

## **Coastal Economy of the Barnegat Estuary**

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**Abstract:** The Barnegat Bay in Ocean County, New Jersey includes a valuable estuary where tourism fuels a \$4 billion annual economy and \$432 million in state and local income taxes with \$95.1 billion in property tax ratables. The annual economic value of the Barnegat Bay watershed ranges from \$2.3 billion from the natural goods and services provided by ecosystems habitat to \$4 billion based on estimates of economic activity from public parks, recreation, water quality, forests, fish/wildlife, water supply, and agriculture benefits. The bay watershed is responsible for 50,000 jobs with \$1.8 billion in wages in the coastal, estuary, and watershed sectors. The Barnegat Estuary affords substantial benefits to the regional coastal economy.

**Keywords:** coastal economy; estuary; ecosystem services

### **Objectives**

This research estimates the economic value of the Barnegat Bay watershed in Ocean County, New Jersey along the Atlantic coast of the United States. The objective of this research is to estimate the economic value of the Barnegat Bay watershed related to: (1) economic activity from market and nonmarket use and nonuse value from the water resources, tourism, and recreation sectors, (2) ecosystem services (natural capital) of goods and services provided by habitat, and (3) jobs dependent on the bay and its tributaries.

### **Background**

The Barnegat Bay watershed and its rivers, beaches, wetlands, and forests in Ocean County, New Jersey have long supported a multi-billion-dollar coastal tourism, recreation, and hunting/fishing/birding economy (Table 1). In 1995, tourists spent \$1.71 billion in Ocean County and accounted for 45,000 recreation jobs with \$631 million in wages (BBNEP 2002). Longwoods International (1988) found tourists expended \$1.67 billion annually in Ocean County and accounted for 51,300 jobs with \$726 million in wages. Approximately 45 miles or 1/3 of the Jersey Shore is in Ocean County where the tourism industry alone generates \$3.35 billion in revenue for the local economy (Ocean County Planning Board 2011).

New Jersey has 130 miles of Atlantic Ocean coast that supports \$8 billion in coastal tourism expenditures and \$1 billion in commercial fishing and aquaculture revenue (New Jersey Division of Travel and Tourism 2011). Ocean County ranked 3rd highest in the state in tourism expenditures after Atlantic and Cape May counties and had the largest increase in tourism sales among the four shore counties in 2011 with an 8.3% increase compared to Monmouth County (4.3%), Cape May County (4.5%), and Atlantic County (1.5%).

In 2011, Ocean County tourism fueled a \$4 billion annual economy with \$1.3 billion in lodging, \$0.9 billion in food/beverage, \$0.8 billion in retail, \$0.5 billion in recreation, and \$0.4 billion in transportation expenditures. Ocean County tourism contributed \$432 million in state and local taxes in 2011 with \$295 million from county property tax revenues. The Ocean County Board of Taxation (2012) reported the assessed value of property tax ratables is \$95.1 billion.

**Table 1.** Previous Estimates of Economic Value in the Barnegat Bay watershed

Source	Sector	Spending	Jobs
BBNEP 2002	Tourism	\$1.71 billion	45,000
Longwoods International 1988	Tourism	\$1.67 billion	51,300
Ocean County Planning Board 2011	Tourism	\$3.35 billion	
Ocean Co. Board of Taxation 2012	State/local taxes	\$727 million	

### The Barnegat Estuary

The Barnegat Bay has been a prosperous place ever since the indigenous people of the coast, the Lenni Lenape, subsisted on oysters, clams, mussels, fish, muskrat, deer, otter, and bird eggs (Barnegat Bay Partnership 2011). The aboriginal Americans picked cranberries, strawberries, and blueberries, and taught the early European settlers how to grow corn, potatoes, peanuts, tobacco, beans and squash.

One of the first Europeans to explore the coast was Englishman Henry Hudson who anchored the *Half Moon* off Barnegat Inlet in 1609 while searching for an inner passage to the Orient. Dutch Captain Cornelius Mey (see Cape May, NJ) drew a 1614 map that marked places like *Barendegat* (Inlet of Breakers) and *Eyre Haven* (Harbor of Eggs or Egg Harbor). Pirates were said to have buried treasure near the bay and Spanish coins have been found on the Long Island beaches.

The early colonial coastal economy relied on beaver trapping, whaling, milling, and oystering. In the early 1700s, whaler Aaron Inman built a home near present-day Surf City on Long Beach Island. In 1704, Edward Andrews built a gristmill on a beaver pond. In 1719, a law was passed that prohibited oyster harvests from May 10 to September 1. In the 1760s, sawmills were operating along Ocean County creeks and Toms River was a growing port town where fish and lumber were shipped by schooner to New York and Philadelphia.

During the Revolutionary War, American privateers harassed the British Navy from the secluded coastal coves. Skirmishes were fought over the salt works on the bay. The British killed 40 American troops during a raid at the Batsto bog iron works in the Pine Barrens interior.

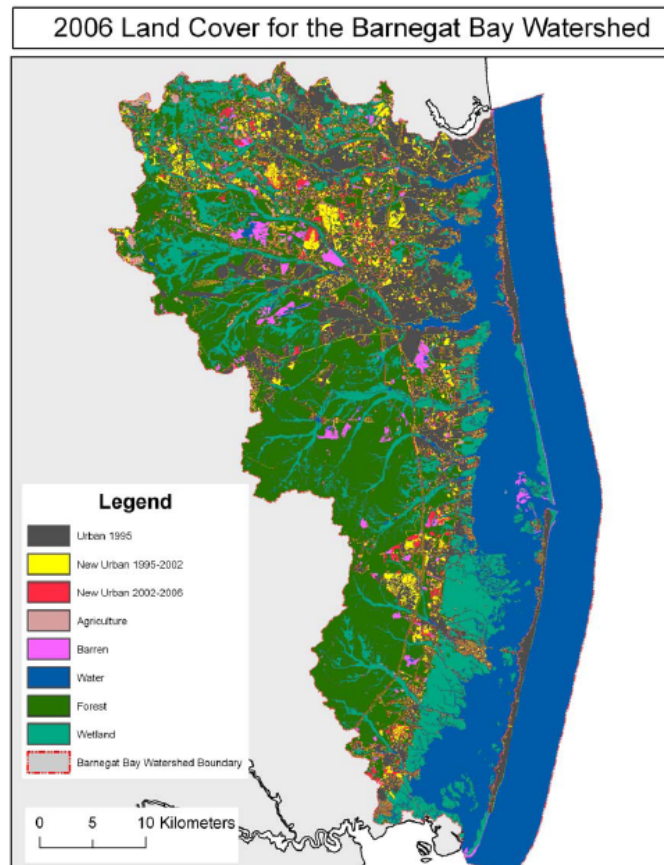
During the 19<sup>th</sup> century, timber from the inland forests fed the shipbuilding industry that later produced the Barnegat Bay sneak box, a small sailboat specially adapted for clamming and hunting in the shallow bay. Coastal storms often changed the seascape in the “Graveyard of the Atlantic” where over 30 ship wrecks occurred in 1830 and 350 people died in the wreck of the *Powhatan* off LBI in spring 1854. The U.S. Life Saving Service built houses of refuge for ship wreck survivors at 5-mile intervals along the beach. Island Beach Life Saving Station No. 14 was replaced in 1849. In 1835, a 40 feet high lighthouse was built at Barnegat Inlet and later

replaced in 1858 with a 172 feet lighthouse. Cranberry bogs were dug in 1860s in the Pine Barrens swamps and the industry grew until the cranberry glut at the turn of the 20<sup>th</sup> century.

Today, Ocean County is one of the top 25 fastest growing counties in the nation (by population) with the largest concentration of retirement communities in the U.S. Tourism and health care are the two largest employers in the Barnegat Bay region.

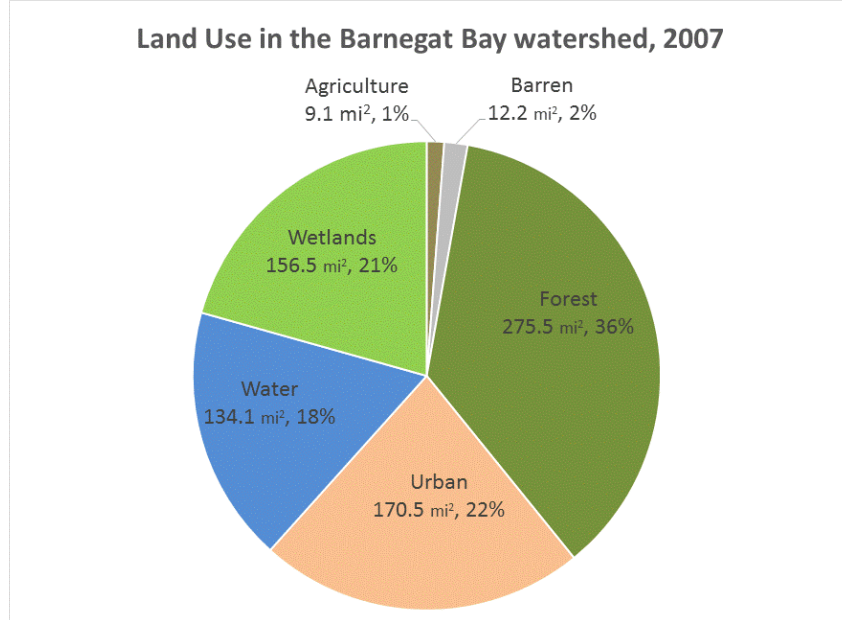
As nominated by the Governor of New Jersey, Congress directed the Environmental Protection Agency to designate the Barnegat Bay as an Estuary of National Significance as part of the National Estuary Program on July 10, 1995 (BBNEP 2002). The 670-square mile Barnegat Bay watershed is home to 576,000 year-round and 1.5 million summer residents in 33 towns in Ocean County and several towns in Monmouth and Burlington Counties, New Jersey. The Barnegat Bay watershed is flat to gently rolling with elevations that range from 100 feet in the sandy Pine Barren forests in the interior to sea level where the streams flow east into the bay (Figure 1).

The Barnegat Bay is a 96-square mile coastal lagoon covering the mouth of the bay itself (64.5 mi<sup>2</sup>), Little Egg Harbor (20.5 mi<sup>2</sup>), Great Bay (7.6 mi<sup>2</sup>), and Manahawkin Bay (3.6 mi<sup>2</sup>). Barnegat Bay is a shallow (3 to 23 feet deep), 43-mile-long lagoon estuary with a volume of 6.4 billion gallons (BBNEP 2002). The Barnegat Bay recirculates ocean water every 3 months primarily through Barnegat Inlet. The overall condition of Barnegat Bay is fair based on ratings of water quality, sediment, benthics, and fish tissue contaminants (EPA 2007).

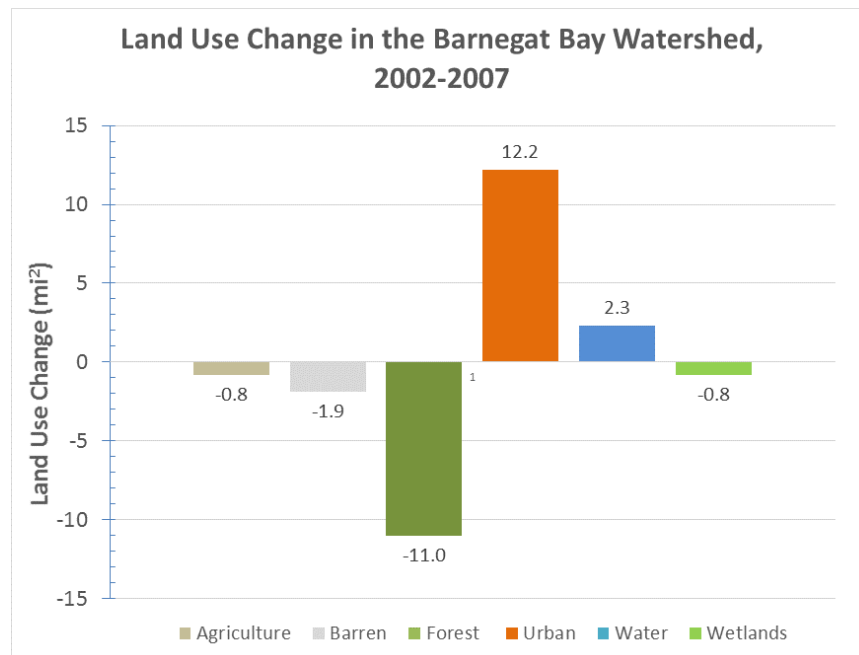


**Figure 1.** Land cover in the Barnegat Bay watershed in 2006 (NJDEP)

Approximately 1/4 of the Barnegat Bay watershed is covered by developed land. The watershed is covered by 36% forest, 22% urban, 21% wetlands, 18% water/bay, 2% barren, and 1% agricultural land uses (Figure 2). Between 2002 and 2007, the watershed lost 11 mi<sup>2</sup> of forest, 0.8 mi<sup>2</sup> of agriculture, and 0.8 mi<sup>2</sup> of wetlands and gained 12.2 mi<sup>2</sup> of urban land (Figure 3).



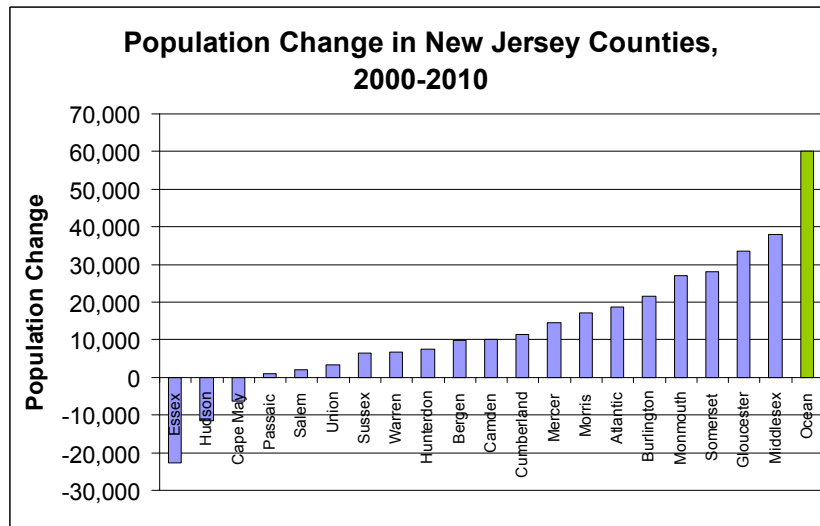
**Figure 2.** Land use in the Barnegat Bay watershed, 2007 (NOAA CSC 2007)



**Figure 3.** Land use change in the Barnegat Bay watershed, 2002-2007 (NOAA CSC 2007)

In 2010, the Barnegat Bay watershed population in Ocean County ranged from 576,567 during the winter to 1,500,000 during the summer tourist season (Ocean County Planning Board 2011). Between 2000 and 2010, the Ocean County population grew by 59,992 people (11.7%) from

513,686 to 576,567. During this period, Ocean County gained the most population of any county in New Jersey (Figure 4). In 2010, total employment in Ocean County was 236,590 with most jobs provided by health care, government, and retail.



**Figure 4.** Population change in New Jersey counties, 2000-2010 (U.S Census Bureau 2010 and Ocean County Planning Board 2011)

## Methods

This research quantifies the economic value of the Barnegat Bay watershed based on three levels of analysis: (1) annual economic activity, (2) ecosystems good and services, and (3) basin-related jobs and wages. The study area is defined by the hydrologic boundaries of the Barnegat Bay watershed from the headwaters in the Pine Barrens of Central New Jersey in Ocean County and Monmouth County and extending east to the two inlets to the Atlantic Ocean at Barnegat Light and Little Egg Harbor including the bay and coastal barrier islands. We gathered from data 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, and ArcGIS map layers of census blocks.

When primary ecological valuation data from the Barnegat Bay watershed was not available, benefits transfer was used to translate data from other sites to the study area. Benefits transfer involves extrapolating benefits calculated by previous studies in other sites to the watershed in question with appropriate adjustments (EPA 2012). Benefits are converted to 2010 dollars based on the average annual change (3%) in the Consumer Price Index (CPI) in the Northeast Region from 1991-2010 as reported by the Bureau of Labor Statistics using the following formula. The discount rate of 3% was chosen as representative of the change in interest rates for borrowing over a 20-year period up to and including the base year of 2010.

$$B_{\$2010} = B_b(1+r)^t$$

Where:

$B_{\$2010}$  = Benefit in 2010 dollars

$B_b$  = Benefits estimated for the base year from the literature

r = Annual change in Consumer Price Index (3%)  
t = Time in years counted from the base year through 2010

**Annual Economic Activity:** We estimated the annual value of agriculture, water quality, water supply, fishing, hunting, recreation, boating, ecotourism, and navigation in the basin 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). Valuation methods include avoided cost which accounts for the costs if certain ecosystems are not present or lost such as the loss of wetlands that may increase economic flood damages. Replacement costs account for natural services lost and replaced by more expensive manmade systems, for instance, forests provide water filtration benefits that are replaced by costly water filtration plants. Net factor income by enhancement of income is derived where improved water quality water enhances fisheries and crabbing industries and, in turn, boosts jobs and wages. Travel cost involves visitors willing to pay to travel and visit ecosystems and natural resources for hunting, fishing, and birding. The hedonic pricing method involves residents willing to pay more for property values that are higher along scenic bay and river coastlines. Contingent valuation surveys estimate how much people may be willing to pay more in source water fees.

**Ecosystem Goods and Services:** We tabulated the natural capital or value of habitat in the watershed such as wetlands, forests, farmland, and open water. Ecosystem services (ecological services) are provided by nature and represent benefits such as water filtration, flood reduction, and drinking water supply. Using GIS, we defined ecosystem areas using 2006 NOAA Coastal Services Center land cover data for wetlands, marine, farmland, forest, barren, urban, beach/dune, and riparian buffer habitats. Ecosystem services were estimated using value (benefits) transfer where published data and literature from other watersheds are transferred to the resource in question (the Delaware Basin). We computed ecosystem services value by multiplying land use area by the ecosystem value (\$/acre). Value transfer involves selecting data from published literature from another watershed and applying the dollar per acre values to the basin in questions. Values from previous studies were adjusted to \$2010 based on 3% change in consumer price index (CPI) annually. Net present values were calculated based on an annual discount rate of 3% in perpetuity (over 100 years in the future).

**Jobs and Wages:** We obtained employment and wage data from the U. S. Department of Labor, U. S. Census Bureau, and National Ocean Economics Program and calculated direct/indirect jobs by North American Industry Classification System (NAICS) code for shipbuilding, marine transportation/ports, fisheries, recreation, minerals, trade, agriculture, and other industries tied to the function of the rivers. Jobs/wages were scaled for each basin county from 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 water supply and wastewater treatment utilities. Jobs and salaries were obtained from U. S. Bureau of Labor Statistics and U. S. Census Bureau data bases for the following scenarios:

- Total jobs in each county within the watershed classified by NAICS industry code (formerly SIC code) and then grouped by census tract.

- Direct watershed-related jobs such as water/sewer construction, living resources, maritime, tourism/recreation, ports, environmental services, and water/wastewater management for each NAICS code by state and county within the basin boundary.
- Indirect jobs/wages from purchases of goods/services by direct jobs earners in the watershed in the interlinked regional economy. Indirect jobs were estimated by multipliers of 2.2 applied to direct jobs and 1.8 to direct wages (Latham and Stapleford 1987), i.e. 100 direct jobs support 120 indirect jobs and direct wages of \$1,000 provide \$800 indirect wages.

## Results

**Annual Economic Activity:** The value of the economy and ecology in the Barnegat Bay watershed exceeds \$4 billion from public parks (\$1.8 billion), recreation (\$1.5 billion), water quality (245 million), forests (\$208 million), fish/wildlife (\$189 million), water supply (\$59 million), and agriculture (\$12 million) benefits (Table 4 and Figure 6).

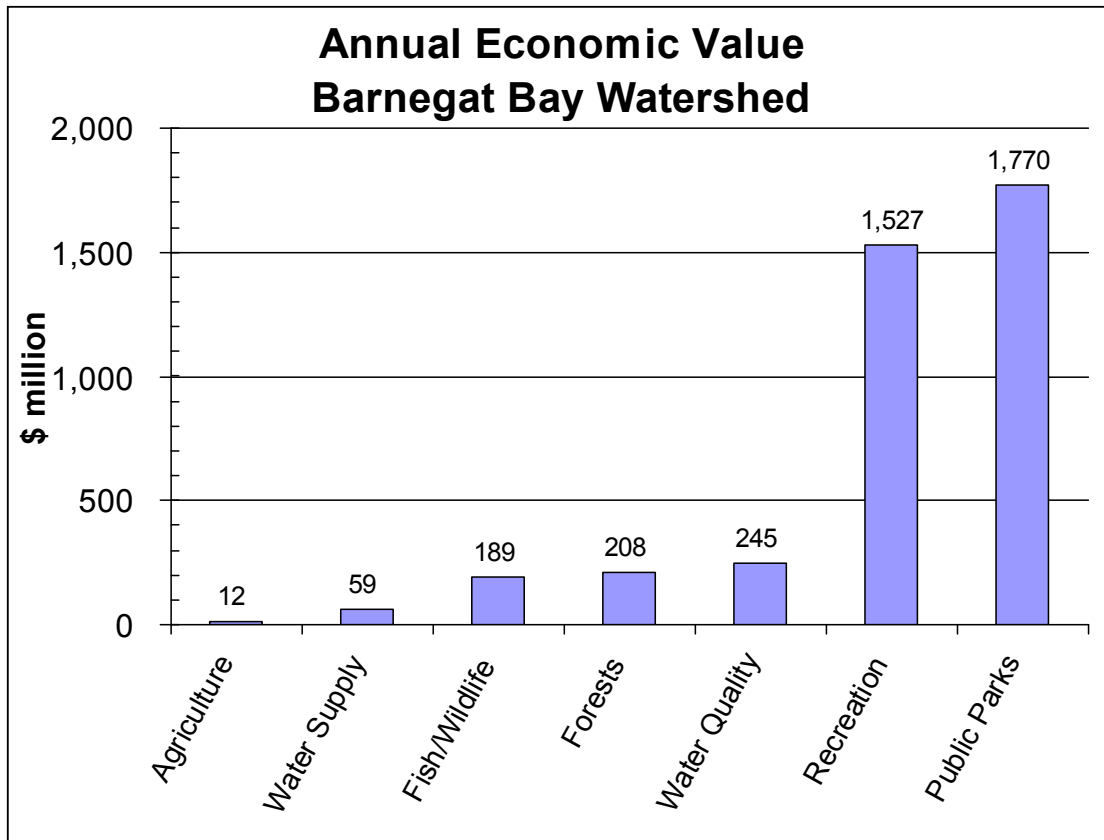
**Table 4.** Annual economic value of the Barnegat Bay watershed

Activity	2010 (\$ million)	Source
<b>Recreation</b>		
Swimming (\$13.40/trip)	33	Johnston et al. 2002, Leeworthy and Wiley 2001
Boating (\$30.00/trip)	28	Johnston et al. 2002, Leeworthy and Wiley 2001
Fishing (\$62.79/trip)	60	Johnston et al. 2002, Leeworthy and Wiley 2001
Wildlife/Bird Watching (\$77.73/trip)	138	Johnston et al. 2002, Leeworthy and Wiley 2001
Outdoor Recreation (228,000 participants)	256	Outdoor Industry Association 2006
Power-Boating (22,505 registered boaters)	590	Marine Trades Assn. of New Jersey 2008
Beach Visits (\$27.66/visitor day along 45 mile coast)	395	Parsons et al. 1999, Seneca 2011
<b>Water Quality</b>		
Boatable (WTP 13.20/p., 576,000–1,500,000 pop.)	20	Helm, Parsons, and Bondelid 2003
Fishable (WTP 13.22/p., 576,000–1,500,000 pop.)	20	Helm, Parsons, and Bondelid 2003
Swimmable (WTP \$112.75/p., 576,000–1,500,000 pop.)	170	Helm, Parsons, and Bondelid 2003
Water Treatment by Forests (\$75/mgd)	2	Trust for Public Land and AWWA 2004
Wastewater Treatment (no discharges to bay)	0	Ocean County 2010
Increased Property Value (+8% over 20 years)	33	EPA 1973, Brookings Institute 2010
<b>Water Supply</b>		
Drinking Water Supply (\$1.168/1,000 gallons)	23	USGS 2005, NJWSA 2012
Irrigation Water Supply (\$300/acre-foot)	1	USDA 2009, Frederick et al. 1996
Thermoelectric-Power Water Supply (\$44 acre-foot)	34	Frederick et al. 1996, USGS 2005
Industrial Water Supply (\$200/acre-foot)	1	Frederick et al. 1996, USGS 2005
<b>Fish/Wildlife</b>		
Commercial Fish Landings (\$0.60/lb)	49	NMFS, NOEP 2010
Fishing (11-18 trips/angler, \$17-\$53/trip)	58	U.S. Fish and Wildlife Service 2007
Hunting (16 trips/hunter, \$16-50/trip)	11	U.S. Fish and Wildlife Service 2007)
Wildlife/Bird-watching (8-13 trips/yr, \$15-\$27/trip)	41	U.S. Fish and Wildlife Service 2007
Forsythe National Wildlife Refuge, 196,000 visits/yr	4	Carver and Caudill 2007
Hard Clams (15,000 lb @ \$5.50/lb)	0.1	NMFS
Blue Crab (7 million lb @ \$1.10/lb)	1	NMFS, NOEP 2010
Summer Flounder (\$10.26/trip, 2.5 million trips) trips/yr)	25	Liggett in Bricker et al. 2007, Lipton 2006
<b>Agriculture</b>		
Nursery, crop, poultry, livestock value (\$2,600/ac)	12	USDA Census of Agriculture 2009
<b>Forests</b>		
Carbon Storage (176,000 ac @ \$827/ac)	145	Nowak et al. 2008
Carbon Sequestration (176,000 ac @ \$29/ac)	5	Nowak et al. 2008
Air-Pollution Removal (176,000 ac @ \$266/ac)	47	Nowak et al. 2008



Building Energy Savings (176,000 ac @ \$56/ac)	10	Nowak et al. 2008
Avoided Carbon Emissions (176,000 ac @ \$3/ac)	1	Nowak et al. 2008
<b>Public Parks</b>		
State Parks (\$21/visit, 32,601 acres)	27	Mates and Reyes 2006
Health Benefits (\$9,734/ac)	1,313	Trust for Public Land 2009
Community Cohesion (\$2,383/ac)	321	Trust for Public Land 2009
Stormwater Benefit (\$921/ac)	124	Trust for Public Land 2009
Air-Pollution Control (\$88/acr)	12	Trust for Public Land (2009)
<b>Barnegat Bay Watershed</b>	<b>&gt;4 billion</b>	

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



**Figure 6.** Annual economic value of the Barnegat Bay watershed

Recreation: Travel cost demand data transferred from the Peconic Estuary (Johnston et al. 2002) indicate the annual consumer surplus for swimming, boating, fishing, and bird watching/wildlife viewing totals \$260 million given recreation activity in the bay watershed accounts for 883,000 participants and 11.1 million visitor days annually (Leeworthy and Wiley 2001). Paddling-based recreation such as canoeing, kayaking, and rafting in the Barnegat Bay watershed involves 228,000 participants, \$257 million in gear retail and trip sales, and 3,029 jobs based on scaled estimates by population from the Outdoor Industry Association (2006). Recreational boating supported 182 marinas in the watershed (Ocean County Planning Department 2011) and 19,000 boats in commercial boats in storage. The Barnegat Bay ranked No. 1 as the most popular boating area in New Jersey with 22,505 registered boaters that represent 28% of all the boats registered in the Garden State. Recreational boating contributes \$590-\$740 million annually to the Barnegat Bay economy and is responsible for 5,000-6,300 jobs (Marine Trades Association of New Jersey (2008).



New Jersey had 3,965,000 annual ocean beach visits for a total of 40,881,000 beach visitor days (Seneca 2011). If the mean beach travel cost is \$27.66 per visitor day in 2010 dollars (Kline and Swallow 1998, Leeworthy and Wiley 1991, Parsons et. al 1999) and Ocean County beaches cover 45 miles or 35% of New Jersey's 130-mile ocean coast, then the scaled economic value of beach visits to the Barnegat Bay watershed is \$395 million.

Water Quality: Swimmable (\$65 to \$169 million), fishable (\$8 to \$20 million), and boatable (\$8 to \$20 million) benefits due to improved water quality range from \$80 to \$209 million (\$139 per person) for a watershed population that varies from 576,000 year-round to 1,500,000 during the summer as scaled from Helm, Parsons, and Bondelid (2003) in \$2010. Loss of forests that occupy 36% of the Barnegat Bay watershed would increase treatment costs for public water supplies by \$1.5 million/yr given that for every 10% increase in forest area, water treatment costs decline by 20% (Trust for Public Land and AWWA, 2004). There are no wastewater treatment plant discharges to the Barnegat Bay therefore the bay is not called upon to provide wastewater assimilation services. Property valued at \$283,000/ac within 2000 feet of the 119-mile bay shoreline will increase 8% by \$653 million or \$33 million/yr over 20 years due to water quality improvements in the Barnegat Bay watershed (EPA 1973).

Water Supply: The annual economic value of water supplies withdrawn from the Barnegat Bay watershed is \$ 59 million. The value of public drinking water supplies in the bay watershed (54.5 mgd) is \$23.2 million based on the value of raw (untreated) public water supply in the Manasquan system at \$1,168 per million gallons (NJWSA 2012). Irrigation withdrawals mainly for corn, soybean, and vegetable crops is rising due to warmer temperatures during the summer and the value is based on withdrawals of 4.2 mgd (USGS 2005) is \$1.4 million/year given the median value of irrigation withdrawals is \$0.92/1000 gal) in \$2010 from Frederick et al. (1996). The economic value of water to irrigate 4,423 acres of cropland (USDA 2009) in Ocean County is \$240,000 based on irrigation water needs of 9 inches from June through September at a unit value of \$300/acre-foot (Frederick et al. 1996). The Oyster Creek Nuclear Generating Station withdraws 662 mgd of non-contact cooling water from the bay watershed and value of thermoelectric power plant water withdrawals is \$34 million/yr based on a unit value of \$0.14/1000 gallons from Frederick et al. (1996). The annual value of industrial water supply withdrawals (3.1 mgd) in the bay watershed (USGS 2005) is \$690,000 based on a unit value of \$200/ac ft adjusted to \$2010 from Frederick et al. (1996).

Fish/Wildlife: The annual economic value of fish and wildlife in the Barnegat Bay watershed is \$189 million. The annual value of commercial fish landings from the 32<sup>nd</sup> (Barnegat Light) and 36<sup>th</sup> (Point Pleasant) most valuable fishing ports in the U.S. was \$48.6 million in \$2010 according to the National Marine Fisheries Service (NOEP 2010). Scaled by ratio of watershed area to state area, the annual value of trip and gear expenditures for fishing (\$57.9 million), hunting (\$11.2 million), and wildlife/birding viewing recreation (\$41.4 million) is \$110.5 million in the bay watershed (USFWS 2007). The 47,000 acre Edwin B. Forsythe National Wildlife Refuge was the 15th most visited refuge in the nation with nearly 196,000 recreational visits in 2006 and the monetary value from recreational visitor spending was \$4.4 million which contributed to 41 jobs with \$1.5 million in annual wages (Carver and Caudill 2007).

NMFS data indicates hard clam landings dropped from 1.2 million lb in 1970 to 15,000 lb in 2005 where at \$5.50/lb, hard clam landings (15,000 lb) had an estimated value of \$82,500. The NMFS reports that in 2007 (NOEP 2010), 4.8 million lb of blue crabs were harvested in New Jersey with a landed value of \$5.5 million adjusted to 2005 dollars and if blue crab landings in the Barnegat Bay total about 15% of New Jersey's total commercial catch, the estimated value of the bay's blue crab fishery is \$825,000. A study of the value of mid-Atlantic recreational fisheries estimated a. Summer flounder accounts for 2.5 million trips or 42% of 5.9 million inland fishing trips in the Barnegat Bay, therefore, at a \$10.26 benefit due to increased catch per trip, the estimated benefit to summer flounder fishers from improved in water quality in Barnegat Bay is \$25.4 million/year (Liggett in Bricker et al. 2007, Lipton 2006, McConnell and Strand 1994).

**Agriculture:** The USDA National Agricultural Statistics Service (2009) estimated the annual market value of agricultural products sold in Ocean County was \$11.5 million on 4,423 acres from nurseries, vegetables, fruit, horses, grain, poultry, cattle, poultry, and Christmas trees.

**Forests :** The U. S. Forest Service and Delaware Center for Horticulture (Nowak et al., 2008) estimated forests in New Castle County, Delaware have carbon storage (\$79/ac), carbon sequestration (\$29/ac), air pollution removal (\$266/ac), building energy savings (\$56/yr), and avoided carbon emissions (\$3/ac) benefit of \$5.9 million (\$827/ac) and air pollution removal of \$1.9 million (\$266/ac/yr). Applying these per acre multipliers, 176,320 forested acres in the Barnegat Bay watershed provide economic benefits that total \$208 million/yr. These economic benefits in carbon, air pollution, and energy savings are quite significant as 34% of the bay watershed is covered by forests.

**Parks:** Mates and Reyes (2007) from the NJDEP reported at a central estimate of \$21 per visit, 14.2 million visitors per year to the New Jersey state park and forest system contributed \$304 to \$347 million annually from 2000-2005 to the State economy and supported about 7,000 jobs. In fiscal year 2011, the state parks recorded 18.8 million visitors. Island Beach State Park, Byrne State Forest, Bass River State Forest, and Double Trouble State Park cover 32,601 acres in the Barnegat Bay watershed. Scaling by proportion of state parks in the watershed to the area of New Jersey (32,601 ac /422,000 ac or 7.7%), state parks in the Barnegat Bay watershed contribute approximately \$23 to \$27 million and 539 jobs to the local economy.

Public parks on 135,000 acres provide \$1.8 billion in annual economic value to the Delaware River Basin. The Trust for Public Land (2009) found the City of Wilmington park system provides annual economic savings to the public due to health benefits from exercise in the parks (\$9,734/ac), community cohesion benefit from socializing in the parks (\$2,383/ac), water pollution benefits from treating stormwater (\$921/ac), and air pollution mitigation by tree and shrub absorption (\$88/ac). Transferring the unit values from the City of Wilmington study, public parks (135,000 ac) within the Barnegat Bay watershed provide health (\$1.3 billion), community cohesion (\$321 million), water pollution (\$124 million), and air pollution mitigation (\$12 million) benefits.

**Ecosystem Services:** Ecosystem services provided by natural habitat 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. 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.

Other studies have defined ecosystem services in areas near the Barnegat Bay watershed (Table 5). A Cecil County, Maryland study by the Conservation Fund found that riparian forest wetlands provide significant stormwater/flood control (\$32,000/ac), water supply (\$8,630/ac), and clean water (\$1,925/ac) functions (Weber 2007). The NJDEP and University of Vermont estimated the value of New Jersey’s natural capital was \$20 billion/yr (+/- \$9 billion/year) in \$2004 with a net present value of \$681 billion based on a discount rate of 3% calculated over 100 years in the future (Mates and Reyes 2007). The Wilderness Society (Krieger 2001) concluded temperate forest ecosystem services from climate regulation, water supply, water quality, and recreation totaled \$392/ac in \$1994. A contingent value study by University of Rhode Island economists found natural resources values in the Peconic Estuary watershed on Long Island in New York ranged from \$6,560/ac for wetlands to \$9,979/ac for farmland in \$1995 (Johnston et al. 2002). Ingraham and Foster (2008) from the University of Maryland determined ecosystem values of forests and freshwater wetlands in the National Wildlife Refuge System were \$845/ac and \$6,268/ac, respectively. The Audubon Society found the economic value of ecosystems in Massachusetts ranged from \$984/ac for forests to \$15,452/ac for saltwater wetlands (Breunig 2003). The market value of agricultural crops, poultry, and livestock sold from 4,423 acres of farmland in Ocean County within the Barnegat Bay watershed was \$11.5 million (\$9.3 million in crops and \$2.2 million in livestock/poultry) or \$2,600/ac (USDA 2009).

**Table 5.** Comparison of ecosystem goods and services values from various studies

Ecosystem	Cecil Co. Md. <sup>1</sup> 2006 (\$/ac/yr)	NJDEP <sup>2</sup> 2007 (\$/ac/yr)	Wilderness Society <sup>3</sup> 2001 (\$/ac/yr)	Peconic Estuary <sup>4</sup> 1995 (\$/ac/yr)	U.S. Wildlife <sup>5</sup> 2008 (\$/ac/yr)	Mass. Audubon <sup>6</sup> 2003 (\$/ac/yr)	USDA Census <sup>7</sup> 2007 (\$/ac/yr)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	2,600 <sup>1</sup>
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			

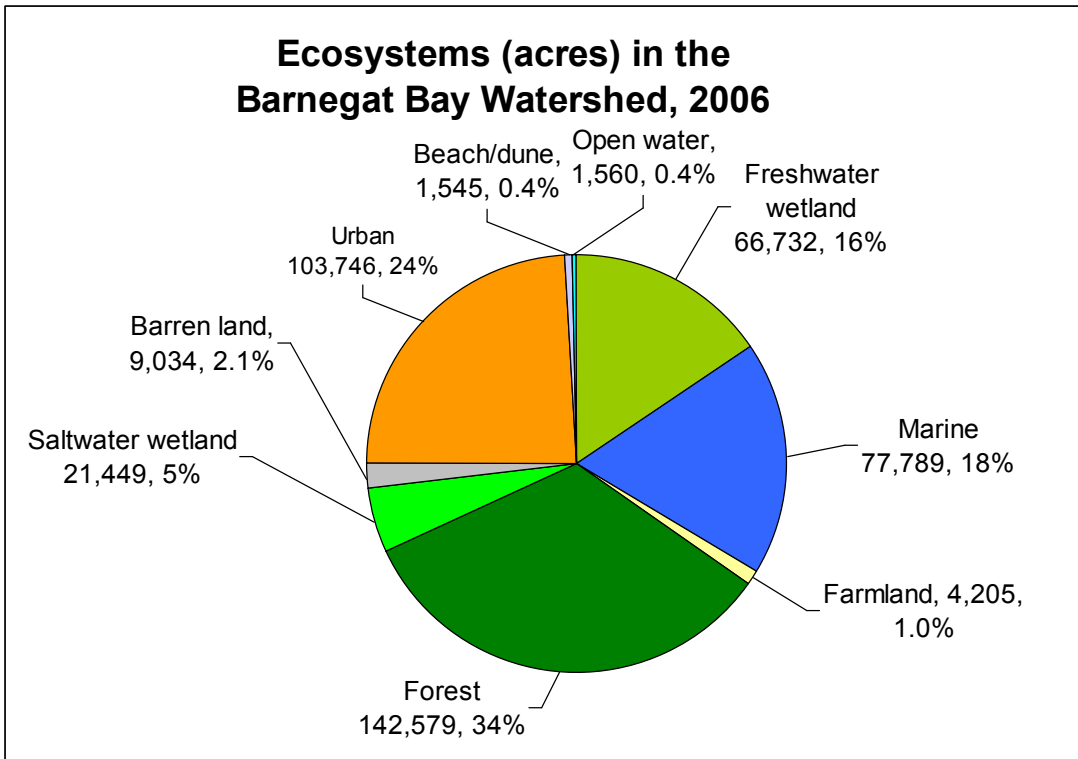
1. Weber 2007. 2. Mates and Reyes 2007. 3. Krieger 2001. 4. Johnston et al. 2002. 5. Ingraham and Foster 2008. 6. Breunig 2003. 7. USDA 2009.

The estimated value of natural goods and services provided by ecosystems in the Barnegat Bay watershed (428,639 ac or 670 mi<sup>2</sup>) is \$2.3 billion (in 2010 dollars) with a net present value (NPV) of \$73.3 billion based on an annual interest rate of 3% (Table 6). If lowest or highest per acre estimates of ecosystem services values from other studies were employed for value transfer in place of the NJDEP values, the value of natural resources in the Barnegat Bay watershed would range from \$1.4 billion to \$6.0 billion. Ecosystems within the Barnegat Bay watershed (Figure 7) are comprised of forests (34%), open water/marine (18%), freshwater wetlands (16%), saltwater wetlands (5%), and farmland (1%). Over 24% of the Barnegat Bay watershed is urban. Freshwater wetlands (\$908 million or \$13,621/ac), marine/bay (\$778 million or \$10,005/ac), forests (\$282 million or \$1,978/ac), and saltwater wetlands (\$155 million or \$7,236/ac) provide the highest ecosystems goods and services values (Figure 8). The natural capital value of the watershed will decrease if urban land replaces forests that currently cover 1/3 of the watershed.

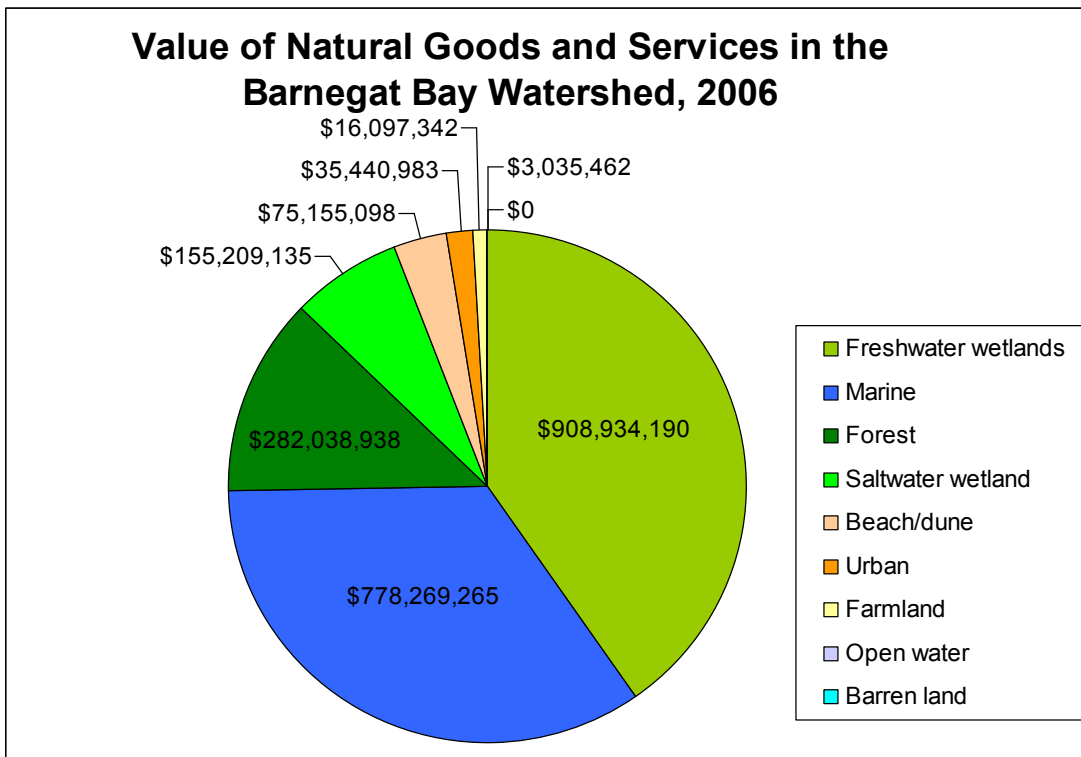
**Table 6. Ecosystem Services Values in the Barnegat Bay Watershed**

Ecosystem	Area (ac)	\$/ac/yr 2010	PV 2010 \$	NPV \$
<b>Low Range</b>				
Freshwater wetlands	66,732	6,268 <sup>5</sup>	418,276,176	13,593,975,720
Marine	77,789	8,670 <sup>2</sup>	674,430,630	21,918,995,475
Farmland	4,205	1,387 <sup>6</sup>	5,832,335	189,550,888
Forest land	142,579	641 <sup>3</sup>	91,393,139	2,970,277,018
Saltwater wetland	21,449	6,269 <sup>2</sup>	134,463,781	4,370,072,883
Barren land	9,034	0	0	0
Urban	103,746	296 <sup>2</sup>	30,708,816	998,036,520
Beach/dune	1,545	42,149 <sup>2</sup>	65,120,205	2,116,406,663
Open water	1,560	217 <sup>5</sup>	338,520	11,001,900
Total	428,639		1,420,563,602	46,168,317,065
<b>Mid-Point Estimate</b>				
Freshwater wetlands	66,732	13,621	908,934,190	29,540,361,169
Marine	77,789	10,005	778,269,265	25,293,751,116
Farmland	4,205	3,828	16,097,342	523,163,602
Forest	142,579	1,978	282,038,938	9,166,265,479
Saltwater wetland	21,449	7,236	155,209,135	5,044,296,887
Barren land	9,034	0	0	0
Urban	103,746	342	35,440,983	1,151,831,952
Beach/dune	1,545	48,644	75,155,098	2,442,540,696
Open water	1,560	1,946	3,035,462	98,652,528
Total	428,639		2,254,180,413	73,260,863,428
<b>High Range</b>				
Freshwater wetlands	66,732	43,685 <sup>1</sup>	2,915,187,420	94,743,591,150
Marine	77,789	8,670 <sup>2</sup>	674,430,630	21,918,995,475
Farmland	4,205	9,979 <sup>4</sup>	41,961,695	1,363,755,088
Forest land	142,579	12,033 <sup>1</sup>	1,715,653,107	55,758,725,978
Saltwater wetland	21,449	28,146 <sup>1</sup>	603,703,554	19,620,365,505
Barren land	9,034	0	0	0
Urban	103,746	296 <sup>2</sup>	30,708,816	998,036,520
Beach/dune	1,545	42,149 <sup>2</sup>	65,120,205	2,116,406,663
Open water	1,560	1,686 <sup>2</sup>	2,630,160	85,480,200
Total	428,639		6,049,395,587	196,605,356,578

1. Weber 2007. 2. Mates and Reyes 2007. 3. Krieger 2001. 4. Johnston et al. 2002. 5. Ingraham and Foster 2008. 6. Breunig 2003.



**Figure 7.** Ecosystem service areas in the Barnegat Bay watershed



**Figure 8.** Value of ecosystem services within the Barnegat Bay watershed

**Jobs and Wages:** The Barnegat Bay watershed supports over 60,000 direct and indirect jobs with over \$2 billion in annual wages in the coastal, fishing/hunting/birding, farm, tourism, recreation, water/wastewater, and watershed sectors (Table 7). It is noted that use of indirect jobs benefits is debated in many economic circles. While certainly not null, indirect jobs benefits calculated by multipliers are summarized here to estimate some part of the spinoff effect to the economy from jobs directly related to the waters of the Delaware Basin.

**Table 7.** Jobs and wages directly and indirectly related to the Barnegat Bay watershed

Sector	Jobs	Wages (\$ million)	Data Source
Direct Watershed-Related	25,630	851	U.S. Bureau of Labor Statistics 2010
Indirect Watershed-Related	30,756	681	U.S. Census Bureau 2010
Coastal	11,565	206	National Coastal Economics Program 2010
Farm	1,045	50	Awokuse et al. 2010
Fishing/Hunting/Birding	3,364	110	U.S. Fish and Wildlife Service 2008
National Wildlife Refuge	41	1.5	Carver and Caudill 2007
Wetlands	360	23	NOAA Coastal Services Center 2011
Boating	5,000	200	Marine Trades Association of NJ 2008
Outdoor Recreation	3,029	150	Outdoor Industry Association 2006
State Parks	539	27	Mates and Reyes 20067
Watershed Organizations	50	3.1	N. J. Environmental Center and BLS
Water Supply Utilities	535	30	Ocean County water purveyors
Wastewater Utilities	50	3	Ocean County Utilities Authority
<b>Barnegat Bay Watershed</b>	<b>&gt;60,000</b>	<b>&gt;\$2 billion</b>	

The Barnegat Bay watershed is home to 236,590 nonfarm jobs with \$12.7 billion in wages in Ocean County, New Jersey (Bureau of Labor Statistics 2010) as summarized in Table 8. Jobs directly associated with the Barnegat Bay watershed (Table 9) such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports employed 25,630 people with \$851 million in wages. Jobs indirectly related to the Barnegat Bay watershed (based on multipliers of 2.2 for jobs and 1.8 for salaries) employed 30,756 people with \$681 million in wages.

**Table 8.** Barnegat Bay watershed jobs and wages in 2010

Category	Jobs	Wages (\$ million)
Total Ocean County, NJ	236,590	12,700
Direct Watershed-related	25,630	851
Indirect Watershed-related	30,756	681

**Table 9.** Direct and indirect watershed-related jobs in the Barnegat Bay watershed, 2009

Sector	North American Industry Classification System (NAICS)	NAICS code	Direct Watershed Jobs <sup>1</sup>	Direct Annual Watershed Wages <sup>1</sup> (x\$1000)	Indirect Watershed Jobs <sup>2</sup>	Indirect Annual Wages <sup>2</sup> (x\$1000)
Construction	Water and sewer construction	23711	0	6,853	0	5,482
Living Resources	Fishing, hunting, trapping	114	43	1,367	52	1,094
	agriculture and forestry	115	21	191	25	153
	Seafood prep./ packaging	3117			0	0
	Wineries	31213			0	0
	Fish and seafood wholesalers	42446	36	1,457	43	1,166
	Nursery, garden center, farm	44422	90	3,970	108	3,176
	Fish and seafood markets	44522	24	1,006	29	805
	Fruit and vegetable markets	44523	22	752	26	602
Minerals	Mining, quarrying	21	61	3,957	73	3,166
	Electric power generation	2211	1,079	117,145	1,295	93,716
Boat Building	Ship and boat building	3366	12	591	14	473
Tourism/Recreation	Sporting/recreational goods	42391	31	1,481	37	1,185
	Sporting goods stores	45111	256	5,893	307	4,714
	Recreational goods rental	532292		431	0	345
	Commercial water transport.	532411			0	0
	Recreational vehicle dealers	44121	88	4,327	106	3,462
	Boat dealers	441222	285	13,160	342	10,528
	Museums, historical sites	712			0	0
	Amusement parks and arcades	7131		37,931	0	30,345
	Amusement arcades	71312	303	8,812	364	7,050
	Amusement/recreation	7139	2,402	52,020	2,882	41,616
	Golf courses/	71391	295	9,029	354	7,223
	Marinas	71393	266	12,838	319	10,270
	Fitness/recreational sports	71394	1,584	20,278	1,901	16,222
	Amusement/recreation	71399	129	7,804	155	6,243
	Accommodation	721	599	16,217	719	12,974
	Hotels and motels	72111	549	14,707	659	11,766
	Bed-and-breakfast inns	721191		203	0	162
	Recreational vehicle, camps	7212	39	1,307	47	1,046
	Full-service restaurants	7221	5,511	95,445	6,613	76,356
	Limited-service restaurants	722211	3,530	50,991	4,236	40,793
Snack/beverage bars	722213	693	10,105	832	8,084	
Food service contractors	72231	738	13,705	886	10,964	
Caterers	722320	265	4,613	318	3,690	
Mobile food services	72233	47	445	56	356	
Transportation	Coastal, water transportation	483		305	0	244
	Inland water transportation	4832	15	192	18	154
	Scenic/sightseeing transport.	487		1,603	0	1,282
	Marine cargo handling	4883	46	2,363	55	1,890
	Navigational services/shipping	488320	60	1,546	72	1,237
	Water transportation	48839	36	1,530	43	1,224
Environmental	Architectural, engineering	541	5,680	290,841	6,816	232,673
	Environmental, conservation	813211	151	3,574	181	2,859
	Civic and social organizations	8134	122	1,901	146	1,521
Water/Wastewater	Water, sewage systems	2213	129	8,636	155	6,909
	Waste management services	562	393	19,443	472	15,554
<b>Total</b>			<b>25,630</b>	<b>850,965</b>	<b>30,756</b>	<b>680,772</b>

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



According to the National Ocean Economic program (2010) that tabulates jobs in the Marine Transportation, Tourism and Recreation, Living Marine Resources, Marine Construction, Ship and Boat Building, Mineral Extraction sectors, the coastal economy in Ocean County that covers nearly the entire Barnegat Bay watershed, contributed 145,966 jobs with \$5.7 billion in annual wages (Table 10). The Ocean County ocean economy contributed 11,565 jobs with 206 million in wages (Table 11).

**Table 10.** Coastal employment, wages, and GDP in Ocean County, New Jersey (NOEP 2010)

<b>Sector</b>	<b>Employment</b>	<b>Wages (\$ million)</b>
Construction	6,690	324.8
Financial Activities	5,873	269.4
Education/Health Services	46,938	2,064.7
Information	1,151	76.9
Leisure/Hospitality	18,825	310.4
Manufacturing	4,500	221.3
Natural Resources/Mining	264	9.3
Other Services	5,212	137.0
Professional/Business	10,873	463.7
Public Administration	10,434	626.5
Trade/Transportation/Utilities	33,993	1,132
Misc.	1,213	31.6
<b>Total</b>	<b>145,966</b>	<b>5,667,588.5</b>

**Table 11.** Ocean/coastal employment, wages, and GDP in Ocean County, New Jersey (NOEP 2010)

<b>Sector</b>	<b>Employment</b>	<b>Wages (\$ million)</b>
Marine Construction	<b>181</b>	9.6
Living Resources	57	1.1
Minerals	78	4.7
Tourism & Recreation	11,089	183.5
Marine Transportation	160	7.2
Ship and Boat Building		
<b>Total</b>	<b>11,565</b>	<b>206.1</b>

In 2007 there were 255 farms in Ocean County, New Jersey with in the Barnegat Bay watershed (USDA 2007). The USDA estimates each farm employs 4.1 full time equivalent jobs so farming provides 1,045 jobs with \$50.3 million in wages in the bay watershed. The average annual salary per ecotourism job is \$32,843 using data 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 Barnegat Bay watershed accounts for \$110.5 million in annual economic activity in 2006 dollars), then fishing, hunting, and wildlife associated recreation provides for 3,364 jobs.

Recreational pursuits that rely on clean and plentiful water resources in the Barnegat Bay watershed provide thousands of jobs in the regional economy. The Edwin B. Forsythe National Wildlife Refuge was the 15<sup>th</sup> most visited refuge in the nation and contributed to 41 jobs with \$1.5 million in annual wages (Carver and Caudill 2007). At an average salary of \$32,843, fishing, hunting, and bird/wildlife-associated recreation accounts 3,364 jobs in the Barnegat Bay watershed (USFWS 2007). The NOAA Coastal Services Center (2011) estimates wetlands cover 160 mi<sup>2</sup> (25% of Ocean County) and support 360 commercial, recreational, and charter fishing jobs in Barnegat Bay watershed with \$22.7 million in wages. Registered boaters accounted for \$2.1 billion in total recreational boating expenditures in New Jersey and 27.9% of N.J. recreational boats are docked in Ocean County, therefore, by proportion recreational boating in the Barnegat Bay watershed is responsible for 5,000 jobs with \$200 million in wages (Marine Trades Association of New Jersey 2008). Scaled estimates from the Outdoor Industry Association (2006) indicates recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing in the Barnegat Bay watershed (pop. 576,567) contributes 3,029 jobs. Island Beach State Park, Byrne State Forest, Bass River State Forest, and Double Trouble State Park cover 32,601 acres in the Barnegat Bay watershed and these state parks in support 539 jobs with \$27 million in the local economy.

Public and private water utilities withdraw over 53 mgd of drinking water from surface and groundwater supplies in Ocean County and at an average salary of 55,407, the water utilities employ at least 535 jobs with annual wages of \$29.6 million. The Ocean County Utilities Authority employs 50 staff who operate 3 wastewater treatment plants with a capacity of 80 mgd and serve 36 towns in Ocean County and Monmouth County, New Jersey. Thirteen nonprofit watershed and environmental organizations employ at least 50 professionals with an average salary of \$61,700 who earn at least \$3.1 million in wages on programs to restore the watersheds in the Barnegat Bay watershed.

## **Discussion and Conclusions**

The Barnegat Bay watershed in Ocean County, New Jersey includes a valuable estuary and ecosystems where tourism fuels a \$4 billion annual economy and \$432 million in state and local income taxes with \$95 billion in property tax ratables (Ocean County Board of Taxation 2012). The annual economic value of the Barnegat Bay watershed is a least \$4 billion based on estimates of economic activity, ecosystem services, and jobs and wages related to the waters of the watershed. The Barnegat Bay watershed contributes \$4 billion in annual economic activity from public parks (\$1.8 billion), recreation (\$1.5 billion), water quality (245 million), forests (\$208 million), fish/wildlife (\$189 million), water supply (\$59 million), and agriculture (\$12 million) benefits. The value of natural goods and services from ecosystems in the Barnegat Bay watershed is \$2.3 billion from freshwater wetlands (\$908 million or \$13,621/ac), marine/bay (\$778 million or \$10,005/ac), forests (\$282 million or \$1,978/ac), and saltwater wetlands (\$155 million or \$7,236/ac). The Barnegat Bay watershed that supports over 60,000 direct and indirect jobs with over \$2 billion in annual wages in the coastal, fishing/hunting/birding, farm, tourism, recreation, water/wastewater, and watershed sectors.

This analysis demonstrates that the natural resources of the Barnegat Bay watershed provide real and significant economic benefits to the regional economy and are worthy of investment to keep

them healthy and productive. It is important to note that the economic values in the three categories described above may not be summed because there is some measure of overlap between certain values within each category that could result double-counting. It is also important to note that the estimates presented in this report are not meant to be used to compare/contrast different uses of the basin for their value. Some values were not included in these estimates because the data to assess them is not readily available, or does not exist. Values for the activities and resources vary in how they were applied by value transfer techniques from nearby watersheds to the Barnegat Bay watershed making it difficult to accurately compare values across uses and activities. Gathering more primary economic data from research in the Barnegat Bay watershed (such as local willingness to pay for clean water surveys) would improve comparability of information across uses as well as make value estimates more comprehensive by including confidence intervals with range and error bar estimates.

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