Economic Value of the Christina River Watershed

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The Christina Basin Clean Water Partnership

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Executive Summary

The water, natural resources, and ecosystems in the Christina River watershed contribute an economic value of $40 million to $7 billion annually to the Pennsylvania, Delaware, and Maryland economies. This report examines that economic value in three different ways:

1. **Economic value directly related to the Christina River watershed water resources and habitats.** The Christina River watershed contributes to over $7 billion in annual economic activity from water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits.

2. **Value of goods and services provided by the Christina River watershed ecosystems.** Using natural capital as a measure of value, habitat in the Christina River watershed provides $98.9 million annually in ecosystem goods and services in 2010 dollars, with a net present value (NPV) of $3.2 billion calculated over a 100-year period.

3. **Employment related to Christina River watershed resources and habitats.** Using employment as a measure of value, natural resources within the Christina River watershed directly and indirectly supports over 19,000 jobs with over $40 million in annual wages.

The purpose of these estimates is to demonstrate that the Christina River watershed provides real and significant economic benefits to Pennsylvania, Delaware and Maryland, benefits that are worthy of investment to keep these natural resources healthy and productive. Estimates were made by taking values from existing literature and studies and applying them to the Christina River watershed using ecological economics and benefits-transfer techniques described in this report. Values are converted to 2010 dollars based on the change in the Northeast Region Consumer Price Index except where noted.

Note that the values in the three categories are not summed because there is some overlap between certain values within each category that could result in double counting. For example, the jobs of fishermen that contribute to employment and wages are also a factor in the economic activity generated from fishing, and the ecosystem values of forests for water-quality benefits may be at least partially captured in the economic value of water supply. Accurately determining (and eliminating) this overlap is difficult within the scope of this analysis.

The estimates presented in this report are as inclusive as could be due to a lack of data for some economic sectors, nor are they meant to be used to compare and contrast uses of the Christina River watershed's water resources for their value. Some values were not included in these estimates because the data to assess them either are not readily available or do not exist. For example, the full amount of economic activity and jobs associated with the industries that rely on the Christina River watershed for their processes is not included here, because identifying those companies and gathering information on their economic activity is beyond the scope of this analysis.

Introduction

Objectives

This report summarizes the socioeconomic value of water, natural resources, and ecosystems in the Christina River watershed estimated as:

1. Economic activity including market and non-market value of agriculture, water supply, fishing, hunting, recreation, boating, ecotourism, and port benefits.
2. Ecosystem goods and services (natural capital) value provided by habitat such as wetlands, forests, farms, and open water.
3. Jobs and wages directly and indirectly associated with the Christina River watershed.

These estimates demonstrate that the natural resources of the Christina River watershed provide real and significant economic benefits to the region and is worthy of investment to keep it healthy and productive. Value-transfer techniques were applied by selecting data from existing studies and applying them to the Christina River watershed using ecological-economics techniques.

Values in the three categories above are not summed because there may be overlap and double-counting. For example, the jobs of fishermen are also a factor in economic activity from fishing. The ecosystem values of forests for water-quality benefits are at least partially captured in the economic value of water supply. Accounting for this overlap is difficult. However, each of the above estimates clearly indicates that the Christina River watershed is an economic engine that contributes between $40 million to $7 billion annually to the Pennsylvania, Maryland and Delaware economies.

The estimates presented in this report can be considered in the low range because the data to assess economic value are not readily available in some categories. For example, the full amount of economic activity and jobs associated with the companies and industries that rely on the watershed for their processes is not included here, because identifying those companies and gathering information on their economic activity is complicated and beyond the scope of this analysis. Since some estimates were made by taking values from existing literature, the values for various activities differ greatly in how they were determined and applied to the creek's water resources, making it difficult to accurately compare values across uses.

Other values are not included in this work because they are not yet well documented in the literature on valuation. The field of ecosystem services valuation in particular is still a new and growing field. As our knowledge and understanding of these valuation techniques grows and is applied to more resources, we will continue to incorporate them in our understanding of the value of the Christina River watershed.

History

The Christina River watershed was originally named after Queen Christina of Sweden, daughter of King Gustavus Adolphus. During Queen Christina's reign from 1632 to 1654, two ships left Sweden and landed near present-day Old Swedes Church in Wilmington in March of 1638. Fort Christina was built at this location and became the first permanent European settlement in Delaware. Several years after the settlement under Queen Christina, Dutch soldiers under the command of Peter Stuyvesant came down from New Netherland (present day New York) and established Fort Casimir, what is now New Castle, just 7 miles south of Fort Christina in 1651.

Since the Dutch were under the belief that the Delaware Valley should be under their control, they built the fort to threaten the Swedes. In 1645, the Swedes then captured Fort Casimir, renaming it Fort Trinity. However, a year later in 1655, the Dutch took back Fort Casimir and then went on to capture Fort Christina, putting them in control of the Delaware Valley. In the early 1660s, King Charles II of England wanted to add the land controlled by the Dutch to his empire. By 1674, Delaware was under control of the Duke of York and the area remained under English control for the rest of the colonial period.

The Port of Wilmington located in the Christina River watershed holds significant economic importance and has played a crucial role in the importing of various products. In 1923, the first marine terminal was completed. Del Monte, an American food production and distribution company, made the port its "principal North American port-of discharge" for bananas and pineapples in 1972 followed by Volkwagon of America choosing the port for imports of automobiles in North America in 1976. The Port of Wilmington became the first port to implement the Transportation Worker Identification Credential in October of 2007. This program of the Transportation Security Administration and US Coast Guard was able to provide a tamper-resistant biometric credential to maritime workers. The TWIC program required unescorted access to secure areas of port facilities, outer continental shelf facilities, and vessels regulated under the Maritime Transportation Security Act of 2002, as well as US Coast Guard credentialed merchant mariners.

The Christina River watershed has been a heavily urbanized area since the mid-18th century. Since that time, many wetland areas have been filled in for industrial purposes. Based on a Reconnaissance Study in August 2002, impaired areas of the watershed and recommended potential solutions were identified. Some of these solutions include reducing flood damage, ecosystem restoration, improving fish and wildlife habitat, and improving water quality.

The Watershed

The Christina River watershed drains 78 square miles in Delaware, Pennsylvania, and Maryland (Figure 1). State boundaries break down the 78 sq. mi. of drainage area in the Christina River watershed to 3% (2 sq. mi.) located in Pennsylvania, 87% (67.6 sq. mi.) located in Delaware and 11% (8.4 sq. mi.) located in Maryland.

The Christina River watershed is the most densely populated of the four watersheds in the Christina Basin. It is located within the Wilmington-Newark I-95 Corridor and is formed by the Christina River, a 35-mile long river tributary to the Delaware River. Head waters of the Christina River begin in Franklin Township, Chester County, Pennsylvania and flow from southeastern Pennsylvania, through northeastern Maryland in Cecil County into New Castle County, Delaware near Newark. Once in Delaware, it flows through western Newark, and then turns northeast, flowing through Newport to its confluence with the Brandywine Creek in Wilmington. Here it forms the Port of Wilmington, which opened to international trade in 1923. White Clay Creek is a tributary to the Christina River and joins with it just west of Newport.

The Christina River watershed is the most urbanized of the watersheds in the Christina Basin. Storage of municipal drinking water is provided in Smalley's Pond, a 40 million gallon reservoir located approximately 4.5 miles southeast of Newark, Del. Sport fishing is also enjoyed along the Christina River and trout are stocked in both the Upper Christina River near Newark and in Mill Creek. Tidal waters of the Christina River also support a fishery and spawning grounds for striped bass. The watershed currently provides 75% of the public water supply for residents and businesses in New Castle County.

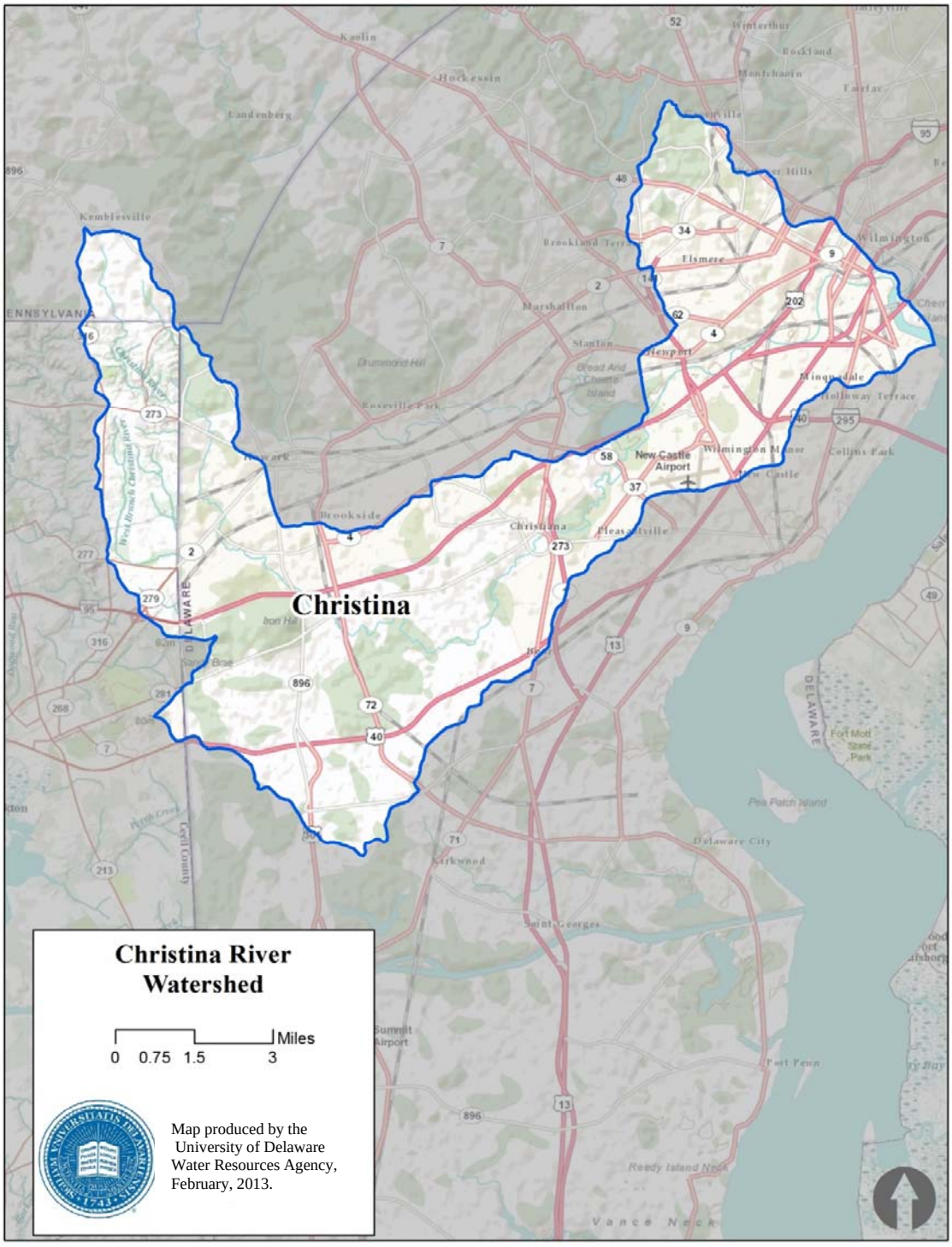

Figure 1. The Christina River watershed

Land Use

The Christina River watershed is dominated by urban land use with over half of the watershed categorized as urban. The Christina River watershed is covered by 59% urban land, 10% farmland, 23% forestland, 5% freshwater wetlands, 1% saltwater wetlands, and 2% marine ecosystem (Table 1, Figure 2, Figure 3).

Table 1. Land use in Christina River watershed

Ecosystem	Area (mi^2)	Percent Area
Urban	46	59%
Farmland	8	10%
Forest land	18	23%
Freshwater wetlands	4	5%
Saltwater Wetland	1	1%
Marine	1	2%
Total	**78**	**100%**

Source: NOAA CSC, 2006

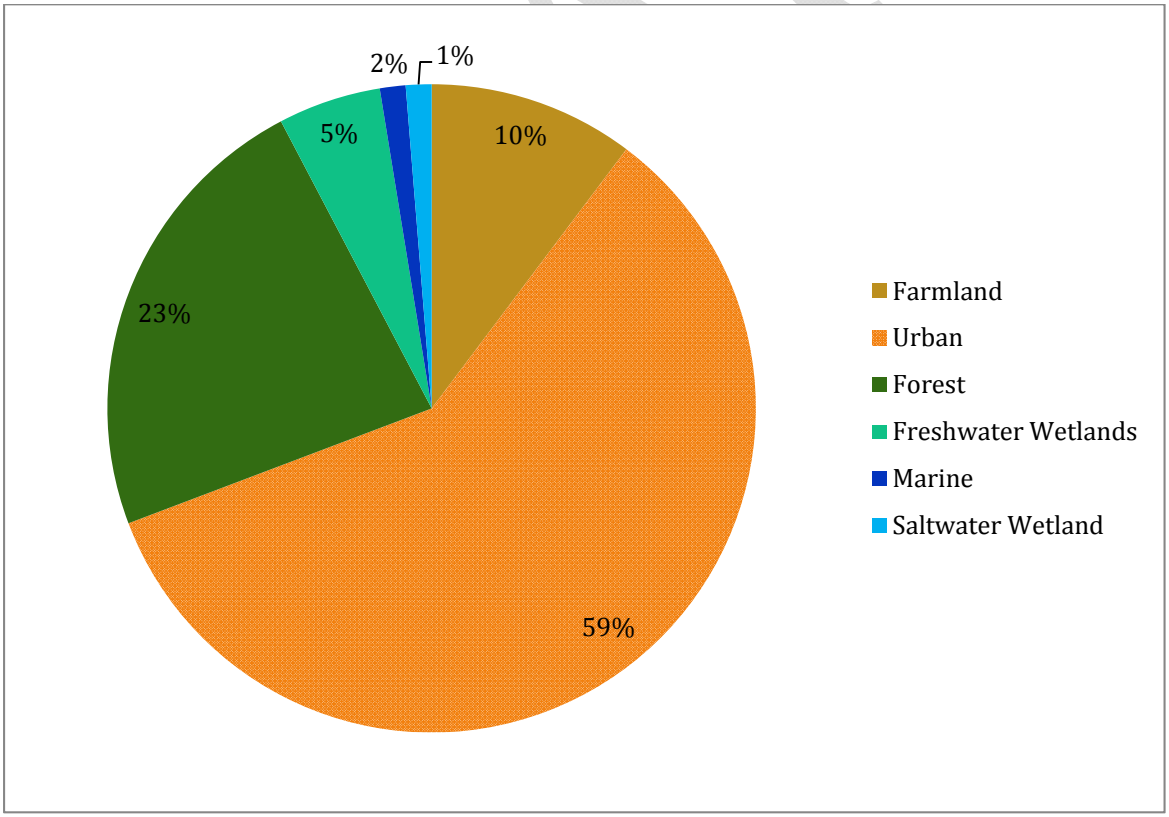

Figure 2. Christina River watershed land use

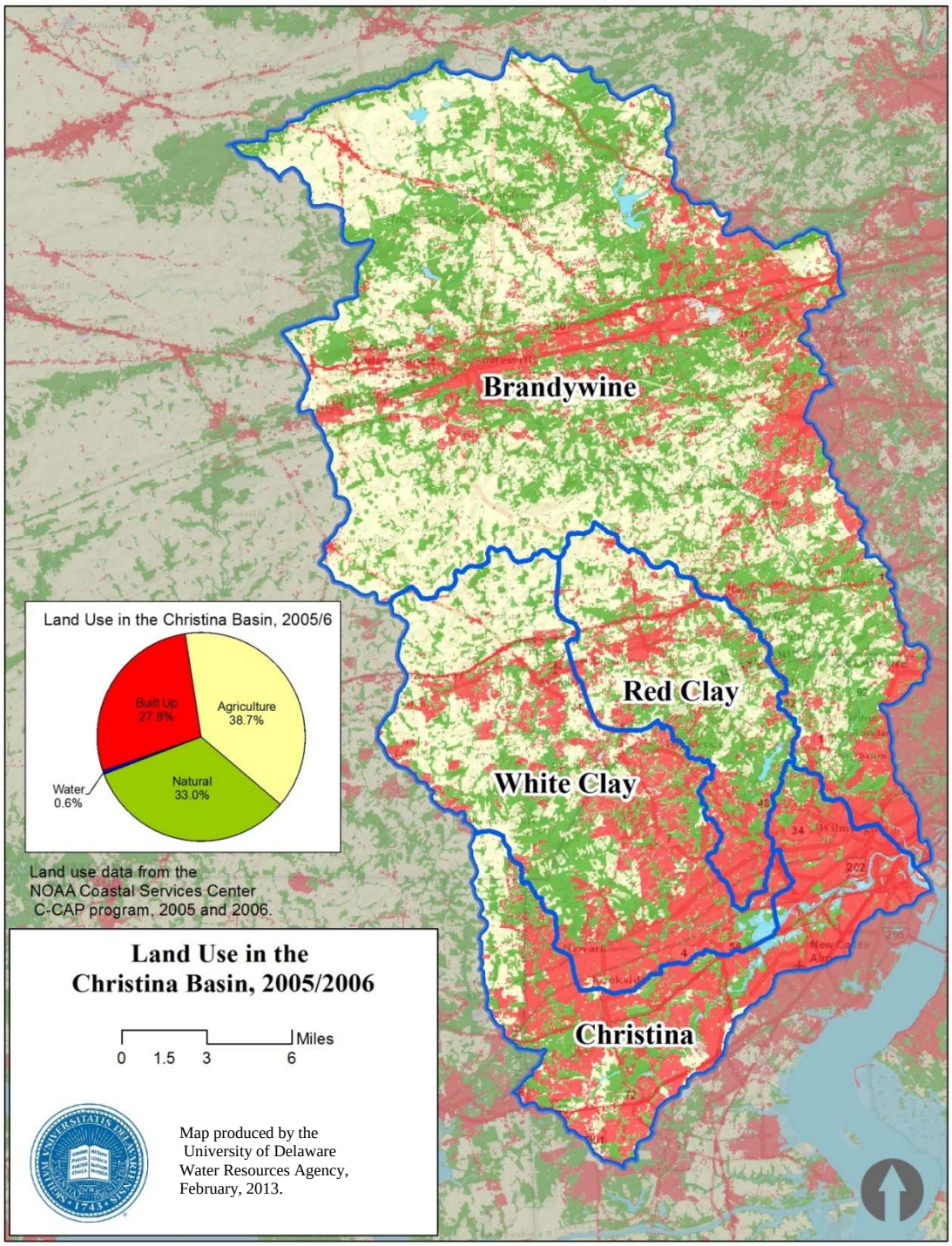

Figure 3. Land cover in the Christina River watershed (NOAA CSC 2006)

Population

Between 2000 and 2010, the population in the watershed grew by 20,245, with 166,435 in 2000 to 186,680 in 2010 (Table 3). In 2010, the Christina River watershed population was 186,680 with 789, 177,964, and 7,927 living in the Pennsylvania, Delaware, and Maryland portions of the watershed respectively (Table 2).

Table 2. Population of Christina River watershed by state

State	Area[1]	2010 pop.[2]	2010 (people/mi²)
Pennsylvania	2	789	394
Delaware	67	177,964	2,656
Maryland	8	7,927	991
Total	**77**	**186,680**	**4,041**

Source: U.S. Census 2. NOAA CSC, 2006

Table 3. Population change in Christina River watershed, 2000-2010

Watershed	Area (mi²)	2000 pop.	2010 pop.	Change	2000 (people/mi²)	2010 (people/mi²)
Christina River	78	166,435	186,680	20,245	2,134	2,393

Source: U.S. Census 2010

Employment

In 2010, the total employment in the Christina River watershed was 89,818, compared to Chester and New Castle counties at 249,515 and 261,530, respectively (Table 4).

Table 4. Total Employment in the Christina River watershed in 2010

County	County[1] Population	Watershed[1] Population	County[2] Employment	Watershed[3] Employment
Chester County	498,886	789	249,515	395
New Castle County	538,479	177,964	261,530	86,434
Cecil County	1,037,365	7,927	511,045	3,905
Total	**182,321**	**186,680**	**89,818**	**91,965**

1. US Census 2010. 2. U.S. Bureau of Labor Statistics 2011.
3. Scaled by ratio of watershed population to county population and multiplied by county employment.

1. Methods

Valuation Techniques

The University of Delaware derived the economic value of the Christina River watershed from published studies that employed the following valuation techniques:

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

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

Net Factor Income by Enhancement of Income: Improved water quality is known to enhance fishing productivity and boost fishing jobs/wages.

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

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

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

Scope of Work

The University of Delaware established the socioeconomic value of the Christina River watershed according to the following scope of work.

1. Area of Interest: The area of interest is defined as the Christina River watershed. The University of Delaware developed ArcGIS map layers of watersheds, population, ecosystems, habitat, and land use/land cover to perform the analysis.

2. Literature Review: Gather published literature and socioeconomic data relevant to the Christina River watershed including databases from the U.S. Census Bureau, U.S. Bureau of Labor Statistics, U.S. Department of Agriculture, U.S. Forest Service, and U.S. Fish and Wildlife Service.

3. Annual Economic Value: Estimate the direct (market) and indirect (non-market) economic value of agriculture, water quality, water supply, fishing, hunting recreation, boating, ecotourism, and navigation in the Christina River watershed by utilizing population, employment, industrial activity, and land-use data. Total economic activity is the sum of direct and indirect uses, option demand, and non-use values (Ingraham and Foster 2008). Direct-use

(market) values are derived from the sale or purchase of natural goods such as drinking water, boating, recreation, and commercial fishing. Indirect (non-market) values are benefits from ecosystems such as water filtration by forests and flood control/habitat protection from wetlands. Option demand is public willingness to pay for benefits from water quality or scenic value of the water resources. Non-use (existence) values are treasured by a public who may never visit the resource but are willing to pay to preserve the existence of the resource. Values are converted to 2010 dollars based on the change in the Consumer Price Index (CPI) in the Northeast Region as reported by the Bureau of Labor Statistics.

4. Ecosystem Services: Tabulate the market value of natural resources (ecosystem services value) in the Christina River watershed for habitat such as wetlands, forests, farmland, and open water. Ecosystem services (ecological services) are economic benefits provided to society by nature such as water filtration, flood reduction, and drinking water supply. Using ArcGIS, map and tabulate ecosystem areas (acres) using 2006 NOAA Coastal Services Center (CSC) land cover data in the following classifications: (a) freshwater wetlands, (b) marine, (c) farmland, (d), forest, (e) barren, (f) saltwater wetland, (g) urban, (h) beach/dune, and (i) open freshwater. . Review published research studies and gather economic value ($/acre) data for these ecosystem goods and services: (a) carbon sequestration, (b) flood control, (c) drinking water supply, (d) water-quality filtration, (e) waste treatment and assimilation, (f) nutrient regulation, (g) fish and wildlife habitat, (h) recreation and aesthetics. Compute ecosystem services value by multiplying land-use area (acres) by ecosystem value ($/acre).

Ecosystem services are estimated using value (benefits) transfer where published data and literature from similar watersheds are reviewed and applied to the resource in question. Value-transfer techniques include selecting data from published literature from another watershed or study area and applying the dollars-per-acre values to Christina River watershed land-use areas. While primary research data from the area in question is preferable and is used in many cases in this report, value transfer is the next best practical way to value ecosystems, especially when, in the absence of such data, the worth of ecosystems have previously been deemed zero.

5. Jobs and wages: Obtain employment and wage data from the U.S. Department of Labor, U.S. Census Bureau, National Ocean Economics Program, and other sources. . Estimate direct/indirect jobs by North American Industry Classification System (NAICS) codes such as shipbuilding, marine transportation/ports, fisheries, recreation, minerals, trade, agriculture, and others. NAICS data were supplemented with farm jobs data from the USDA Agricultural Statistics Bureau, U.S. Fish and Wildlife Service ecotourism jobs data, and jobs provided by water purveyors and watershed organizations.

6. Report: Prepare a report and GIS mapping that summarizes (1) annual economic value of activities related to the Christina River watershed, (2) ecosystem goods and services (natural capital), and (3) jobs and wages directly and indirectly related to the Christina River watershed.

3. Economic Value

Hodge and Dunn (1992) illustrated the total economic value of water resources based on use and non-use values (Figure 4). Use values include direct values, such as market goods from sales of crops, fish, and timber; unpriced benefits from recreation and aesthetic view sheds; and ecological-function values (ecosystem services) from flood control, water storage, and waste-assimilation services of wetland and forest habitat. Non-use values include future-option values such as future drug discoveries from wetland plants and future recreation, existence values from satisfaction that a water resource exists but may never be visited, and bequest values such as preserving water quality for future generations.

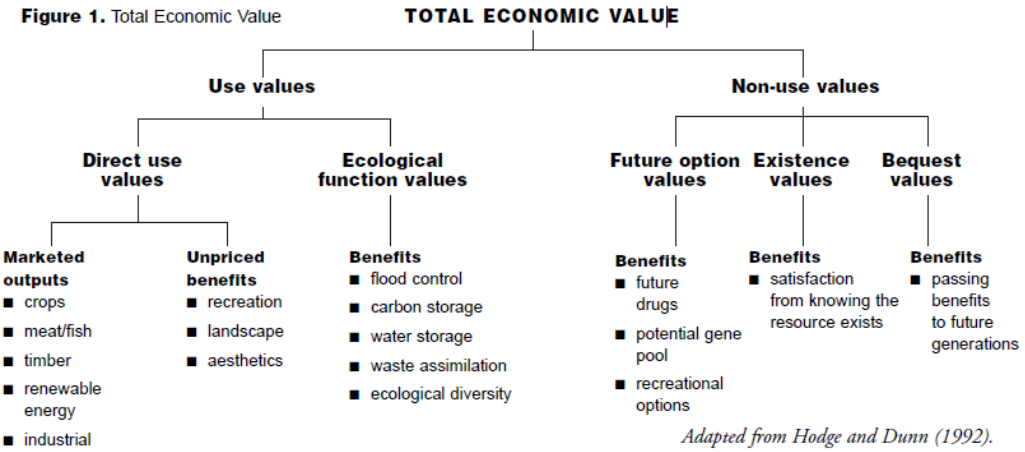

Figure 4. Economic value of water resources (Hodge and Dunn, 1992)

The economic value of the Christina River watershed from water quality, water supply, fish/wildlife, recreation, agriculture, forests and public parks benefits exceed $7 billion (Figure 5 and Table 5). Given the magnitude of the value of Port of Wilmington, the ports data are not included in Table 5.

Water Quality	$27 million
Water Supply	$38 million
Fish/Wildlife	$11 million
Recreation	$18 million
Agriculture	$17 million
Ports	$3,266 million
Forests	$14 million
Public Parks	$26 million
Total	**>$7 billion**

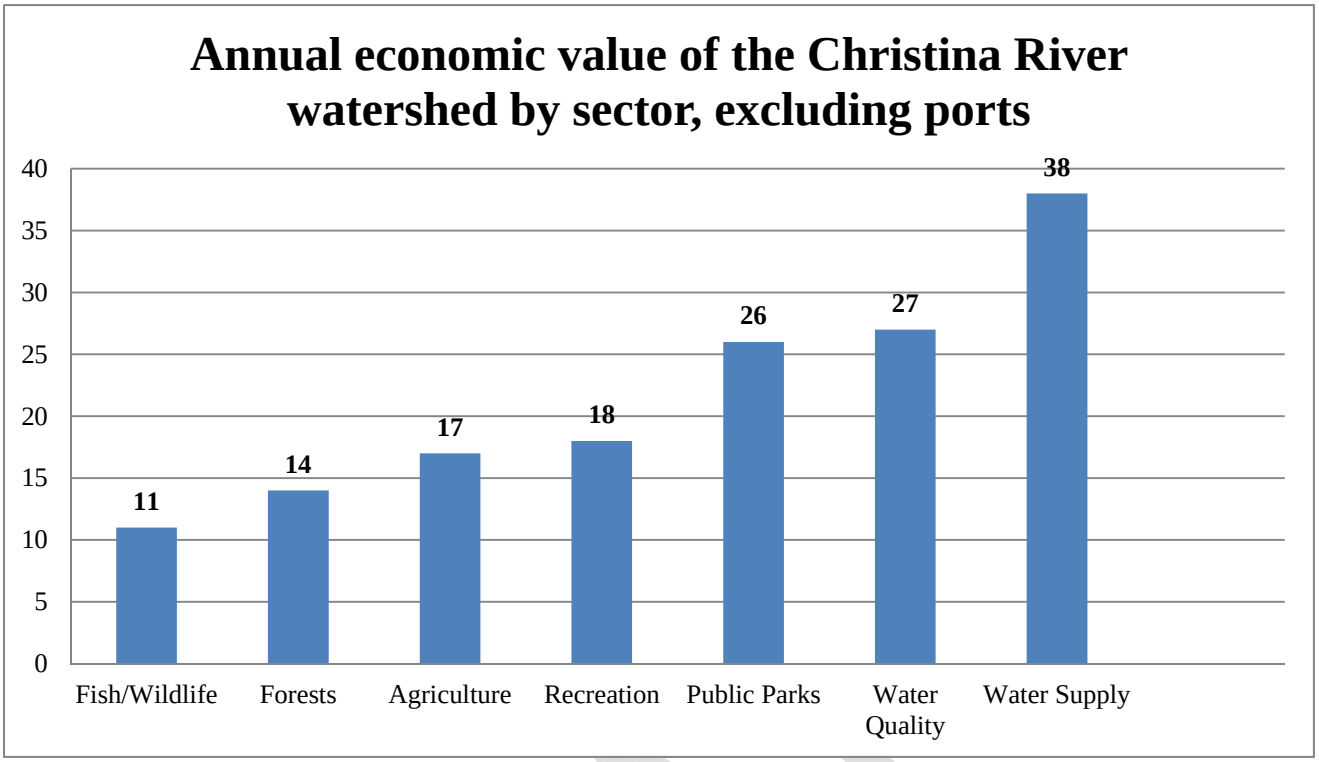

Figure 5. Annual economic value of the Christina River watershed by sector

Table 5. Annual economic value of the Christina River watershed

Sector	Activity	2010 ($ million)	Source
Water Quality	Boatable (WTP=$13.20)	2	University of Delaware (2003)
	Fishable (WTP=$13.22)	2	University of Delaware (2003)
	Swimmable (WTP=$112.75)	21	University of Delaware (2003)
	Increased Property Value (+8% over 20 years)	104	EPA (1973), Brookings Institute (2010)
	Water Treatment by Forest ($76/mgd)	0.1	Trust for Public Land, AWWA (2004)
	Wastewater Treatment	0.7	DNREC (2010), WRA
Water Supply	Drinking Water Supply ($7.85/1,000 gallons)	38	WRA, Chester County Conservation District, & Chester Water Resources Authority (1998)
	Irrigation Water Supply ($300/acre-foot)	0.1	Resources for the Future (1996), USDA (2007)
	Industrial Water Supply ($200/acre-foot)	0	Resources for the Future (1996), USGS (2005)
Fish/Wildlife	Fishing	4	U.S. Fish and Wildlife Service (2008)
	Hunting	2	U.S. Fish and Wildlife Service (2008)
	Wildlife/Bird-watching	5	U.S. Fish and Wildlife Service (2008)
Recreation	Outdoor Recreation	18	Outdoor Industry Foundation (2006)
	State Parks ($53/visit, 8,374 acres)	0	PA DEP and Penn State
Agriculture	Crop, poultry, livestock value ($3,482/acre)	17	USDA Census of Agriculture 2007 (2009)
Ports	Navigation ($15/acre-foot)	66	
	Port Activity	3,200	
Forests	Carbon Storage ($827/acre)	10	U.S. Forest Service, Del Ctr. Hort. (2008)
	Carbon Sequestration ($29/acre)	0.3	U.S. Forest Service, Del Ctr. Hort. (2008)
	Air Pollution Removal ($266/acre)	3	U.S. Forest Service, Del Ctr. Hort. (2008)
	Building Energy Savings ($56/acre)	0.7	U.S. Forest Service, Del Ctr. Hort. (2008)
	Avoided Carbon Emissions ($3/acre)	0.03	U.S. Forest Service, Del Ctr. Hort. (2008)
Public Parks	Health Benefits ($9,734/acre)	20	Trust for Public Land
	Community Cohesion ($2,383/acre)	5	Trust for Public Land
	Stormwater Benefit ($921/acre)	2	Trust for Public Land
	Air Pollution Control ($88/acre)	0.2	Trust for Public Land
Total for Watershed		**7025.3**	

Water Quality

Improved Water Quality

Helm, Parsons, and Bondelid (2003) measured the economic benefits of water-quality improvements to recreational users in the New England states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut and found per person willingness to

pay (WTP) for good water quality ranged from $8.25 for boating, $8.26 for fishing, and $70.47 for swimming use support in 1994 dollars. Adjusting to 2010 dollars based on the change in the Consumer Price Index (CPI) in the Northeast Region as reported by the Bureau of Labor Statistics, per person WTP is estimated at $13.20 for boating, $13.22 for fishing, and $112.75 for swimming uses (Table 7).

In 2010, the Christina River watershed population reached 186,680 (U.S. Census 2010). Based on value transfer data from the study in six New England states, WTP for the Christina River watersheds is approximately $26 million in monetary value. The greatest WTP value comes from a swimmable quality level, at $21,048,170, followed by fishable quality and boatable quality at $2,467,910 and $2,464,176, respectively (Table 6).

Table 6. Annual WTP for water quality benefits in Christina River watershed

Quality Level	WTP per person[1] ($1994)	WTP per person[2] ($2010)	Watershed Population	WTP ($2010)
Boatable	8.25	13.20	186,680	2,464,176
Fishable	8.26	13.22	186,680	2,467,910
Swimmable	70.47	112.75	186,680	21,048,170
Total	**86.98**	**139.17**	**186,680**	**25,980,256**

1. Helm, Parsons, and Bondelid (2003). 2. Adjusted to 2010 based on change in Northeast Region CPI (BLS). 3. WTP based on Brandywine Creek watershed population.

Increased Property Value

Studies along rivers and bays in the U.S. indicate that improved water quality can increase shoreline property values by 4 to 18 percent (Table7). The EPA (1973) estimated improved water quality can raise property values by up to 18% next to the water, 8% at 1,000 feet from the water, and 4% at 2,000 feet from the water. Leggett et al. (2000) estimated improved bacteria levels to meet water quality standards along the western shore of the Chesapeake Bay in Maryland could raise property values by 6 percent. Poor et al. (2007) studied 1,377 residential property sales in the St. Mary's River watershed on the western shore of Chesapeake Bay and concluded that a 1 mg/l increase in dissolved inorganic nitrogen reduced the average $200,936 property value of a house by $17,642 or 8.8 percent. Austin et al. (2007) from the Brookings Institute (2007) projected that investing $26 billion to restore the Great Lakes would increase shore property values by 10%.

Table 7. Increased property resulting from improved water quality

Study	Watershed	Increased Property Value
EPA (1973)	San Diego Bay, Calif.	
- Next to water	Kanawha, Ohio	18%
- 1000 ft from water	Willamette River, Ore.	8%
- 2000 ft from water		4%
Leggett et al. (2000)	Chesapeake Bay	6%
Poor et al. (2007)	Chesapeake Bay	9%
Brookings Institute (2007)	Great Lakes	10%

With improved water quality, property values within 2,000 feet of the Christina River watershed and its tributaries are estimated to increase by 8% % which is the adjusted midpoint between 18% next to the water and 4% at 2000 feet from the water. The Christina River has 184 stream miles. If the median household property value in the Christina River is $293,550/acre, based on housing data from the U.S. Census, then properties within 2,000 feet of the stream have an estimated value of $26.2 billion. Property values within 2,000 feet of the water would increase by 8% or $2.1 billion due to improved water quality (Table 8). Since increased property value is a one-time benefit, the annual value over a 20-year period is estimated at $104.8 million.

Table 8. Added property value due to improved water quality in Christina watershed

Stream Length (miles)	Stream Length (ft)	Area within 2,000 ft of Stream (ac)	Property Value @ $293,550/ac	Increased Value @ 8%	Annual Value 20 years
184	**971,520**	**89,212**	**$26,188,218,182**	**$2,095,057,455**	**$104,752,872**

Water Treatment by Forests

Forests provide significant water-quality and water-treatment benefits. The Trust for Public Land and American Water Works Association (2004) found for every 10% increase in forested watershed land, drinking water treatment and chemical costs are reduced by approximately 20% (Table 9). If the public drinking water supply is 6 mgd and forests cover 11,520 acres (23%) of the Christina River watershed, then loss of these forests would increase drinking water treatment costs by $52 per mgd ($139/mgd @ 0% forested minus $56/mgd @ 42% forested) or $312/day or $113,880 /year.

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

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

Trust for Public Land and AWWA, 2004

Wastewater Treatment

There are 2 permitted surface-discharge-sewage-treatment plants in the Christina River watershed, both being located in the Maryland portion of the watershed (EPA TMDL Report).

The NPDES wastewater dischargers in Maryland possess Federal and state water-quality permits to treat and discharge 0.5 million gallons per day to the waters of the Christina River watershed. An analysis of wastewater utilities conducted by WRA computes that the average

wastewater rate in the watershed is $4.00 per 1,000 gallons, which, for an average residence of four people (at 50 gpcd), is a fee of $290 per year. The total market value based on treated-wastewater rates in the Christina River watershed is $2,000 per day or $730,000 per year (Table 10).

Table 10. Value of Sewage-Treatment Plants' Discharge in the Christina River watershed

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	$/day ($4.00/1,000gal)	$/Year
West Branch				
MD00651450	Highlands WWTP WB Christina River Municipal Small STP	0.05	200	73,000
MD0022641	Meadowview Utilities, Inc. WB Christina River Municipal Small STP	0.45	$1,800	657,000
	Total	**0.5**	**2,000**	**730,000**

Water Supply

Drinking Water Supply

The streams and wells of the Christina River watershed provide over 13.6 million gallons per day (mgd) of public drinking water. The annual value of public water supplies in the Christina River watershed is $38.1 million per year or $13.7 million from surface water and $24.4 million from groundwater.

Surface waters of the Christina River watershed provide 6 mgd of drinking water. The rivers and streams in the watershed serve as a major drinking water source for a portion of New Castle County in Delaware. The Christina River watershed includes the United Water Delaware system. At the water rates charged by the water utilities, the annual value of 6 mgd of treated surface water in the Christina River watershed is $13.7 million, over $37,000 per day (Table 11).

Table 11. Public surface water withdrawals for Christina River watershed

State	County	Purveyor	Capacity (mgd)[1]	Water Rate ($/1,000 gal)[2]	$ Value/day treated (Actual Rate/1,000 gal)	$ Value/year treated (Actual Rate/1,000 gal)
DE	New Castle	United Water DE	6	6.28	37,680	13,753,200
Total for watershed			**6**		**37,680**	**13,753,200**

1. Phase I & II Report Christina River Basin, Water Quality Management Strategy, May 1998. UDWRA 2012

The community public water supply wells in the Christina river watershed provide approximately 7.6 mgd of drinking water to the region. These wells serve as drinking water sources for northern Delaware. The value per year of treated water supply from 7.6 mgd community public water supply wells is $24.4 million (Table 12).

Table 12. Community public water supply wells in the Christina River watershed

Owner	Capacity (mgd)	Rate ($/1,000 gal)[1]	$ Value/day treated (Actual Rate/1,000 gal)	$ Value/year treated (Actual Rate/1,000 gal)
Artesian Water Co.	4.946	10.34	51,142	18,666,699
Newark Water Dept.	2.649	5.92	15,682	5,723,959
Christina River Total	**7.595**		**66,824**	**24,390,658**

1 Artesian Water Co. and Newark Water Department's Actual Rates are available. All other wells use the $7.85 average.

Reservoir Storage

Public water supply reservoirs store over 6,600 million gallons of water in the Brandywine Creek watershed (Table 13). The New Jersey Water Supply Authority delivers untreated water to public water purveyors from the Raritan River reservoir system at an estimated market price of $0.394/1,000 gallons (NJWSA 2011). Given the raw water storage value $0.394/1000 gallons, the annual value of reservoir storage in the Brandywine Creek watershed is $15,760.

Table 13. Economic value of reservoir storage in the Christina River watershed

Reservoir	Storage (MG)	Value ($0.394/1000 gal)
Smalley's Pond	40	15,760
Total	**40**	**15,760**

Irrigation Water Supply

In a study of the economic value of freshwater in the United States, Resources for the Future (Frederick et al., 1996) estimated the median market value of irrigation water withdrawals is $198/acre-ft in 1996 dollars or $300/acre-ft ($0.92/1,000 gal) in 2010 dollars, adjusting for change in the CPI (Table 14). In 2007, 5,120 acres of cropland were cultivated and 123 acres were irrigated (USDA 2009). Annual irrigation-water needs from June through September are 9 inches for corn, soybeans, and grain (2,600 gpd/ac for 1,090 irrigated acres or 2.4 mgd). In the Christina River watershed, the annual value of irrigation to water 9 inches of water over 123 acres at a use value of $0.92/1,000 gal is $107,110/yr (Table 15).

Table 14. Freshwater-use values in the United States

Use	1996 Median[1] ($/ac-ft)	2010 Median[2] ($/ac-ft)	2010 Median ($/1,000 gal)
Navigation	10	15	0.02
Irrigation	198	300	0.92
Industrial Process	132	200	0.61
Thermoelectric Power	29	44	0.14

1. Frederick et al., 1996
2. Adjusted to 2010 dollars based on change in Northeast Region CPI (BLS).

Table 15. Value of agriculture irrigation in the Christina River watershed

County	Farmland by County[1] (ac)	Irrigation by County[1] (ac)	Farmland in Watershed (ac)	Irrigation in Watershed (ac)	Irrigation @ 2,600 gpd/ac (gpd)	Value of Irrigation @ $0.92/1,000 gal ($/day)	Value of Irrigation ($/yr)
Chester	117,145	1,659					
Cecil	60,147	1,122					
New Castle	51,913	2,711					
Total	**229,205**	**5,492**	**5,120**	**123**	**318970**	**293**	**$107,110**

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

Fish/Wildlife

Fishing, Hunting, and Bird/Wildlife Watching

The U.S. Fish and Wildlife Service (2008) conducted a survey of the 2006 annual economic value of recreational fishing, hunting, birding and wildlife-associated activities in the U.S. The annual economic value of recreational fishing, hunting, birding and wildlife-associated activities was $4,343 million in Pennsylvania, $269 million in Delaware, and $1,411 million in Maryland in 2006 dollars. Using these state-wide totals and adjusting for percentage of the state in the Brandywine Creek watershed, the annual economic value of the recreational fishing, hunting, birding and wildlife-associated activities for the Christina River watershed was $10.9 million (Table 16).

Table 16. Value of wildlife recreation in the Christina River watershed

Activity	Value PA[1] ($2006)	PA in watershed[2] ($2006)	DE[1] ($2006)	DE in watershed[2] ($2006)	MD[1] ($2006)	MD in watershed[2] ($2006)	Christina River watershed ($2006)
Fishing	1,291,211,000	129,121	96,775,000	3,300,028	568,211,000	511,389	3,940,539
Hunting	1,609,045,000	160,905	41,381,000	1,411,092	210,087,000	$189,078	1,761,075
Wildlife/Birding	1,442,582,000	144,258	130,832,000	4,461,371	633,699,000	$570,329	5,175,959
Total	**4,342,838,000**	**434,284**	**268,988,000**	**9,172,491**	**1,411,997,000**	**$1,270,797**	**10,877,572**

Recreation

Outdoor Recreation

The Outdoor Industry Foundation (2006) concluded there were 16.3 million participants in recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing in the mid-Atlantic region (NJ, NY, Pa.) who contributed $18.3 billion ($15.6 billion

in gear/trip sales) and 216,396 jobs to the regional economy. Given the population of the three states total 40.9 million (NJ 8.8 million, NY 19.4 million, and Pa. 12.7 million), by proportion outdoor recreation activity in the Christina River watershed (pop. 186,680) contributes $83.7 million and 988 jobs to the economy (Table 17).

Table 17. Outdoor recreation activity in the Christina River watershed

Recreation	Activity	Christina River[2]	Mid-Atlantic Region[1]
Bicycling	Gear Trip/Sales	$15,390,830	$3,372,000,000
	# Participants	11,393	2,496,000
	Jobs	183	40,121
Camping	Gear Trip/Sales	$34,291,610	$7,513,000,000
	# Participants	8,554	1,874,000
	Jobs	408	89,384
Fishing	Gear Trip/Sales	$8,069,688	$1,768,000,000
	# Participants	8,627	1,890,000
	Jobs	78	17,195
Hunting	Gear Trip/Sales	$3,336,506	$731,000,000
	# Participants	2,054	450,000
	Jobs	33	7,234
Paddling	Gear Trip/Sales	$3,578,414	$784,000,000
	# Participants	7,239	1,586,000
	Jobs	43	9,331
Hiking	Gear Trip/Sales	$11,004,535	$2,411,000,000
	# Participants	13,912	3,048,000
	Jobs	131	28,686
Wildlife Viewing	Gear Trip/Sales	$8,014,916	$1,756,000,000
	# Participants	22,776	4,990,000
	Jobs	112	24,445
Total	**Gear Trip/Sales**	**$ 83,686,499**	**$18,335,000,000**
	# Participants	**74,553**	**16,334,000**
	Jobs	**988**	**216,396**

1. Outdoor Industry Foundation 2006
2. Scaled by population of watershed to Mid-Atlantic region population. (Christina River: 186,680)

Agriculture

In 2007, the USDA National Agricultural Statistics Service (2009) estimated the annual market value of agricultural products sold in Chester, Lancaster, and Delaware counties in Pennsylvania and in New Castle County in Delaware at $1.7 billion. Spanning through Chester, Cecil, and New Castle Counties, the Christina River watershed has a cropland and agriculture value of $16 million in 2010 dollars (Table 18).

Table 18. Value of cropland and agriculture in the Christina River watershed

County	Farmland by County[1] (ac)	2007 Value by County[1] ($ million)	Farmland in Watershed (ac)[2]	2007 Value in Watershed ($ million)
Chester	117,145	553.3		
Cecil	60,147	95.8		
New Castle	51,913	45.7		
Total	**229,205**	**695**	**5,120**	**16**

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

Port of Wilmington

The Port of Wilmington is located at the confluence of the Delaware and Christina Rivers, 65 miles from the Atlantic Ocean. The port is one of the largest importers of orange juice, Chilean grapes, bananas, and automobiles nationally. The port has significant economic value to the region and the water resources of the Christina River watershed play a significant role in this as it relates to both navigation and port activity.

Navigation

The 130-mile-long Delaware River and Bay ship channel from Cape Henlopen to the head of tide at Trenton has significant instream navigation–use value. The water-resource value from transport shipping is distinct from the port activities described below. The volume of the 216-sq.-mi. Delaware River and Bay within Delaware's boundaries at a mean depth of 32 feet is 4.4 million acre-feet (1.4 trillion gallons). Frederick et al. (1996) concluded the median navigation-use value in the U.S. is $10/acre-foot in 1996 dollars ($15/acre-foot in 2010 dollars adjusting for 3% annually). Therefore, the annual navigation use value of the Delaware River/Bay from the Atlantic Ocean to the Port of Wilmington within state boundaries is $66 million.

Port Activity

The Martin Associates report (2005), prepared for the Diamond State Port Corporation, cited that the marine cargo activity at the Port of Wilmington's terminals generated a total of $3.2 billion of total economic activity in the region. This total economic activity can be broken down into direct business revenue and the value of output to the state. Just over $400 million ($409.1 million) is direct business revenue by the firms dependent on the port's marine terminals and providing maritime services and inland transportation services to the cargo handled at the marine terminals and the vessels calling the terminals. The remaining $2.8 billion represents the value of the output to the state that is created due to the cargo moving via the Diamond State Port Corporation's marine terminals (Martin Associates, 2005).

Located at the confluence of the Delaware and Christina Rivers, the Port of Wilmington was founded in 1923, and is one of the busiest terminals on the Delaware River. The port is a full-service deepwater port and marine terminal. The Port of Wilmington:

- Is the world's largest banana hub.
- Is the leading gateway for imports of fresh fruit and juice concentrate.
- Is the Mid-Atlantic regional port of discharge for Volkswagen America.
- Handles 400 vessels annually.
- Imports and exports over four million tons of cargo annually.
- Generates $7 million in tax revenues to Delaware (Table 24).

Table 19. Tax revenues from the Port of Wilmington (2005)

Type	Delaware
Individual Income Tax	$2,538,803
Sales and Use Tax	
Corporate Income Tax	$888,055
Selective Tax	$1,075,499
Other State Tax, License, Fees	$2,536,226
Total State and Local Tax	**$7,038,583**

Source: Economy League of Greater Philadelphia, 2008

The City of Wilmington's marine terminal along the Christina River handles commodities such as:

- Containerized cargo (primarily bananas)
- Fresh fruit
- Frozen breakbulk beef
- Iron and steel products
- Lumber and newsprint
- Breakbulk juices
- Autos
- Salt
- Minerals and other dry bulk commodities
- Bulk juice
- Petroleum products

According to the report, Maritime Commerce in Greater Philadelphia (2008), the Port of Wilmington tripled its TEU (twenty-foot equivalent unit) share between 1985 and 2005, increasing from 0.47 to 1.33 percent of the East Coast market and from 0.20 to 0.60 percent of the U.S. market. In the container business, this growth is the largest proportionate growth among the 20 largest U.S. container ports during this time period. In 2005 the Port of Wilmington contributed 251,000 TEUs, or 1.3 percent of the container market share, of East Coast ports (2005) (Table 20). The port handles 8,445 tons per year, or 1.4 percent of the container market share, of East Coast ports (Table 21).

The Economy League of Greater Philadelphia (2008) reported that among U.S. ports in 2005 the Port of Wilmington ranked:

- 33rd in import tonnage (6,896,499 short tons imported)
- 37th in import cargo value ($5,499,289,565)
- 67th in export tonnage (381,567 short tons exported)
- 24th in export cargo value ($2,175,543,116)

Table 20. Port of Wilmington total TEUs as a share of East Coast and U.S. markets, 1985-2005

Year	Total TEUs	Share of East Coast	Share of U.S.
1985	18,790	0.47%	0.20%
1990	91,623	1.58%	0.67%
1995	156,940	1.81%	0.78%
2000	192,091	1.64%	0.70%
2005	250,507	1.33%	0.60%

Source: Economy League of Greater Philadelphia, 2008

Table 21. Port of Wilmington total tonnage as a share of East Coast and U.S. markets, 1985-2005

Year	Tonnage (thousands)	Share of East Coast	Share of U.S.
1985	2,362	0.56%	0.15%
1990	4,209	0.90%	0.20%
1995	4,273	0.96%	0.20%
2000	5,184	0.94%	0.22%
2005	8,445	1.44%	0.36%

Source: Economy League of Greater Philadelphia, 2008

Forests

The U.S. Forest Service and Delaware Center for Horticulture (Nowak et al., 2008) estimated that 7,137 acres of forests in New Castle County provide environmental benefits such as carbon storage of $5.9 million ($827/acre) and air-pollution removal of $1.9 million ($266/acre/year).

Applying these multipliers, 11,520 acres (18 mi^2) of forests in the Christina River watershed have benefits of carbon storage ($9.5 million), carbon sequestration ($334 thousand), air-pollution removal ($3.06 million), building-energy savings ($645 thousand), and avoided carbon emissions ($34.6 thousand) (Table 27). Forests in the Christina River watershed provide environmental benefits by regulating climate change, cooling, and air-emissions control including 460,800 tons of carbon-storage capacity, 16,128 tons of carbon sequestration,

460 tons of air-pollution removal, and 1,612 tons of avoided carbon-emissions capacity (Table 22).

Table 22. Economic and environmental benefits of forest in the Christina River watershed

Forest Benefits	Forests New Castle County[1]		Forests Christina River[2]	
	Environmental (tons/acre)	Economic ($/acre)	Environmental (tons)	Economic ($)
Carbon Storage	40	827	460,800	9,527,040
Carbon Sequestration	1.4	29	16,128	334,080
Air Pollution Control	0.04	266	460	3,064,320
Energy Savings		56		645,120
Avoided Carbon Emissions	0.14	3	1,612	34,560
Total				**13,605,120**

1. Nowak et al., 2008
2. Computed for 11,520 acres of forest in the Christina River watershed

Public Parks

The Trust for Public Land (2009) found the 444-acre Wilmington park system provides annual economic value and savings to the public from health benefits from exercise in the parks ($4,322,000 or $9,734/ac), community-cohesion benefits as people socialize in the parks ($1,058,000 or $2,383/ac), water pollution–mitigation benefits in treating stormwater ($409,000 or $921/ac), and air pollution–mitigation value from tree and shrub absorption ($39,000 or $88/ac).

Presuming the data gathered for the City of Wilmington study are appropriate for value (benefits) transfer, the 2,011 acres of public parks within the Christina River watershed provide health benefits ($19,576,826), community cohesion benefits ($4,792,642), clean-water benefits ($1,852,297), and air-pollution-mitigation value ($176,984).

Table 23. Value of public parks in the Christina River watershed

State	Parks in Watershed (acres)	Health Benefits (at $9,734/acre)	Community Cohesion (at $2,383/acre)	Stormwater Benefit (at $921/acre)	Air Pollution (at $88/acre)
PA	34	327,062	80,069	30,946	2,957
DE	1,952	19,004,467	4,652,522	1,798,142	171,809
MD	25	245,297	60,052	23,209	2,218
Total	**2,011**	**19,576,826**	**4,792,642**	**1,852,297**	**176,984**

4. Ecosystem Services

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

- Cecil County green infrastructure study by the Conservation Fund, Annapolis, Md. (2007)
- New Jersey Department of Environmental Protection with the University of Vermont (2007)
- Ecosystem services value of forests by the Wilderness Society (2001)
- Ecosystem services value of Peconic Estuary watershed by University of Rhode Island (2002)
- U.S. National Wildlife Refuge System by University of Maryland and the Nature Conservancy (2008)
- Economic value of ecosystem services in Massachusetts by the Audubon Society (2003).

Related Research

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

The N.J. Department of Environmental Protection (2007) partnered with the University of Vermont and estimated the value of New Jersey's natural capital at $20 billion/year in 2004 dollars with a net present value (NPV) of $681 billion. NPV takes the value of a dollar today and projects it into the future summed annually over a lifetime (say 100 years) given the annual value is discounted by a rate (3%) due to inflation based on the Consumer Price Index.

Others have calculated the value of natural capital in ecosystems along the Atlantic seaboard and across the United States. Weber (2007) from the Conservation Fund found the largest ecosystem services values in Cecil County, Maryland are from stormwater/flood control, water supply, and clean water functions (Table 29). The Wilderness Society (Krieger 2001) concluded that forest ecosystem services for climate regulation, water supply, water quality, and recreation benefits totaled $392/ac in 1994 dollars or $631/ac in 2010 dollars based on change in the Northeast Region CPI (Table 30). A contingent value study by University of Rhode Island economists found that natural resources values in the Peconic Estuary watershed in Suffolk County on Long Island New York ranged from $6,560/ac for wetlands to $9,979/ac for farmland in 1995 dollars (Johnston et al. 2002). The University of Maryland studied the U.S. National Wildlife Refuge System and determined that ecosystem values of freshwater wetlands and forests are $6,268/ac and $845/ac, respectively (Ingraham and Foster 2008). The

Audubon Society found the economic value of ecosystems in Massachusetts ranged from $984/ac for forests to $15,452/ac for saltwater wetlands (Breunig 2003). According to the 2007 USDA Census of Agriculture (2009) the market value of agricultural crops, poultry, and livestock sold from 166,891 acres of farmland in Chester County was $553 million, or $3,315/ac. The market value of agriculture from 66,891 acres of farmland in New Castle County was $46 million, or $682/ac.

Table 24 compares ecosystem services values from other watersheds. Data from the NJDEP study and crop value of Chester County agriculture are used for value transfer to the Brandywine Creek watershed as the study area shares similar ecosystems (forests/wetlands), climate (humid continental at 40 degrees north in latitude), and physiographic provinces. NJDEP ecosystem-services values are lower than Cecil County's for wetlands and forests and MassAudubon's for wetlands. NJDEP estimates are higher than the Wilderness Society's for forests and U.S. Wildlife Refuge values for freshwater wetlands and forests.

Table 24. Comparison of ecosystem goods and services values from various studies

Ecosystem	Cecil Co. Md. 2006 ($/ac/yr)	NJDEP 2007 ($/ac/yr)	Wilderness Society 2001 ($/ac/yr)	Peconic Estuary 1995 ($/ac/yr)	U.S. Wildlife 2008 ($/ac/yr)	Mass. Audubon 2003 ($/ac/yr)	USDA Census[1] 2007 ($/ac/yr)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	3,315[1]
Forest land	12,033	1,714	641		845	984	
Saltwater wetland	28,146	6,269		6,560		12,580	
Undeveloped				2,080			
Urban		296					
Beach/dune		42,149					
Open freshwater		1,686			217	983	
Riparian buffer	52,765	3,500					
Shellfish areas				4,555			

1. Value of natural goods only measured by crops, livestock, and poultry sold in Chester County (USDA 2009).

Watershed Ecosystem Services

Ecosystem goods and services in the Christina River watershed using the NJDEP and USDA farm-good values are worth $98.8 million (2010 dollars) or $3.2 billion (NPV), which are conservatively in the lower end of the range. If lower per-acre estimates of ecosystem services from other studies were used instead of the NJDEP values, ecosystem services in the Christina River watershed would be $47.9 million or NPV = $1.6 billion. If higher per-acre estimates from other studies were used, the value of ecosystems in the Christina River watershed would be $326.6 million or NPV = $10.6 billion.

Estimate	PV ($B)	NPV ($B)
Low	$47.9 million	$1.6 billion
NJDEP	$98.8 million	$3.2 billion
High	$326.6 million	$10.6 billion

Ecosystem-services areas within the Christina River watershed are composed of forests (22.5%), farmland (10.9%), freshwater wetlands (4.9%), marine (1.2%), saltwater wetland (1.1%), and open water (0.3%). Roughly 59 percent of the land in the Christina River watershed is urban (Figure 6).

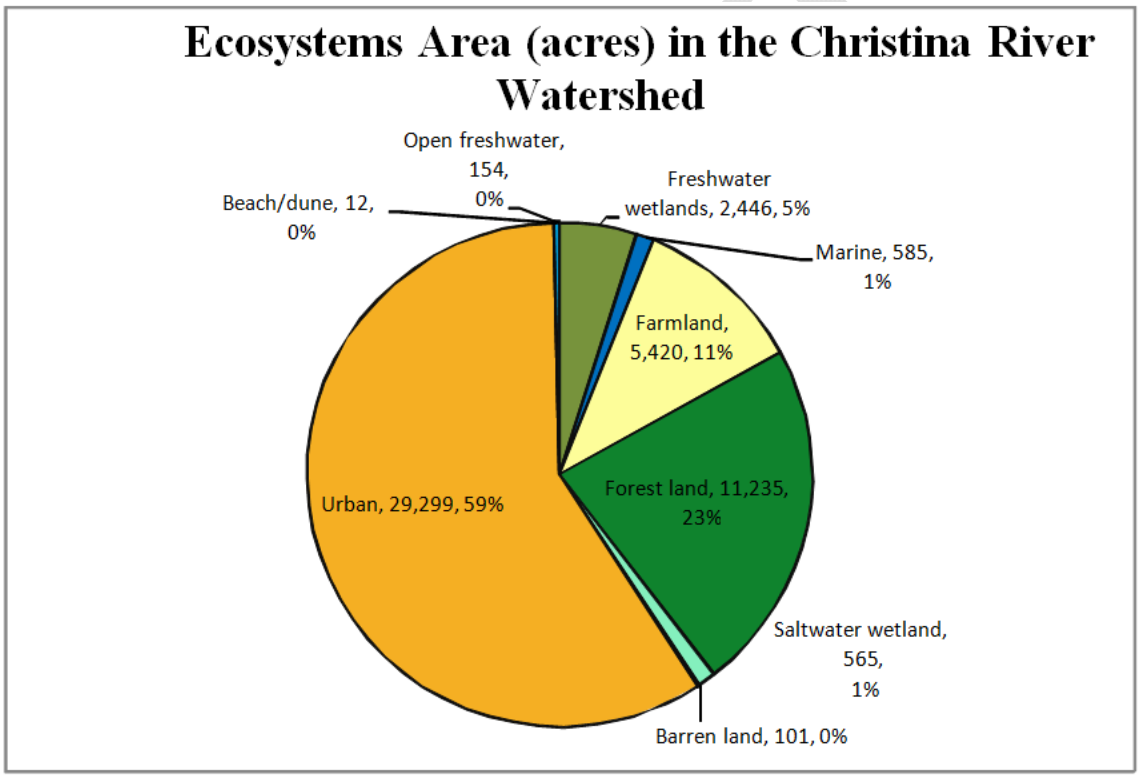

Figure 6. Ecosystem Service areas in the Christina River watershed

Table 25. Value of ecosystem goods and services in the Christina River watershed

Ecosystem	Area (acres)	$/acre/yr	PV $	NPV $
Freshwater wetlands	2,446	13,621	33,322,031	1,082,966,003
Marine	585	10,006	5,851,704	190,180,371
Farmland	5,420	4,124	22,452,630	729,710,469
Forest land	11,235	1,978	22,223,894	722,276,565
Saltwater wetland	565	7,235	4,089,856	132,920,324
Barren land	101	0	0	0
Urban	29,299	342	10,008,850	325,287,611
Beach/dune	12	48,644	587,175	19,083,175
Open water	154	1,946	300,266	9,758,629
Total	**49,818**	**1,984**	**98,836,405**	**3,212,183,148**

Table 26. Low range of ecosystem services in the Christina River watershed

Ecosystem	Area (acres)	$/acre/year	PV ($)	NPV ($)
Freshwater wetlands	2,446	6,268	15,334,236	498,362,680
Marine	585	8,670	5,070,370	164,787,021
Farmland	5,420	1,387	7,517,655	244,323,787
Forest land	11,235	641	7,201,529	234,049,678
Saltwater wetland	565	6,269	3,543,768	115,172,476
Barren land	101	0	0	0
Urban	29,299	296	8,672,443	281,854,410
Beach/dune	12	42,149	508,774	16,535,143
Open water	154	217	33,486	1,088,299
Total	**49,818**	**961**	**47,882,261**	**1,556,173,493**

Table 27. High range of ecosystem services in the Christina River watershed

Ecosystem	Area (acres)	$/acre/year	PV ($)	NPV ($)
Freshwater wetlands	2,446	43,685	106,872,386	3,473,352,530
Marine	585	8,670	5,070,370	164,787,021
Farmland	5,420	9,979	54,087,007	1,757,827,737
Forest land	11,235	12,033	135,188,757	4,393,634,590
Saltwater wetland	565	28,146	15,910,497	517,091,163
Barren land	101	0	0	0
Urban	29,299	296	8,672,443	281,854,410
Beach/dune	12	42,149	508,774	16,535,143
Open water	154	1,686	260,173	8,455,633
Total	**49,818**	**6,555**	**326,570,407**	**10,613,538,226**

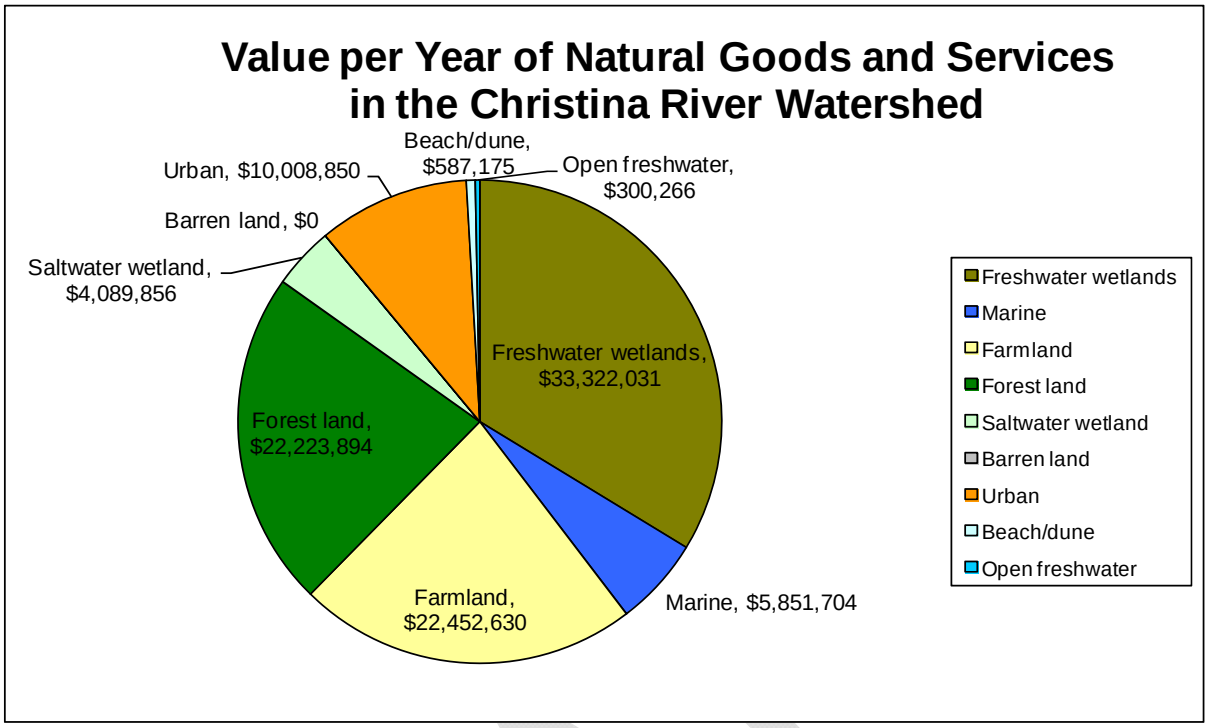

Figure 7. Value of natural goods and services by ecosystem in the Christina River watershed

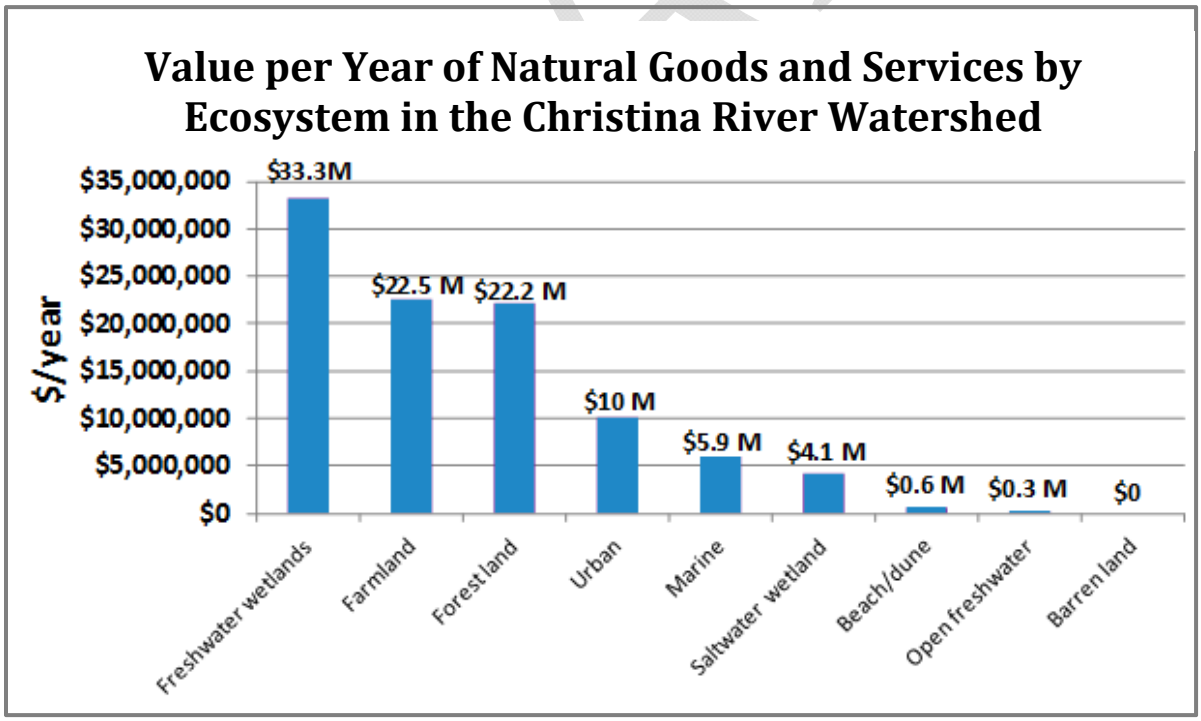

Figure 8. Ecosystem service value (2010 dollars) in the Christina River watershed

5. Jobs and Wages

The Christina River watershed contains water resources and habitats that support more than 15,000 direct and indirect jobs and with over $35 million in annual wages in the coastal, farm, ecotourism, recreation, watershed organization, port, and water supply/wastewater industries (Table 28).

Table 28. Jobs and wages directly and indirectly related to Christina River watershed

Sector	Jobs	Wages ($)	Data Source
Direct Watershed-Related	15,728	732,533	U.S. Census Bureau (2010)
Indirect Watershed-Related	18,873	586,026	U.S. Census Bureau (2010)
Coastal	2,974	59,479,024	National Coastal Econ. Program (2009)
Farm	69	204,672	U.S. Dept. of Agriculture., (2007)
Fishing/Hunting/Birding	373	12,242,803	U.S. Fish and Wildlife Service (2008)
Watershed Organizations	129	6,192,000	WRA and DRBC (2010)
Water Supply Utilities	18	997,326	Delaware Tourism Office (2008)
Public Wells	23	1,262,448	WRA and DRBC (2010)
Wastewater Utilities	2	94,000	WRA and DRBC (2010)
Total	**>15,000**	**>35,000**	

Direct and indirect jobs and wages in the Christina River watershed were obtained from the U.S. Census Bureau (2010) databases (Table 29, Table 30, Appendix A). Note the NAICS database does not include jobs for certain known water-related industries, such as commercial fishing and boat building; therefore, the columns are left blank. Hence, the number of watershed-related jobs is likely undercounted. Christina River watershed-related jobs are tabulated for three categories: (1) total jobs in the Christina River watershed, (2) direct Christina River watershed jobs, and (3) indirect watershed jobs.

The U.S. Census Bureau (2010) indicates there were 91,965 nonfarm jobs in the Christina River watershed (Table 29).

Table. 29. Total employment in the Christina River watershed

County	County[1] Population	Watershed[1] Population	County[2] Employment	Watershed[3] Employment
Chester County	498,886	789	249,515	395
New Castle County	538,479	177,964	261,530	86,434
Cecil County	1,037,365	7,927	511,045	3,905
Total	**182,321**	**186,680**	**89,818**	**91,965**

1. US Census 2010. 2. U.S. Bureau of Labor Statistics 2011.
3. Scaled by ratio of watershed population to county population and multiplied by county employment.

Direct Christina River watershed-related jobs such as water/sewer construction, living resources, maritime, tourism/recreation, ports, environmental services, and water/wastewater management were determined for each NAICS code the Christina River watershed. Industries

directly associated with the Christina River watershed (including water/sewer construction, water utilities, fishing, recreation, tourism, and transportation) employed 15,728 people with $732.5 million in wages (Table 30).

Indirect jobs and wages funded by purchase of goods/services by direct jobs earners are estimated by a multiplier of 2.2 for direct jobs and 1.8 for direct wages (Latham and Stapleford, 1990). The United Nations Environment Program (2011) estimates each tourism job generated 1.5 indirect jobs. For this report, we assume that each direct watershed job funds 1.2 indirect jobs and a dollar in direct wages funds $0.80 in indirect wages. Indirect jobs in the watershed (based on multipliers of 2.2 for jobs and 1.8 for salaries) employed 18,873 people with $586 million in wages (Table 30).

Table 30. Direct and indirect watershed related jobs in the Christina River watershed, 2009

Sector	North American Industry Classification System (NAICS) code	NAICS code	Direct Jobs[1]	Direct Wages[1] (x$1000)	Indirect Jobs[2]	Indirect Wages[2] (x$1000)
Construction	Water and sewer line and related structures construction	23711	57	3,483	69	2,787
Living Resources	Support activities for agriculture and forestry	115	11	329	14	263
	Wineries	31213				
	Fish and seafood merchant wholesalers	42446				
	Nursery, garden center, and farm supply stores	44422	69	2,177	82	1,742
	Fish and seafood markets	44522	9	172	10	138
	Fruit and vegetable markets	44523		2		2
Minerals	Mining, quarrying, and oil and gas extraction	21		518		414
	Electric power generation, transmission and distribution	2211		0		
Tourism/ Recreation	Sporting and recreational goods and supplies merchant wholesalers	42391		138		110
	Sporting goods stores	45111	126	2,376	151	1,900
	Recreational goods rental	532292				
	Commercial air, rail, and water transportation equipment rental and leasing	532411				
	Recreational vehicle dealers	44121				
	Boat dealers	441222	31	1,207	37	966
	Museums, historical sites, and similar institutions	712	228	6,714	274	5,371
	Amusement parks and arcades	7131	8	131	9	105
	Amusement arcades	71312		32		26
	Other amusement and recreation industries	7139	919	15,618	1,102	12,494
	Golf courses and country clubs	71391	192	6,227	231	4,981
	Marinas	71393		210		168
	Fitness and recreational sports centers	71394	622	7,251	746	5,801
	All other amusement and recreation industries	71399	42	1,208	51	966
	Accommodation	721	509	10,213	611	8,171
	Hotels (except casino hotels) and motels	72111	480	9,592	576	7,674
	Bed-and-breakfast inns	721191				
	RV (recreational vehicle) parks and recreational camps	7212		3		3
	Full-service restaurants	7221	2,993	46,044	3,592	36,835
	Limited-service restaurants	722211	1,694	21,354	2,032	17,084
	Snack and nonalcoholic beverage bars	722213	260	3,602	312	2,881
	Food service contractors	72231	414	10,302	497	8,242
	Caterers	722320	68	1,219	82	975
Transportation	Water transportation	483		5,795		4,636
	Inland water transportation	4832		0		0
	Scenic and sightseeing transportation	487	5	253	6	203
	Scenic and sightseeing transportation, water	4872	5	253	6	203
	Support activities for water transportation	4883	159	6,519	190	5,215
	Marine cargo handling	488320	137	5,311	164	4,248
Environmental	Professional, scientific, and technical services	541	6,359	539,484	7,630	431,587
	Grantmaking foundations	813211		1,948		1,558
	Civic and social organizations	8134	1	4,184	1	3,347
Water/ Wastewater	Water, sewage and other systems	2213	105	7,270	126	5,816
	Waste management and remediation services	562	226	11,394	271	9,115
SUM OF ALL INDUSTRIES			**15,728**	**732,533**	**18,873**	**586,026**

1. Direct jobs/wages are those directly related to the Brandywine Creek 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.

National Coastal Economy

The National Ocean Economic Program (2009) published a report that summarized the coastal economy in the United States for the following industrial sectors: Marine Construction, living Marine Resources, Mineral Extraction, Ship and Boat Building, Tourism and Recreation, and Transportation. According to the NOEP (2009), coastal counties in the Delaware portion of the Christina River watershed contributed 2,974 coastal jobs, representing over $59.5 million in annual wages and $30 million toward the state GDP (Table 31).

Table 31. Ocean/coastal employment, wages, and GDP in the Delaware portion of the Christina River watershed

Economic Sector	Establishments	Employment	Wages ($)	GDP ($)
Construction	6	34	1,739,040	2,833,853
Living Resources	5	37	1,212,895	2,765,348
Minerals	D	D	D	D
Ship & Boat Building	D	D	D	D
Tourism & Recreation	152	2,553	40,815,947	84,970,003
Transportation	8	339	15,193,369	22,001,151
All Ocean Sectors	**172**	**2,974**	**59,479,024**	**114,293,123**

Source: NOEP, 2009
Based on 2010 Delaware and New Castle County, DE population estimates
D = Disclosure issues prevent this data from being presented.

Farm Jobs

The USDA 2007 Census of Agriculture indicates that the agricultural industry contributes about 69 farm jobs in the Christina River watershed and $204,672 in wages (Table 32).

Table 32. Agriculture jobs and wages in the Christina River watershed

Region	Farmland (ac)	Farm Jobs	Wages ($)
PENNSYLVANIA			
Chester County	166,891	7,708	5,047,000
Christina River Portion	1,052	49	31,824
DELAWARE			
New Castle County	66,981	565	4,892,000
Christina River Portion	2,367	20	172,848
Watershed Total	**3,419**	**69**	**204,672**

County prorated by Census of Agriculture data. Farmland prorated by GIS land use/land cover data.

Fishing/Hunting/Bird and Wildlife Recreation Jobs

A 2007 study by the NJDEP estimated the average annual salary per ecotourism job is $32,843, based on figures from the 2001 U.S. Fish and Wildlife Service report on fishing, hunting, and wildlife-associated recreation (NJDEP 2007). Using this wage multiplier, fishing, hunting, and bird/wildlife-associated recreation in the Brandywine Creek watershed account for 373 jobs, a value of $12 million in annual economic activity in 2010 dollars (Table 33). While this estimate of ecotourism jobs is not exact, it provides a reasonable estimate of the jobs provided by fishing, hunting, and bird/wildlife-associated recreation in the Brandywine Creek watershed.

Table 33. Jobs from fishing, hunting, wildlife/birding recreation in the Christina River watershed

Recreation Activity	Recreation Value[1] ($2010)	Jobs[2] in 2010 Dollars
Fishing	**4,435,111**	**135**
Trip Related	2,192,843	67
Equipment	2,242,268	68
Hunting	**1,982,105**	**60**
Trip Related	617,432	19
Equipment	1,364,673	42
Wildlife/Birding	**5,825,587**	**177**
Trip Related	611,799	19
Equipment	5,213,788	159
Total	**12,242,803**	**373**

1. USFWS, Survey conducted in 2006, report issued 2008
2. Scaled by the percentage of each state that is in the Christina River watershed
3. Jobs estimated at $32,843 average salary.

Port Jobs

Martins Associates (2007) reported that the Port of Wilmington, Del.:

- Supports 2,295 direct jobs, 1,766 induced jobs, and 539 indirect jobs for a total of 4,600 jobs (Table 34 and 35).
- Provides $307 million in annual wages with an average salary of $40,890 annually.
- Generates $2.76 billion in annual economic activity.

Table 34. Jobs generated by the Port of Wilmington

Employment Type	Jobs	Wages ($)	Economic Activity ($)
Direct Jobs	2,295	93,856,000	
Induced Jobs	1,766	191,700,000	
Indirect Jobs	539	21,529,000	
Total Jobs	**4,600**	**307,085,000**	**2,762,187,000**

Source: Martins Associates, 2007

Table 35. Direct jobs by category and sector at the Port of Wilmington

Employment Type	Jobs
Surface Transportation	
Rail	10
Truck	783
Subtotal	793
Maritime Services	
Terminal Operations	404
ILA	340
Towing	17
Pilots	39
Agents	15
Surveyors	35
Forwarders	91
Warehouse	321
Government	26
Marine Construction	139
Barge	8
Subtotal	1,435
Port Administration	67
Total	**2,295**

Source: Martins Associates, 2007

Outdoor Recreation

The Outdoor Industry Foundation (2006) concluded that 16.3 million participants in watershed-based recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing in the mid-Atlantic region (New Jersey, New York, and Pennsylvania) and contributed 216,396 jobs. Given the population of the three states total 40.9 million (NJ 8.8 million, NY 19.4 million, and Pa. 12.7 million), by proportion outdoor recreation activity in the Christina River watershed (population 186,680) contributes to 988 jobs (Table 36).

Table 36. Outdoor recreation jobs in the Christina River watershed

Activity	Mid-Atlantic Region	Christina River[2]	Total Wages Earned ($)
Bicycling	40,121	183	6,010,269
Camping	89,384	408	13,399,944
Fishing	17,195	78	2,561,754
Hunting	7,234	33	1,083,819
Paddling	9,331	43	1,412,249
Hiking	28,686	131	4,302,433
Wildlife Viewing	24,445	112	3,678,416
Total	**216,396**	**988**	**32,448,884**

1. Outdoor Recreation Foundation 2006.
2. Scaled by population of watershed to Mid-Atlantic region population.
Christina River: 186,680

Watershed Organization Jobs

Seventeen nonprofit watershed and environmental organizations employ at least 129 staff to work on programs to protect the Christina River watershed (Table 37). Assuming that the average salary of an environmental scientist/specialist is $61,700 (Bureau of Labor Statistics), these watershed organization jobs account for $6.2 million in annual wages.

Table 37. Watershed organization jobs in the Christina River watershed

Watershed Organization	Town	Jobs	Salaries ($)
PENNSYLVANIA			
Delaware Nature Society	Hockessin	20	960,000
Stroud Water Research Center	Avondale	45	2,160,000
Total for Pennsylvania		**65**	**3,120,000**
DELAWARE			
Christina Conservancy, Inc.	Wilmington	1	48,000
Delaware Audobon Society	Wilmington	1	48,000
Delaware Center for Horticulture	Wilmington	18	864,000
Delaware Chapter of the Sierra Club	Wilmington	0	0
Delaware Greenways	Wilmington	6	288,000
Fairfield Watershed Association	Newark	0	0
Friends of Lums Pond	Bear	0	0
Green Delaware	Wilmington	-	-
League of Women Voters of Delaware	Wilmington	5	240,000
Nature Conservancy - Delaware Chapter	Wilmington	2	96,000
Partnership for the Delaware Estuary	Wilmington	16	768,000
Sierra Club	Wilmington	0	0
Urban Environmental Center	Wilmington	1	48,000
Waterfront Watch of Wilmington	Wilmington	1	48,000
Widener Environmental and Natural Resources Law Clinic[2]	Wilmington	1	48,000
Total for Delaware		**52**	**2,496,000**
Total for Watershed		**129**	**6,192,000**

Water Supply Jobs

Public and private water utilities withdrawal 6.0 mgd of drinking water from surface-water and groundwater supplies in the Christina River watershed. According to the American Water Works Association, the average salary of a water-system employee is $55,407. The total number of jobs provided by water utilities in the Christina River watershed is 18, with annual wages of $997,326 (Table 38).

Table 38. Jobs from public water utilities in the Christina River watershed

Water Purveyor	State	Withdrawal (mgd)	Jobs	Salaries ($)
United Water DE	DE	6.0	18	997,326

Wastewater Utility Jobs

Two wastewater utilities discharge 0.5 million gallons per day of treated wastewater to the Christina River watershed. The wage information is computed using the assumption that the average wastewater utility salary is $40,000/year. These wastewater utilities employ 2 employees who earn $94 thousand in wages annually (Table 39).

Table 39. Wastewater treatment jobs in the Christina River watershed

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	Jobs	Salaries
West Branch				
MD00651450	Highlands WWTP WB Christina River Municipal Small STP	0.05	1	$40,000
MD0022641	Meadowview Utilities, Inc. WB Christina River Municipal Small STP	0.45	1	$54,000
Total for watershed		**0.5**	**2**	**$94,000**

Appendix - Employment Codes by Industry, 2009

(U.S. Bureau of Labor Statistics)

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

		Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256
		Other Chemical Product and Preparation Manufacturing	3259
	Plastics and Rubber Products Manufacturing		326
	Nonmetallic Mineral Product Manufacturing		327
		Cement and Concrete Product Manufacturing	3273
		Lime and Gypsum Product Manufacturing	3274
		Other Nonmetallic Mineral Product Manufacturing	3279
	Primary Metal Manufacturing		331
	Fabricated Metal Product Manufacturing		332
	Machinery Manufacturing		333
	Computer and Electronic Product Manufacturing		334
		Computer and Peripheral Equipment Manufacturing	3341
		Communications Equipment Manufacturing	3342
		Audio and Video Equipment Manufacturing	3343
		Semiconductor and Other Electronic Component Manufacturing	3344
		Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	3345
		Manufacturing and Reproducing Magnetic and Optical Media	3346
	Electrical Equipment, Appliance, and Component Manufacturing		335
	Transportation Equipment Manufacturing		336
		Motor Vehicle Manufacturing	3361
		Motor Vehicle Body and Trailer Manufacturing	3362
		Motor Vehicle Parts Manufacturing	3363
		Aerospace Product and Parts Manufacturing	3364
		Railroad Rolling Stock Manufacturing	3365
		Ship and Boat Building	3366
		Other Transportation Equipment Manufacturing	3369
	Furniture and Related Product Manufacturing		337
	Miscellaneous Manufacturing		339
Wholesale Trade			42
	Merchant Wholesalers, Durable Goods		423
	Merchant Wholesalers, Nondurable Goods		424
	Wholesale Electronic Markets and Agents and Brokers		425
Retail Trade			44
	Motor Vehicle and Parts Dealers		441
	Furniture and Home Furnishings Stores		442
	Electronics and Appliance Stores		443
		Electronics and Appliance Stores	4431
	Building Material and Garden Equipment and Supplies Dealers		444
	Food and Beverage Stores		445
	Health and Personal Care Stores		446
	Gasoline Stations		447
	Clothing and Clothing Accessories Stores		448
	Sporting Goods, Hobby, Book, and Music Stores		451
	General Merchandise Stores		452
	Miscellaneous Store Retailers		453
	Nonstore Retailers		454
Transportation and Warehousing			48
	Air Transportation		481
		Scheduled Air Transportation	4811
		Nonscheduled Air Transportation	4812
	Rail Transportation		482
		Rail Transportation	4821

	Water Transportation		483
		Deep Sea, Coastal, and Great Lakes Water Transportation	4831
		Inland Water Transportation	4832
		Support Activities for Water Transportation	4883
	Truck Transportation		484
		General Freight Trucking	4841
		Specialized Freight Trucking	4842
	Transit and Ground Passenger Transportation		485
		Urban Transit Systems	4851
		Interurban and Rural Bus Transportation	4852
		Taxi and Limousine Service	4853
		School and Employee Bus Transportation	4854
		Charter Bus Industry	4855
		Other Transit and Ground Passenger Transportation	4859
	Pipeline Transportation		486
		Pipeline Transportation of Crude Oil	4861
Information			51
	Publishing Industries (except Internet)		511
	Motion Picture and Sound Recording Industries		512
	Broadcasting (except Internet)		515
	Telecommunications		517
	Data Processing, Hosting, and Related Services		518
	Other Information Services		519
Finance and Insurance			52
	Monetary Authorities-Central Bank		521
	Credit Intermediation and Related Activities		522
	Securities, Commodity Contracts, and Other Financial Investments and Related Activities		523
	Insurance Carriers and Related Activities		524
	Funds, Trusts, and Other Financial Vehicles		525
Real Estate and Rental and Leasing			53
	Real Estate		531
	Rental and Leasing Services		532
	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)		533
Professional, Scientific, and Technical Services			54
	Professional, Scientific, and Technical Services		541
		Management, Scientific, and Technical Consulting Services	5416
		Scientific Research and Development Services	5417
Management of Companies and Enterprises			55
	Management of Companies and Enterprises		551
Administrative and Support and Waste Management and Remediation Services			56
	Administrative and Support Services		561
		Travel Arrangement and Reservation Services	5615
	Waste Management and Remediation Services		562
Educational Services			61
	Educational Services		611
		Colleges, Universities, and Professional Schools	6113
		Technical and Trade Schools	6115
		Educational Support Services	6117
Health Care and Social Assistance			62
	Ambulatory Health Care Services		621
	Hospitals		622
	Nursing and Residential Care Facilities		623

	Social Assistance		624
Arts, Entertainment, and Recreation			71
	Performing Arts, Spectator Sports, and Related Industries		711
	Museums, Historical Sites, and Similar Institutions		712
	Amusement, Gambling, and Recreation Industries		713
		Other Amusement and Recreation Industries	7139
Accommodation and Food Services			72
	Accommodation		721
		Traveler Accommodation	7211
		RV (Recreational Vehicle) Parks and Recreational Camps	7212
		Rooming and Boarding Houses	7213
	Food Services and Drinking Places		722
Other Services (except Public Administration)			81
	Repair and Maintenance		811
	Personal and Laundry Services		812
	Religious, Grantmaking, Civic, Professional, and Similar Organizations		813
		Social Advocacy Organizations	8133
		Business, Professional, Labor, Political, and Similar Organizations	8139
	Private Households		814
Public Administration			92
	Executive, Legislative, and Other General Government Support		921
	Justice, Public Order, and Safety Activities		922
	Administration of Human Resource Programs		923
	Administration of Environmental Quality Programs		924
	Administration of Housing Programs, Urban Planning, Community Development		925
	Administration of Economic Programs		926
	Space Research and Technology		927
	National Security and International Affairs		928

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