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Economic Value of Nature and Ecosystems in the Delaware River Basin

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Abstract: The Delaware River basin is a valuable ecological and economic resource that supplies drinking water to five percent of the population of the United States. Located in Delaware, New Jersey, New York, and Pennsylvania, the basin supplies drinking water to the nation's first (New York City) and seventh (Philadelphia) largest metropolitan economies, and supports the largest freshwater port in the world while sustaining a recovering anadromous shad and striped bass fishery. The Delaware basin contributes over $22 billion in annual economic activity from potential Marcellus Shale gas extraction ($425 million), recreation ($1.2 billion), fish/wildlife ($1.5 billion), public parks ($1.8 billion), water quality ($2.5 billion), navigation ($2.6 billion), agriculture ($3.4 billion), water supply ($3.8 billion), and forest ($5.1 billion) benefits. The value of natural goods and services from Delaware basin ecosystems is $21 billion ($2010) with net present value of $683 billion with contributions from Delaware ($2.5 billion), New Jersey ($6.6 billion), New York ($3.5 billion), and Pennsylvania ($8.6 billion). The Delaware basin supports 600,000 direct/indirect jobs with $10 billion in wages in the coastal, farm, ecotourism, water/wastewater, ports, and recreation industries. This research demonstrates that the Delaware River basin provides significant economic benefits to the region and is worthy of priority investments by elected officials and decision-makers to protect and restore these natural resources.

Keywords: *watershed, river basin, ecological economics, ecosystem services*

Many economists agree that water is an undervalued resource. The dilemma inherent in defining the economic value of water goes back two centuries to the 1776 *Wealth of Nations* when Adam Smith described the "diamond-water paradox" (U.S. Environmental Protection Agency (U.S. EPA) 2012). If water is more valuable to society than a precious gem, then why is drinking water sold for a penny per 100 gallons or not valued at all as an ecological resource in the river? Society tends to underprice water based on its marginal value for single uses (i.e. drinking water) and not consider the full value for its myriad of uses. If water is society's most valuable chemical, then the Delaware River, with a mean annual flow of 2.7 trillion gallons, is an invaluable economic resource.

Natural systems have substantial economic value in terms of ecosystems goods and services. The estimated annual value of global natural capital ranges from $33 trillion (Costanza et al. 1997) to $125 trillion (Costanza et al. 2014). Ingraham and Foster (2008) concluded the ecosystem services value of the U.S. National Wildlife Refuge System was $27 billion. The New Jersey Department of Environmental Protection (NJDEP) found the value of habitat in the Garden State was $20 billion (Mates 2007). The watersheds and ecosystems in the First State of Delaware are valued at $6.7 billion annually (Narvaez et al. 2012). The economic value of the Barnegat Bay in New Jersey is at least $2.3 billion (Kauffman and Cruz-Ortiz 2012).

Watersheds have significant economic value and restoration of these resources can result in favorable benefit-cost ratios for society. The University of Maryland reported in 1988 that the Chesapeake Bay was worth $678 billion and with the rise in the cost of living the value of the bay exceeded $1 trillion (Chesapeake Blue Ribbon Panel 2003). The Brookings Institution (Austin et al. 2007) estimated restoration of the Great

Lakes would cost $26 billion and provide tourism, fishing, recreation, property value, and water treatment benefits that would exceed $50 billion, a 2:1 benefit/cost ratio. The Everglades Foundation concluded the Comprehensive Everglades Restoration Plan (CERP) would provide $6 billion in benefits with a benefit/cost ratio of 4:1 and generate 443,000 jobs over 50 years (McCormick 2010).

Two decades ago, economists concluded the Delaware River and Bay in Delaware, New Jersey, and Pennsylvania possessed significant economic value. Latham and Stapleford (1987) estimated the Delaware Estuary within Delaware accounted for 10,500 jobs with $222 million in annual wages and each direct estuary job accounted for 2.2 indirect jobs. 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 a wetlands replacement value of $638 million.

Economic benefits are the maximum dollar value of goods and services that individuals are voluntarily willing to pay (WTP) for improved water quality (Cech 2005). In environmental economics, WTP measures how much people are willing to pay for a given good or service regardless of whether they actually pay or not (Goulder and Kennedy 1997). Consumer surplus is the area under the demand (marginal benefit) curve above its price (or value) measured by the difference between the amount individuals actually pay and the amount they are willing to pay for a benefit such as clean drinking water or enhanced fishing provided by improved water quality (Figure 1). That is, consumer surplus is the amount people are willing to pay above the price they pay for it (Thurston et al. 2009). If an individual is willing to pay $6.00 per 1000 gallons for drinking water and the price is $5.00, the consumer surplus is $1.00.

Research Objectives

The following research quantifies the multi-objective value of water *in toto* for its wide range of habitat, recreation, water quality, and water supply uses in the Delaware River basin along the East Coast of the United States. We update the 1990's economic analyses of the Delaware River and Bay and incorporate modern valuation methods from the emerging fields of ecological economics and ecosystem services to estimate the "21st century" value of the interstate Delaware basin in Delaware, New Jersey, New York, and Pennsylvania. The objective of this research is

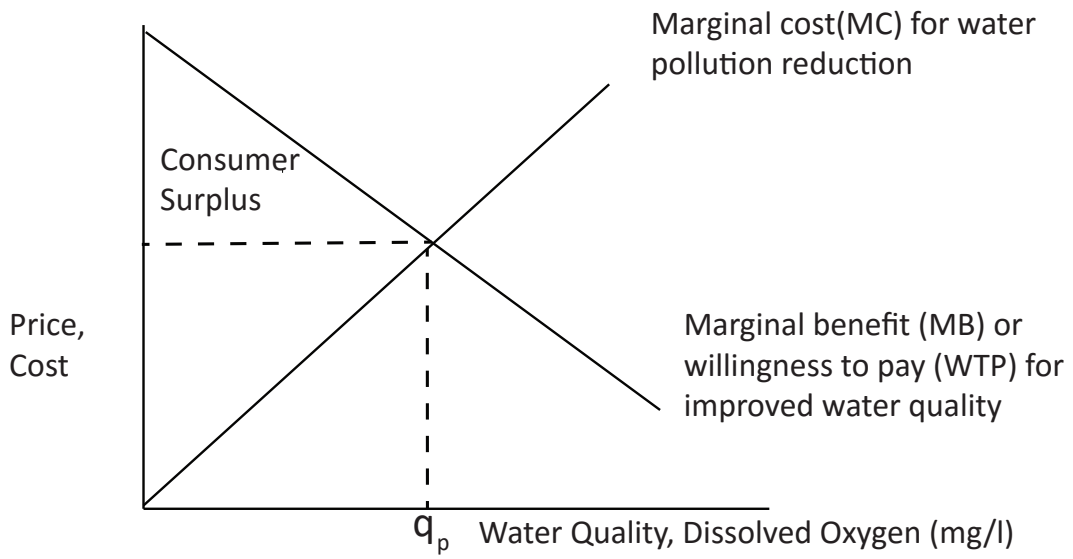

Figure 1. Consumer surplus as willingness to pay for improved water quality. Consumer surplus is the difference between the amount that individuals actually pay and the amount that they would have been willing to pay for improved water quality.

to estimate the economic value of the Delaware River basin in the aforementioned states by examining: (1) economic activity derived from market and nonmarket use and nonuse value of water supply, recreation, fishing, hunting, boating, ecotourism, agriculture, and navigation sectors, (2) ecosystem services value (natural capital) of goods and services provided by habitat such as wetlands, forests, farms, and open water, and (3) jobs/wages directly and indirectly associated with the river, bay, and tributaries.

The Delaware River Basin

For over four centuries, the Delaware River has been utilized for economic gain. Henry Hudson discovered the bay off Cape May in August 1609 during an unsuccessful quest to find an inner trade route to Asia for the Dutch East India Company. When William Penn founded Philadelphia in 1682 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. By the 18th century, prosperous Philadelphia Quaker merchants established triangular 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 third largest port in the British Empire after London and Liverpool. In 1790 Ben Franklin was so concerned about pollution that he willed funds to build the first municipal water system in the U.S. for Philadelphia.

The river as an economic engine kicked into high gear during the Industrial Revolution with hydropower and steam power. In 1802, the DuPont family searched up and down the Atlantic Seaboard and established gunpowder mills along the Brandywine River falls above Wilmington, 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 steam ships made fast transatlantic trips. In 1895, the Corps of Engineers dredged the Delaware River to 26 ft. from the natural depth of 17 ft. (Economy League of Greater Philadelphia 2008).

By the end of the 19th century, the Delaware River supported the largest commercial American shad and sturgeon fishery along the Atlantic coast, highlighting an annual spring rite that fascinated artists like Thomas Eakins and the poet Walt Whitman. The sturgeon was such a lucrative fish that boom town Caviar near Greenwich, New Jersey processed the roe for worldwide export. By the 1880s, 1,400 sailing vessels harvested 22 million lbs. of oysters from the Delaware Bay. In 1886, nationally famous hotels in Gloucester, New Jersey served 10,000 planked shad dinners at events that resembled modern day blue crab feasts. In 1896 over 14 million lbs. of shad were caught with a value of $400,000 ($10 million in $2008). Also in 1896, a fisheries report to the Governor of Pennsylvania listed the catch of a 76 lb. striped bass just across the river from Philadelphia in Gloucester, New Jersey (Kauffman 2010).

During the First World War, the Delaware became known as the "Clyde of America," with ship building that rivaled its Scottish cousin. In 1912, Philadelphia manufactured 5% of all goods in the United States and exported coal, iron, cotton, leather, grain, lumber, tobacco, and gunpowder. By 1914, the Panama Canal opened access from the East Coast to the Hawaiian sugar cane fields and Philadelphia refined 1/6 of all the sugar in the United States (Kauffman 2010).

The Delaware River ship channel was deepened to 41 ft. in 1941 and 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 base declined due to waning demand for Pennsylvania coal and Lehigh Valley steel. In 1995, the U.S. Navy closed the Philadelphia Navy Yard and decommissioned the ghost fleet.

In 1931 and 1954, the U.S. Supreme Court issued decrees authorizing New York City to divert 800 million gallons per day from three reservoirs in the upper Delaware basin to the Hudson River basin. The Delaware River supplies half of the city's drinking water via an 85-mile long, 13-feet diameter concrete aqueduct running from the Catskill reservoirs to the five boroughs.

By 2010, a billion gallons per day were withdrawn from the Delaware basin to sustain the region's economy and supply drinking water to the 1st (New York City) and 7th (Philadelphia) largest metropolitan economies in the U.S. In 1965, Congress formed the Delaware Water Gap National Recreation Area that receives 5 million visits annually, the 8th most visited unit in the National Park System. The Delaware River is the largest freshwater port in the world yet supports a recovering American shad and striped bass fishery. After the turn of the 21st century, new horizontal drilling and hydraulic fracturing technology kicked off the Marcellus Shale natural gas drilling boom that threatened to take place in the upper 36% of the upper Delaware basin in New York and Pennsylvania.

Over the last half century, Federal, state, and local governments, nonprofits, and the private sector have focused on restoring the Delaware basin (Figure 2). In 1961, President John F. Kennedy and the governors of Delaware, New Jersey, New York, and Pennsylvania signed the 100-year Delaware River Basin Compact (DRBC) as the first ever Federal-state watershed accord. Four years before Congress passed the Clean Water Act, the DRBC in 1968 issued waste load allocations to reduce pollutant discharges from over 80 wastewater treatment plants. In 1996, Congress designated the Delaware Bay as one of only 28 National Estuary Programs in the United States and the Partnership for the Delaware Estuary was established to implement a Comprehensive Conservation and Management Plan. In 2011, the DRBC celebrated the 50th anniversary of its founding by JFK and the four governors (Kauffman 2010).

The Delaware basin occupies 12,769 square miles where Delaware, New Jersey, New York, and Pennsylvania cover 8%, 23%, 20%, and 49% of the basin, respectively. The basin covers 50% of Delaware and is home to 74% of the First State's population. The basin covers 40% of New Jersey and holds 22% of the Garden State's population. The basin covers 5% of New York but holds less than 1% of the Empire State's population. The basin covers 14% of Pennsylvania yet is home to 43% of the Keystone State's population. The Delaware basin drains just 0.4% of the continental U.S. yet supplies drinking water to 5% of the nation's population.

In 2010, 8.2 million people lived in the basin including 640,000 people in Delaware (9%), 2,300 in Maryland, 1,950,000 in New Jersey (24%), 125,000 in New York (2%), and 5,530,000 in Pennsylvania (66%). An additional 8 million people in New York City and northern New Jersey draw drinking water from the Delaware River via interbasin transfers. The Delaware basin population exceeds 8.2 million, which as a single jurisdiction would be the 12th most populous state in the nation after New Jersey but ahead of Virginia. Between 2000 and 2010, the basin population increased by 7% or a half million people (Figure 3). In 2010, nearly 3,500,000 people worked in the Delaware basin with 316,000 jobs in Delaware, 1,200 jobs in Maryland, 823,000 jobs in New Jersey, 70,000 jobs in New York, and 2,271,000 jobs in Pennsylvania.

Methods

This research quantifies the economic value of the Delaware basin based on three levels of analysis: (1) annual economic activity, (2) ecosystem goods and services, and (3) basin-related jobs and wages. The study area is defined by the hydrologic boundaries of the basin from the headwaters in the Catskill Mountains of New York to the mouth of the bay at Cape Henlopen, Delaware. We drew from data gathered by 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 Delaware basin was not available, benefits transfer was utilized to translate data to the basin from other watersheds. Benefits transfer involves extrapolating the benefits calculated by previous studies in other sites to the watershed in question with appropriate adjustments (U.S. EPA 2012). Benefits transfer is relatively inexpensive to implement; however, it must be applied carefully to avoid redundancy and double-counting of benefits. The benefit transfer method is most reliable when the original site and study site are similar in location and population characteristics,

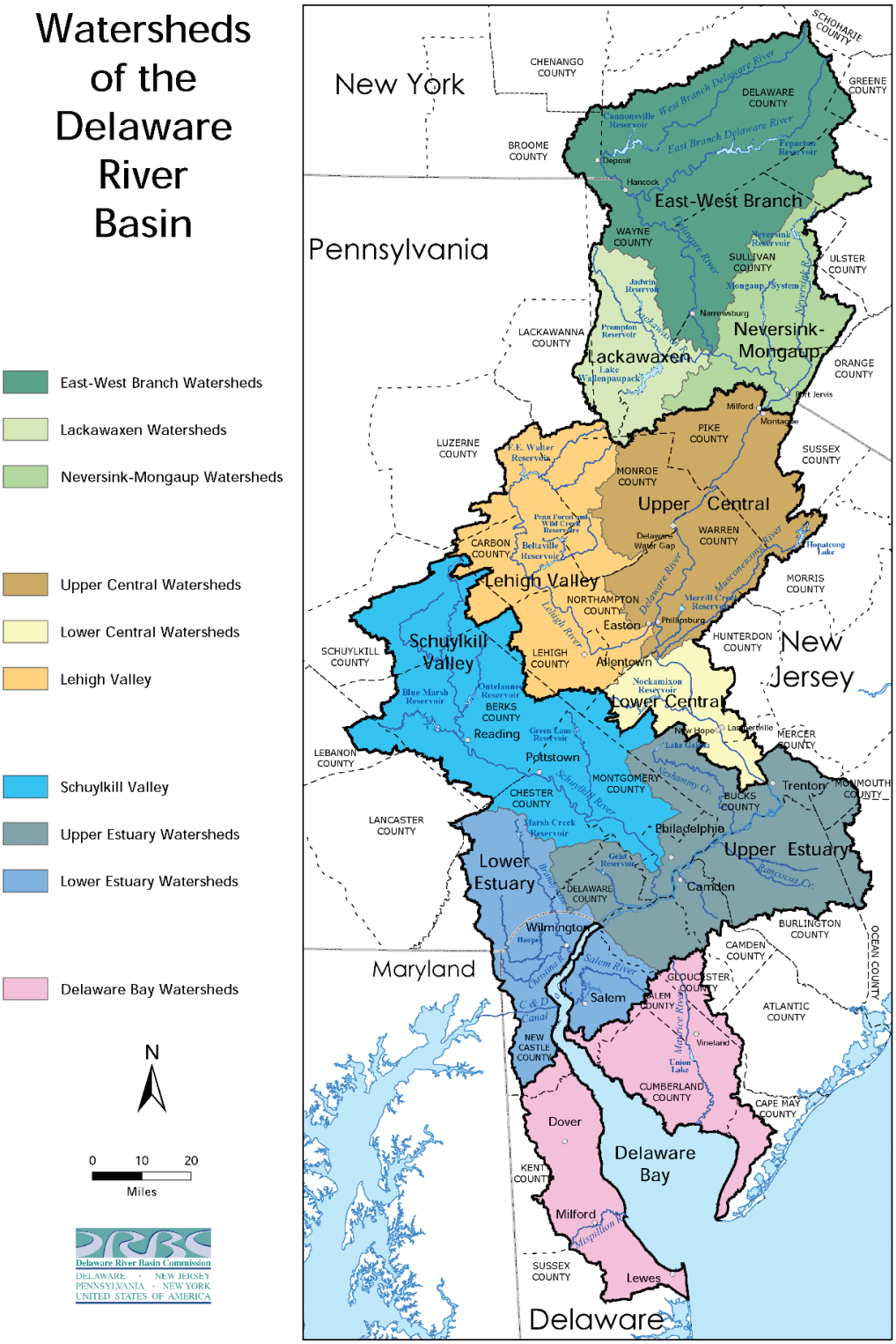

Figure 2. The Delaware River basin drains 13,000 square miles in Delaware, New Jersey, New York, and Pennsylvania (DRBC 2013).

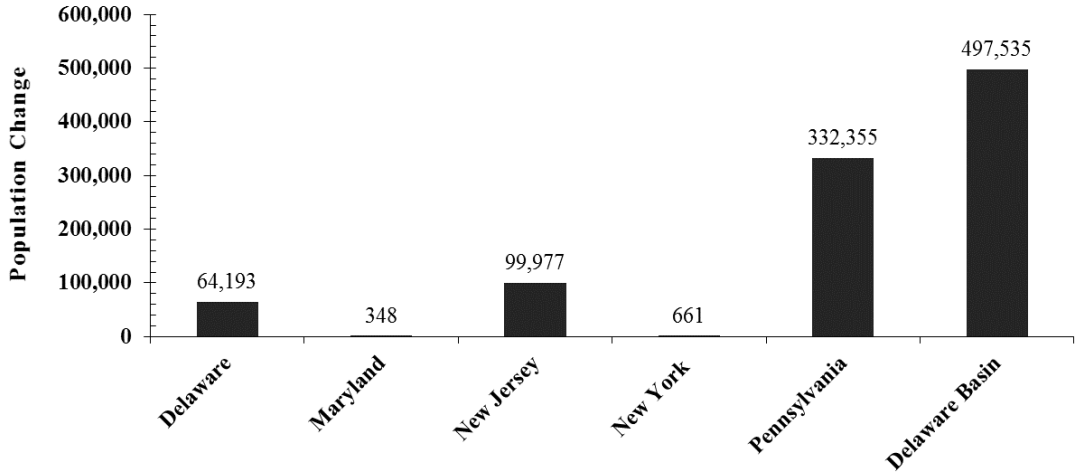

Figure 3. Population change in the Delaware basin for Delaware, New Jersey, New York, and Pennsylvania from 2000 to 2010 (U.S. Bureau of the Census 2010).

when water quality change is similar for the two sites, and when the original study used sound valuation techniques (WBCSD 2011). EPA employs benefit transfer to estimate nonmarket benefits of proposed water quality regulations from the Federal Clean Water Act. While it has limitations, the benefit transfer method was used here to estimate the economic benefits of the Delaware River basin.

To transfer data to the Delaware River, benefits are defined based on the population in the basin who benefit from improved water quality according to the following four steps. The first step in benefits transfer is to identify existing study values that can be utilized for the site in question (U.S. EPA 2012). The second step is to decide whether existing values are transferable based on several criteria. Is the benefit valued comparable to the value in the existing studies? The third step is to evaluate the quality of transferred studies. If the quality of the initial study is good, then the transferred value will be more accurate. The final step is to adjust original values to reflect the characteristics of the study site.

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 (2015) 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.

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

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%); and

t = Time in years counted from the base year through 2010.

Annual Economic Activity

For the first level of analysis, 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 nonuse 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 improved water quality or knowing that the scenic value of the bay will be preserved. Nonuse (existence) values accrue to a public who may never visit the resource, but are willing to pay to preserve the resource for future generations.

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 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 the higher property values along scenic bay and river coastlines. Contingent valuation surveys estimate how much more people may be willing to pay in source water fees.

Ecosystem Goods and Services

For the second level of analysis, we tabulated the natural capital or value of habitat in the watershed provided by 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 National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center land cover data for wetlands, marine, farmland, forest, barren, urban, beach/dune, and riparian buffer habitats.

Ecological resources provide marketable goods and services such as timber, water, and fish and wildlife and equipment for recreation, hiking, and boating/kayaking. Natural capital are goods (commodities like water, crops, and timber that can be sold) and services (functions such as flood control, water filtration, and wildlife/fisheries habitat) provided by ecosystems such as wetlands, forests, farms, and open water. Ecosystems provide benefits for hunters, fishermen, boaters, and hikers who spend money to visit natural sites due to improved water quality.

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 question. While primary research data from the Delaware basin is preferable and used where available in this analysis, value transfer is a practical way to value ecosystems especially when in the absence of such data the worth of ecosystems have previously been deemed zero. Values from previous studies were adjusted to $2010 based on 3% change in 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

For the third level of analysis, 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 Delaware basin classified by NAICS industry code (formerly SIC code) and then grouped by census tract.
- Direct Delaware basin-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 Delaware basin in the interlinked regional economy. Indirect jobs were estimated by multipliers of 1.2 applied to direct jobs and 0.8 to direct wages (Latham and Stapleford 1990), i.e. 100 direct jobs support 120 indirect jobs and direct wages of $1,000 provide $800 indirect wages.

Results

Annual Economic Activity

The economic value of the Delaware basin exceeds $22 billion/yr. from potential Marcellus Shale gas extraction ($425 million), recreation ($1.2 billion), fish/wildlife ($1.5 billion), public parks ($1.8 billion), water quality ($2.5 billion), navigation ($2.6 billion), agriculture ($3.4 billion), water supply ($3.8 billion), and forest ($5.1 billion) benefits (Table 1).

Recreation. The annual economic value of recreation in the Delaware basin is $1.2 billion. Swimming ($57 million), fishing ($24 million), boating ($6 million), and viewing ($5 million) benefits due to improved water quality total $92 million ($11.10 per person) for a basin population of 8,255,000 as scaled from Parsons et al. (2003). 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 $211 million. Nine ski areas draw water (1 mgd) for snowmaking on 1,005 ac (407 ha) where the economic value ranges from $88 million (based on 1.9 million ski visits at a lift ticket rate of $45/day) to $325 million (based on scaled estimates from the Pennsylvania Ski Areas Association (2009)).

Paddling-based recreation such as canoeing, kayaking, and rafting in the Delaware basin involves 621,000 participants, $362 million in gear retail and trip sales, and 4,226 jobs based on scaled estimates by population from the Outdoor Industry Association (2006). River recreation economic output along the upper Delaware River and Delaware Water Gap National Recreation Area is roughly $41 million in $2010 based on Cordell et al. (1990) from the U.S. Forest Service and National Park Service. Thirty-seven canoe and kayak liveries along the Delaware, Lehigh, Schuylkill, and Brandywine Rivers lease watercraft to 225,000 visitors with earnings of $9 million/yr. assuming a daily rental fee of $40/person (Canoe and Kayak Liveries 2011). The National Marine Manufacturers Association (2010) found that New York, Delaware, Pennsylvania, and New Jersey ranked 3rd, 7th, 17th, and 23rd in the U.S., respectively, in expenditures for recreational powerboats which, scaled by population, totaled $395 million/yr. in the Delaware basin.

Water Quality. The annual economic value of water quality benefits in the Delaware basin is $2.4 billion. Willingness to pay to make Delaware Estuary water quality acceptable to the public was $658 million in $2010 for a basin population of 6,700,000, based on value transfer from the Chesapeake Bay where 43% of the population were users willing to pay $121/yr. and 57% of the population were nonusers willing to pay $38/yr. to restore the bay (Bockstael, McConnell, and Strand 1989). Loss of forests that occupy 53% of the Delaware basin would increase treatment costs for public water supplies by $63 million/yr. given that for every 10% increase in forest area, water treatment costs decline by 20% (Trust for Public Land and AWWA 2004). The value of wastewater treatment is $1.7 billion/yr. for National Pollutant Discharge Elimination System (NPDES) permit holders that discharge 1,180 mgd to the Delaware basin based on a mean wastewater rate of $4.00/1000 galions (Yagecic et al. 2014). While wastewater treatment may be construed as a cost, the waters of the Delaware River basin provide assimilative capacity to treat these wastes and the rate paid by the public is an estimate of what consumers are willing to pay for this resource use and is therefore counted as a benefit. The value of property within 2000 feet of the 143-mile shoreline will increase by 8% ($256 million or $13 million/yr. over 20 years) due to water quality improvements in the Delaware Estuary watershed (U.S. EPA 1973).

Water Supply. The annual economic value of water supplies in the Delaware basin is $3.8 billion.

The value of public drinking water supplies (Barr and Sayers 2013) in the Delaware basin (1,803 mgd) is $3.1 billion based on an average water rate set by public and private water purveyors of $4.78/1000 gallons (Corrozi and Seymour 2008). The annual value of storage (369 billion gallons) at 11 reservoirs in the Delaware basin is $145 million based on an estimated market price of $0.394/1,000 gallon that water purveyors are willing to pay to access this storage when needed during drought or emergency (NJWSA 2011). Irrigation withdrawals, mainly for corn, soybean, and vegetable crops, are rising due to warmer temperatures during the summer. The value of irrigation is $12 million/yr. based on DRBC allocations of 36.5 mgd (Barr and Sayers 2013), given the median value of withdrawals is $300/ac-ft. ($0.92/1000 gallons) in 2010, adjusted from Frederick et al. (1996). The economic value of water to irrigate 141,138 ac of cropland (USDA 2009) in the Delaware basin is $32 million, based on irrigation water needs of nine inches from June through September at a unit value of $300/ac-ft. (Frederick et al. 1996). The value of thermoelectric power plant water withdrawals (Barr and Sayers 2013) generating 13,458 megawatts of electricity in the Delaware basin is $297 million/yr., based on a unit value of $0.14/1000 gallons developed by Frederick et al. (1996). The annual value of industrial water supply withdrawals (804 mgd) in the Delaware basin (Barr and Sayers 2013) is $179 million based on a unit value of $200/ac-ft. (Frederick et al. 1996), adjusted for 2010. The annual value of hydropower based on DRBC allocations of 539 mgd is $20 million based on the median value of $0.10/1000 gallons in 2010, adjusted from Frederick et al. (1996).

Fish/Wildlife. The annual economic value of fish and wildlife in the Delaware basin is $1.5 billion. The annual value of commercial fish landings was $25.4 million in 2000 or $34.1 million in 2010 according to the National Marine Fisheries Service (NOEP 2009), including blue crab ($14.4 million), summer flounder ($5.3 million), Atlantic menhaden ($4.3 million), eastern oyster ($3.7 million), striped bass ($2.3 million), and American eel ($0.8 million) in the Delaware Estuary. Scaled by ratio of basin area to state area, the annual value of fishing ($576 million), hunting ($340 million), and wildlife viewing recreation ($561 million) trip and gear expenditures is $1.5 billion in the Delaware basin or $134 million in Delaware, $574 million in New Jersey, $160 million in New York, and $608 million in Pennsylvania (US DoI, FWS 2006). Based on 63,000 angler days, the annual value based on willingness to pay $102/trip/angler for the Delaware River shad fishery is $6.5 million in 2010 (The Pennsylvania Fish and Boat Commission 2011). Along the east branch, west branch, and upper Delaware River in the Catskills of New York, wild trout fishing contributed over $29 million in economic activity and nearly 350 jobs with $3.6 million in wages (Maharaj, McGurrin, and Carpenter 1998).

Agriculture. The Delaware basin covers 12,769 mi^2 or just 13% of the combined land area of Delaware, New Jersey, New York, and Pennsylvania, yet accounts for $3.4 billion or 27% of farm products sold in the four states from 3,010 mi^2 of farmland (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, 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) benefits of $5.9 million ($827/ac). Applying these per acre multipliers, 4,343,190 forested acres in the Delaware basin provide economic benefits that total $5.1 billion/yr. These economic benefits in carbon, air pollution, and energy savings are quite significant as half of the Delaware basin is covered by forests.

Parks. Public parks provide $1.8 billion in annual economic value to the Delaware River basin. The Trust for Public Land (2009) found the 444-acre 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 (169 mi^2) within the Delaware basin provide health ($1.3 billion), community cohesion ($314 million), water pollution ($121 million), and air pollution

Table 1. Annual economic activity in the Delaware River basin in 2010.

Activity	2010 ($ mil)	Source
Recreation (Boating, Fishing, Swimming)		
Clean Water Act Restoration		
• Viewing/Aesthetics ($0.58/person)	5	Parsons et al. (2003), University of Delaware
• Boating ($0.76/person)	6	Parsons et al. (2003), University of Delaware
• Fishing ($2.95/person)	24	Parsons et al. (2003), University of Delaware
• Swimming ($6.88/person)	57	Parsons et al. (2003), University of Delaware
Water Quality Based Recreation		
• Swimming ($13.40/trip)	9	Johnston et al. (2002), University of Rhode Island
• Boating ($30/trip)	47	Johnston et al. (2002), University of Rhode Island
• Fishing ($62.79/trip)	52	Johnston et al. (2002), University of Rhode Island
• Wildlife/Bird-watching ($77.73/trip)	104	Johnston et al. (2002), University of Rhode Island
Skiing (1.9 million ski-days @$45/day)	88-325	Pennsylvania Ski Areas Association (2009)
Paddling-based Recreation (621,000 paddlers)	362	Outdoor Industry Association (2006)
Del. Water Gap River Recreation (267,000 visitors)	41	Cordell et al. (1990), National Park Service
Canoe/Kayak/Rafting (225,000 visits)	9	Canoe and Kayak Liveries (2011)
Powerboating (232,000 boat registrations)	395	National Marine Manufacturers Association (2010)
Water Quality		
Willing to Pay for Clean Water ($38-$121/user)	659	Bockstael et al. (1989), University of Maryland
Water Treatment by Forests ($96/mgd)	63	Trust for Public Land and AWWA (2004)
Wastewater Treatment ($4.00/1000 gallons)	1,722	Yagecic et al. (2014)
Increased Property Value (+8%)	13	USEPA (1973)
Water Supply		
Drinking Water Supply ($4.78/1000 gallons)	3,145	Corrozi and Seymour (2008); Barr and Sayers (2013)
Reservoir Storage ($0.394/1000 gallons)	145	NJWSA (2011)
Irrigation Water Supply ($300/ac-ft)	32	Frederick et al. (1996); USDA (2009)
Thermoelectric Power Water Supply ($44/ac-ft)	297	USEIA (2002); USNETL (2009)
Industrial Water Supply ($200/ac-ft)	179	Frederick et al. (1996); Barr and Sayers (2013)
Hydropower Water Supply ($32/ac-ft)	20	Frederick et al. (1996); Barr and Sayers (2013)

Table 1 (continued). Annual economic activity in the Delaware River basin in 2010.

Activity	2010 ($ mil)	Source
Fish/Wildlife		
Commercial Fish Landings ($0.60/lb)	34	National Ocean Economics Program (2009)
Fishing (11-18 trips/angler, $17-$53/trip)	576	U.S. Fish and Wildlife Service (2008)
Hunting (16 trips/hunter, $16-50/trip)	340	U.S. Fish and Wildlife Service (2008)
Wildlife/Bird-watching (8-13 trip/yr, $15-$27/trip)	561	U.S. Fish and Wildlife Service (2008)
Shad Fishing (63,000 trips, $102/trip)	6	Pennsylvania Fish and Boat Commission (2011)
Wild Trout Fishing	29	Maharaj et al. (1998)
Agriculture		
Crop, Poultry, Livestock Value ($1,180/ac)	3,371	USDA Census of Agriculture 2007 (2009)
Forests		
Carbon Storage ($827/ac)	3,592	Nowak et al. (2008)
Carbon Sequestration ($29/ac)	126	Nowak et al. (2008)
Air Pollution Removal ($266/ac)	1,155	Nowak et al. (2008)
Building Energy Savings ($56/ac)	243	Nowak et al. (2008)
Avoided Carbon Emissions ($3/ac)	13	Nowak et al. (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)
Del. Water Gap Natl. Rec. Area (5.6 million visits)	160	Stynes (2011)
Marcellus Shale Gas		
Natural Gas (4.0 trillion ft^3@ $2.68/1000 ft^3)	425	USEIA (2010); Coleman et al. (2011)
Navigation		
Port Activity	2,400	Economy League of Greater Philadelphia (2008)
Delaware River Basin	**≥$22 billion**	

mitigation ($12 million) benefits. Stynes (2011) from Michigan State University estimated the National Park system at the Delaware Water Gap National Recreation Area and Upper Delaware National Wild and Scenic River drew 5,592,229 recreation visits in 2010 with total visitor spending of $160 million, generating 2,198 jobs and $61 million in wages.

Marcellus Shale Natural Gas. While a moratorium on natural gas drilling holds in place in the Delaware basin, it remains a critical water-energy nexus issue for the region and the value of the fossil fuel activity is discussed here. Approximately 9% of the 54,000 mi^2 Marcellus Shale Formation lies in the upper third of the Delaware basin. Buffers set by proposed DRBC and New York State (NYSDEC) rules, existing Pennsylvania Act 13, and drilling bans in four New York towns would exclude 2,363 mi^2 or nearly half of the 4,940 mi^2 Marcellus Shale region in the Delaware basin from natural gas drilling, leaving 2,577 mi^2 available for extraction (Kauffman and Homsey 2013). With buffers in place to shield sensitive water resources from hydraulic fracturing, the estimated economic value of 4.0 trillion cubic feet (tcf) of potentially recoverable Marcellus Shale gas in the basin at the 2012 wellhead price ($2.68/1000 cf) is $425 million/yr. or three times less than the value at the 2008 price (Table 2).

Navigation. The Delaware River docked nearly 2,900 ships in 2006 and is the largest freshwater port in the world with $2.4 billion in total economic output. The five Delaware River ports 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 Delaware River port, from Wilmington to Philadelphia to Trenton, imports 1/2 of the nation's cocoa beans, 1/3 of the bananas, 1/4 of all fruit and nuts, and 51% of container trade value nationwide (Economy League of Greater Philadelphia 2008).

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 the value of improved water quality and habitat.

Other studies have defined ecosystem services in watersheds in and around the Delaware basin. A Cecil County, Maryland study by the Conservation Fund found that riparian forest wetlands provided 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 to be $20 billion/yr. (+/- $9 billion/yr.) 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 2007). The Wilderness Society (Krieger 2001) concluded that 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 that 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 ecosystem services value of agriculture captures the value of the soil and soil moisture. 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

Table 2. Potential value of Marcellus Shale gas in the Delaware basin.

Year	Available Marcellus Shale Area (mi^2)	Available Natural Gas[1] (tcf)	Annual Wellhead Price[2] ($/1000 cf)	Natural Gas Value ($ mil)	Annual Natural Gas Value[3] ($ mil/yr)
without buffers					
2008	4,940	7.6	$7.97	60,572	2,423
2009	4,940	7.6	$3.67	27,892	1,116
2010	4,940	7.6	$4.48	34,048	1,362
2011	4,940	7.6	$3.95	30,020	1,201
2012	4,940	7.6	$2.68	20,368	815
with buffers[4]					
2008	2,363	4.0	$7.97	31,880	1,275
2009	2,363	4.0	$3.67	14,680	587
2010	2,363	4.0	$4.48	17,920	717
2011	2,363	4.0	$3.95	15,800	632
2012	2,363	4.0	$2.68	10,625	425

[1]Source: Coleman et al. 2011. [2]Source: USEIA 2010. [3]Assumes 25-year recovery period. [4]w/ DRBC, NY, and PA buffers.

billion ($1,676/ac) or $2,502/ac in Delaware, $1,192/ac in New Jersey, $562/ac in New York, and $2,070/ac in Pennsylvania (USDA 2009).

The estimated value of natural goods and services provided by ecosystems in the Delaware River basin (12,742 mi^2) is $21 billion in 2010 with a net present value (NPV) of $683 billion (based on an annual interest rate of 3%) which includes $2.5 billion for Delaware, $6.6 billion for New Jersey, $3.5 billion for New York, and $8.6 billion for Pennsylvania (Table 3). If the 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 Delaware basin would range from $9.6 billion to $94.7 billion. These estimates do not include the ecosystem services value of $61 billion (1,946/ac) of open water habitat (720 mi^2) in the tidal Delaware River and Bay between the shores of Delaware, Pennsylvania, and New Jersey.

Ecosystems within the Delaware basin are comprised of forests (53%), farmland (24%), freshwater wetlands (5%), saltwater wetlands (2%), and open water/marine (1%) (Figure 4). Over 15% of the Delaware basin is urban (Figure 5). Forests ($8.6 billion or $1,978/ac) provide the largest ecosystem services values in the Delaware basin followed by freshwater wetlands ($5.8 billion or $13,261/ac), farmland ($4.8 billion or $2,503/ac), and saltwater wetlands ($1.1 billion or $7,235/ac).

Jobs and Wages

The Delaware basin supports 600,000 direct and indirect jobs with $10 billion in annual wages in the coastal, farm, ecotourism, recreation, water/wastewater, and port industries (Table 4). It is noted that use of indirect jobs benefits is debated in many economic circles. Indirect jobs benefits calculated by multipliers are summarized here to roughly estimate the spinoff effect to the economy from jobs directly related to the waters of the Delaware basin.

The Delaware basin is home to 3,480,483 jobs with $172.6 billion in wages in 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), and Pennsylvania (2,271,317 jobs, $115.5 billion wages).

According to the National Ocean Economic program (NOEP 2009), 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 5 summarizes employment, wages, and employment within the Delaware basin 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.

Jobs directly associated with the Delaware basin (Table 6), such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports, employed a total of 240,621 people with $4.9 billion in wages. The breakdown per state follows: Delaware (15,737 jobs, $340 million wages), New Jersey (62,349 jobs, $1.3 billion wages), New York (32,171 jobs, $550 million wages), and Pennsylvania (130,364 jobs, $2.8 billion wages). Jobs indirectly related to the Delaware basin (based on multipliers of 1.2 for jobs and 0.8 for salaries) employed 288,745 people with $4.0 billion in wages between the states of Delaware (18,884 jobs, $270 million wages), New Jersey (74,819 jobs, $1.0 billion wages), New York (38,605 jobs, $400 million wages), and Pennsylvania (156,437 jobs, $2.2 billion wages).

In 2007 there were 30,455 farms in Delaware basin counties or 21,840 farms within the basin boundary. The USDA (2009) estimates each farm employs 2.1 full time workers. Farming provides 45,865 jobs with $1.9 billion in wages in the Delaware basin. The New Jersey Department of Environmental Protection (Mates 2007) estimated that the average annual salary per ecotourism job in 2007 was $32,843 using data from the U.S. Department of Interior Fish and Wildlife Service and U.S. Census Bureau (2008) 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.

Over 300 public and private water utilities withdraw up to 1,800 mgd of drinking water from the Delaware basin (Barr and Sayers 2013) and employ at least 8,750 jobs with annual wages of $485 million. More than 60 wastewater utilities discharge almost 1.2 billion gallons per day of treated wastewater to the Delaware basin (Yagecic et al. 2014) and employ 1,298 employees who earn $61 million in annual wages. Over 100 nonprofit watershed and environmental organizations (DRBC 2013) employ at least 200 professionals who earn at least $9.5 million in wages on programs to restore the watersheds in the Delaware basin.

Recreational pursuits that rely on clean and plentiful water resources in the Delaware basin provide thousands of jobs in the regional economy. In the Pocono Mountains of Pennsylvania, nine ski resorts provide 1,753 direct jobs in the Delaware basin generating aggregate annual revenues of $87,655,063 from 1,908,228 skier visits. In the Mid-Atlantic census division (NY, NJ, PA), the Outdoor Industry Association (2006) estimated that paddling-based recreation is practiced by 11% of the population and is responsible for 22,844 jobs or 4,226 jobs when scaled by population to the Delaware basin. Stynes (2011) from Michigan State University estimated that the Delaware Water Gap National Recreation Area and Upper Delaware Wild and Scenic River drew 5,592,229 recreation visits in 2010 with total visitor spending of $160 million that generated 2,198 jobs and $61 million in wages. The 37 canoe and kayak liveries along the Delaware, Lehigh, 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. Along the Beaverkill, east branch, west branch and upper Delaware River in New York, wild trout fishing provides for 350 jobs with $3.6 million in wages (Maharaj, McGurrin, and Carpenter 1998)

The Economy League of Greater Philadelphia (2008) reported that Delaware River ports employ 4,056 workers earning $326 million in wages. Each port activity job indirectly supports an additional two jobs and employee spending for a total of 12,121 port jobs with $772 million in wages and a $2.4 billion annual economic output.

Table 3. Ecosystem services values in the Delaware River basin.

Ecosystem	Area (ac)	Unit Value ($/ac/yr 2010)	Present Value (2010 $)	Net Present Value ($)
Low Range				
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	8,173,554		9,579,181,174	311,323,388,171
Mid-Point Estimate				
Freshwater Wetlands	422,838	13,621[2]	5,759,329,048	187,178,194,067
Marine	16,588	10,006[2]	165,982,947	5,394,445,767
Farmland	1,926,524	2,503[2]	4,823,030,404	156,748,488,136
Forest Land	4,343,190	1,978[2]	8,591,367,360	279,219,439,184
Saltwater Wetland	145,765	7,235[2]	1,054,617,851	34,275,080,170
Urban	1,206,504	342[2]	412,157,579	13,395,121,322
Beach/Dune	900	48,644[2]	43,758,633	1,422,155,566
Open Water	92,615	1,946[2]	180,210,703	5,856,847,857
Total	8,154,924		$21,030,454,525	$683,489,772,069
High Range				
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	**8,173,554**		**94,755,764,230**	**3,079,562,337,486**

[1]Weber 2007. [2]Mates 2007. [3]Krieger 2001. [4]Johnston et al. 2002. [5]Ingraham and Foster 2008. [6]Breunig 2003.
[7]Value of goods only as measured by agricultural crops, livestock, and poultry sold from USDA 2009.

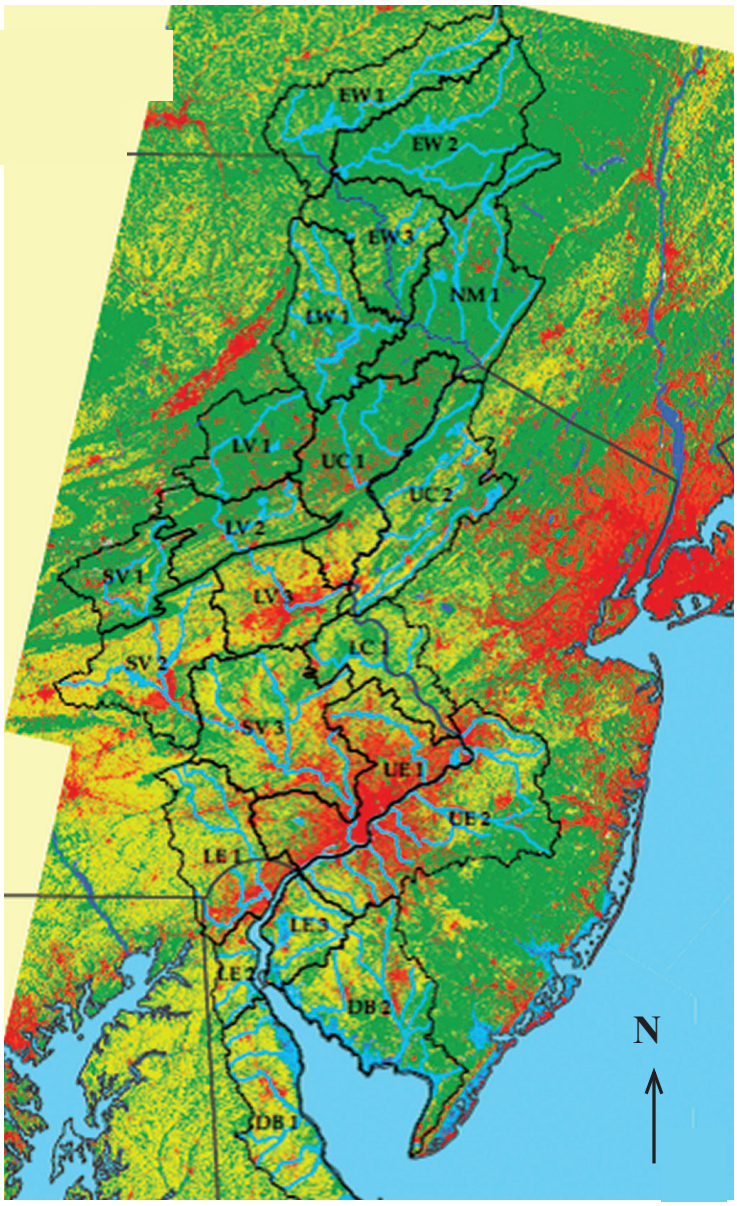

Figure 4. Land use in the Delaware Basin, 2006 (U.S. NOAA CSC 2006). Denoted by Urban/Suburban (Red), Forests/Open Space (Green), Agriculture (Yellow), and Wetlands/Water (Blue). Subwatersheds outlined in black.

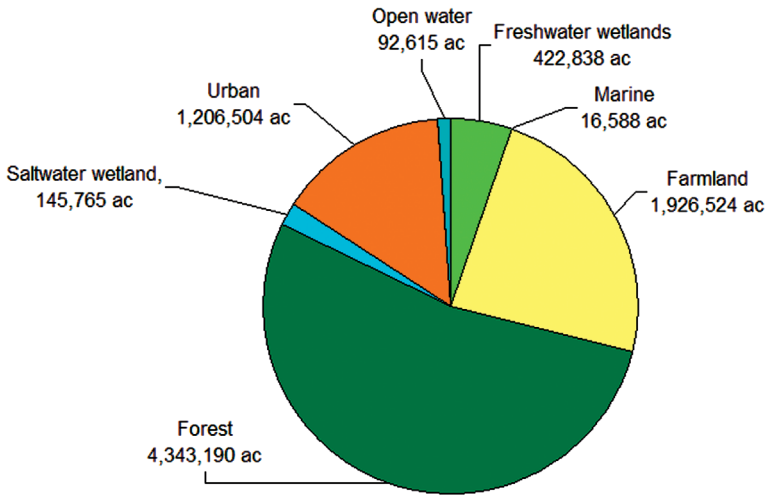

Figure 5. Ecosystem service areas within the Delaware River basin for forest, saltwater wetland, freshwater wetland, open water, marine, farmland, and urban habitat.

Table 4. 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. DOL Bureau of Labor Statistics (2010)
Indirect Basin Related	288,745	4,000	U.S. DOL Bureau of Labor Statistics (2010)
Coastal	44,658	947	National Ocean Economics Program (2009)
Farm	45,865	1,880	USDA Census of Agriculture (2009)
Fishing/Hunting/Birding	44,941	1,476	U.S. Fish and Wildlife Service (2008)
Water Supply Utilities	8,750	485	Corrozi and Seymour (2008); Barr and Sayers (2013)
Wastewater Utilities	1,298	61	Yagecic et al. (2014)
Watershed Organizations	201	10	DRBC (2013)
Ski Area Jobs	1,753	88	Pennsylvania Ski Areas Association (2009)
Paddling-based Recreation	4,226	148	Outdoor Industry Association (2006)
Canoe/Kayak/Rafting	225	8	Canoe and Kayak Liveries (2011)
Wild Trout Fishing	350	4	Maharaj, McGurrin, and Carpenter (1998)
Delaware Water Gap National Recreation Area	2,198	61	Stynes (2011)
Port Jobs	12,121	772	Economy League of Greater Philadelphia (2008)
Delaware Basin Total	**> 600,000**	**>$10 billion**	

Table 5. Coastal employment, wages, and GDP in the Delaware River basin (National Ocean Economics Program 2009).

Sector	Employment	Wages ($ million)	GDP ($ million)
Delaware Basin	44,658	947	1,831
Marine Construction	*ND	ND	12
Living Resources	354	8	195
Offshore Minerals	ND	ND	14
Tourism and Recreation	33,430	151	947
Marine Transportation	1,744	53	560
Ship and Boat Building	ND	ND	72

*ND = No data reported.

Table 6. Direct and indirect basin-related jobs in the Delaware River basin, 2009 (U.S. Department of Labor, Bureau of Labor Statistics 2010).

Sector	Industry	1997 NAICS Codes	Direct Jobs[1]	Direct Wages (x $1,000)	Indirect Jobs[2]	Indirect Wages (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
Ship/Boat Building	Boat Building Repair	336612	0	0	0	0
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
	Refrigerated Warehousing	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 Systems	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

[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 1.2 for jobs and 0.8 for wages.

Table 6 (continued). Direct and indirect basin-related jobs in the Delaware River basin, 2009 (U.S. Department of Labor, Bureau of Labor Statistics 2010).

Sector	Industry	1997 NAICS Codes	Direct Jobs[1]	Direct Wages (x $1,000)	Indirect Jobs[2]	Indirect Wages (x $1,000)
Minerals	Sand & Gravel	212321	166	8,109	199	6,487
	Industrial Sand and Gravel Mining	212322	81	3,865	97	3,092
	Oil & Gas	541360	55	4,554	66	3,643
Tourism/Recreation	Recreation	487990	52	1,184	62	947
	Sports and Recreation Instruction	611620	1,044	18,084	1,253	14,467
	Recreation Good Rental	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
	Restaurants	722211	53,260	616,854	63,912	493,483
	Cafeteria	722212	1,715	26,874	2,058	21,499
	Snack Bar	722213	10,958	165,699	13,150	132,559
	Hotels & Lodging	721110	9,938	307,236	11,926	245,789
	Bed & Breakfast InN	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 Goods	339920	1,192	19,039	1,430	15,231
	Zoos, Aquaria	712130	55	1,959	66	1,567
	Nature Park	712190	524	31,870	629	25,496
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 1.2 for jobs and 0.8 for wages.

Summary and Conclusions

The Delaware River basin in Delaware, New Jersey, New York, and Pennsylvania is a valuable ecological and economic resource. The 13,000 square mile watershed supplies drinking water to 5% of the United States including the nation's 1st (New York City) and 7th (Philadelphia) largest metropolitan economies. Furthermore, the Delaware River supports the largest freshwater port in the world while sustaining a recovering anadromous shad and striped bass fishery (Kauffman 2010).

The annual economic value of the Delaware River basin is at least $22 billion based on estimates of economic activity, ecosystem services, and jobs and wages related to the waters of the watershed. The Delaware basin contributes over $22 billion in annual economic activity from potential Marcellus Shale gas extraction ($425 million), recreation ($1.2 billion), fish/wildlife ($1.5 billion), public parks ($1.8 billion), water quality ($2.5 billion), navigation ($2.6 billion), agriculture ($3.4 billion), water supply ($3.8 billion), and forest ($5.1 billion) benefits. The value of natural goods and services from ecosystems in the Delaware basin is $21 billion ($2010) including provisions by Delaware ($2.5 billion), New Jersey ($6.6 billion), New York ($3.5 billion), and Pennsylvania ($8.6 billion). 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.

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 Delaware basin, making it difficult to accurately compare values across uses and activities. Gathering more primary economic data from research in the Delaware River basin (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.

This economic analysis documents the vast worth of the Delaware River as an economic, ecological, and civic resource. The economic data presented in this analysis may be useful in translating the value of the Delaware River basin to the public. Elected officials, public decision makers, and public, private, nonprofit organizations may use the economic data to set priorities for investment in the Delaware River basin. States, counties, and municipalities may employ this monetary data by linking the economy of the watershed to state, regional, and local economic development and workforce development programs. This research demonstrates the Delaware River basin provides significant economic benefits to the region and is worthy of priority investments by elected officials and decision-makers to protect and restore these natural resources.

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