwater in the U.S. estimated the median 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 23). The value of irrigation withdrawals based on DRBC allocations is $33,630 per day or $12,275,000 per year (Table 24).

Table 23 Freshwater values in the United States by use

Use	2006 Median[1] ($/ac-ft)	2010 Median[2] ($/ac-ft)	2010 Median ($/1000 gal)
Hydropower	21	32	0.10
Industrial Process	132	200	0.61
Irrigation	198	300	0.92
Navigation	10	15	0.02
Thermoelectric Power	29	44	0.14

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

Table 24. Value of agricultural irrigation supply in the Delaware River Basin

Watershed	Withdrawal (mgd)	Irrigation Value/day ($0.92/1000 gal)	Irrigation Value/year ($0.92/1000 gal)
Upper Region	0.65	597	217,731
Upper Central	4.91	4,515	1,647,916
Lehigh Valley	0.20	184	67,118
Lower Central	1.51	1,389	507,084
Schuylkill Valley	0.02	23	8,358
Upper Estuary	4.15	3,819	1,394,036
Lower Estuary	7.58	6,976	2,546,164
Delaware Bay	17.53	16,128	5,886,540
Delaware Basin	**36.55**	**33,630**	**12,274,946**

Over 209,882 acres or 7% of cropland are irrigated in Delaware Basin counties (USDA 2009). About 1,926,524 acres or 24% of the basin is farmland, therefore, by proportion about 141,138 acres are irrigated (Table 25). Annual irrigation water needs from June - September are 9 inches for corn, soybeans, and grain (2,600 gpd/ac, 366 mgd). The economic value of water to irrigate 141,138 acres is $31.8 million, or $13.8 million in Del., $14.3 million in NJ, 0.9 million in NY, and $2.7 million in Pa.. The value of irrigation water demand = (9 in/12 in/ft)(141,138)($300/ac-ft) = $31,756,104/yr.

Table 25. Value of agriculture irrigation water demand in the Delaware River Basin

County	Cropland by county[1] (ac)	Irrigation by county[1] (ac)	Farmland in basin (ac)	Irrigated land in basin (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**	**$13,815,748**
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			
Hunterdon	100,027	1,501			
Mercer	21,736	1,028			
Monmouth	44,130	5,976			
Ocean	9,833	1,090			
Salem	96,530	18,001			
Sussex	65,242	454			
Warren	74,975	2,426			
New Jersey	**631,150**	**79,333**	**505,507**	**63,540**	**$14,296,541**
Broome	86,613	150			
Delaware	165,572	65			
Greene	44,328	735			
Orange	80,990	4,560			
Sullivan	50,443	75			
Ulster	75,205	4,707			
New York	**503,151**	**10,292**	**187,561**	**3,837**	**$863,230**
Berks	170,760	1,260			
Bucks	58,012	1,421			
Carbon	20,035	132			
Chester	117,145	1,659			
Delaware	1,646	36			
Lackawanna	39,756	258			
Lancaster	326,648	5,366			
Lebanon	89,566	1,276			
Lehigh	72,737	1,189			
Luzerne	66,577	60			
Monroe	29,165	97			
Montgomery	28,563	668			
Northampton	68,252	247			
Philadelphia	150	0			
Pike	27,569	12			
Schuylkill	81,276	1,896			
Wayne	99,939	118			
Pennsylvania	**1,297,796**	**15,695**	**979,313**	**11,843**	**$2,664,765**
Total	**2,864,870**	**209,882**	**1,926,524**	**141,138**	**$31,756,104**

1. Census of Agriculture 2007 (USDA 2009). 2. Frederick, VandenBerg, and Hansen 1996.

Thermoelectric Power Water Supply

Cooling water withdrawals for thermoelectric power plants in the Delaware Basin provide significant economic value. Over 89% of the energy in the United States is produced by thermoelectric power plants which evaporate water during cooling of condensate. The Delaware Basin provides 5,809

mgd of cooling water to run nuclear, coal, and gas fired power plants to generate 13,458 megawatts of electricity along the Delaware, Schuylkill, and Lehigh. About 95% of the cooling water returns to the river or bay (nonconsumptive use) and 5% evaporates (consumptive use). Table 26 lists power plants and associated cooling water withdrawals within the Delaware Basin obtained from U. S. Energy Information Administration (2002) and U.S. National Energy Technology Laboratory (2009) inventories of electric utility power plants and DRBC water allocation dockets.

Resources for the Future in a study of the economic value of freshwater in the United States estimated the median $1996 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 water withdrawals is $44 per ac-ft or $0.14/1000 gal. At $0.14/1000 gal, the value of thermoelectric water withdrawals in the Delaware Basin is $297 million/yr or $24 million/yr in Delaware, $196 million/yr in New Jersey, and $77 million/yr in Pennsylvania (Table 27).

Table 26. Thermoelectric power plant water withdrawals in the Delaware River Basin

State/Power Plant	Type	Capacity[1] (megawatts)	Withdrawal (mgd)	Value/day[2] ($0.14/1000 gal)[1]	Value/year ($0.14/1000 gal)
Delaware		**1,009**	**479**	**67,060**	**24,476,900**
Delmarva Delaware City		9	9		
Conectiv Edgemoor	Coal/Gas	1,000	470		
New Jersey		**4,920**	**3,830**	**536,200**	**195,713,000**
PSEG Salem 1 and 2	Nuclear	2,275	2,643		
PSEG Hope Creek	Nuclear	1,268	52		
Chambers Cogen. Salem	Coal	285			
Deepwater Station	Coal	82	219		
Logan Generating	Coal	242	38		
PSEG Mercer Trenton	Coal	768			
Pennsylvania		**7,529**	**1,500**	**210,000**	**76,650,000**
PECO Chester	Coal	56			
PECO Cromby	Coal	417			
PECO Croyden	Coal	546			
PECO Delaware (Phila.)	Coal	392			
PECO Eddystone	Coal	1,448			
PECO Fairless Hills	Coal	75			
PECO Falls	Coal	64			
PECO Limerick	Nuclear	2,230			
PECO Moser	Coal	64			
PECO Richmond (Phila.)	Coal	132			
PECO Schuylkill (Phila.)	Oil	233			
PECO Southwark (Phila.)	Coal	74			
PGE Northamp. Lehigh	Coal	134			
PPL Martins Creek	Coal	1,664	Shut 2007		
Delaware Basin		**13,458**	**5,809**	**813,260**	**296,839,900**

1. EIA 2002, NETL 2009, and DRBC. 2. Frederick et al. 1996 adjusted to $2010 at 3% annually.

Table 27. Value of thermoelectric power withdrawals in the Delaware River Basin

Watershed	Withdrawal [1] (mgd)	Value/day[2] ($0.14/1000 gal)	Value/year ($0.14/1000 gal)
Upper Region	0	0	0
Upper Central	394	55,160	20,133,400
Lehigh Valley	2	280	102,200
Lower Central	24	3,360	1,226,400
Schuylkill Valley	232	32,480	11,855,200
Upper Estuary	1,461	204,540	74,657,100
Lower Estuary	3,696	517,440	188,865,600
Delaware Bay	0	0	0
Delaware Basin	**5,809**	**813,260**	**296,839,900**

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

Industrial Water Supply

Industrial water withdrawals allocated by DRBC total 804 mgd in the Delaware River Basin (Table 28). A study of the economic value of freshwater in the U.S. indicates the median 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 $490,684 per day or $179,099,660 per year.

Table 28. Value of industry process water withdrawals in the Delaware River Basin

Watershed	Withdrawal [1] (mgd)	Industry Value/day[2] ($0.61/1000 gal)	Industry Value/year ($0.61/1000 gal)
Upper Region	0	0	0
Upper Central	31	18,727	6,835,355
Lehigh Valley	73	44,591	16,275,715
Lower Central	71	43,188	15,763,620
Schuylkill Valley	40	24,583	8,972,795
Upper Estuary	132	80,703	29,456,595
Lower Estuary	446	271,877	99,235,105
Delaware Bay	12	7,015	2,560,475
Delaware Basin	**804**	**$490,684**	**$179,099,660**

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

Hydropower Water Supply

Hydropower water supply withdrawals allocated by DRBC total 539 mgd in the upper Delaware Basin at the Delaware Water Gap at Yards Creek and above Pt. Jervis (Table 29). A study of the economic value of freshwater in the U.S. indicates the median value of hydropower withdrawals is $21/ac-ft in $1996 (Frederick et al. 1996) or $32/ac-ft ($0.10/1000 gal) in $2010 adjusting for 3%

annually. The value of hydropower water withdrawals based on DRBC allocated supplies is $53,879 per day or $19,662,550 per year.

Table 29. Value of hydroelectric water supplies in the Delaware River Basin

Watershed	Withdrawal[1] (mgd)	Hydropower Value/day[2] ($0.10/1000 gal)	Hydropower Value/year ($0.10/1000 gal)
Upper Region	393	39,330	14,355,450
Upper Central	145	14,540	5,307,100
Lehigh Valley	0	0	0
Lower Central	0	0	0
Schuylkill Valley	0	0	0
Upper Estuary	0	0	0
Lower Estuary	0	0	0
Delaware Bay	0	0	0
Delaware Basin	**539**	**53,870**	**19,662,550**

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

Fish/Wildlife

Fish Landings

The annual value of fish landings (Table 30) in the tidal Delaware River and Bay is $25.4 million in $2000 or $34.1 million in $2010 as reported to the National Marine Fisheries Service and tabulated by the National Ocean Economics Program (2007). Table 31 ranks the most lucrative fisheries in the Delaware Estuary 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 8 charts fish landings for Delaware Estuary species.

Table 30. Fish landings and landed value in the Delaware Estuary in $2000

	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.

Table 31. Fish landings and value in the Delaware Estuary in $2010

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
Carp. Common	$27,670	$37,078
Drum, Black	$22,311	$29,897
Catfish, Channel	$3,929	$5,265
Herring, Blueback	$609	$816
Total	**$25,422,840**	**$34,066,606**

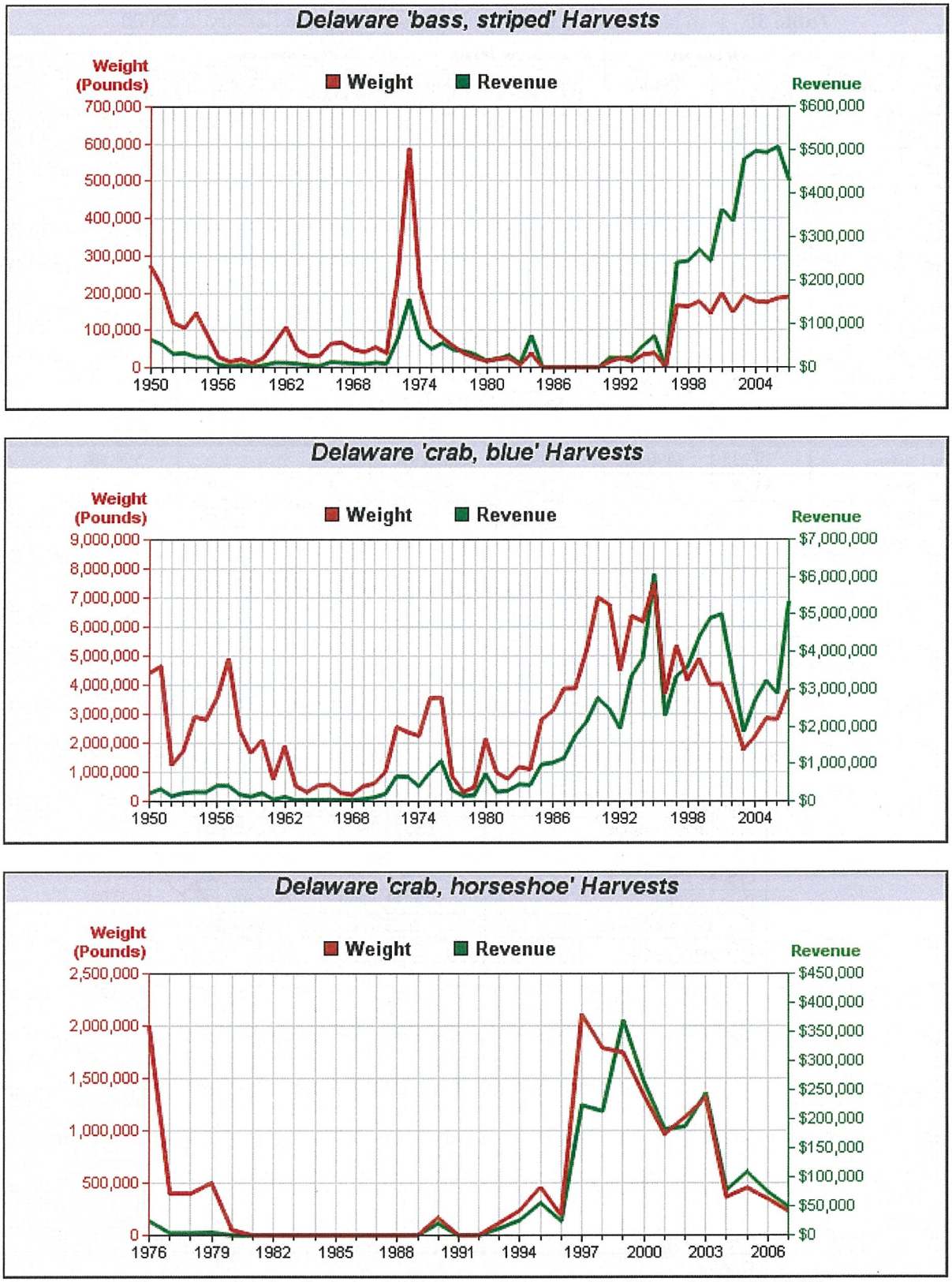


Figure 8. Fish landings in the Delaware Estuary (NMFS and NOEP 2007)

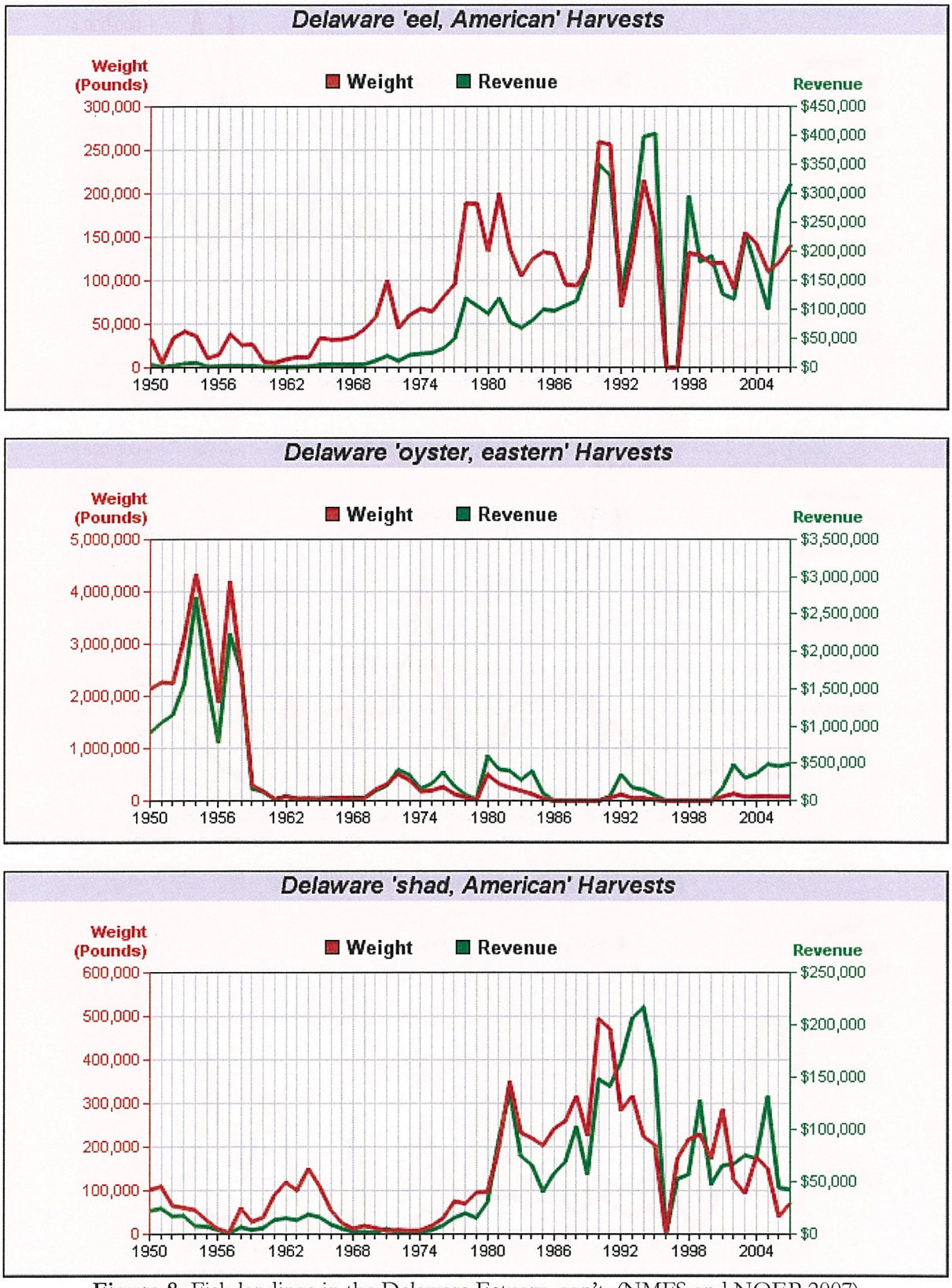
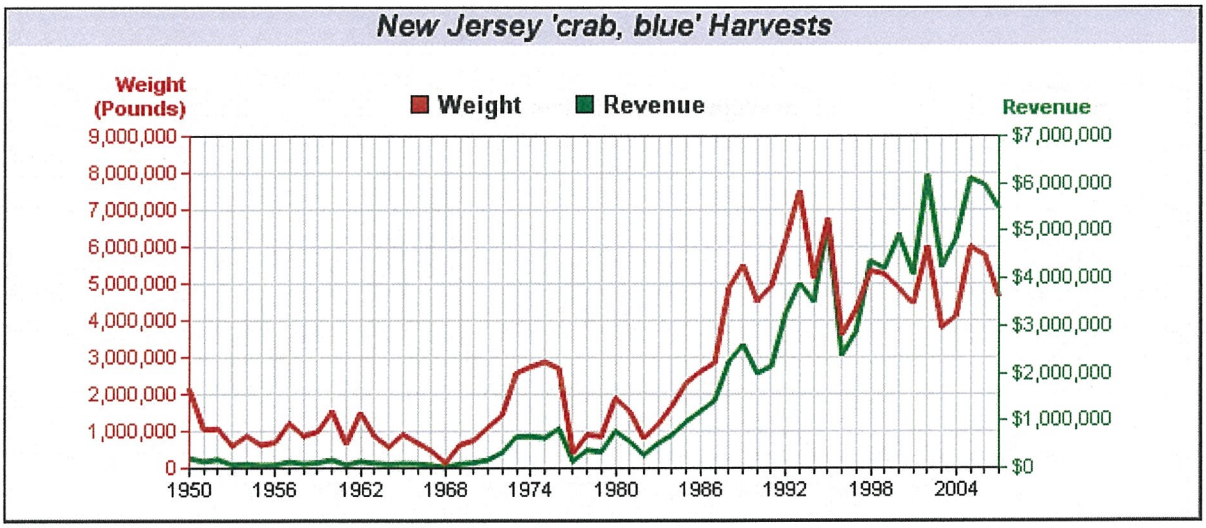
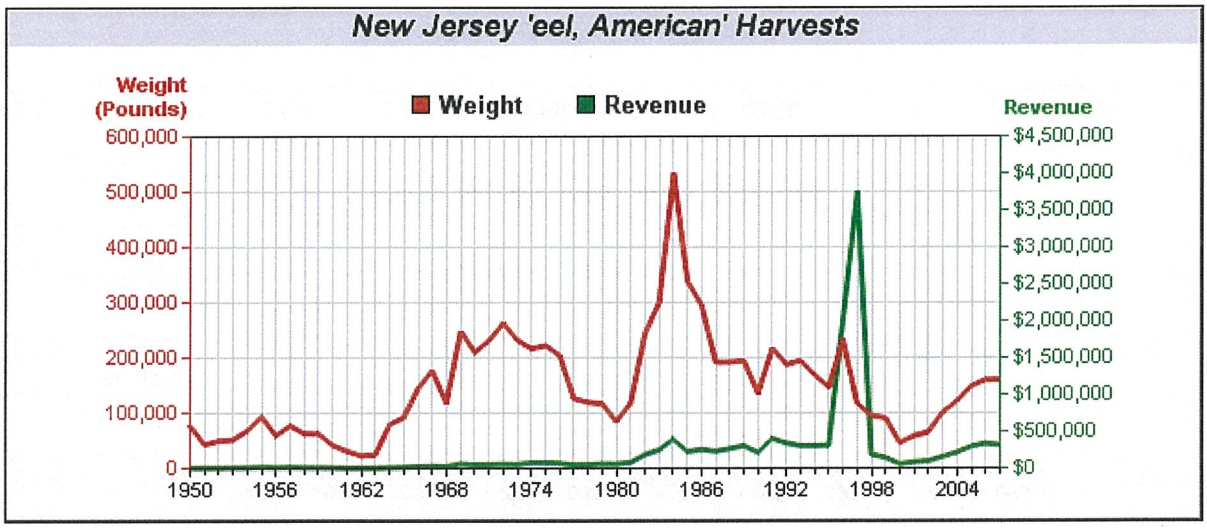


Figure 8. Fish landings in the Delaware Estuary, con't. (NMFS and NOEP 2007)





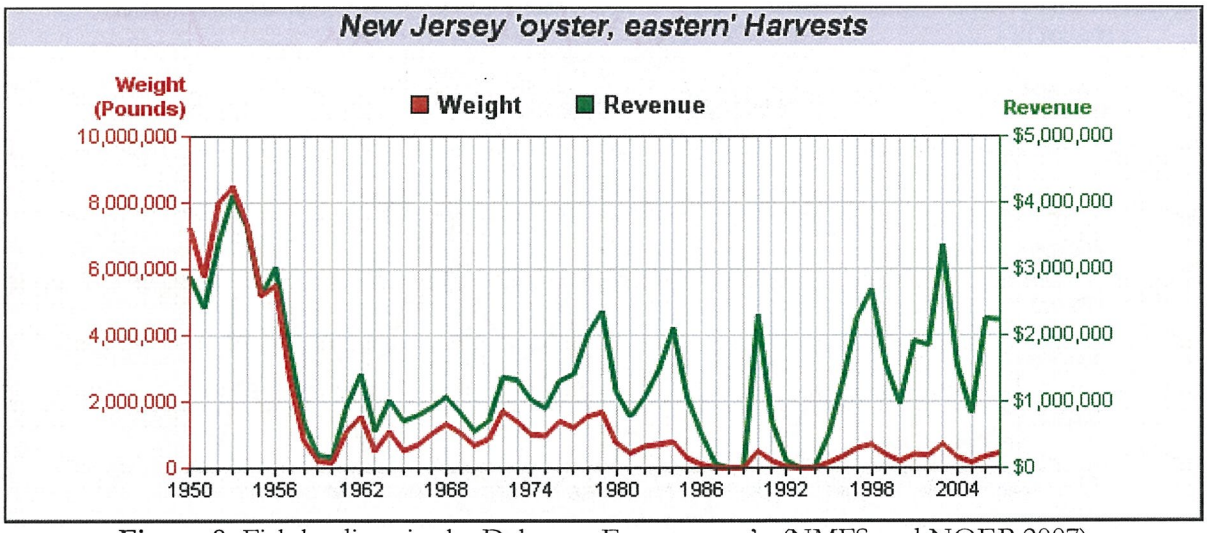


Figure 8. Fish landings in the Delaware Estuary, con't. (NMFS and NOEP 2007)

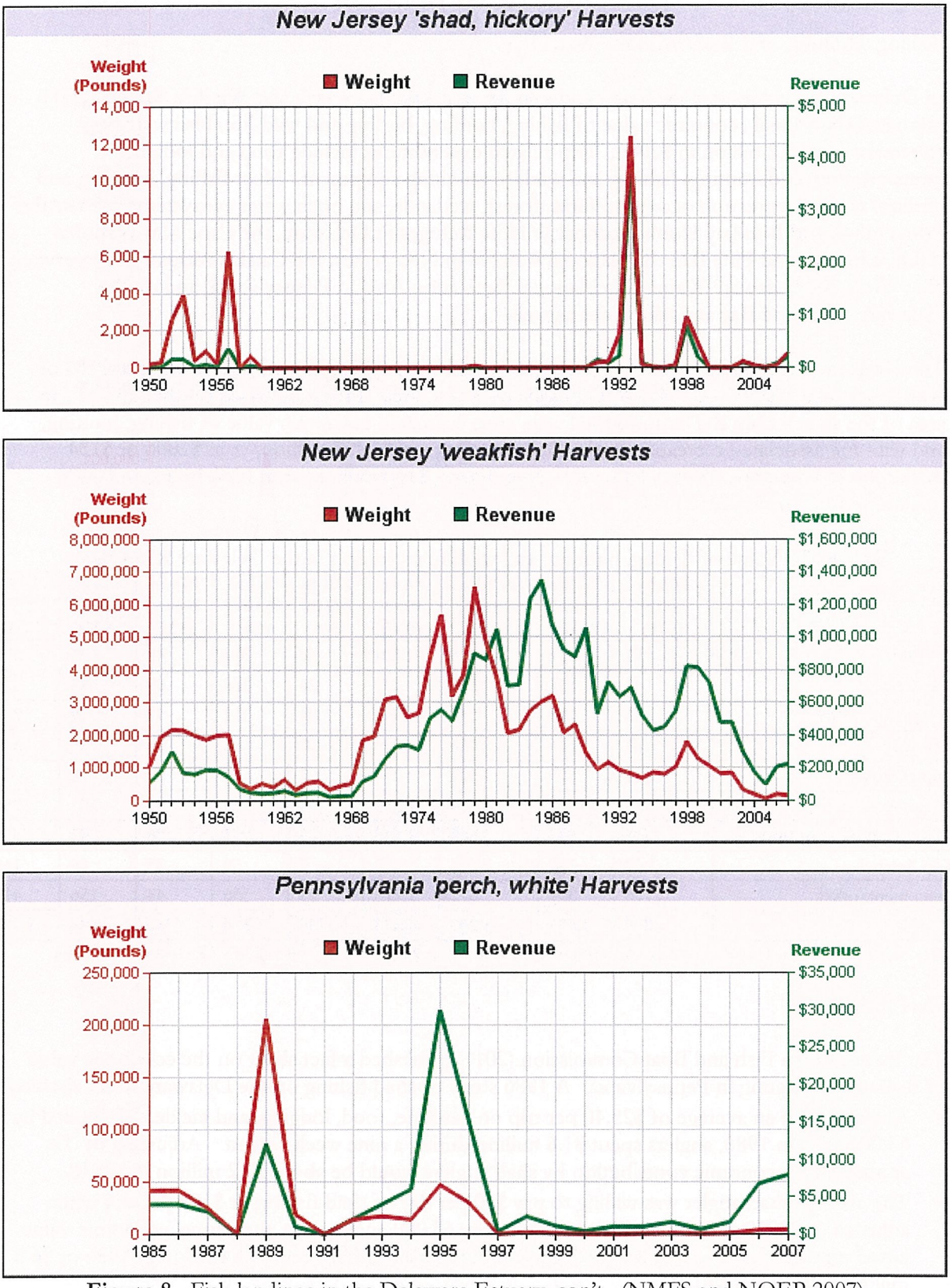


Figure 8. Fish landings in the Delaware Estuary, con't. (NMFS and NOEP 2007)

Fishing, Hunting, and Bird/Wild-life Watching

In Delaware, New Jersey, New York, and Pennsylvania, the U. S. Fish and Wildlife Service (2008) estimated the annual economic value of fishing, hunting, birding and wild-life/bird watching recreation was $9.2 billion in $2006. Trip-related expenditures include food and lodging, transportation, and hunting, fishing, and wildlife watching equipment. Most fishing, hunting, and birding/wildlife recreation occurs on farm, forest, 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, the Catskill Mountain Preserve in New York, the Delaware Water Gap National Recreation Area in Pennsylvania, and on the Delaware River and Bay and tributaries as well.

The Delaware Basin includes 50% of Delaware's land area, 40% of New Jersey's land area, 5% of New York State's land area, 14% of Pennsylvania's land area. Prorating based on the ratio of the area of the state within the basin to total state area, estimated economic value of fishing, hunting, and wild-life associated recreation in the Delaware Basin is $1,477 million/yr in $2006 or $134 million/yr in Delaware, $574 million/yr in New Jersey, $160 million/yr in New York, and $608 million/yr in Pennsylvania (Table 32).

Table 32. Value of fishing, hunting, and wildlife recreation in the Delaware River Basin

Recreation Activity	DE by state[1] ($M)	NJ by state[1] ($M)	NY by state[1] ($M)	PA by state[1] ($M)	DE in basin[2] ($M)	NJ in basin[2] ($M)	NY in basin[2] ($M)	PA in basin[2] ($M)	Del. Basin ($M)
Fishing	**97**	**752**	**926**	**1,291**	**48**	**301**	**46**	**181**	**576**
Trip Related	**49**	**471**	**585**	**299**	**24**	**188**	**29**	**42**	**284**
Equipment/other	**48**	**281**	**341**	**993**	**24**	**112**	**17**	**139**	**293**
Hunting	**41**	**146**	**716**	**1,609**	**21**	**58**	**36**	**225**	**340**
Trip-related	14	73	202	274	7	29	10	38	84
Equipment/other	28	73	514	1,335	14	29	26	187	256
Wildlife/Bird-watching	**131**	**537**	**1,568**	**1,443**	**65**	**215**	**78**	**202**	**561**
Trip Related	13	146	696	325	7	59	35	46	145
Equipment/other	118	391	872	1,118	59	156	44	156	415
Total	**269**	**1,436**	**3,209**	**4,343**	**134**	**574**	**160**	**608**	**1,477**

1. (USFWS 2008). Prorated by ratio of basin to state land area, Del. (50%), NJ (40%), NY (5%), and Pa. (14%).

Shad Fishing

The Pennsylvania Fish and Boat Commission (2011) published a fact sheet on the economic value of fishing and boating in Pennsylvania. A 1986 study of shad fishing on the Delaware River showed:

- Anglers spent an average of $25.40 per trip on gasoline, food, lodging, and tackle. Multiplied by 63,000 trips in 1986, anglers spent $1.6 million during a nine week season. Adjusting by 3% annually, the economic contribution by shad anglers would be about $3.2 million in $2010.
- The average shad angler was willing to pay $50 per day of shad fishing or $102 per day when adjusted to $2010 at 3% annually. Multiplied by 63,000 angler days, the annual economic value based on willingness to pay for the Delaware River shad fishery was $3.2 million in 1986 or $6.5 million adjusted to $2010.

Wild Trout Fishing

Releases from New York City reservoirs and excellent water quality in the forested Catskill watersheds contribute to a thriving cold water fishery in the upper Delaware Basin. Along the Beaverkill and East Branch, West Branch, and upper main stem of the Delaware River in New York, wild trout fishing contributes almost $18 million in annual business revenue, over $29 million in economic activity, and almost 350 jobs with $3.6 million in wages (Maharaj, McGurrin, and Carpenter, 1998).

Agriculture

In Delaware Basin counties, the USDA (2009) estimates the annual market value of agricultural products sold is $4.79 billion on 2,857,870 acres (4,465 sq mi) for crops (corn, wheat, oats, barley, soybeans, potatoes, and vegetables) and livestock and poultry (Table 33). On 1,926,524 acres (3,010 sq mi) of farmland within the Delaware Basin, the prorated annual market value of agricultural products sold is $3.37 billion or $1,750 per acre. The Delaware Basin covers 12,769 sq mi or just 13% of the combined land areas of Delaware (1,953 sq mi), New Jersey (7,417 sq mi), New York (47,214 sq mi), and Pennsylvania (44,816 sq mi) yet accounts for $3.37 billion or 27% of total annual farm products sold in the four states (Table 34).

Table 33. Farm products sold in the Delaware River Basin

State	State area (sq mi)	Area in Del. Basin (sq mi)	Ratio area basin/area state (%)	Farm products sold in state ($ million)	Farm products Del. Basin ($ million)	Products in basin/state (%)
Delaware	1,953	965	49%	1,083	636	59%
New Jersey	7,417	2,961	40%	987	603	61%
New York	47,214	2,555	5%	4,418	105	2%
Pennsylvania	44,816	6,280	14%	5,808	2,027	35%
Total	**101,400**	**12,761**	**13%**	**12,296**	**3,371**	**27%**

Table 34. Value of cropland and agriculture in the Delaware River Basin

County	Farmland by county[1] (ac)	Products sold by county[1] ($ million)	Products sold by county ($/ac)	Farmland in Del. Basin (ac)	Products sold in Del. Basin ($ 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		
Hunterdon	100,027	69.7	697		
Mercer	21,736	18.6	856		
Monmouth	44,130	105.4	2,388		
Ocean	9,833	11.5	1,170		
Salem	96,530	80.0	829		
Sussex	65,242	21.2	325		
Warren	74,975	75.5	1,007		
New Jersey	**631,150**	**752.2**	**1,192**	**505,507**	**602**
Broome	86,613	29.9	345		
Delaware	165,572	55.1	333		
Greene	44,328	16.4	370		
Orange	80,990	73.7	910		
Sullivan	50,443	42.1	835		
Ulster	75,205	65.6	872		
New York	**503,151**	**282.8**	**562**	**187,561**	**105**
Berks	170,760	367.8	2,154		
Bucks	58,012	70.6	1,217		
Carbon	20,035	8.9	444		
Chester	117,145	553.3	4,723		
Delaware	1,646	9.4	5,711		
Lackawanna	39,756	16.2	407		
Lancaster	326,648	1,072.1	3,282		
Lebanon	89,566	257.1	2,871		
Lehigh	72,737	72.1	991		
Luzerne	66,577	18.1	272		
Monroe	29,165	7.8	267		
Montgomery	28,563	30.0	1,050		
Northampton	68,252	31.8	466		
Philadelphia	150	0.5	3,333		
Pike	27,569	2.5	91		
Schuylkill	81,276	124.7	1,534		
Wayne	92,939	29.4	316		
Pennsylvania	**1,290,796**	**2,672.3**	**2,070**	**979,313**	**2,027**
Delaware Basin	**2,857,870**	**4,790.3**	**1,676**	**1,926,524**	**3,371**

1. Census of Agriculture 2007 (USDA 2009)

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 have a carbon storage benefit of $5.9 million ($827/ac) and air pollution removal of $1.9 million ($266/ac/yr). Applying these multipliers, Tables 35 and 36 indicate 4,343,190 (6,786 sq mi) of forests in the Delaware Basin have economic benefits from carbon storage ($3,591 million), air pollution removal ($1,155 million), building energy savings ($243 million), and carbon sequestration ($126 million).

Table 35. Economic benefits of forests in the Delaware River Basin

Forest Benefits	New Castle County.[1] ($/ac)	Delaware. Basin[2] ($ mil.)
Carbon storage	827	3,592
Carbon Sequestration	29	126
Air Pollution Removal	266	1,155
Building Energy Savings	56	243
Avoided Carbon Emissions	3	13

1. Nowak et al. 2008.
2. Computed for Delaware Basin forests (4,343,190 ac).

Table 36. Economic benefits of forests in the Delaware River Basin by state

Forest Benefits	Del. ($ mil.)	NJ ($ mil.)	NY ($ mil.)	Pa. ($ mil.)	Del. Basin ($ mil.)
Carbon Storage	78.8	564.8	1,147.5	1,800.8	3,592
Carbon Sequest.	2.8	19.8	40.2	63.1	126
Air Pollution Contr.	25.4	181.7	369.1	579.2	1,155
Energy Savings	5.4	38.2	77.7	121.9	243
Avoid Carbon Emiss.	0.3	2.0	4.2	6.5	13

Open Space

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 ($9,734/ac), community cohesion benefit from people socializing in the parks ($2,383/ac), water pollution benefit from parks in treating stormwater ($921/ac), air pollution mitigation value from tree and shrub absorption ($88/ac).

Using value transfer from the data gathered for the City of Wilmington study, Table 37 indicates public parks (169 sq mi) within the Delaware Basin provide the following annual economic value:

- Health benefits from exercise in the parks ($1,283 million).
- Community cohesion benefit from people socializing in the parks ($314 million).
- Water pollution benefit from parks in treating stormwater ($121million).
- Air pollution mitigation value from tree and shrub absorption ($12 million).

Table 37. Value of public parks in the Delaware River Basin

State/county	Parks in Del. Basin (ac)	Health Benefits ($9,734/ac)	Community Cohesion ($2,383/ac)	Stormwater Benefit ($921/ac)	Air Pollution ($88/ac)
Kent	4,587	44,649,858	10,930,821	4,224,627	403,656
New Castle	12,440	121,090,960	29,644,520	11,457,240	1,094,720
Sussex	1,389	13,520,526	3,309,987	1,279,269	122,232
Delaware[1]	**18,416[1]**	**179,261,344**	**43,885,328**	**16,961,136**	**1,620,608**
Burlington	7,970	77,579,980	18,992,510	7,340,370	701,360
Camden	2,985	29,055,990	7,113,255	2,749,185	262,680
Cape May	2,911	28,335,674	6,936,913	2,681,031	256,168
Cumberland	2,640	25,697,760	6,291,120	2,431,440	232,320
Gloucester	4,868	47,385,112	11,600,444	4,483,428	428,384
Hunterdon	3,170	30,856,780	7,554,110	2,919,570	278,960
Mercer	8,283	80,626,722	19,738,389	7,628,643	728,904
Monmouth	105	1,022,070	250,215	96,705	9,240
Ocean	199	1,937,066	474,217	183,279	17,512
Salem	2,144	20,869,696	5,109,152	1,974,624	188,672
Sussex	2,961	28,822,374	7,056,063	2,727,081	260,568
Warren	5,563	54,150,242	13,256,629	5,123,523	489,544
New Jersey[2]	**31,800[2]**	**426,339,466**	**104,373,017**	**40,338,879**	**3,854,312**
Broome	389	3,786,526	926,987	358,269	34,232
Delaware	546	5,314,764	1,301,118	502,866	48,048
Orange	413	4,020,142	984,179	380,373	36,344
Sullivan	1,570	15,282,380	3,741,310	1,445,970	138,160
Ulster	50	486,700	119,150	46,050	4,400
New York[3]		**28,890,512**	**7,072,744**	**2,733,528**	**261,184**
Berks	3,979	38,731,586	9,481,957	3,664,659	350,152
Bucks	11,402	110,987,068	27,170,966	10,501,242	1,003,376
Carbon	2,820	27,449,880	6,720,060	2,597,220	248,160
Chester	12,020	117,002,680	28,643,660	11,070,420	1,057,760
Delaware	6,274	61,071,116	14,950,942	5,778,354	552,112
Lehigh	2,500	24,335,000	5,957,500	2,302,500	220,000
Luzerne	195	1,898,130	464,685	179,595	17,160
Monroe	875	8,517,250	2,085,125	805,875	77,000
Montgomery	14,138	137,619,292	33,690,854	13,021,098	1,244,144
Northampton	1,393	13,559,462	3,319,519	1,282,953	122,584
Philadelphia	9,689	94,312,726	23,088,887	8,923,569	852,632
Pike	125	1,216,750	297,875	115,125	11,000
Schuylkill	829	8,069,486	1,975,507	763,509	72,952
Wayne	350	3,406,900	834,050	322,350	30,800
Pennsylvania[4]	**58,331[3]**	**648,177,326**	**158,681,587**	**61,328,469**	**5,859,832**
Total	**108,547**	**1,282,668,648**	**314,012,676**	**121,362,012**	**11,595,936**

1. State, county, and municipal park land in Delaware from county and local comprehensive plans.
2. County and municipal park land from New Jersey State Comprehensive Outdoor Recreation Plan (SCORP).
3. County/municipal parks in New York from county and local comprehensive plans.
4. County/municipal parks in Pennsylvania from DVRPC 2007 & Berks/Schuylkill counties comprehensive plans.

Delaware Water Gap National Recreation Area

The Delaware Water Gap National Recreation Area (DWGNRA) preserves almost 109 square miles of forest and floodplain along 40 miles of the upper Delaware River and 29 miles of the Appalachian Trail. Stynes and Sun (2002) estimated the DWGNRA had 4,867,272 recreation visits in 2001 including 487,727 local day trips, 3,650,455 non-local day trips, 486,727 motel visits, and

243,364 camping overnights. Total visitor spending in the DWGNRA in 2001 was $100 million including $12.4 million for local day trips, $46.5 million for non-local day trips, $30.9 million for motels, and $10.3 million for camping overnights. In 2001, the DWGNRA generated $106 million in sales, and 7,563 direct/indirect jobs with $100 million in wages.

Marcellus Shale Natural Gas

The U.S. Geological Survey concluded that the Marcellus Shale Formation is a voluminous economic resource that lies under 4,700 square miles or 36% of the Delaware River Basin. Drilling for natural gas through the hydraulic fracturing process requires large quantities of water and has the potential to consume sizable tracts of land in the forested headwaters of the Delaware Basin (Figure 9). Hydraulic fracturing requires pumping water under high pressure to open fractures in the shale to allow natural gas to flow to the well. The hydrofracturing water must be recovered and treated before disposal to surface and ground waters. In forests, natural gas well drilling can require clearing of pads that range from 3 to 5 acres in area.

The DRBC is considering revisions to Article 7 of the Water Quality Regulations to protect the water resources of the Delaware Basin during construction and operation of natural gas projects with the following considerations:

- Gas drilling projects in the Marcellus Shale may reduce the flow in streams and aquifers.
- On-site drilling operations may potentially release pollutants into ground or surface water.
- The recovered hydrofracturing water must be treated and disposed of properly.

The Marcellus Shale Formation covers 54,000 square miles and lies up to a mile and a half below parts of Kentucky, New Jersey, New York, Ohio, Pennsylvania, and West Virginia (Figure 10). The Marcellus Shale lies under 4,700 square miles or 36% of the Delaware River Basin in New York, Pennsylvania, and a small tip of New Jersey (Figure 11). About 8.7% of the Marcellus Shale Formation lies within the Delaware River Basin (4,700 sq mi/54,000 sq mi).

The U.S. Geological Survey (Coleman et al. 2011) estimated the entire 54,000 square-mile Marcellus Shale Formation potentially contains a mean volume of 84 trillion cubic feet of recoverable natural gas with a range of 43 tcf (95 percentile) to 144 tcf (5 percentile). If the Delaware River Basin covers 4,700 sq mi or 8.7% of the Marcellus Shale, then by proportion approximately 7.3 trillion cubic feet of natural gas is potentially recoverable within the basin boundary (0.087 x 54,000). These estimates can vary as the thickness of Marcellus Shale in the Delaware Basin generally increases to the north toward the New York/Pennsylvania border and may range from 50 feet thick near Stroudsburg to more than 250 feet thick at Lackawaxen in Wayne County, Pennsylvania (Figure 12).

The U.S. Energy Information Administration (2011) reported the 2010 mean natural gas wellhead price was $4.16/1000 cf. The price of natural gas for residential customers was $11.21/1000 cf. At these unit prices, the estimated value of natural gas from the Marcellus Shale Formation within the Delaware River Basin is $30.4 billion at the wellhead and $81.8 billion when sold to residential customers (Tables 38 and 39).

Environmental economists classify natural gas as a nonrenewable resource with finite stock value over a defined time frame (say 25 or 50 years). Assuming the natural gas can be recovered within 25

years, the annual value of the Marcellus Shale gas recoverable from within the Delaware Basin is $1.2 billion/year at the wellhead and $3.3 billion/year when sold to residential customers.

Table 38. Wellhead value of Marcellus shale natural gas within the Delaware River Basin

State/Basin	Area Marcellus Shale (sq mi)	Wellhead Natural Gas Price[1] ($/1000 cf)	Volume Natural Gas[2] (tcf)	Wellhead Natural Gas Value ($ billion)	Wellhead Natural Gas Value[3] ($ billion/yr)
Pennsylvania	2,338	$4.16	3.6	$15.0	$0.6
New York	2,362	$4.16	3.7	$15.4	$0.6
Delaware Basin	**4,700**	**$4.16**	**7.3**	**$30.4**	**$1.2**

1. EIA 2010. 2. USGS 2011. 3. Assumes 25 year natural gas recovery period.

Table 39. Residential value of Marcellus shale natural gas within the Delaware River Basin

State/Basin	Area Marcellus Shale (sq mi)	Residential Natural Gas Price[1] ($/1000 cf)	Volume Natural Gas[2] (tcf)	Residential Natural Gas Value ($ billion)	Wellhead Natural Gas Value[3] ($ billion/yr)
Pennsylvania	2,338	$11.21	3.6	$40.4	$1.6
New York	2,362	$11.21	3.7	$41.5	$1.7
Delaware Basin	**4,700**	**$11.21**	**7.3**	**$81.8**	**$3.3**

1. EIA 2010. USGS 2011. 3. Assumes 25 year natural gas recovery period.

On a per volume basis, the value of untreated drinking water in streams and wells (at $7.48/1000 cf or $1.00/1000 gal) exceeds the value of natural gas at the wellhead (at $4.16/1000 cf) in the Delaware Basin. The total value of untreated drinking water from streams/wells (1,803 mgd) in the Delaware Basin is $0.7 billion/year, less than the estimated value of natural gas recoverable at the wellhead ($1.2 billion/year). The value of treated drinking water in the basin (at $35.70/1000 cf or $4.78/1000 gal) is $3.1 billion/year which is comparable to the total natural gas value sold to residential customers or $3.3 billion/year (Table 40).

Table 40. Value of Marcellus shale gas compared to drinking water in the Delaware River Basin

Price/ Value	Natural Gas	Drinking Water
Quantity	7.3 trillion cf	1,803 mgd
Unit Price Wellhead Gas or Untreated Drinking Water	$4.16/1000 cf	$7.48/1000 cf
Total Value Wellhead Gas or Untreated DrinkingWater	$1.2 billion/yr	$0.7 billion/yr
Unit Price Residential Gas or Treated Drinking Water	$11.21/1000 cf	$35.70/1000 cf
Total Value Residential Gas or Treated Drinking Water	$3.3 billion/yr	$3.1 billion/yr

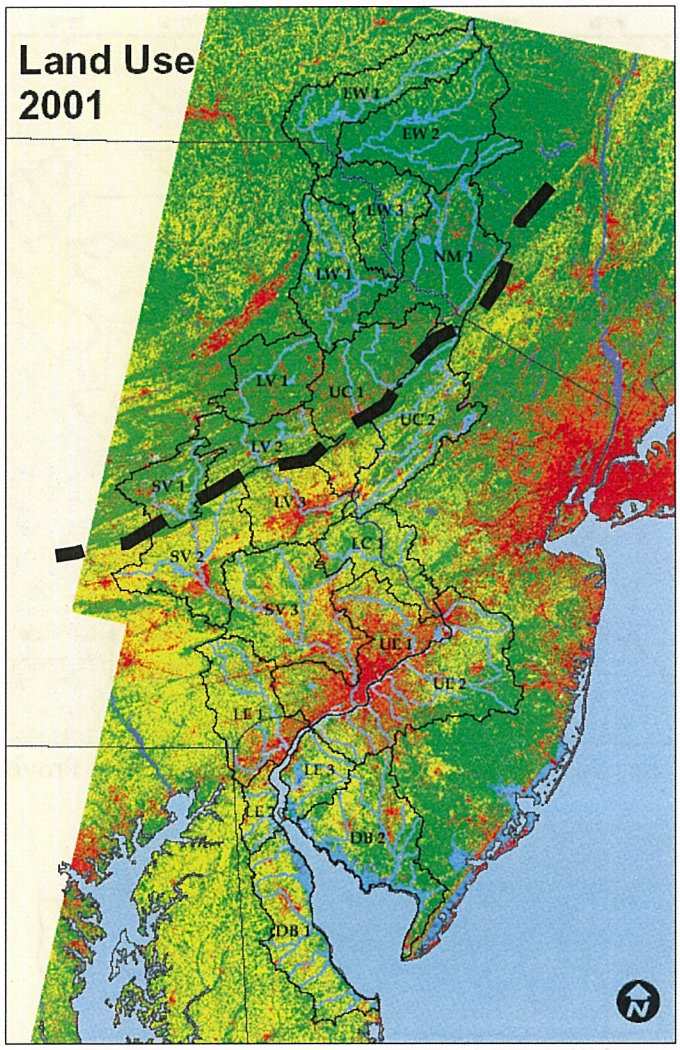


Figure 9. Land use including forested headwaters in the Delaware Basin (Marcellus Shale southerly boundary delineated as dashed line).

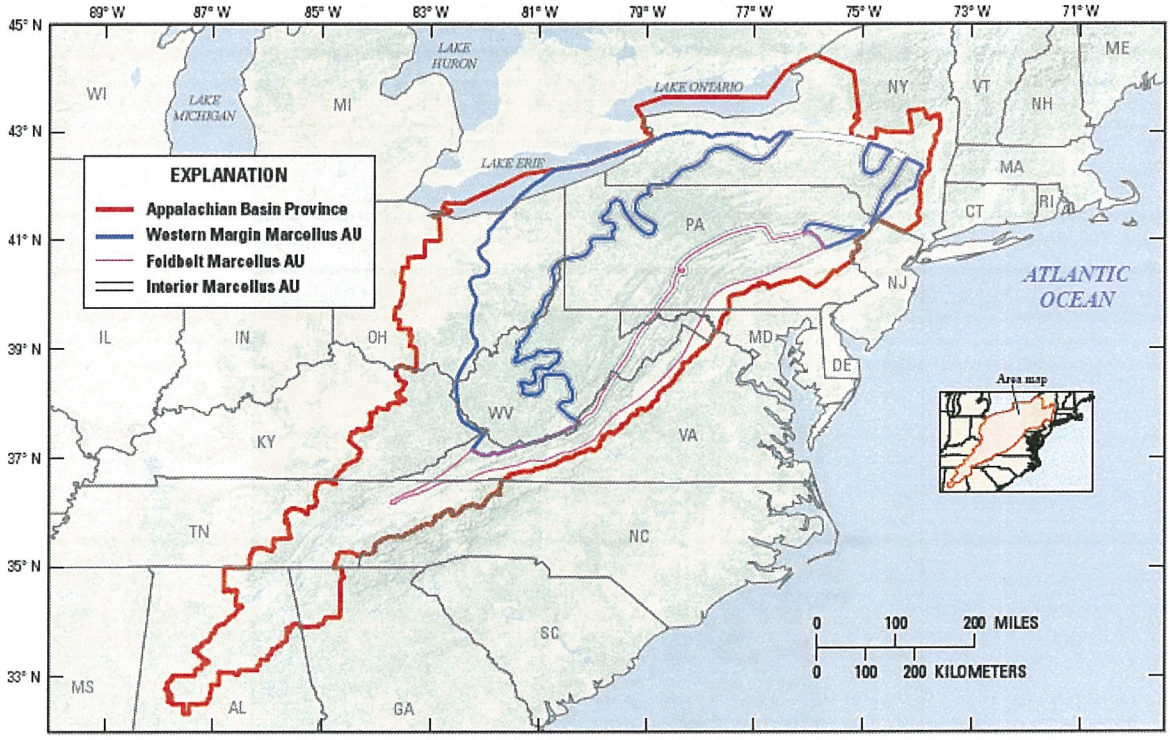


Figure 10. Marcellus Shale Formation in the Appalachian Basin Province (USGS 2011)

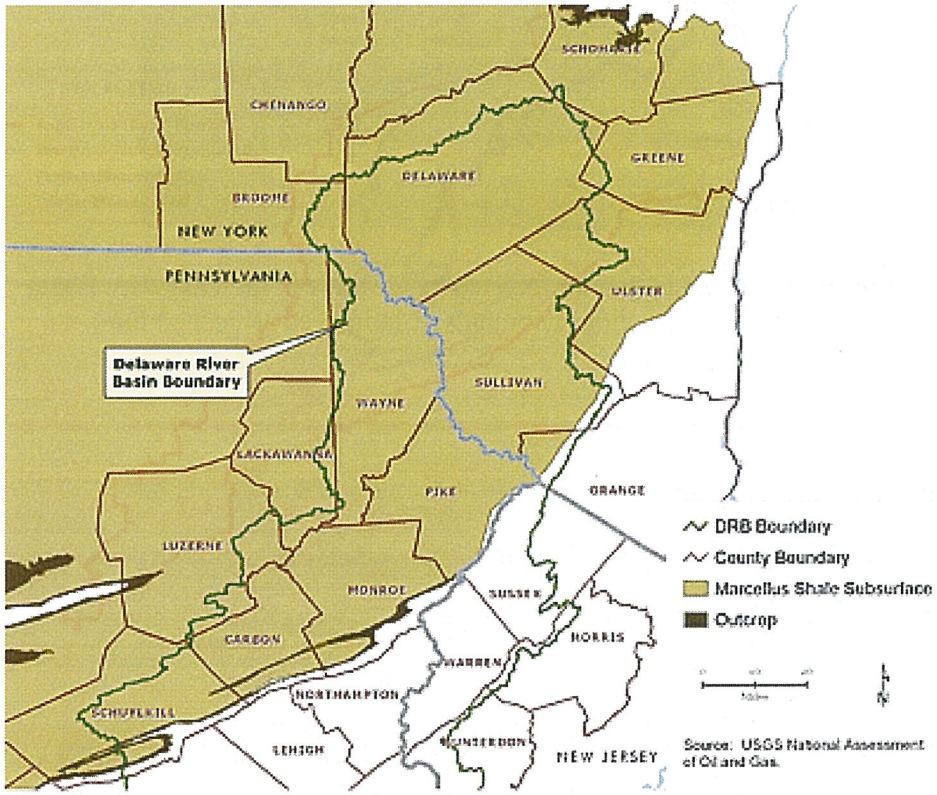


Figure 11. Marcellus Shale Formation within the Delaware River Basin (USGS)

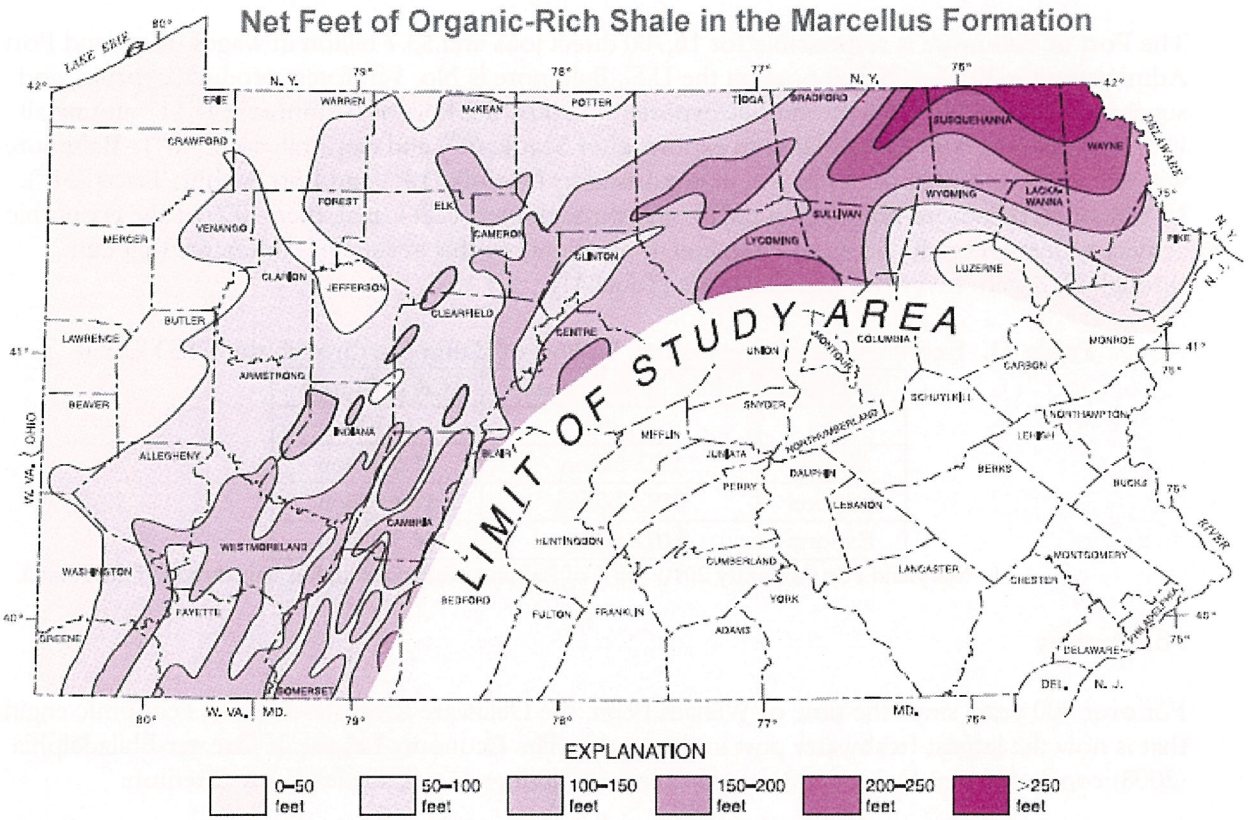


Figure 12. Thickness of Marcellus shale in Pennsylvania (Pennsylvania Geological Survey)

Maritime Transportation

Navigation

The 130-mile long Delaware River and Bay ship channel from Cape Henlopen to the head of navigation at Trenton has significant instream navigation use value. The Delaware River port from Wilmington to Chester, Paulsboro, Camden, and Philadelphia is the 6th largest port in the U.S. based on imports. The volume of the 720 square mile Delaware Estuary at mean depth of 32 feet is 14.7 million ac-ft or 4.8 trillion gallons. A study of the economic value of freshwater in the U.S. estimated the median value of instream navigation uses is $10/ac-ft in $1996 (Frederick et al. 1996) or $15/ac-ft in $2010 based on 3% annually. Accordingly, the instream navigation value of the Delaware River and Bay (14.7 million ac-ft) from the ocean to head of tide at Trenton is $220 million.

C&D Canal

The 35-feet deep Chesapeake & Delaware Canal is a valuable commercial conduit that flows through the Delaware Basin in Delaware and carries 40% of all ship traffic to/from the Port of Baltimore. The C&D Canal trims 300 miles from the trip for ships that would otherwise sail up the Chesapeake Bay to Baltimore from the ocean. Normally 6 to 35 ships per day sail through the C&D Canal.

The Port of Baltimore is responsible for 16,700 direct jobs and $3.7 billion in wages (Maryland Port Administration 2010). Of 360 ports in the U.S., 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, Texas (11th). If 40% of all Baltimore-bound ship traffic sails through the C&D Canal, then 40% of the economic activity generated by the port can be indirectly attributed to this avenue of commerce that cuts through Delaware River Basin in Delaware (Table 41).

Table 41. Economic activity generated by 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 Authority 2010. 40% of Baltimore-bound shipping sails through C&D Canal.

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) concluded that Delaware River ports from Wilmington to Philadelphia to Trenton:

- Collectively is the largest freshwater port in the world with $2.4 billion in total economic output.
- Generate $81 million in tax revenues to Delaware, Pennsylvania, New Jersey (Table 42).
- 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.
- In Chester, Philadelphia, Wilmington, Camden and Paulsboro handled 16% of container trade in the U.S. and 51% of container trade value nationwide.
- Biggest commodity is petroleum that accounts for 65% of the port's imports while fruits and nuts account for 4%.

Table 42. 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**

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 43).

Table 43. Delaware River port vessel calls, 1996-2000
(Economy League of Greater Philadelphia 2008)

Year	General	Container	Roll on	Refrg	Bulk	Tanker	Chem	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 port exports (Table 44) are motor vehicles (31% and petroleum products (12%) and top imports are petroleum (65%) and iron and steel (7%).

Table 44. Top exports and imports at Delaware River ports (Economy League 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%

In 2005, Delaware River ports at Philadelphia, Chester, and Camden were the 6th, 35th, and 37th largest ports in the U.S. based on imports of goods and cargo (Table 45). The five ports along the Delaware River had combined imports of $41 billion, 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. The five ports along the Delaware had combined exports of $6.4 billion making it the 20th largest port in the USA after Oakland (CA) and Baltimore but ahead of Charleston (SC).

Table 45. Rank of Delaware River imports/exports in United States by value of goods, 2005

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

Other Studies

Data from the following studies were examined to estimate the value of ecosystem services in the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania:

- 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).

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. A Cecil County, Md. study by the Conservation Fund (Table 46) found the largest ecosystem services values result from stormwater/flood control, water supply, and clean water functions (Weber 2007).

Table 46. Ecosystem services values for Cecil County, Maryland (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 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 47 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 greatest ecosystem services.

Table 47. 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 values from climate regulation, water supply, water quality, and recreation benefits totaled $392/ac in $1994 or $631/ac in $2010 at a 3% annual discount rate (Table 48).

Table 48. 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.

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 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).

According to the 2007 USDA Census of Agriculture (2009) the market value of agricultural crops, poultry, and livestock sold from 1,926,524 acres of farmland in the Delaware River Basin was $3.37 billion or $1,676/ac. The market value of agriculture from 254,143 acres of farmland in Delaware in the basin was $636 million or $2,502/ac. The market value of agriculture from 505,507 acres of farmland in New Jersey was $602 million or $1,192/ac. The market value of agriculture from 187,561 acres of farmland in New York in the basin was $105 million or $562/ac.
The market value of agriculture from 979,313 acres of farmland in Pennsylvania counties in the basin was $2.0 billion or $2,070/ac.

Table 49 compares ecosystem services values ($/acre) from other studies. Data from the NJDEP/University of Vermont study are used for value transfer since the Delaware Basin includes New Jersey ecosystems and two adjacent states in the watershed (Del. and Pa.) share a similar climate (humid continental) at 40 degrees north in latitude, similar physiographic provinces (Piedmont/Coastal Plain) and similar aquifers, soils, and ecosystems. Farmland natural goods values are estimated from market values from the 2007 USDA Census of Agriculture. Cecil County, Maryland occupies a small sliver of the Delaware Basin and utilized higher ecosystem values on a per acre basis for forests and wetlands than the other studies. The NJDEP ecosystem service estimates ($/ac) are lower than Cecil County values for wetlands/forests and Mass Audubon values for

wetlands but higher than Wilderness Society values for forests and U. S. Wildlife Refuge values for freshwater wetlands and forests. Values from previous studies were adjusted to $2010 based on 3% annually. Net present values were calculated based on an annual discount rate of 3% in perpetuity (over 100 years in the future).

Table 49. 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)	US 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	1,676
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 goods only as measured by agricultural crops, livestock, and poultry sold.

Delaware Basin

The estimated value of natural goods and services provided by ecosystems in the Delaware River Basin (12,742 sq mi) is $21 billion ($2010) with a net present value (NPV) of $683 billion (Table 50). The ecosystems services value of the Delaware portion of the Delaware Basin (965 sq mi) is $2.5 billion ($2010) with a NPV of $81.4 billion (Figure 13). The ecosystems services value of the New Jersey portion of the Delaware Basin (2,960 sq mi) is $6.6 billion ($2010) with a NPV of $213.4 billion. The ecosystems services value of the New York portion of the Delaware Basin (2,556 sq mi) is $3.5 billion ($2010) with a NPV of $113.6 billion. The ecosystems services value of the Pennsylvania portion of the basin (6,290 sq mi) is $8.6 billion ($2010) with a NPV of $279.6 billion. NPV is based on an annual discount rate of 3% over a perpetual life time (>100 years).

Natural goods are commodities that can be sold such as water supply, farm crops, fish, timber, and minerals). Natural services provide ecological benefits to society such as flood control by wetlands, water filtration by forests, and fishery habitat by beach and marine areas. Ecosystems within the Delaware Basin are comprised of forests (53%), farmland (24%), freshwater wetlands (5%), saltwater wetlands (2%), and open water/marine (1%). Over 15% of the Delaware Basin is urban (Figure 14).

Farms, freshwater wetlands, forests, and saltwater wetlands provide the highest total ecosystems goods and services values (Table 51 and Figures 15 and 16). Ecosystems that provided the highest natural good values are farmland ($3.2 billion or $1,676/ac/ yr), followed by forest ($1.2 billion or $275/ac), and freshwater wetlands ($114 million or $270/ac). The highest natural ecosystem services values are provided by forests ($7.4 billion or $1,703/ac) followed by freshwater wetlands

($5.6 billion or $13,351/ac), farmland ($1.6 billion or $827/ac), and saltwater wetlands ($1.0 billion or $7,076/ac).

The DB2 Delaware Bay ($2,497,635,761), UE2 New Jersey Coastal Plain ($2,093,235,974), DB1 Delaware Bay ($1,922,732,778), NM1 Neversink R. ($1,212,219,295), EW2 West Branch Del. R. ($1,137,547,038), UC1 Pocono Mt. ($1,106,108,992), UC2 NJ Highlands ($1,072,263,808), SV3 Schuylkill above Philadelphia ($1,098,758,690), and LW1 Lackawaxen R. ($1,006,865,455) watersheds each provide over $1 billion in annual ecosystem services value (Table 52 and Figure 17).

Watersheds with the highest value of annual ecosystem services per acre include the DB2 Delaware Bay ($4,991/ac), DB1 Delaware Bay ($4,797/ac), LE3 Salem River ($4,288/ac), LE2 C&D Canal ($3,941/ac), UE2 New Jersey Coastal Plain ($3,205/ac), LW1 Lackawaxen R. ($2,631/ac), NM1 Neversink R. ($2,321/ac), SV2 Schuylkill above Valley Forge ($2,276/ac), and LV1 Lehigh River above Lehighton ($2,263/ac) as these systems have high amounts (over 75%).of forests, wetlands, and farm habitat (Figure 18).

The above estimates do not include the ecosystem services value of open water (720 sq mi) in the tidal Delaware River and Bay between the shores of Delaware, Pennsylvania, and New Jersey. The ecosystem services value of open water habitat in the river and bay is $61 billion or $1,946/ac.

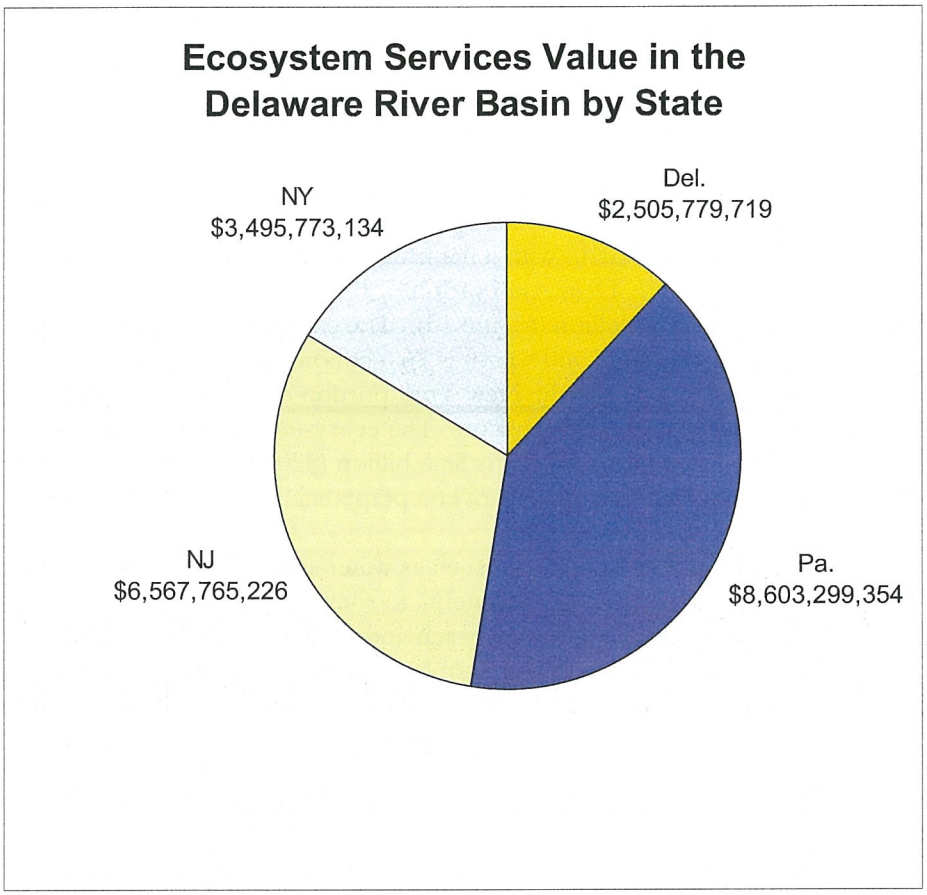


Figure 13. Ecosystem service value in the Delaware Basin by state

Table 50. Ecosystem services values in the Delaware River Basin by state

Ecosystem	Area (ac)	$/ac/yr 2010	PV 2010 $	NPV $
Delaware Basin				
Freshwater wetlands	422,838	13,621	5,759,329,048	187,178,194,067
Marine	16,588	10,006	165,982,947	5,394,445,767
Farmland	1,926,524	2,503	4,823,030,404	156,748,488,136
Forest land	4,343,190	1,978	8,591,367,360	279,219,439,184
Saltwater wetland	145,765	7,235	1,054,617,851	34,275,080,170
Urban	1,206,504	342	412,157,579	13,395,121,322
Beach/dune	900	48,644	43,758,633	1,422,155,566
Open water	92,615	1,946	180,210,703	5,856,847,857
Total	**8,154,924**		**$21,030,454,525**	**$683,489,772,069**
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
Urban	123,048	342	42,034,778	1,366,130,274
Beach/dune	256	48,644	12,429,832	403,969,529
Open water	6,467	1,946	12,583,745	408,971,719
Total	**615,541**		**$2,505,779,719**	**$81,437,840,867**
New Jersey				
Freshwater wetlands	246,857	13,621	3,362,352,134	109,276,444,364
Marine	314	10,006	3,142,040	102,116,307
Farmland	505,507	2,019	1,020,866,015	33,178,145,495
Forest land	682,931	1,978	1,350,922,709	43,904,988,032
Saltwater wetland	83,563	7,235	604,583,594	19,648,966,813
Urban	321,090	342	109,688,612	3,564,879,893
Beach/dune	499	48,644	24,253,858	788,250,378
Open water	47,259	1,946	91,956,264	2,988,578,571
Total	**1,888,020**		**6,567,765,226**	**213,452,369,853**
New York				
Freshwater wetlands	34,792	13,621	473,886,107	15,401,298,475
Marine	0	10,006	0	0
Farmland	187,561	1,389	260,613,634	8,469,943,113
Forest land	1,387,514	1,978	2,744,673,732	89,201,896,298
Saltwater wetland	0	7,235	0	0
Urban	20,806	342	7,107,761	231,002,225
Beach/dune	0	48,644	0	0
Open water	4,878	1,946	9,491,900	308,486,749
Totalac	**1,635,551**		**3,495,773,134**	**113,612,626,859**
Pennsylvania				
Freshwater wetlands	82,799	13,621	1,127,773,445	36,652,636,971
Marine	0	10,006	0	0
Farmland	979,313	2,897	2,837,548,786	92,220,335,530
Forest land	2,177,399	1,978	4,307,165,285	139,982,871,763
Saltwater wetland	585	7,235	4,231,672	137,529,329
Urban	741,560	342	253,326,429	8,233,108,930
Beach/dune	145	48,644	7,074,943	229,935,659
Open freshwater	34,011	1,946	66,178,794	2,150,810,818
Total	**4,015,812**		**8,603,299,354**	**279,607,229,001**

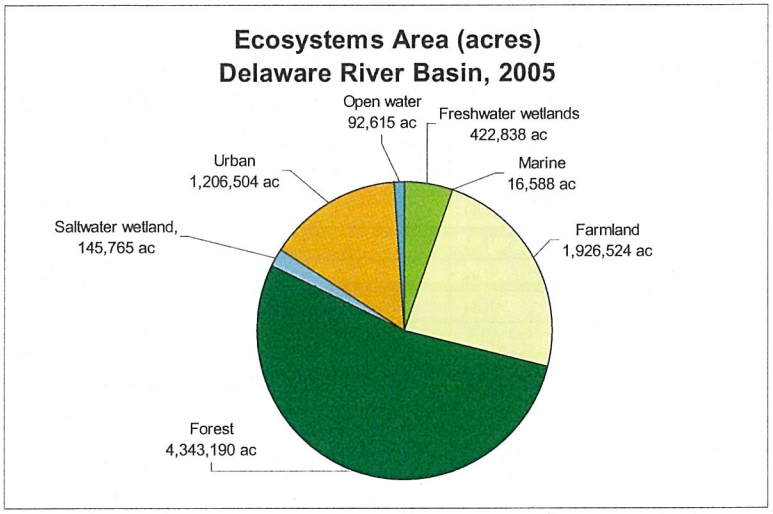


Figure 14. Ecosystem service areas within the Delaware River Basin

Table 51. Value of ecosystem goods and services in the Delaware River Basin

Natural Goods						
Ecosystem	**Area (ac)**	**$/ac/yr 2004**	**$/yr 2004**	**$/ac/yr 2010**	**$/yr 2010**	**NPV $**
Freshwater wetlands	422,838	234	98,943,997	270	114,191,069	3,711,209,745
Marine	16,588	1,125	18,661,829	1,298	21,537,580	699,971,336
Farmland	1,926,524	1,676	3,228,854,342	1,676	3,228,854,342	104,937,766,110
Forest land	4,343,190	238	1,033,679,112	275	1,192,966,996	38,771,427,378
Saltwater wetland	145,765	139	20,261,377	160	23,383,615	759,967,482
Urban	1,206,504	13	15,684,557	15	18,101,515	588,299,247
Beach/dune	900	0	0	0	0	0
Open water	92,615	921	85,298,217	1,063	98,442,502	3,199,381,302
Total	**8,154,924**		**4,501,383,431**		**4,697,477,618**	**152,668,022,601**
Natural Services						
Ecosystem	**Area (ac)**	**$/ac/yr 2004**	**$/yr 2004**	**$/ac/yr 2010**	**$/yr 2010**	**NPV $**
Freshwater wetlands	422,838	11,568	4,891,385,289	13,351	5,645,137,979	183,466,984,322
Marine	16,588	7,544	125,142,079	8,707	144,426,223	4,693,852,233
Farmland	1,926,524	717	1,381,317,758	827	1,594,176,062	51,810,722,026
Forest land	4,343,190	1,476	6,410,547,773	1,703	7,398,400,363	240,448,011,806
Saltwater wetland	145,765	6,131	893,687,073	7,076	1,031,402,464	33,520,580,080
Urban	1,206,504	283	341,440,730	327	394,056,064	12,806,822,075
Beach/dune	900	42,149	37,915,873	48,644	43,758,633	1,422,155,566
Open water	92,615	765	70,850,311	883	81,768,202	2,657,466,554
Total	**8,154,924**		**14,152,286,885**		**16,333,125,990**	**530,826,594,663**
Goods & Services						
Ecosystem	**Area (ac)**	**$/ac/yr 2004**	**$/yr 2004**	**$/ac/yr 2010**	**$/yr 2010**	**NPV $**
Freshwater wetlands	422,838	11,802	4,990,329,286	13,621	5,759,329,048	187,178,194,067
Marine	16,588	8,670	143,820,496	10,006	165,982,947	5,394,445,767
Farmland	1,926,524	2,503	4,823,030,404	2,503	4,823,030,404	156,748,488,136
Forest land	4,343,190	1,714	7,444,226,885	1,978	8,591,367,360	279,219,439,184
Saltwater wetland	145,765	6,269	913,802,685	7,235	1,054,617,851	34,275,080,170
Urban	1,206,504	296	357,125,287	342	412,157,579	13,395,121,322
Beach/dune	900	42,149	37,915,873	48,644	43,758,633	1,422,155,566
Open water	92,615	1,686	156,148,527	1,946	180,210,703	5,856,847,857
Total	**8,154,924**		**18,866,399,443**		**21,030,454,525**	**683,489,772,069**

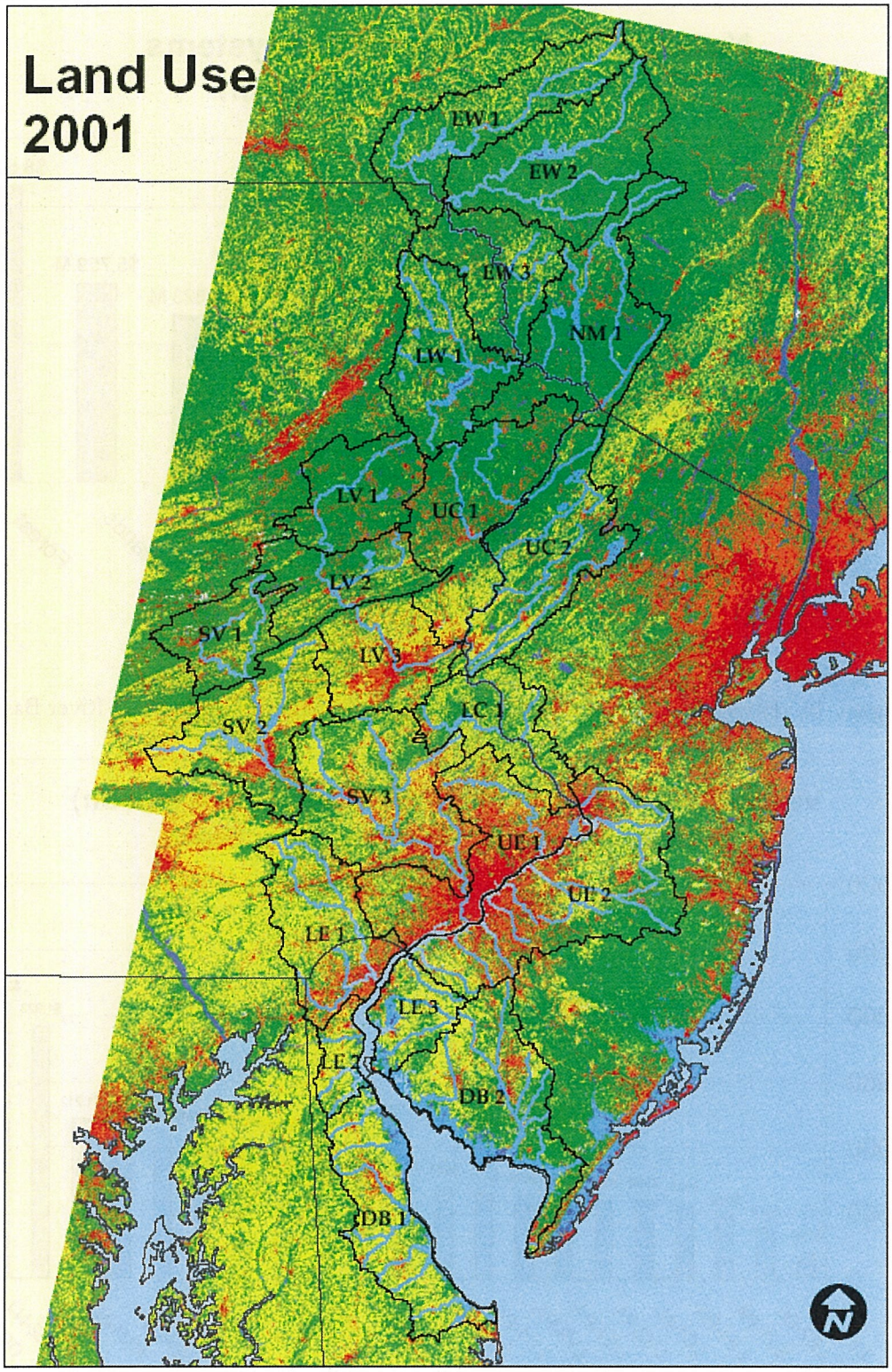


Figure 15. Land cover in the Delaware River Basin (NOAA CSC 2001)

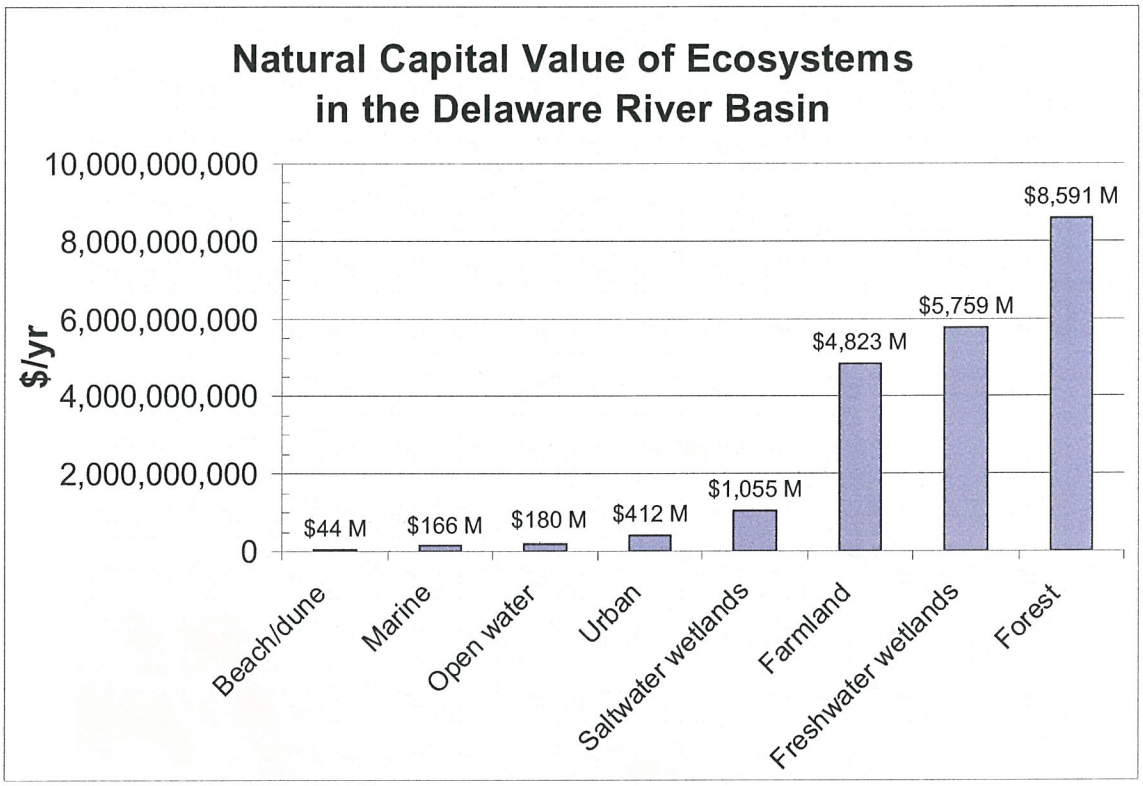


Figure 16. Ecosystem service value ($2010) of habitat within the Delaware River Basin

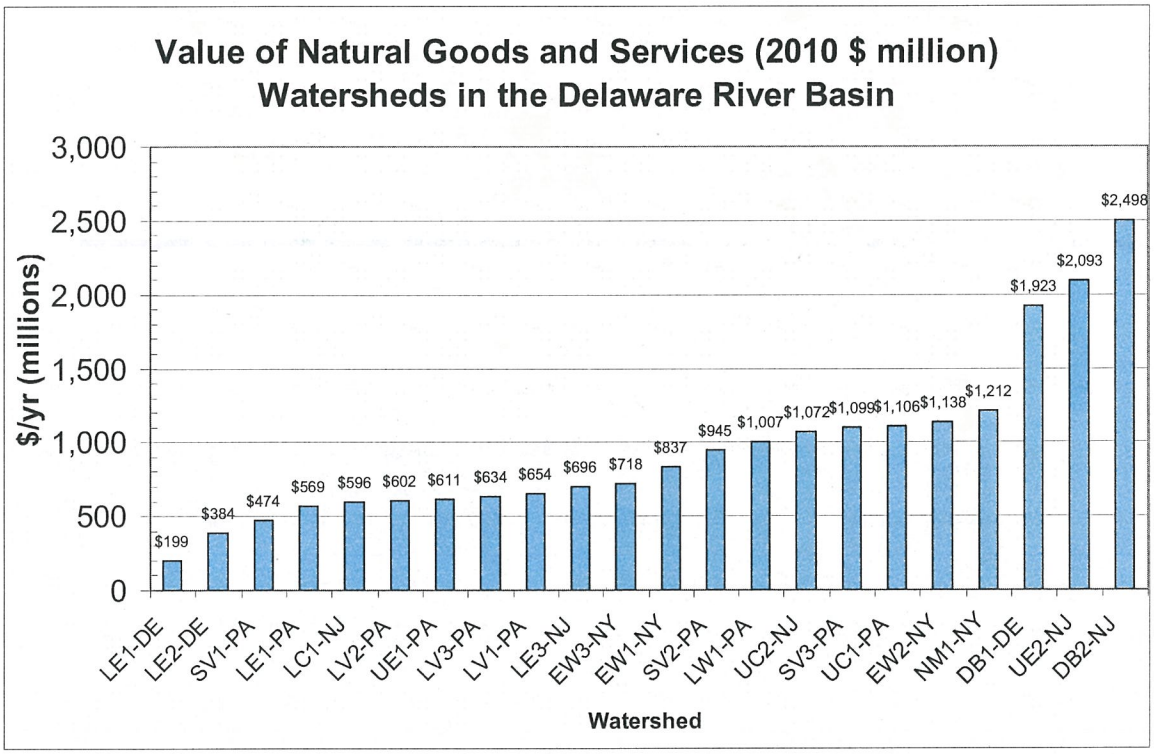


Figure 17. Ecosystem services values of watersheds within the Delaware River Basin

Table 52. Ecosystem services value of watersheds in the Delaware River Basin

Watershed	Area (sq mi)	2010 $/yr	2010 $/ac/yr
LE1 Brandywine/Christina	187	199,035,649	1,664
LE2 C&D Canal	152	384,011,292	3,941
DB1 Delaware Bay	626	1,922,732,778	4,797
Delaware	**962**	**2,505,779,719**	**4,071**
UC2 NJ Highlands	745	1,072,263,808	2,248
LC1 Del. R. above Trenton	159	208,902,978	2,053
UE2 New Jersey Coastal Plain	1,021	2,093,235,974	3,205
LE3 Salem River	254	695,858,091	4,288
DB2 Delaware Bay	782	2,497,635,761	4,991
New Jersey	**2,950**	**6,567,765,226**	**3,479**
EW1 East Branch Del. R.	666	836,579,484	1,963
EW2 West Branch Del. R.	841	1,137,547,038	2,114
EW3 Del. R. above Pt. Jervis	314	430,101,000	2,142
NM1 Neversink R.	734	1,076,794,000	2,321
New York	**2,556**	**3,495,773,134**	**2,137**
EW3 Del. R. above Pt. Jervis	210	287,647,100	2,142
NM1 Neversink R.	82	135,425,000	2,321
LW1 Lackawaxen R.	598	1,006,865,455	2,631
UC1 Pocono Mt.	779	1,106,108,992	2,219
LV1 Lehigh River above Lehighton	451	653,896,676	2,263
LV2 Lehigh River above Jim Thorpe	430	601,508,831	2,183
LV3 Lehigh River above Bethlehem	480	633,649,592	2,064
LC1 Del. R. above Trenton	295	387,587,286	2,053
SV1 Schuylkill above Reading	348	474,099,567	2,126
SV2 Schuylkill above Valley Forge	649	945,100,081	2,276
SV3 Schuylkill above Philadelphia	874	1,098,758,690	1,965
UE1 Penna Fall Line	693	611,041,618	1,377
LE1 Brandywine/Christina	401	568,524,810	2,216
Pennsylvania	**6,275**	**8,603,299,354**	**2,142**
Delaware Basin	**12,742**	**21,030,454,525**	**2,579**

Estimates of ecosystem services in the Delaware River Basin using the NJDEP/University of Vermont values coupled with market values from the USGS Census of Agriculture ($21.0 billion or $683.5 billion NPV) are conservative and in the lower end of the range. 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 Delaware Basin would be $9.6 billion or NPV = $311 billion (Table 53). If higher per acre estimates of ecosystem services value from other studies were used, the total value of natural resources in the Delaware Basin would be $94.7 billion or NPV = $3.1 trillion (Table 54).

Estimate	PV $B	NPV $B
Low	9.6	311
NJDEP/USDA	21.0	683
High	94.7	3,100

Table 53. Low range estimate of ecosystem services in the Delaware River Basin

Ecosystem	Area (ac)	$/ac/yr	PV $	NPV $
Freshwater wetlands	422,838	6,268[5]	2,650,346,040	86,136,246,300
Marine	16,588	8,670[2]	143,820,496	4,674,166,116
Farmland	1,926,524	1,387[6]	2,672,088,886	86,842,888,779
Forest land	4,343,190	641[3]	2,783,984,500	90,479,496,255
Saltwater wetland	145,765	6,269[2]	913,802,685	29,698,587,269
Barren land	18,630	0	0	0
Urban	1,206,504	296[2]	357,125,287	11,606,571,818
Beach/dune	900	42,149[2]	37,915,873	1,232,265,862
Open water	92,615	217[5]	20,097,408	653,165,771
Total acres	**8,173,554**		**9,579,181,174**	**311,323,388,171**
sq mi	**12,771**			

Table 54. High range estimate of ecosystem services in the Delaware River Basin

Ecosystem	Area (ac)	$/ac/yr	PV $	NPV $
Freshwater wetlands	422,838	43,685[1]	18,471,660,300	600,328,959,736
Marine	16,588	8,670[2]	143,820,496	4,674,166,116
Farmland	1,926,524	9,979[4]	19,224,783,698	624,805,470,173
Forest land	4,343,190	12,033[1]	52,261,599,829	1,698,501,994,444
Saltwater wetland	145,765	28,146[1]	4,102,710,221	133,338,082,193
Barren land	18,630	0	0	0
Urban	1,206,504	296[2]	357,125,287	11,606,571,818
Beach/dune	900	42,149[2]	37,915,873	1,232,265,862
Open water	92,615	1,686[2]	156,148,527	5,074,827,144
Total acres	**8,173,554**		**94,755,764,230**	**3,079,562,337,486**
sq mi	**12,771**			

1. Cecil Co., Md. 2006. 2. NJDEP 2007. 3. Wilderness Society 2001. 4. Peconic Estuary 1995. 5. U. S. Nat'l. Wildlife Refuge 2008. 6. Mass Audubon Society 2003. 7. USDA Agric. Census 2007.

5. Jobs and Wages

The Delaware River Basin is a jobs engine that supports 600,000 direct and indirect jobs with $10 billion in annual wages in the coastal, farm, ecotourism, water/wastewater, recreation, and port industries (Table 55).

Table 55. Direct and indirect jobs and wages related to the Delaware River Basin

Sector	Jobs	Wages ($ million)	Data Source
Direct Basin Related	240,621	4,900	U.S. Bureau of Labor Statistics, 2009
Indirect Basin Related	288,745	4,000	U.S. Census Bureau, 2009
Coastal	44,658	947	National Coastal Economics Program, 2009
Farm	45,865	1,880	USDA Census of Agriculture, 2007
Fishing/Hunting/Birding	44,941	1,476	U.S. Fish and Wildlife Service, 2008
Water Supply Utilities	8,750	485	UDWRA and DRBC, 2010
Wastewater Utilities	1,298	61	UDWRA and DRBC, 2010
Watershed Organizations	201	10	UDWRA and DRBC, 2010
Ski Area Jobs	1,753	$88	Penna. Ski Areas Association
Paddling-based Recreation	4,226		Outdoor Industry Association (2006
River Recreation	448	$9	U. S. Forest Service/Nat'l. Park Service, 1990
Canoe/Kayak/Rafting	225		Canoe Liveries and UDWRA, 2010
Wild Trout Fishing	350	$4	Maharaj, McGurrin, and Carpenter, 1998
Del. Water Gap Nat'l. Rec. Area	7,563	101	Stynes and Sun, 2002
Port Jobs	12,121	772	Economy League of Greater Phila., 2008
Delaware Basin Total	**> 600,000**	**>$10 billion**	

Jobs and salaries in the Delaware Basin were obtained from U. S. Bureau of Labor Statistics (2009) and U. S. Census Bureau (2009) data bases for the following scenarios (Tables 56-58):

1. Total number of jobs in each county within the Delaware Basin with jobs determined by NAICS industry code (formerly SIC code) and then grouped by census tract.
2. Direct Delaware Basin-related jobs such as water and 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 basin boundary.
3. Indirect jobs/wages provided by purchases of goods and services by direct jobs earners within the Delaware Basin in the interlinked regional economy. Indirect jobs were estimated by a multiplier of 2.2 applied to direct jobs and 1.8 to direct wages (Latham and Stapleford 1990), i.e., 100 direct jobs fund 120 indirect jobs and direct wages of $1,000 provide $800 indirect wages.

Within the Delaware Basin are 3,480,483 jobs earning $172.6 billion in annual wages including:

- Delaware (316,014 jobs, $16.5 billion wages)
- New Jersey (823,294 jobs, $38.1 billion wages)
- New York (69,858 jobs, $2.5 billion wages)
- Pennsylvania (2,271,317 jobs, $115.5 billion wages)

Jobs directly associated with the Delaware River Basin (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employ 240,621 with $4.9 billion in wages including:

- Delaware (15,737 jobs, $340 million wages)
- New Jersey (62,349 jobs, $1.3 billion wages)
- New York (32,171 jobs, $550 million wages)
- Pennsylvania (130,364 jobs, $2.8 billion wages)

Jobs indirectly related to the waters of the Delaware Basin (based on multipliers of 2.2 for jobs and 1.8 for salaries) employ 288,745 people with $4.0 billion in wages including:

- Delaware (18,884 jobs, $270 million wages)
- New Jersey (74,819 jobs, $1.0 billion in wages)
- New York (38,605 jobs, $400 million in wages)
- Pennsylvania (156,437 jobs, $2.2 billion in wages)

National Coastal Economy Report

The National Ocean Economic Program (2009) published a report that summarized the coastal economy in the United States that includes 6 industrial sectors:

- Marine Transportation
- Tourism and Recreation
- Living Marine Resources
- Marine Construction
- Ship and Boat Building
- Mineral Extraction.

According to the National Ocean Economic program (2009), the coastal counties within the Delaware Basin boundary contribute 44,658 coastal jobs with $947 million in annual wages with contributions of $1.8 billion toward the GDP. Table 59 summarizes employment, wages, and employment within the Delaware Basin obtained by multiplying the 2009 NOEP report county-wide values by the ratios of coastal county area within the basin by total coastal county area within the state which are 80% for Delaware, 5% for New Jersey and 86% for Pennsylvania. Using these ratios, 80%, 5%, and 86% of the employment and wages for coastal counties in Delaware, New Jersey, and Pennsylvania from the NOEP report are within the Delaware Basin boundary.

Table 56. Direct basin-related jobs within the Delaware River Basin by state, 2009

Sector	Industry	1997 NAICS Code	DE Jobs	DE Wages x$1,000	NJ Jobs	NJ Wages $1,000	NY Jobs	NY Wages $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	2,485	109,527	551	36,387	3,138	211,691
	Construction	237990	126	5,678	318	19,547			306	16,427
Living Resources	Fish Hatcheries	112511								
	Aquaculture	112512								
	Fishing/Forestry	11411			50	2,028	21	424	67	2,485
	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								
	Ship Bldg. Repair	336611								
	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	2,426	35,967	11,537	162,246	2,008	31,251
	Misc. Recreation				0	0	1,100	16,574	0	0
	Boat Dealers	441222	198	7,489	157	5,945				
	Restaurants	722110	3,714	173,787	26,512	415,604	17,029	264,832	59,217	974,264
		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	37	748				
	Sporting Good	339920	0	0	245	5,287	702	9,972	245	3,780
	Zoos, Aquaria	712130							55	1,959
		712190			58	3,411			466	28,459
Transportation	Deep Sea Freight	483111								
	Marine Transport.	483112	954	32,378	1,823	71,222			904	43,155
	Search/Navigation	334511	39	2,856					716	61,370
	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
Education/Research	Environ.organizations	813312	83	2,976	61	2268	103	1,221	682	23,574
	Environ. consulting	54162	205	10,745	1,193	61,107	133	7,700	1,441	895
Water/Wastewater	Water/sewage systms	2213	267	20,004	679	8,169	23	1,101	203	774
	Waste management	562	146	6,028	1,928	92,495	882	41,649	2,372	113,437
	Septic tank services	562991	17	644	215	10,381	90	4,173	274	10,145
Total			**15,737**	**342,140**	**62,349**	**1,292,136**	**32,171**	**546,279**	**130,364**	**2,760,244**

Table 57. Jobs and wages directly and indirectly related to the Delaware River Basin, 2009

State/County	(1) Total Jobs	(2) Basin Jobs	(3) Direct Jobs	(4) Indirect Jobs	(1) Total Wages $ billion	(2) Basin Wages $ billion	(3) Direct Wages $ billion	(4) Indirect Wages $ billion
Delaware	**390,900**	**316,014**	**15,737**	**18,884**	**19.5**	**16.5**	**0.34**	**0.27**
Kent	60,100	50,412			2.4	2.0		
New Castle	264,600	252,534			14.7	14.1		
Sussex	66,200	13,068			2.4	0.5		
New Jersey	**1,362,200**	**823,294**	**62,349**	**74,819**	**61.6**	**38.1**	**1.3**	**1.0**
Burlington	194,500	187,758			9.1	8.8		
Camden	196,800	169,909			8.7	7.5		
Cape May	47,500	14,545			1.4	0.4		
Cumberland	62,000	61,868			2.5	2.5		
Gloucester	99,100	89,183			3.9	3.6		
Hunterdon	47,300	23,650			2.8	1.4		
Mercer	222,900	178,320			12.4	9.9		
Monmouth	246,600	9,864			11.4	0.5		
Ocean	149,900	7,495			5.5	0.3		
Salem	21,900	21,900			1.0	1.0		
Sussex	38,200	23,302			1.4	0.9		
Warren	35,500	35,500			1.5	1.5		
New York	**341,300**	**69,858**	**32,171**	**38,605**	**12.8**	**2.5**	**0.55**	**0.4**
Broome	94,100	11,292			3.4	0.4		
Delaware	16,000	14,240			0.6	0.5		
Greene	14,300	572			0.5	19.9		
Orange	130,700	10,456			5.2	0.4		
Sullivan	26,300	25,511			0.9	0.9		
Ulster	59,900	7,787			2.2	0.3		
Pennsylvania	**2,596,260**	**2,271,317**	**130,364**	**156,437**	**126.5**	**115.5**	**2.8**	**2.2**
Berks	159,106	150,665			6.2	5.9		
Bucks	244,453	244,453			10.6	10.6		
Carbon	16,730	16,730			0.5	0.5		
Chester	231,368	212,996			13.6	12.5		
Delaware	201,208	201,208			10.1	10.1		
Lackawanna	96,604	4,830			3.2	0.2		
Lebanon	45,826	2,750			1.5	0.1		
Lehigh	166,932	166,932			7.4	7.4		
Luzerne	134,574	8,074			4.6	0.3		
Monroe	56,025	56,025			2.1	2.1		
Montgomery	453,962	453,771			27.7	27.7		
Northampton	96,536	96,536			3.8	3.8		
Philadelphia	619,396	619,396			33.3	33.3		
Pike	9,874	9,874			0.3	0.3		
Schuylkill	49,116	27,077			1.6	0.9		
Wayne	14,550	14,114			0.5	0.4		
Delaware Basin	**4,690,660**	**3,480,483**	**240,621**	**288,745**	**220.3**	**172.6**	**4.9**	**4.0**

Table 58. Direct basin-related and indirect jobs within the Delaware River Basin, 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	6,703	379,443	8,044	303,554
	Construction	237990	750	41,652	900	33,322
Living Resources	Fish Hatcheries	112511	0	0	0	0
	Aquaculture	112512	0	0	0	0
	Fishing/Foresty	11411	138	4,937	166	3,950
	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	16,221	233,566	19,465	186,853
	Misc. Recreation		1,100	16,574	1,320	13,259
	Boat Dealers	441222	355	13,434	426	10,747
	Restaurants	722110	106,472	1,828,487	127,766	1,462,790
		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	55	1,141	66	913
	Sporting Good	339920	1,192	19,039	1,430	15,231
	Zoos, Aquaria	712130	55	1,959	66	1,567
		712190	524	31,870	629	25,496
Transportation	Deep Sea Freight	483111	0	0	0	0
	Marine Transport.	483112	3,681	146,755	4,417	117,404
	Search/Navigation	334511	755	64,226	906	51,381
	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
Education/Research	Environ.organizations	813312	929	30,039	1,115	24,032
	Environ. consulting	54162	2,972	80,447	3,566	64,357
Water/Wastewater	Water/sewage systms	2213	1,172	30,048	1,406	24,038
	Waste management	562	5,328	253,609	6,394	202,887
	Septic tank services	562991	596	25,343	715	20,275
Total			**240,621**	**4,940,799**	**288,745**	**3,952,639**

1. Direct jobs are directly related to the Delaware Basin. 2. Indirect jobs/salaries are derived from purchases of goods and services calculated by multipliers of 2.2 for jobs and 1.8 for wages.

Table 59. Coastal employment, wages, and GDP within the Delaware River Basin (National Ocean Economic Program 2009)

Sector	Employment	Wages ($ million)	GDP ($ million)
Delaware	**12,139**	**$214**	**$392**
Marine Construction			
Living Resources	354	$8	$15
Offshore Minerals			
Tourism & Recreation	10,398	$151	$299
Marine Transportation	1,744	$53	$72
Ship and Boat Building			
New Jersey	**4,423**	**$140**	**$235**
Marine Construction			$9
Living Resources			$7
Offshore Minerals			$1
Tourism & Recreation	2,939		$110
Marine Transportation			$104
Ship and Boat Building			$4
Pennsylvania	**28,096**	**$593**	**$1,204**
Marine Construction			$4
Living Resources			$172
Offshore Minerals			$13
Tourism & Recreation	**20,093**		$538
Marine Transportation			$383
Ship and Boat Building			$68
Delaware Basin	**44,658**	**$947**	**$1,831**
Marine Construction			$12
Living Resources	354	$8	$195
Offshore Minerals			$14
Tourism & Recreation	33,430	$151	$947
Marine Transportation	1,744	$53	$560
Ship and Boat Building			$72

Farm Jobs

In 2007 there were 30,455 farms in Delaware Basin counties or 21,840 farms within the basin boundary (30,455 x 0.67 = 21,840). The USDA estimates each farm employs 2.1 full time equivalent jobs. Farming provides 45,865 jobs with $1.9 billion in wages in the Delaware Basin (Table 60).

Table 60. Farm jobs in the Delaware River Basin

County	Farmland by County[1] (ac)	Farmland in Del. Basin (ac)	Ratio Farmland County/Basin	Farms in County[1]	No. of Farms in Basin	Farm jobs in Basin (2.1 jobs/farm)
New Castle	51,913			825		
Kent	146,536			347		
Sussex	234,324			1,374		
Delaware	**432,773**	**254,143**	**59%**	**2,546**	**1,495**	**3,140**
Burlington	85,790			922		
Camden	8,760			225		
Cape May	7,976			201		
Cumberland	69,489			615		
Gloucester	46,662			669		
Hunterdon	100,027			1,623		
Mercer	21,736			311		
Monmouth	44,130			932		
Ocean	9,833			255		
Salem	96,530			759		
Sussex	65,242			1,060		
Warren	74,975			933		
New Jersey	**631,150**	**505,507**	**80%**	**8,505**	**6,812**	**14,305**
Broome	86,613			580		
Delaware	165,572			747		
Greene	44,328			286		
Orange	80,990			642		
Sullivan	50,443			323		
Ulster	75,205			501		
New York	**503,151**	**187,561**	**37%**	**3,079**	**1,148**	**2,410**
Berks	170,760			1,980		
Bucks	58,012			934		
Carbon	20,035			207		
Chester	117,145			1,733		
Delaware	1,646			79		
Lackawanna	39,756			417		
Lancaster	326,648			5,462		
Lebanon	89,566			1,193		
Lehigh	72,737			516		
Luzerne	66,577			610		
Monroe	29,165			349		
Montgomery	28,563			719		
Northampton	68,252			486		
Philadelphia	150			17		
Pike	27,569			54		
Schuylkill	81,276			966		
Wayne	92,939			603		
Pennsylvania	**1,290,796**	**979,313**	**76%**	**16,325**	**12,386**	**26,010**
Total	**2,857,870**	**1,926,524**	**67%**	**30,455**	**21,840**	**45,865**

Census of Agriculture 2007 (USDA 2009)

Fishing/Hunting/Bird and Wildlife Recreation Jobs

The 2007 NJDEP study estimates the average annual salary per ecotourism job is $32,843 using figures from the U.S. Fish and Wildlife Service (2001) report on fishing, hunting, and wildlife associated recreation. If fishing, hunting, and bird/wildlife associated recreation in the Delaware

River Basin accounts for $1.5 billion in annual economic activity ($2006), then ecotourism provides for 44,941 jobs (Table 61).

Table 61. Jobs from fishing, hunting, and wildlife recreation in the Delaware River Basin

Recreation Activity[1]	DE in Basin[2] (2006 $M)	NJ in Basin[2] (2006 $M)	NY in Basin[2] (2006 $M)	PA in Basin[2] (2006 $M)	Delaware Basin (2006 $M)
Fishing	48	301	46	181	576
Hunting	21	58	36	225	340
Wildlife/Bird-watching	65	215	78	202	560
Total	**134**	**574**	**160**	**608**	**1,476**
	DE Jobs @ $32,843	**NJ Jobs @ $32,843**	**NY Jobs @ $32,843**	**PA Jobs @ $32,843**	**Del. Basin Jobs @ $32,843**
Fishing	1,461	9,165	1,401	5,511	17,538
Hunting	639	1,766	1,096	6,851	10,352
Wildlife/Bird-watching	1,979	6,546	2,375	6,150	17,051
Total	**4,080**	**17,477**	**4,872**	**18,512**	**44,941**

1. (USFWS 2008). 2. Prorated by ratio of basin area within state to state land area: Delaware (50%), New Jersey (40%), New York (5%) and Pennsylvania (14%).

Water Utility Jobs

Over 300 public and private water utilities (including the City of New York with 5,600 employees and the City of Philadelphia with over 800 water system employees) withdraw up to 1,800 mgd of drinking water from surface water and groundwater supplies in the Delaware River Basin. According to the American Water Works Association, the average salary of a water system employee is $55,407. Therefore, water utilities in the Delaware River Basin employ at least 8,750 jobs with annual wages of $485 million (Table 62).

Wastewater Utility Jobs

Over 60 wastewater utilities discharge almost 1.2 billion gallons per day of treated wastewater to the Delaware River Basin. These wastewater utilities employ 1,298 employees who earn $61 million in annual wages (Table 63).

Table 62. Public water supply jobs in the Delaware River Basin (DRBC and UDWRA 2010)

Water Purveyor	Jobs	Salaries
Delaware	**141**	**7,812,387**
United Water Delaware	55	3,047,385
City of Wilmington	31	1,717,617
City of Dover	14	775,698
City of Newark	7	387,849
City of Milford	6	332,442
Lewes Board of Public Works	5	277,035
Tidewater Utilities	5	277,035
Dover Air Force Base	1	55,407
New Castle Mun. Services Comm.	1	55,407
Town of Smyrna	1	55,407
Harrington	1	55,407
Camden-Wyoming Water Authority	1	55,407
Town of Milton	1	55,407
Other	12	664,884
New Jersey	**823**	**45,599,961**
Delaware and Raritan Canal	123	6,815,061
NJ American Water Co.	118	6,538,026
City of Trenton	78	4,321,746
City of Camden	33	1,828,431
City of Vineland	25	1,385,175
Aqua New Jersey	31	1,717,617
Merchantville-Pennsauken Water	18	997,326
Washington Twp. MUA	14	775,698
Willingboro Twp. MUA	14	775,698
Mount Holly Water	13	720,291
City of Bridgeton	11	609,477
City of Wildwood	11	609,477
Evesham Twp. MUA	8	443,256
Millville City Water Dept.	8	443,256
Evesham MUA	7	387,849
Hackettstown MUS	7	387,849
Millville Water Dept	8	443,256
Moorestown	8	443,256
Bordentown	7	387,849
Burlington Twp.	6	332,442
Mt. Laurel	6	332,442
Glassboro	6	332,442
Collingswood	6	332,442
Mapleshade	6	332,442
West Deptford	5	277,035
Woodbury	5	277,035
Burlington City	5	277,035
Pennsgrove	5	277,035
Deptford Twp.	5	277,035
Nesqehoning Boro Auth.	5	277,035
Medford Twp.	5	277,035
NJ American Mansfield/Oxford	5	277,035
Florence Twp.	5	277,035
Salem City	5	277,035
Other	201	11,136,807

New York	**5,600**	**310,279,200**
New York City	5,600	310,279,200
Pennsylvania	**2,186**	**121,119,702**
City of Philadelphia	863	47,816,241
Aqua Pennsylvania, Inc.	307	17,009,949
Forest Park/Point Pleasant Diversion	50	2,770,350
Bethlehem	46	2,548,722
Allentown	45	2,493,315
North Wales Water Authoriity	45	2,493,315
Bucks Co. Water and Sewer Auth.	45	2,493,315
Reading Area Water Authority	43	2,382,501
Bucks Co. Water and Sewer Auth.	41	2,271,687
Penna. American Water Co.	30	1,662,210
North Penn Water	26	1,440,582
Easton	24	1,329,768
Pennsylvania-American Water Co.	22	1,218,954
Schuylkill Co. Municipal. Authority	15	831,105
Pottstown Water Authority	14	775,698
Schuylkill Co. MUA	13	720,291
Muhlenberg Twp.	12	664,884
Lehigh County	12	664,884
PA American Nazareth	12	664,884
Hazelton	12	664,884
PA American Coatesville	12	664,884
Allentown City	12	664,884
Phoenixville Mun. Waterworks	12	664,884
Northampton Boro.	10	554,070
East Stroudsburg	10	554,070
PA American Yardley	10	554,070
Phoenixville	10	554,070
Morrisville	10	554,070
PA American Home District	10	554,070
PA American Penn District	10	554,070
Falls Twp.	10	554,070
Northampton Bucks Co. Auth.	10	554,070
Warminster Twp. MUA	10	554,070
Horsham Water and Sewer Auth.	10	554,070
Newtown Artesian Water	10	554,070
Milford	7	387,849
Tamaqua MWA	7	387,849
Lehighton MWA	7	387,849
Ambler Boro	7	387,849
Brodhead Creek Reg. Auth.	7	387,849
South Whitehall Twp. Auth.	7	387,849
Emmaus Munic. Water	7	387,849
Warrington Twp.	7	387,849
Wyomissing Boro	7	387,849
Schuylkill Haven Boro.	7	387,849
PA American Water Glen Alsace	7	387,849
Palmerton Mun. Auth.	7	387,849
Quakertown Mun. Water	6	332,442
Other	263	14,572,041
Delaware Basin	**8,750**	**484,811,250**

Table 63. Jobs and salaries at wastewater utilities in the Delaware River Basin

NPDES ID	Facility	Location	State	Jobs	Salaries
DE0020338	Kent Co. Levy Court WWTR	Frederica	DE	15	705,000
DE0021512	Lewes City POTW	Lewes	DE	3	141,000
DE0020320	Wilmington Wastewater Plant	Wilmington	DE	90	4,230,000
Delaware				**108**	**5,076,000**
NJ0027481	Beverly City Sewer Auth. STP	Beverly	NJ	3	141,000
NJ0024678	Bordentown Sewerage Auth.	Bordentown	NJ	5	235,000
NJ0024651	Cumberland Co. Utility Auth.	Bridgeton	NJ	7	329,000
NJ0024660	Burlington City STP	Burlington	NJ	5	235,000
NJ0021709	Burlington Twp. DPW	Burlington	NJ	4	188,000
NJ0026182	Camden County MUA	Camden	NJ	80	3,760,000
NJ0021601	Carneys Point Twp. Sewer Auth	Carneys Point	NJ	3	141,000
NJ0024007	Cinnaminson Sewerage Auth.	Cinnaminson	NJ	4	188,000
NJ0023701	Florence Twp. Sewer Auth.	Florence	NJ	5	235,000
NJ0026301	Hamilton Twp. DPW WWTP	Hamilton.	NJ	16	752,000
NJ0020915	Lambertville City Sewer Auth.	Lambertville	NJ	4	188,000
NJ0024759	Ewing Lawrence Sewer Auth.	Lawrenceville	NJ	16	752,000
NJ0069167	Maple Shade Util, Authority	Maple Shade	NJ	5	235,000
NJ0026832	Medford Twp. Sewer Auth. STP	Medford	NJ	2	94,000
NJ0029467	Millville City Sewer Auth.	Millville	NJ	7	329,000
NJ0024996	Moorestown Twp. Utilities Auth	Moorestown	NJ	6	282,000
NJ0024015	Mount Holly Twp. MUA	Mount Holly	NJ	8	376,000
NJ0020184	Newton Town DPW	Newton	NJ	4	188,000
NJ0024821	Pemberton Twp. MUA STP	Pemberton	NJ	5	235,000
NJ0024023	Penns Grove Sewerage Auth.	Penns Grove	NJ	3	141,000
NJ0021598	Pennsville Twp. Sewer Auth.	Pennsville	NJ	4	188,000
NJ0024716	Phillipsburg Town STP	Phillipsburg	NJ	5	235,000
NJ0022519	Riverside Twp. DPW	Riverside	NJ	3	141,000
NJ0024856	Salem WWTP Facility	Salem	NJ	3	141,000
NJ0024686	Gloucester Co. Util. Auth. STP	Thorofare	NJ	24	1,128,000
NJ0020923	Trenton City DPW Sewer Auth.	Trenton	NJ	20	940,000
NJ0023361	Willingboro Twp. MUA	Willingboro	NJ	6	282,000
New York				**257**	**12,079,000**
NY0020265	Delhi WWTP	Delhi	NY	4	188,000
NY0030074	Liberty WWTF	Liberty	NY	4	188,000
NY0022454	Monticello STP	Monticello	NY	6	282,000
NY0029271	Sidney WWTP	Sidney	NY	6	282,000
New Jersey				**20**	**940,000**
PA0026867	Abington Twp. STP	Abington	PA	6	282,000
PA0026000	Allentown City WWTP	Allentown	PA	45	2,115,000
PA0026042	Bethlehem City STP	Bethlehem	PA	95	4,465,000
PA0021181	Bristol Borough Water/Sewer	Bristol	PA	3	141,000
PA0027103	Delaware Co. Reg. Water Auth.	Chester	PA	44	2,068,000
PA0026859	Coatesville WWTP	Coatesville	PA	6	282,000
PA0026794	Conshohocken Borough Auth.	Conshohocken	PA	4	188,000
PA0026531	Downingtown Regional WPCC	Downingtown	PA	7	329,000
PA0026549	Borough of Doylestown WWTP	Doylestown	PA	29	1,363,000
PA0027235	Easton Area Joint Auth. WWTP	Easton, PA	PA	14	658,000
PA0029441	Upper Dublin Twp. MS4 UA	Ft. Washington	PA	3	141,000
PA0051985	Horsham Twp. STP	Horsham	PA	3	141,000
PA0024058	Kennett Square Borough WWTP	Kennett Sq.	PA	3	141,000

PA0026298	Whitemarsh STP	Lafayette Hill	PA	4	188,000
PA0026182	Lansdale Borough STP	Lansdale	PA	5	235,000
PA0039004	Upper Gwynedd Towam. STP	Lansdale	PA	7	329,000
PA0026468	Morrisville Mun. Auth. Water	Morrisville	PA	10	470,000
PA0027421	Norristown Borough WWTP	Norristown	PA	10	470,000
PA0020532	Upper Montgomery Joint Sewer	Pennsburg	PA	4	188,000
PA0026689	Northeast WPCP	Philadelphia	PA	210	9,870,000
PA0026662	Philadelphia Southeast POTW	Philadelphia	PA	112	5,264,000
PA0026671	SW Water Pollution Control	Philadelphia	PA	200	9,400,000
PA0020460	Quakertown WWTP	Quakertown	PA	10	470,000
PA0026549	Reading WWTP	Reading	PA	29	1,363,000
PA0020168	East Stroudsburg Filtration Plant	Stroudsburg	PA	10	470,000
PA0029289	Stroudsburg STP	Stroudsburg	PA	10	470,000
PA0027031	Goose Creek STP	West Chester	PA	4	188,000
PA0026018	West Chester Taylor Run STP	West Chester	PA	4	188,000
PA0028584	West Goshen STP	West Chester	PA	8	376,000
PA0023256	Upper Gwynedd Twp. WWTP	West Point	PA	7	329,000
PA0025976	Upper Moreland Hatboro Sewer	Willow Grove	PA	7	329,000
Pennsylvania				**913**	**42,911,000**
Del. Basin				**1,298**	**61,006,000**

Watershed Jobs

Over 100 nonprofit watershed and environmental organizations employ at least 200 staff who earn at least 9.5 million in wages on programs to restore the watersheds in the Delaware Basin (Table 64).

Table 64. Watershed organization jobs and salaries in the Delaware River Basin

Watershed Organization	Town	State	Jobs	Salaries
Christina Conservancy, Inc.	Wilmington	DE	1	48,000
Coalition for Natural Stream Valleys	Newark	DE		0
Delaware Audubon Society	Wilmington	DE	1	48,000
Delaware Nature Society	Hockessin	DE	20	960,000
Fairfield Watershed Association	Newark	DE		0
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		0
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		0
St. Jones River Greenway Commission	Magnolia	DE		0
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		0
Crafts Creek Spring Hill Brook Watershed	Bordentown	NJ		0
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
Fairview Lake & Watershed Conservation Foundation	West Caldwell	NJ		0
Friends Hamilton-Trenton-Bordentown Marsh	Robbinsville	NJ		0

Hunterdon Land Trust Alliance	Flemington	NJ	2	96,000
Mantua/Woodbury Creeks Watershed Association	Glassboro	NJ	1	48,000
Musconetcong Watershed Association	Asbury	NJ	1	48,000
New Jersey Coalition of Lake Associations	Sparta	NJ	1	48,000
Newton Creek Watershed Association	Collingswood	NJ	1	48,000
Oldmans Creek Watershed Association.	Mullica Hill	NJ	1	48,000
Paulinskill-Pequest Watershed Association	Blairstown	NJ	1	48,000
Phillipsburg Riverview Organization	Phillipsburg	NJ	3	144,000
Pinelands Preservation Alliance	Southampton	NJ	1	48,000
Pinelands Watershed Alliance	Tuckerton	NJ	1	48,000
Pohatcong Creek Watershed Association	Phillipsburg	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		0
South Jersey Land and Water Trust	Glassboro	NJ	2	96,000
Upper Maurice River Watershed Association	Franklinville	NJ	1	48,000
New Jersey			**26**	**1,248,000**
Neversink River Program/The Nature Conservancy	Cuddebackville	NY	3	144,000
New York			3	
Aquashicola/Pohopoco Watershed Conservancy	Kresgeville	PA	1	48,000
Berks County Conservancy	Reading	PA	5	240,000
Bertsch-Hokendauqua-Catasauqua Watershed Assoc.	Bethlehem	PA	1	48,000
Brandywine Valley Association	West Chester	PA	8	384,000
Brodhead Forest & Stream Association	Stroudsburg	PA	1	48,000
Brodhead Watershed Association	Henryville	PA	1	48,000
Bushkill Stream Conservancy	Tatamy	PA	1	48,000
Chester Creek Watershed Association	Glen Mills	PA	1	48,000
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 River Shad Fishermen's Association	Bethlehem	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 Cherry Valley	Stroudsburg	PA	1	48,000
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 Del. Water Gap Nat'l. Recreation Area	Bushkill	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
Fry's Run Watershed Association	Easton	PA		0
Greater Pottstown Watershed Alliance	Pottstown	PA		0
Green Valleys Association	Pottstown	PA	3	144,000
Hay Creek Watershed Association	Geigertown	PA	1	48,000
Lackawaxen River Conservancy	Rowland PA	PA	1	48,000
Lake Wallenpaupack Watershed Association	Paupack	PA	2	96,000
Little Schuylkill Conservation Club	Delano	PA		0
Lower Merion Conservancy	Gladwyne	PA	6	288,000

Maiden Creek Watershed Association	Kempton	PA		0
Martins-Jacoby Watershed Association	Martins Creek	PA	1	48,000
Mid-Atlantic Council of Watershed Associations	West Chester	PA		0
Middle Anthracite Watershed Association	Sybertsville	PA	1	48,000
Mill Creek Council, Inc.	Philadelphia	PA	1	48,000
Monocacy Creek Watershed Association, Inc.	Bethlehem	PA	1	48,000
Neshaminy Creek Watershed Association	Rushland	PA	1	48,000
North Branch Watershed Association	Doylestown	PA	1	48,000
North Pocono CARE	Thornhurst	PA	2	96,000
Palisades Region Watershed Partnership	Pipersville	PA		0
Paunacussing Watershed Association	Carversville	PA		0
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		0
Red Clay Valley Association	West Chester	PA	4	192,000
Saucon Creek Watershed Association	Bethlehem	PA	1	48,000
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	1	48,000
Southampton Watershed Association	Southampton	PA	1	48,000
Springton Lake/Crum Creek Conservancy	Newtown Square	PA	1	48,000
Stony Creek Watershed Committee	Norristown	PA	1	48,000
Swarthmore College's Watershed Projects	Swarthmore	PA	2	96,000
Tinicum Conservancy	Erwinna	PA	4	192,000
Tinicum Creek Watershed Association	Upper Black Eddy	PA	2	96,000
Tobyhanna/Tunkhannock Creek Watershed Association	Pocono Lake	PA	1	48,000
Tohickon Creek Watershed Association	Pipersville	PA	1	48,000
Tookany/Tacony - Frankford Watershed Partnership	Philadelphia	PA	1	48,000
Upper Perkiomen Watershed Coalition	Palm	PA	1	48,000
Water Resources Association Delaware River Basin	Exton	PA	1	48,000
White Clay Watershed Association	Landenberg	PA	1	48,000
Wildlands Conservancy	Emmaus	PA	5	240,000
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
Pennsylvania			**133**	**6,384,000**
Delaware Basin			**201**	**9,504,000**

Ski Area Jobs

In the Pocono Mountains of Pennsylvania, 9 ski resorts employ 1,753 direct jobs in the Delaware Basin from aggregate annual revenues of $87,655,063 from 1,908,228 skier visits based on an average mid-week lift ticket rate of $45/day.

Paddling-based Recreation

In the Mid-Atlantic census division (NY, NJ, PA), the Outdoor Industry Association (2006) estimates that paddling-based recreation is practiced by 11% of the population and is responsible for 3,356,000 participants and 22,844 jobs. Given the Delaware Basin is the home of 18.5% of the three

state's total population of 40,800,000 people, then the prorated paddling-based recreation in the basin is responsible for 620,860 participants and 4,226 jobs.

River Recreation

Cordel et al. (1990) from the U. S. Forest Service and U.S. National Park Service estimated river recreation along the Upper Delaware River and Delaware Water Gap was responsible for 448 jobs with wages of $8.8 million in $1986.

Canoe/Kayak/Rafting

The 37 canoe and kayak liveries along the Delaware, Lehigh, and Schuylkill, and Brandywine Rivers employ 225 people to lease watercraft to approximately 225,000 visitors with earnings of $9 million per year assuming a daily rental fee of $40 per person.

Wild Trout Fishing

Along the Beaverkill, East Branch, West Branch and upper main stem of the Delaware River in New York, wild trout fishing provides for 350 jobs with $3.6 million in wages.

Delaware Water Gap National Recreation Area

Stynes and Sun (2002) estimated the Delaware Water Gap Nat'l. Recreation Area recorded 4,867,272 visits in 2001 that generated $106 million in sales, 7,563 direct/indirect jobs, and $100 million wages.

Port Jobs

The Economy League of Greater Philadelphia (2008) reported that Delaware River ports:

- Employ 4,056 workers earning $326 million in wages (Table 65).
- Indirectly support an additional two jobs each in port activity and employee spending for a total of 12,121 port jobs with $772 million wages and $2.4 billion 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 65. Jobs at Delaware River ports
(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**

6. References

Austin, J. C., S. Anderson, P. N. Courant, and R. E. Litan, 2007. America's North Coast: A Benefit Cost Analysis of a Program to Protect and Restore the Great Lakes. Brookings Institute, Great Lakes Economic Initiative.

Austin, J. C., S. Anderson, P. N. Courant, and R. E. Litan, 2007. Healthy Waters, Strong Economy: The Benefits of Restoring the Great Lakes Ecosystem. The Brookings Institution. 16 pp.

Bockstael, N. E., K. E. McConnell, and I. E. Stroud, 1989. Measuring the Benefits of Improvements in Water Quality: the Chesapeake Bay. Marine Resource Economics. 6:1-18.

Breunig, K., 2003. Losing Ground: At What Cost? Changes in Land Use and Their Impact on Habitat, Biodiversity, and Ecosystem Services in Massachusetts. Mass Audubon. 43 pp.

Chesapeake Bay Watershed Blue Ribbon Finance Panel, 2003. Saving a National Treasure: Financing the Cleanup of the Chesapeake Bay. A Report to the Chesapeake Executive Council.

Coleman, J. L., R. C. Milici, T.A. Cook, R. R. Charpentier, M. Kirshbaum, T.R. Klett, R. M. Pollastro, and C.J. Schenk, 2011, Assessment of Undiscovered Oil and Gas Resources of the Devonian Marcellus Shale of the Appalachian Basin Province, USGS Fact Sheet 2011–3092, 2 pp.

Cordell, H. K., J. C. Bergstrom, G. A. Ashley, and J. Karish, 1990. Economic Effects of River Recreation on Local Economies. Water Resources Bulletin American Water Resources Association. 26(1), 53-60.

Corrozi, M. and M. Seymour, 2008. Water Rates in Delaware and Surrounding States. University of Delaware Institute for Public Administration-Water Resources Agency.

Dove, L. E. and R. M. Nyman eds., 1995. Living Resources of the Delaware Estuary. Delaware Estuary Program. 529 pp.

Economic League of Greater Philadelphia, 2008. Maritime Commerce in Greater Philadelphia: Assessing Industry Trends and Growth Opportunities for Delaware River Ports. 78 pp.

McCormick, B., 2010. Measuring the Economic Benefits of America's Everglades Restoration. The Everglades Foundation. 173 pp.

National Ocean Economics Program, 2009. State of the U.S. Ocean and Coastal Economies, Coastal and Ocean Economic Summaries of the Coastal States. 62 pp.

Frederick, K. D., T.VandenBerg, and J. Hansen, 1996. Economic Value of Freshwater in the United States. Discussion Paper 97-03. Resources for the Future. Washington, D. C. 37 pp.

Greeley-Polhemus Group, 1993. Final Report: Assessment of Selected Delaware Estuary Economic and Resource Values. Delaware Estuary Program Science & Tech. Advisory Committee. 117 pp.

Ingraham, M. and S. G. Foster, 2008. The Value of Ecosystem Services Provided by the U. S. National Wildlife Refuge System in the Contiguous U. S. Ecological Economics. 67:608-818.

Johnston, R. J., T. A. Grigalunas, J. J. Opaluch, Marisa Mazzotta, and J. Diamantedes, 2002. Valuing Estuarine Resource Services Using Economic and Ecological Models: The Peconic Estuary System Study. Coastal Management. 30:47-65.

Latham, W. R. and J. E. Stapleford, 1987. Economic Impacts of the Delaware Estuary. Delaware Sea Grant College Program. No. DEL-SG-02-87. 12 pp.

Leggett, C. G. and N. E. Bockstael, 2000. Evidence of the Effects of Water Quality on Residential Land Prices. Journal of Environmental Economics and Management. 39:2, 121-144.

Maharaj, V., J. McGurrin, and J. Carpenter, 1998. The Economic Impact of Trout Fishing on the Delaware River Tailwaters in New York. American Sportfishing Association and Trout Unlimited.

National Marine Manufacturers Association, 2010. 2010 Recreational Boating Statistical Abstract. Chicago, Illinois. 94 pp.

New Jersey Department of Environmental Protection, 2007. Valuing New Jersey's Natural Capital: An Assessment of the Economic Value of the State's Natural Resources.

New Jersey Water Supply Authority, 2011. New Jersey Water Supply Authority Basis and Background Statement. Accessed October 4, 2011.
http://www.njwsa.org/html/publications/html.

Nowak, D. J., R. E. Hoehn, J. Wang, A. Lee, V. Krishnamurthy, and G. Schwetz, 2008. Urban Forest Assessment in Northern Delaware. Delaware Center for Horticulture and U. S. Forest Service.

Outdoor Industry Association, 2006. The Active Outdoor Recreation Economy. 20 pp.

Parsons, G. R., E. C. Helm, and T. Bondelid, 2003. Measuring the Economic Benefits of Water Quality Improvements to Recreational Users in Six Northeastern States: An Application of the Random Utility Maximization Model. For the EPA Office of Policy Economics and Innovation

Pennsylvania Fish and Boat Commission, 2011. Economic Value of Fishing and Boating in Pennsylvania. Accessed June 6, 2011.
http://www.fish.state.pa.us/promo/funding/fact_economic_impact.htm.

Pennsylvania Geological Survey, 2010. Map of Marcellus Shale Thickness in Pennsyvania.

Pennsylvania Ski Areas Association, 2009. Accessed June 6, 2011. http://www.skipa.com

Stynes, D. J. and Y. Sun, 2002. Economic Impacts of Selected National Parks, Update to Year 2001. 10 pp.

Trust for Public Land and American Water Works Association, 2004. Protecting the Source: Land Conservation and the Future of America's Drinking Water. 51 pp.

Trust for Public Land, 2009. How Much Value Does the City of Wilmington Receive from its Park and Recreation System? 20 pp.

U. S. Census Bureau, 2010. Property Value: 2008-2009. American Community Survey Briefs. 4 pp.

U. S. Department of Agriculture, 2009. 2007 Census of Agriculture. Delaware State & County Data.

U. S. Department of Agriculture, 2010. Land Values and Cash Rents 2010 Summary. National Agricultural Statistics Service.

U. S. Department of the Interior, Fish and Wildlife Service, 2002. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U. S. Department of the Interior, Fish and Wildlife Service, 2008. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U. S. Energy Information Administration, 2002. Inventory of Electric Utility Power Plants in the United States 2000. U. S. Department of Energy. Washington, D. C. 339 pp.

U.S. Energy Information Administration, 2010. Natural Gas Weekly Update. ResidentialNatural Gas Prices. Accessed October 5, 2011. http://205.254.135.24/oog/info/ngw/ngupdate.asp

U. S. Environmental Protection Agency. 1973. Benefit of Water Pollution Control on Property Values. EPA-600/5-73-005, October 1973.

U. S. Environmental Protection Agency, 1995. A Framework for Measuring the Economic Benefits of Groundwater. Office of Water. Washington, D. C.

U. S. Nat'l. Energy Tech. Laboratory, 2009. Impact of Drought on U. S. Steam Electric Power Plant Cooling Water Intakes & Related Water Resource Management Issues. Washington, D. C. 191 pp.

Van Rossum, M. K., T. Carluccio, and S. Blankinship, 2010. River Values the Value of a Clean and Healthy Delaware River. Delaware Riverkeeper Network. 76 pp.

Weber, T., 2007. Ecosystem Services in Cecil County's Green Infrastructure. The Conservation Fund. Annapolis, Maryland.

Appendix A

Economic Value (Potential) of Marcellus Shale Natural Gas in the Delaware River Basin

The U.S. Geological Survey (Coleman et al. 2011) estimated the entire 54,000 square-mile Marcellus Shale Formation from Kentucky and Ohio to Pennsylvania and New York potentially contains a mean volume of 84 trillion cubic feet of natural gas with a range of 43 tcf (95th percentile) to 144 tcf (5th percentile). If the Delaware River Basin covers 4,700 square miles or 8.7% of the Marcellus Shale, then by proportion a mean volume of 7.3 tcf of natural gas is potentially recoverable within the basin boundary (0.087 x 84 tcf) with a range of 3.7 tcf (95th percentile) to 12.5 tcf (5th percentile). These estimates may vary as the thickness of Marcellus Shale in the Delaware Basin increases to the northeast toward the New York/Pennsylvania border ranging from 50 feet thick near Stroudsburg to more than 250 feet thick under Lackawaxen in Wayne County, Pennsylvania.

In 2010, the U.S. Energy Information Administration reported the mean natural gas wellhead price was $4.16/1000 cf, down from a peak of $7.97/1000 cf in 2008. The residential customer price of natural gas was $11.21/1000 cf, down two dollars from the 2008 peak. Table A1 lists fluctuating annual wellhead and residential consumer prices of natural gas in the U.S. from 2006 through 2010.

Table A1. Wellhead and residential prices of natural gas in the United States, 2006-2010 (EIA)

Year	Wellhead Price ($/1000 cf)	Residential Price ($/1000 cf)
2006	6.39	13.73
2007	6.25	13.08
2008	7.97	13.89
2009	3.67	12.14
2010	4.16	11.21

At the 2010 wellhead unit price (Table A2), the mean value of potentially recoverable natural gas from the Marcellus Shale Formation within the Delaware River Basin is projected to be $30.4 billion with a range of $15.4 billion (95th percentile) to $52.0 billion (5th percentile). Assuming the natural gas can be recovered within 25 years, the mean annual wellhead value of Marcellus Shale gas within the Delaware Basin is potentially $1.2 billion/year with a range of $0.6 billion/year (95th percentile) to $2.0 billion/year (5th percentile). Figures A1 and A2 project total and annual wellhead value of natural gas recoverable from the Delaware Basin based on variable prices from 2006 to 2010.

At the 2010 residential consumer unit price (Table A3), the mean value of natural gas from the Marcellus Shale Formation within the Delaware River Basin is $81.8 billion with a range of $41.5 billion (95th percentile) to $140.1 billion (5th percentile). Assuming the natural gas can be recovered within 25 years, the mean annual residential consumer value of Marcellus Shale gas within the Delaware Basin is $3.3 billion/year with a range of $1.7 billion/year (95th percentile) to $5.6 billion/year (5th percentile). Figures A3 and A4 project total and annual residential consumer value of natural gas recoverable from the Delaware Basin based on prices from 2006 to 2010.

Table A2. Wellhead value of Marcellus Shale natural gas within the Delaware River Basin

State/Basin	Area Marcellus Shale (sq mi)	Wellhead Natural Gas Price[1] ($/1000 cf)	Volume Natural Gas[2] (tcf)	Wellhead Natural Gas Value ($ billion)	Wellhead Natural Gas Value[3] ($ billion/yr)
Mean					
Pennsylvania	2,338	$4.16	3.6	$15.0	$0.6
New York	2,362	$4.16	3.7	$15.4	$0.6
Delaware Basin	4,700	$4.16	7.3	$30.4	$1.2
95th Percentile					
Pennsylvania	2,338	$4.16	1.8	$7.5	$0.3
New York	2,362	$4.16	1.9	$7.9	$0.3
Delaware Basin	4,700	$4.16	3.7	$15.4	$0.6
5th Percentile					
Pennsylvania	2,338	$4.16	6.2	$25.8	$1.0
New York	2,362	$4.16	6.3	$26.2	$1.0
Delaware Basin	4,700	$4.16	12.5	$52.0	$2.0

1. EIA 2010. 2. USGS 2011. 3. Assumes 25 year natural gas recovery period.

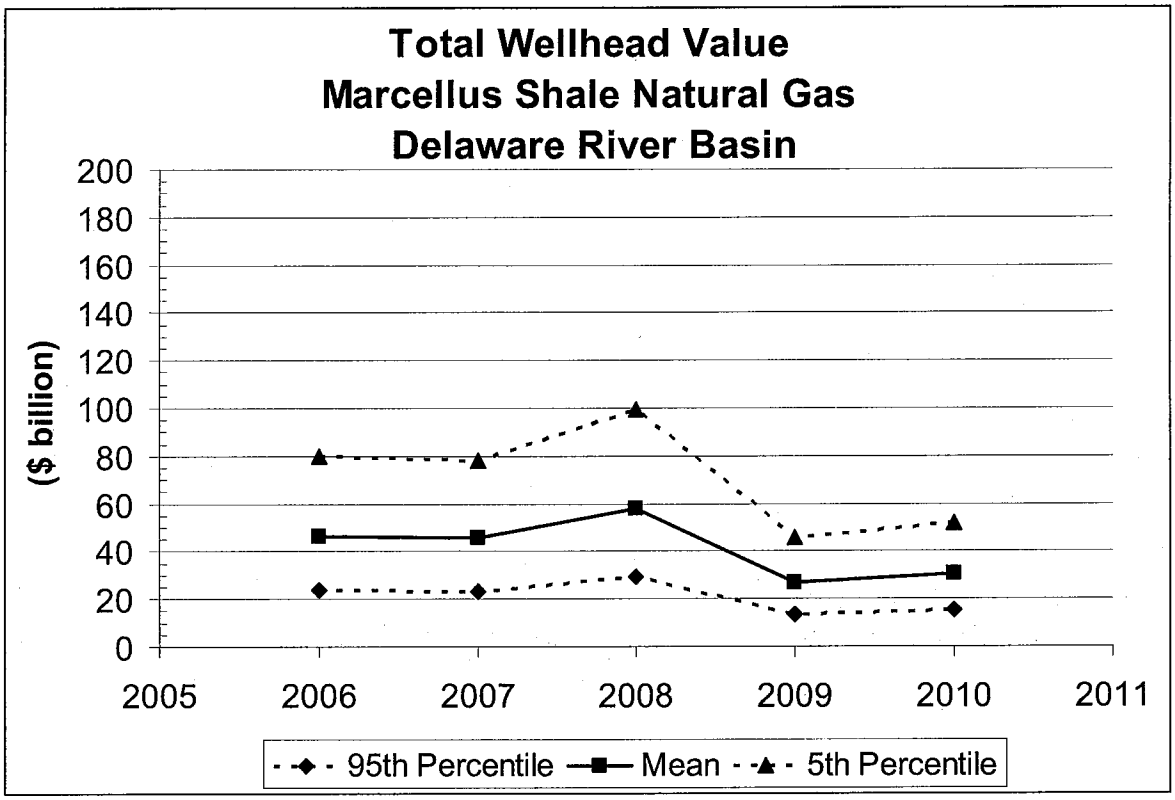


Figure A1. Total wellhead value of Marcellus shale natural gas in the Delaware River Basin Assumes mean volume of 7.3 tcf of natural gas potentially recoverable within basin boundary with a range of 3.7 tcf (95th percentile) to 12.5 tcf (5th percentile) as per Coleman et al. 2011 from the USGS. From EIA (2011), natural gas prices at wellhead ($/1000 cf): 2006 ($6.39), 2007 ($6.25), 2008 ($7.97), 2009 ($3.67), and 2010 ($4.16).

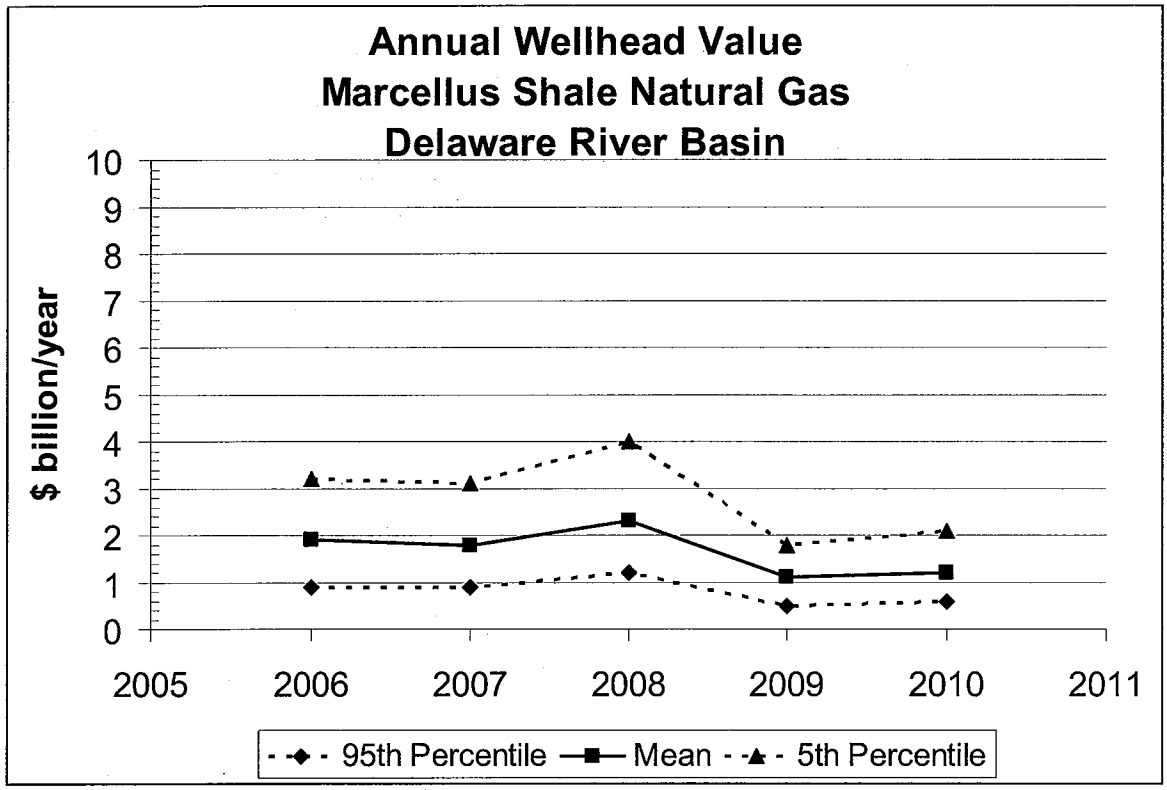


Figure A2. Total wellhead value of Marcellus shale natural gas in the Delaware River Basin Assumes mean volume of 7.3 tcf of natural gas potentially recoverable within basin boundary with a range of 3.7 tcf (95th percentile) to 12.5 tcf (5th percentile) as per Coleman et al. 2011 from the USGS. From EIA (2011), natural gas prices at wellhead ($/1000 cf): 2006 ($6.39), 2007 ($6.25), 2008 ($7.97), 2009 ($3.67), and 2010 ($4.16). Assumes 25 year natural gas recovery period.

Table A3. Residential value of Marcellus Shale natural gas within the Delaware River Basin

State/Basin	Area Marcellus Shale (sq mi)	Residential Natural Gas Price[1] ($/1000 cf)	Volume Natural Gas[2] (tcf)	Residential Natural Gas Value ($ billion)	Residential Natural Gas Value[3] ($ billion/yr)
Mean					
Pennsylvania	2,338	$11.21	3.6	$40.4	$1.6
New York	2,362	$11.21	3.7	$41.5	$1.7
Delaware Basin	4,700	$11.21	7.3	$81.8	$3.3
95th Percentile					
Pennsylvania	2,338	$11.21	1.8	$20.2	$0.8
New York	2,362	$11.21	1.9	$21.3	$0.9
Delaware Basin	4,700	$11.21	3.7	$41.5	$1.7
5th Percentile					
Pennsylvania	2,338	$11.21	6.2	$69.5	$2.8
New York	2,362	$11.21	6.3	$70.6	$2.8
Delaware Basin	4,700	$11.21	12.5	$140.1	$5.6

1. EIA 2010. 2. USGS 2011. 3. Assumes 25 year natural gas recovery period.

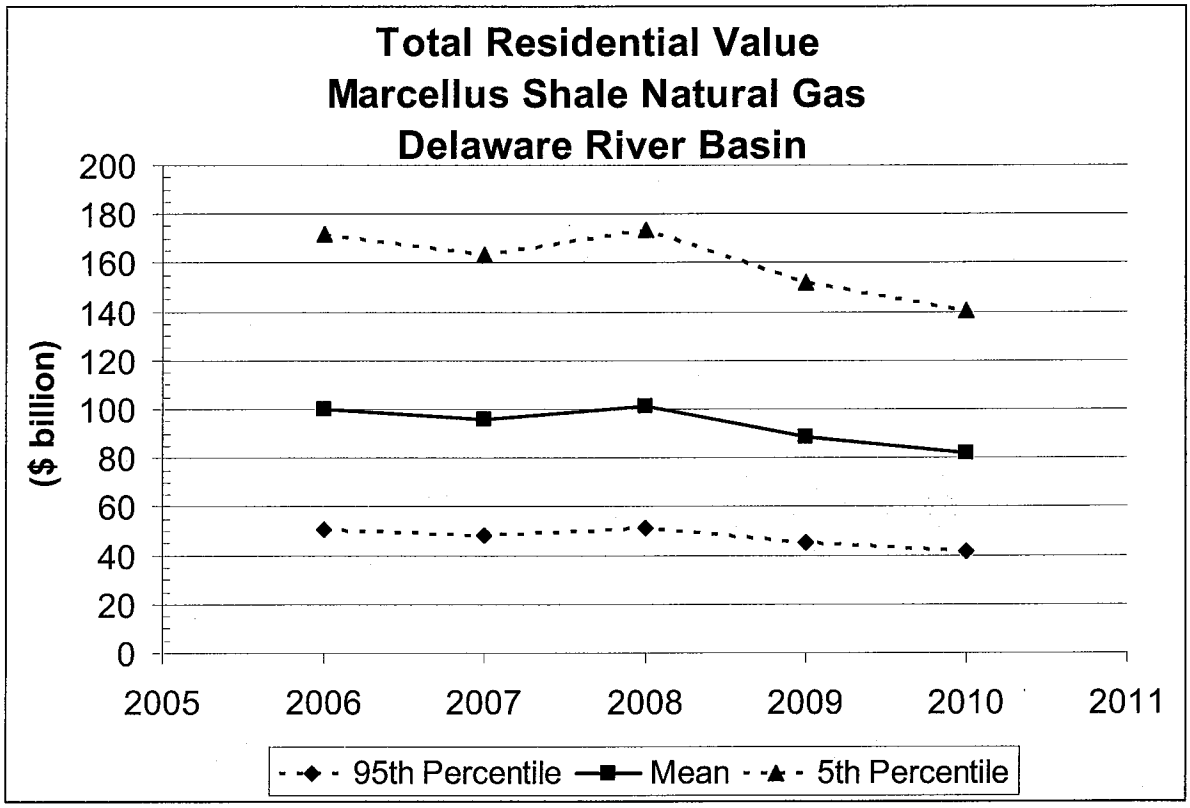


Figure A3. Total residential value of Marcellus shale natural gas in the Delaware River Basin Assumes mean volume of 7.3 tcf of natural gas potentially recoverable within basin boundary with a range of 3.7 tcf (95th percentile) to 12.5 tcf (5th percentile) from Coleman et al. 2011 (USGS). From EIA (2011), natural gas sold to residential consumers ($/1000 cf): 2006 ($13.73), 2007 ($13.08), 2008 ($13.89), 2009 ($12.14), and 2010 ($11.21).

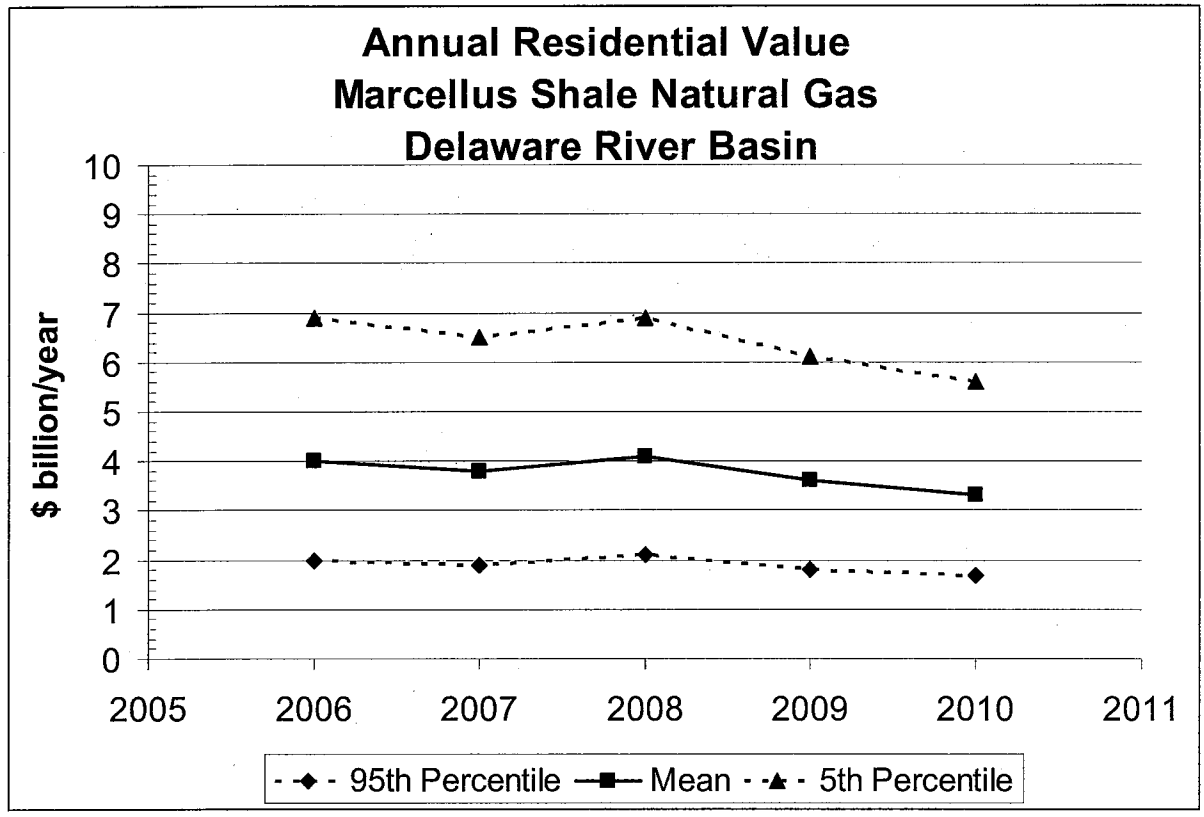


Figure A4. Annual residential value of Marcellus shale natural gas in the Delaware River Basin Assumes mean volume of 7.3 tcf of natural gas potentially recoverable within basin boundary with a range of 3.7 tcf (95th percentile) to 12.5 tcf (5th percentile) from Coleman et al. 2011 (USGS). From EIA (2011), natural gas sold to residential consumers ($/1000 cf): 2006 ($13.73), 2007 ($13.08), 2008 ($13.89), 2009 ($12.14), and 2010 ($11.21). Assumes 25 year natural gas recovery period.

Appendix B

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