

Economic Value of the Red Clay Creek Watershed

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Table of Contents

Section	Page
List of Tables	ii
List of Figures	ii
Executive Summary	iv
1. Introduction.....	1
Objectives	1
History.....	1
The Watershed	2
Land Use	5
Population	7
Employment.....	7
2. Methods.....	8
Valuation Techniques	8
Scope of Work	8
3. Economic Value.....	10
Water Quality.....	13
Water Supply	15
Fish/Wildlife	17
Recreation	18
Agriculture	19
Forests	19
Public Parks	20
4. Ecosystem Services.....	21
Related Research.....	21
Watershed Ecosystem Services.....	22
5. Jobs and Wages.....	26
National Coastal Economy	29
Farm Jobs.....	29
Fishing/Hunting/Bird and Wildlife Recreation Jobs.....	29
Outdoor Recreation.....	30
Watershed Organization Jobs	31
Water Supply Jobs	31
Wastewater Utility Jobs	31
References.....	37

List of Tables

Table	Page
1. Land use in the Red Clay Creek watershed	5
2. Population change in the Red Clay Creek watershed, 2000-2010.....	7
3. Population of Red Clay Creek watershed by state.....	7
4. Employment in the Red Clay Creek watershed in 2010.....	7
5. Annual economic value of the Brandywine Creek watershed.....	12
6. Annual WTP for water quality benefits in the Red Clay Creek watershed.....	13
7. Increased property value resulting from improved water quality.....	14
8. Added property value due to improved water quality in Red Clay Creek watershed.....	14
9. Drinking water treatment costs based on percent of forested watershed.....	15
10. Value of Sewage-Treatment Plants' Discharge in the Red Clay Creek Watershed	15
11. Community Public Water Supply Wells in the Red Clay Creek watershed.....	16
12. Freshwater-use values in the United States	16
13. Value of agriculture irrigation in the Red Clay Creek watershed.....	17
14. Value of wildlife recreation in Red Clay Creek watershed	17
15. Outdoor recreation activity in the Red Clay Creek watershed	18
16. Value of Cropland and Agriculture in the Red Clay Creek watershed.....	19
17. Forest benefits in the Red Clay Creek watershed	20
18. Value of public parks in the Red Clay Creek watershed	20
19. Comparison of ecosystem goods and services values from various studies.....	22
20. Value of Ecosystem Goods and Services in the Red Clay Creek watershed.....	23
21. Low range of ecosystem services in the Red Clay Creek watershed.....	23
22. High range of ecosystem services in the Red Clay Creek watershed.....	23
23. Jobs and wages directly and indirectly related to the Red Clay Creek watershed.....	26
24. Employment in the Red Clay Creek Watershed in 2010	26
25. Direct and indirect watershed-related jobs in the Red Clay Creek watershed, 2009.....	28
26. Coastal employment in the Red Clay Creek watershed.....	29
27. Jobs from farms in the Red Clay Creek Watershed.....	29
28. Jobs from wildlife recreation in the Red Clay Creek watershed	30
29. Outdoor recreation jobs in the Red Clay Creek watershed.....	30
30. Watershed organization jobs in the Red Clay Creek watershed.....	31
31. Wastewater treatment jobs in the Red Clay Creek watershed.....	32

List of Figures

Figure	Page
1. The Red Clay Creek watershed.....	4
2. Land use in the Red Clay Creek watershed	5
3. Land cover in the Red Clay Creek watershed.....	6
4. Economic value of water resources	10
5. Annual economic value of the Red Clay Creek watershed by sector.....	11

6. Ecosystem Service Areas in the Red Clay Creek Watershed 24
7. Value of Natural Goods and Services by Ecosystem in the Red Clay..... 25
8. Ecosystem Service Value (2010 dollars) in the Red Clay Creek watershed 25

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Executive Summary

The water, natural resources, and ecosystems in the Red Clay Creek watershed contribute an economic value of \$9.8 to \$19.7 billion annually to the Pennsylvania and Delaware economies. This report examines that economic value in three different ways:

- 1. Economic value directly related to Red Clay Creek watershed water resources and habitats.** The Red Clay Creek watershed contributes over \$191 million 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 Red Clay Creek watershed ecosystems.** Using natural capital as a measure of value, habitat in the Red Clay Creek watershed provide \$84.3 million annually in ecosystem goods and services in 2010 dollars, with a net present value (NPV) of \$2.7 billion calculated over a 100-year period.
- 3. Employment related to Red Clay Creek watershed resources and habitats.** Using employment as a measure of value, natural resources within the Red Clay Creek watershed directly and indirectly supports over 11,000 jobs with over \$30.4 million in annual wages.

The purpose of these estimates is to demonstrate that the Red Clay Creek watershed provides real and significant economic benefits to Pennsylvania and Delaware, 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 Red Clay Creek 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 Red Clay Creek 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 Red Clay Creek 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.

1. Introduction

Objectives

This report summarizes the economic value of water, natural resources, and ecosystems of the Red Clay Creek watershed in Delaware and Pennsylvania estimated as:

1. Economic activity including market and non-market value of water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits.
2. Ecosystem goods and services (natural capital) value provided by habitat such as wetlands, beaches, open water, forests, and farms.
3. Jobs and wages directly and indirectly associated with the Red Clay Creek watershed.

These estimates demonstrate that the Red Clay Creek watershed provides significant economic benefits to the regional economy and are worthy of investment to keep them healthy and productive. Value-transfer techniques were applied by selecting data from published literature and applying them to the Red Clay Creek 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 ecosystem values of forests for water-quality benefits are at least partially captured in the economic value of water supply. However, each of the above estimates clearly indicates that the Red Clay Creek watershed is an economic engine that contributes between \$38.8 million and 1.16 billion annually to the Delaware and Pennsylvania 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 economic activity and jobs associated with companies and industries that rely on the watershed for their processes are not included here. 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.

History

As the smallest watershed in the Christina Basin, the Red Clay Creek watershed also holds the smallest population with just under 48,000 people (U.S. Census 2010). The watershed residents reside in six Pennsylvania municipalities, including Kennett Township, Kennett Borough, New Garden Township, and East Marlborough Township as well as unincorporated areas of northern Delaware. The Red Clay Creek contributes to water as a drinking source for Delaware, containing surface water intakes and wells for community and commercial water supplies, supporting two community public water-supply systems. United Water Delaware also uses water from the Red Clay Creek watershed as drinking water for its customers, taking water from the Red Clay and White Clay Creeks' confluence (DNREC 2012).

Though evidently important to today's society, the Red Clay Valley has always had a secure place in American history. Kennett Square, for instance, was a known stop for the Underground Railroad with many of the conductors, people who aided fleeing slaves, of Quaker descent. The Red Clay Valley is also the site of the historic Wilmington and Western Railroad (DNREC 2012). Originally chartered in 1867, the Wilmington and Western Railroad ran along the Red Clay Creek, transporting passengers, freight, and industrial materials to and from mills and ports throughout its lifespan. After many changes of hands and uses throughout the past century, about 10 miles of the track remain and is owned and operated by the Historic Red Clay Valley, Inc.

The Red Clay Valley is also partly the home of the world renown, Longwood Gardens. Before the colonies, the Longwood area was inhabited by the Native American tribe the Lenni Lenape, who used its forest and wild resources for survival. In 1700, the land was purchased from William Penn himself by the Peirce family and became a Quaker farm. In 1798, the family established an arboretum within the farm which became known as one of the nation's best collections of trees. The farm even became one of the nation's first public parks. A little over 100 years later, upon threat of the destruction of these trees, Pierre du Pont, great-grandson of Eleuthère Irénée du Pont, founder of E.I. du Pont de Nemours & Company in the nearby Brandywine Valley, purchased the farm to save the arboretum and pursue his conservation and horticulture interests.

Because of the rich natural and American history, the Red Clay Valley was awarded the designation of Red Clay Valley Scenic Byway in 2005.

The Watershed

Spanning about 56 square miles of land, the Red Clay Creek watershed is the smallest of the four watersheds in the Christina Basin (Figure 5). Located in both southern Chester County, PA and northern New Castle County, DE, the Red Clay Creek watershed itself consists of five subwatersheds: Burrows Run, Lower Red Clay Creek, Upper Red Clay Creek, West Branch Red Clay Creek, and East Branch Red Clay Creek. Located within the watershed is Hoopes Reservoir found near Wilmington, Del., which is used by the City of Wilmington for drinking water storage. It is important to note, however, that the source of the reservoir's water is pumped from the Brandywine Creek rather than the Red Clay Creek.

The Red Clay Creek is predominantly a free-flowing stream; although, its lower reaches in Delaware are tidal. Despite this, at the end of its path the Red Clay Creek meets and flows into the White Clay Creek near Stanton, DE. Throughout its journey through Pennsylvania and Delaware, the Red Clay Creek flows through three land uses that are almost evenly spread between them. The land uses include urban/suburban, forest/wetland, and agriculture. The Burrows Run subwatershed has also been designated as a coldwater fishery. With these mixed land uses, the Red Clay Creek is listed in the 303d list of Impaired Waters according to the Clean Water Act of 1972. The main concerns, depending on the segment of the Creek, are bacteria and nutrients such as nitrogen, phosphorous, and zinc. Other contaminants that require attention

include polychlorinated benzenes (PCBs), chlorinated pesticides, and dioxin which have all led to fish consumption advisories (DNREC 2012).

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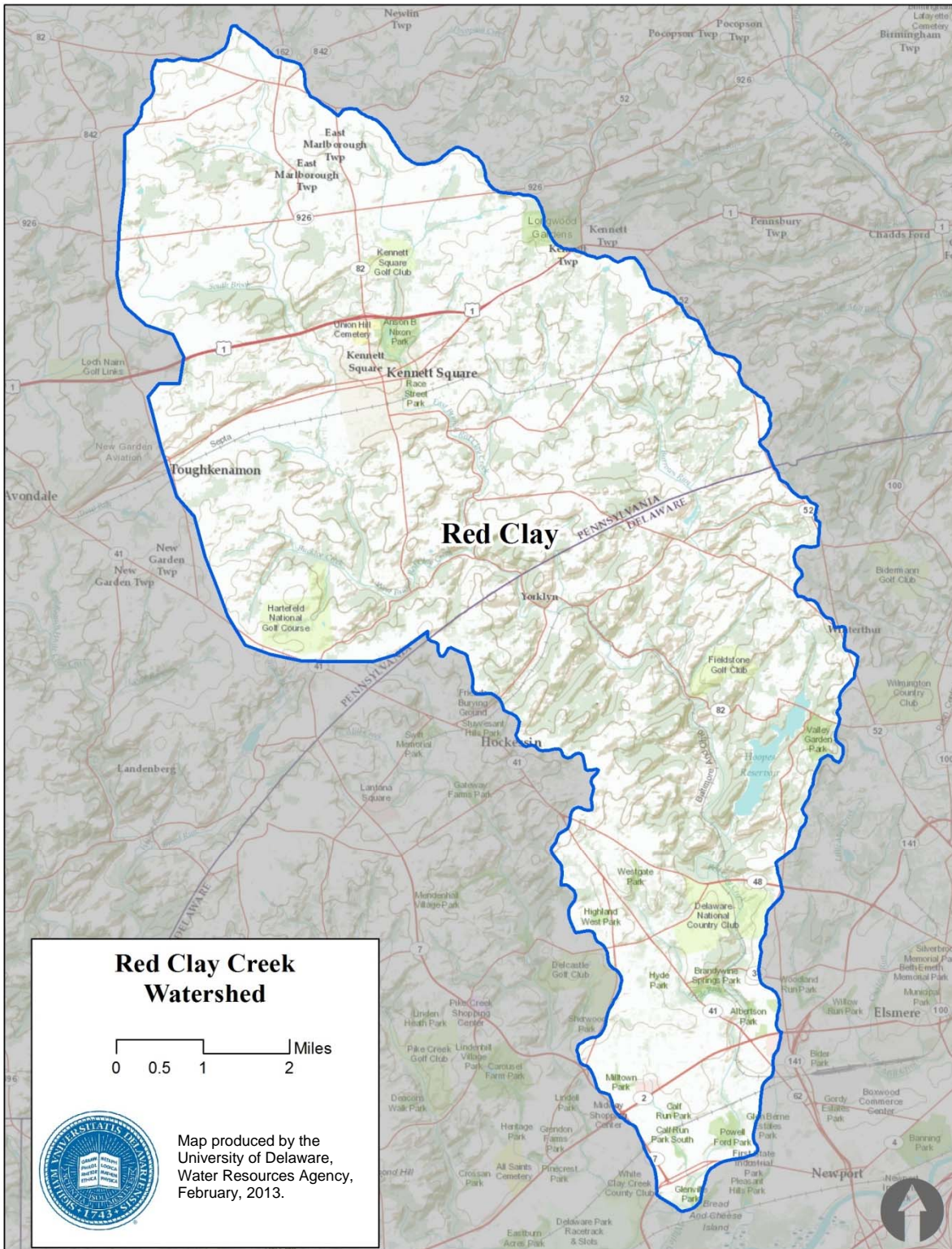


Figure 1. The Red Clay Creek watershed

Land Use

The greatest land cover in the Red Clay Creek is forest land at 39.2%. Farmland is the second largest land use at 30.9% followed by urban land cover at 27.3%. Freshwater wetlands and open freshwater have the smallest cover at 2.0% and 0.6%, respectively. The Red Clay Creek watershed does not contain any saltwater wetlands, beaches, dunes, or marine cover (Table 2, Figure 2, and Figure 3).

Table 1. Land use in the Red Clay Creek watershed

Ecosystem	Area (mi ²)	% Area
Urban	15	27.3%
Farmland	17	30.9%
Forest land	21	39.2%
Freshwater wetlands	1	2.0%
Total	324	100.0%

Citation

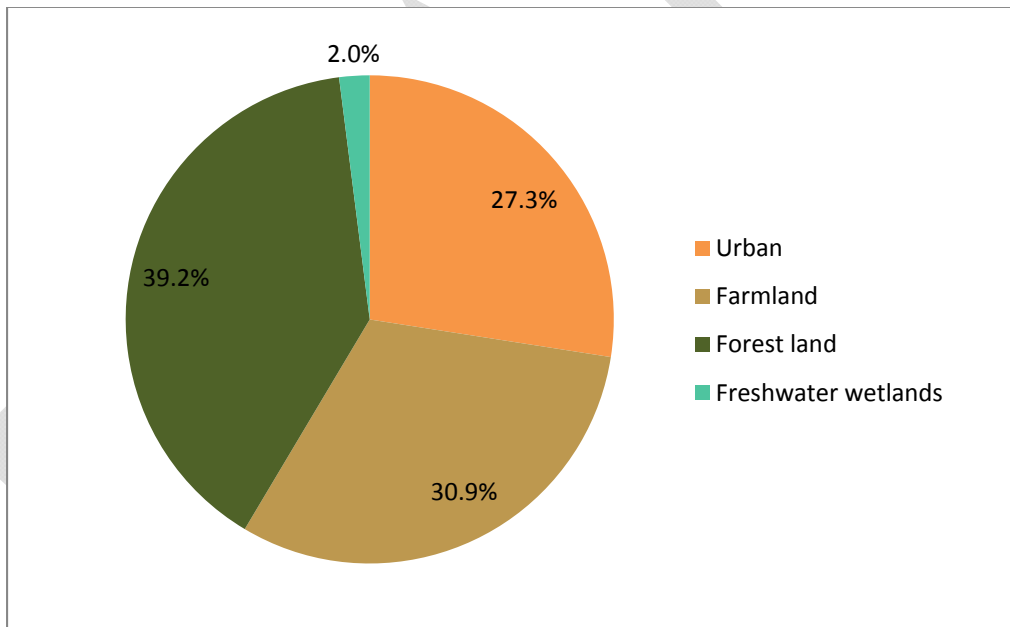


Figure 2. Land use in the Red Clay Creek watershed
(NOAA CSC 2006)

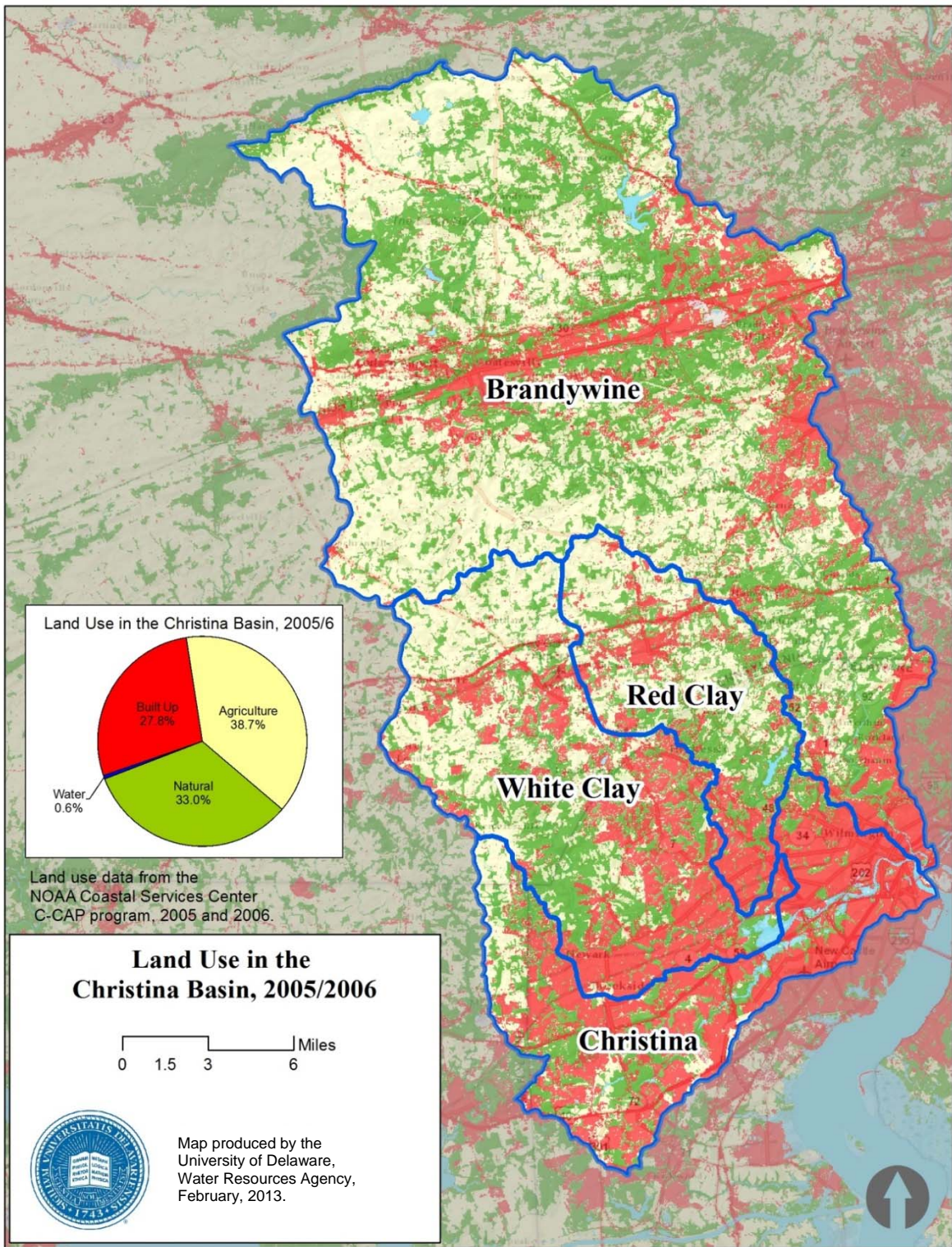


Figure 3. Land cover in the Red Clay Creek watershed (NOAA CSC 2006)

Population

Between 2000 and 2010, the population in the Red Clay Creek watershed population grew by 5,032 (11.8%) from 42,630 to 47,662 (Table 3). The watershed is most populated in its Delaware portion, which is also the portion with the greatest land area, at 24,083 people. The smaller Pennsylvania portion of the watershed houses the remaining 23,579 people (Table 3).

Table 2. Population change in the Red Clay Creek watershed, 2000-2010

Area (mi ²)	2000 pop.	2010 pop.	Change	2000 (people/ mi ²)	2010 (people/ mi ²)
54	42,630	47,662	5,032	789	883

U.S. Census 2010

Table 3. Population of Red Clay Creek watershed by state

State	Area ¹	2010 pop. ²	2010 (people/mi ²)
Pennsylvania	33	23,579	715
Delaware	21	24,083	1,147
Total	54	47,662	1,862

1. U.S. Census 2. NOAA CSC 2006

Employment

In 2010, employment in the Red Clay Creek watershed was 23,490, compared to 498,886 in Chester County, PA and 538,479 in New Castle County, PA (Table 4).

Table 4. Employment in the Red Clay Creek watershed in 2010

County	County ¹ Population	Watershed ¹ Population	County ² Employment	Watershed ³ Employment
Chester County	498,886	23,579	249,515	11,793
New Castle County	538,479	24,083	261,530	11,697
Total	1,037,365	47,662	511,045	23,490

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.

2. Methods

Valuation Techniques

The University of Delaware derived the economic value of the Red Clay Creek 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 economic value of the Red Clay Creek watershed according to the following scope of work.

1. Area of Interest: The area of interest is defined as the Red Clay Creek watershed in Chester County, Delaware County, and Lancaster County, Pennsylvania and New Castle County, Delaware. 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 Red Clay Creek 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 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 Red Clay Creek 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 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 Red Clay Creek 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 Brandywine Creek watershed, (2) ecosystem goods and services (natural capital), and (3) jobs and wages directly and indirectly related to the bay and watershed in 2010 dollars.

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.

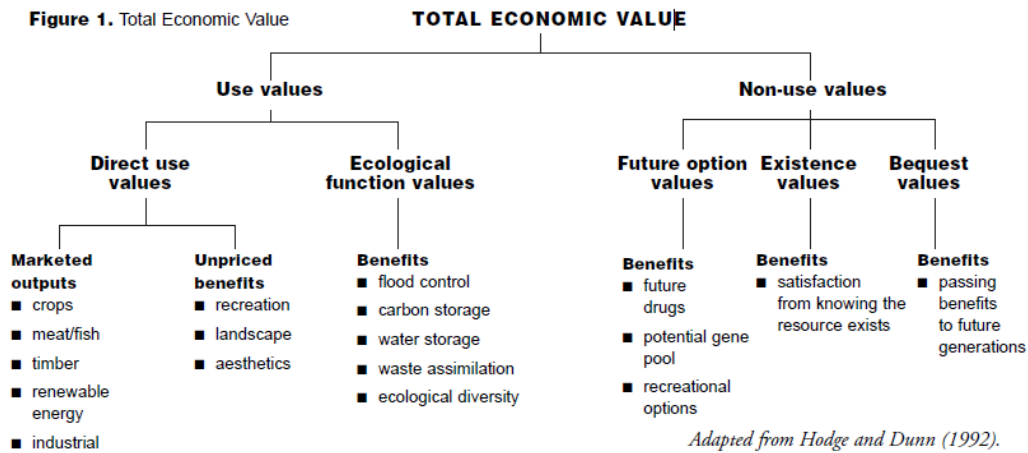


Figure 4. Economic value of water resources (Hodge and Dunn 1992)

The annual economic value of the Red Clay Creek watershed from water quality, water supply, fish/wildlife, recreation, agriculture, forests and public parks benefits exceeds \$191 million (Figure 5 and Table 5).

Water Quality	\$97 million
Water Supply	\$2 million
Fish/Wildlife	\$6 million
Recreation	\$21 million
Agriculture	\$39 million
Forests	\$16 million
Public Parks	\$11 million
Total	> \$191 million

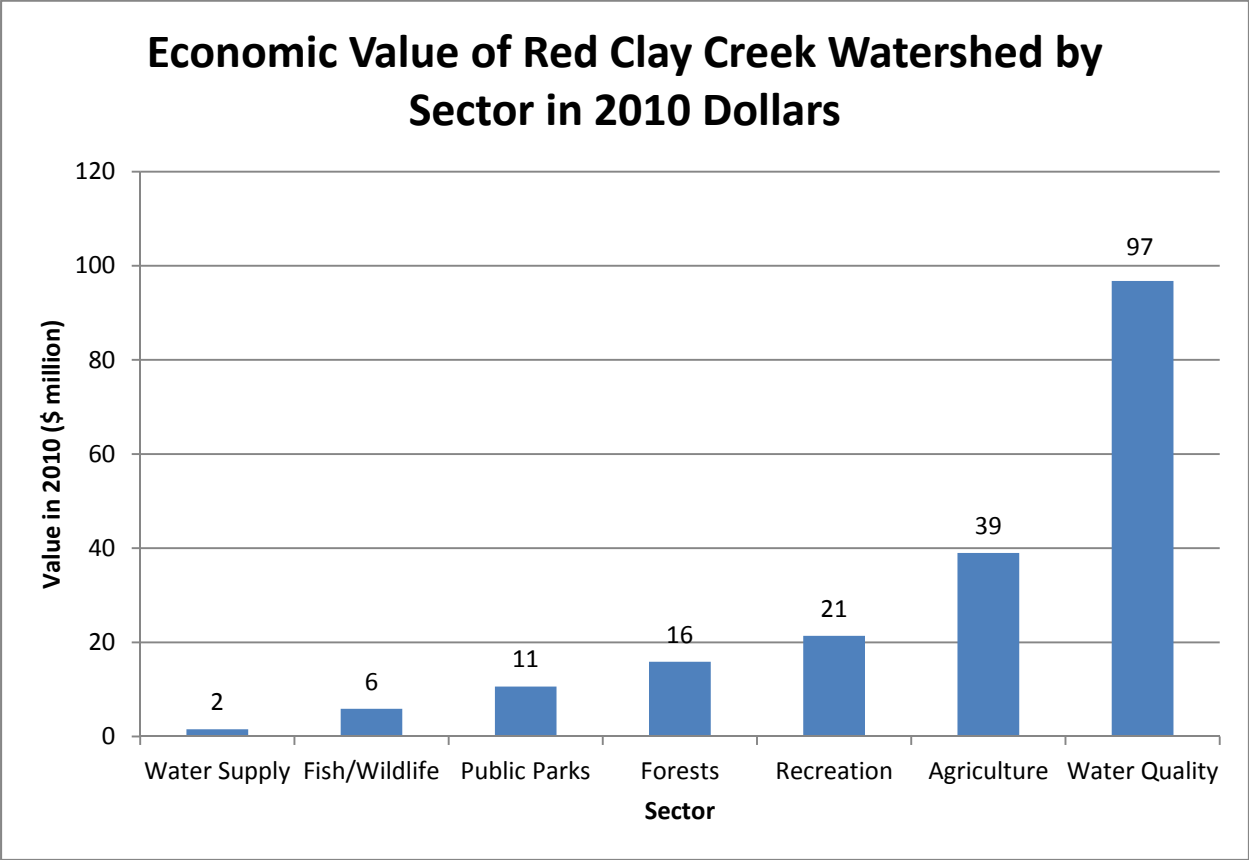


Figure 5. Annual economic value of the Red Clay Creek watershed by sector

Table 5. Annual economic value of the Brandywine Creek watershed

Sector	Activity	2010 (\$ mil)	Source
Water Quality	Boatable (WTP=\$13.20)	0.63	University of Delaware (2003)
	Fishable (WTP=\$13.22)	0.63	University of Delaware (2003)
	Swimmable (WTP=\$112.75)	5.4	University of Delaware (2003)
	Increased Property Value (+8% over 20 years)	88.2	EPA (1973), Brookings Institute (2010)
	Water Treatment by Forest (\$76/mgd)	0	Trust for Public Land, AWWA (2004)
	Wastewater Treatment	1.9	DNREC (2010), UDWRA
Water Supply	Drinking Water Supply (\$7.85/1,000 gallons)	1.3	UDWRA, CCCD, CCWRA
	Reservoir Storage	0	NJWSA (2011)
	Irrigation Water Supply (\$300/acre-foot)	0.25	Resources for the Future (1996), USDA (2007)
	Industrial Water Supply (\$200/acre-foot)	0	Resources for the Future (1996), USGS (2005)
Fish/Wildlife	Fishing	1.9	U.S. Fish and Wildlife Service (2008)
	Hunting	1.6	U.S. Fish and Wildlife Service (2008)
	Wildlife/Bird-watching	2.4	U.S. Fish and Wildlife Service (2008)
Recreation	Outdoor Recreation (241,020 participants)	21.4	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)	39	USDA Census of Agriculture 2007 (2009)
Forests	Carbon Storage (\$827/acre)	11.1	U.S. Forest Service, Del Ctr. Hort. (2008)
	Carbon Sequestration (\$29/acre)	0.39	U.S. Forest Service, Del Ctr. Hort. (2008)
	Air Pollution Removal (\$266/acre)	3.6	U.S. Forest Service, Del Ctr. Hort. (2008)
	Building Energy Savings (\$56/acre)	0.75	U.S. Forest Service, Del Ctr. Hort. (2008)
	Avoided Carbon Emissions (\$3/acre)	0.04	U.S. Forest Service, Del Ctr. Hort. (2008)
Public Parks	Health Benefits (\$9,734/acre)	7.9	Trust for Public Land
	Community Cohesion (\$2,383/acre)	1.9	Trust for Public Land
	Stormwater Benefit (\$921/acre)	0.75	Trust for Public Land
	Air Pollution Control (\$88/acre)	0.07	Trust for Public Land
Total for Watershed		191.1	

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

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 6).

In 2010, the Red Clay Creek watershed population reached 47,662 (U.S. Census 2010). Based on value transfer data from the study in six New England states, annual WTP for improved water quality in the Red Clay Creek exceeds \$6.6 million in monetary value. The greatest WTP value comes from a swimmable quality level, at \$5.4 million followed by fishable quality and boatable quality at \$6.3 million each (Table 6).

Table 6. Annual WTP for water quality benefits in the Red Clay Creek watershed

Quality Level	WTP per person ¹ (\$1994)	WTP per person ² (\$2010)	Watershed Population	WTP (\$2010)
Boatable	8.25	13.20	47,662	629,138
Fishable	8.26	13.22	47,662	630,092
Swimmable	70.47	112.75	47,622	5,373,891
Total	86.98	139.17	47,662	6,633,121

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% (Table 9). 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%. 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%. Austin et al. (2007) from the Brookings Institution projected that investing \$26 billion to restore the Great Lakes would increase shore property values by 10%.

Table 7. Increased property value 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 Red Clay Creek and its tributaries are estimated to increase by 8% which is the adjusted midpoint between 18% next to the water and 4% at 2000 ft from the water. The Red Clay Creek and its tributaries flow for 155 stream miles. If the median property value in the Red Clay Creek is \$293,550/acre, based on housing data from the U.S. Census, then properties within 2,000 feet of the creek have an estimated value of \$22 billion. Property values within 2,000 feet of the water would increase by 8% or \$1.76 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 \$88.2 million.

Table 8. Added property value due to improved water quality in Red Clay Creek watershed

Stream Length (miles)	Stream Length (ft)	Area 2,000 ft of Stream (ac)	Property Value @ \$293,550/ac (\$)	Increased Value @ 8% (\$)	Annual Value 20 years (\$)
155	818,400	75,152	22,060,727,273	1,764,858,182	88,242,909

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). However, there are no public surface water withdrawals within the Red Clay Creek across its 13,440 forested acres, so treatment costs due to loss of forest were unable to be calculated for the Red Clay Creek.

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

According to DNREC’s Surface Discharges Section and the U.S. EPA’s High Flow TMDL report, there are 3 permitted surface-discharge-sewage-treatment plants in the Red Clay Creek watershed, only one of which is located in the Delaware portion of the watershed.

The NPDES wastewater dischargers in Pennsylvania and Delaware possess Federal and state water-quality permits to treat and discharge 1.27mgd to the Red Clay Creek watershed. An analysis of wastewater utilities conducted by the 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 Red Clay Creek watershed is \$5,060 per day or \$1.85 million per year (Table 13).

Table 10. Value of Sewage-Treatment Plants’ Discharge in the Red Clay Creek Watershed

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	\$/day	\$/Year
			(\$4.00/1,000gal)	
<i>Main Stem</i>				
DE0021709	Greenville Country Club	0.015	60	21,900
PA0055107	East Marlborough Township STP TB-EB Red Clay Creek Municipal Large STP	0.15	600	219,000
<i>West Branch</i>				
PA0024058	Kennett Square Boro. WWTP WB Red Clay Creek Municipal Large STP	1.1	4,400	1,606,000
Total		1.265	5,060	1,846,900

Water Supply

Drinking Water Supply

There are no public surface water withdrawals in the Red Clay Creek watershed.

The community public water supply wells in the Red Clay Creek watershed provide approximately 0.45mgd of drinking water to the region. Both wells are found in the Pennsylvania portion of the watershed. The value per year of treated water supply from 0.45mgd community public water supply wells is \$1.3 million (Table 15).

Table 11. Community Public Water Supply Wells in the Red Clay Creek watershed

Owner	Capacity (mgd)	Water Rate (\$/1,000 gal)	Value/day (\$)	Value/year (\$)
Kennett Square Water Co.	0.373	\$7.85	\$2,928	\$1,068,738
Longwood Gardens	0.078	\$7.85	\$612	\$223,490
Total	0.451		\$3,540	\$1,292,228

Wells use the \$7.85 average.

Reservoir Storage

The Red Clay Creek houses the Hoopes Reservoir within New Castle County, DE with a storage capacity of 2,000 million gallons. The economic value of this water is \$788,000, calculated at \$0.394/1,000gal (NJWSA 2011). However, even though the reservoir’s location is within the Red Clay Creek watershed, its water is actually drawn from the Brandywine Creek watershed. Thus, the economic value of the Hoopes Reservoir is included the report, *The Economic Value of the Brandywine Watershed*, rather than this report.

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 value of irrigation water withdrawals was \$198/ac-ft in 1996 dollars or \$300/ac-ft (\$0.92/1,000 gal) in 2010 dollars, adjusting for change in the CPI (Table 17). In 2007, 169,058 acres of cropland were cultivated in the Red Clay Creek watershed and 4,370 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). Thus, in the Red Clay Creek watershed, the annual value of irrigation over 4,370 acres at a use value of \$0.92/1,000 gal is \$245,544/yr.

Table 12. 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 based on change in Northeast Region CPI (BLS).

Table 13. Value of agriculture irrigation in the Red Clay Creek 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					
New Castle	51,913	2,711					
Total	169,058	4,370	10,880	281	731,220	\$673	\$245,544

1. Census of Agriculture, 2007, (USDA, 2009)

2. Frederick et al., 1996

Industrial Water Supply

There are no industrial-water withdrawals within the Red Clay Creek watershed.

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 and \$269 million in Delaware in 2006 dollars. Using these state-wide totals and adjusting for percentage of the state in the Red Clay Creek watershed, the annual economic value of the recreational fishing, hunting, birding and wildlife-associated activities for the watershed was \$5.95 million (Table 20).

Table 14. Value of wildlife recreation in Red Clay Creek watershed

Activity	PA ¹ (\$2006)	PA in watershed ² (\$2006)	DE ¹ (\$2006)	DE in watershed ² (\$2006)	Red Clay Creek Watershed ³ (\$2006)
Fishing	1,291,211,000	903,848	96,775,000	1,045,170	1,949,018
Hunting	1,609,045,000	1,126,332	41,381,000	446,915	1,573,246
Wildlife/Birding	1,442,582,000	1,009,807	130,832,000	1,412,986	2,422,793
Total	4,342,838,000	3,039,987	268,988,000	2,905,070	5,945,057

1. USFWS, Survey conducted in 2006, report issued 2008.

2. Scaled by the percentage of each state that is in the Red Clay Creek watershed (0.0007 PA and 0.0108 DE).

3. Sum of scaled values.

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 3 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 Red Clay Creek watershed (population 47,662) contributes \$21.4 million and 252 jobs to the economy (Table 15).

Table 15. Outdoor recreation activity in the Red Clay Creek watershed

Recreation	Activity	Mid-Atlantic Region ¹	Red Clay Creek ²
Bicycling	Gear Trip/Sales/Contributions	\$3,372,000,000	\$3,929,493
	Participants	2,496,000	2,909
	Jobs	40,121	47
Camping	Gear Trip/Sales/Contributions	\$7,513,000,000	\$8,755,125
	Participants	1,874,000	2,184
	Jobs	89,384	104
Fishing	Gear Trip/Sales/Contributions	\$1,768,000,000	\$2,060,304
	Participants	1,890,000	2,202
	Jobs	17,195	20
Hunting	Gear Trip/Sales/Contributions	\$731,000,000	\$851,856
	Participants	450,000	524
	Jobs	7,234	8
Paddling	Gear Trip/Sales/Contributions	\$784,000,000	\$913,619
	Participants	1,586,000	1,848
	Jobs	9,331	11
Hiking	Gear Trip/Sales/Contributions	\$2,411,000,000	\$2,809,611
	Participants	3,048,000	3,552
	Jobs	28,686	33
Wildlife Viewing	Gear Trip/Sales/Contributions	\$1,756,000,000	\$2,046,320
	Participants	4,990,000	5,815
	Jobs	24,445	28
Total	Gear Trip/Sales	\$18,335,000,000	\$21,366,327
	Participants	16,334,000	19,035
	Jobs	216,396	252

1. Outdoor Industry Foundation 2006.

2. Scaled by population of the Red Clay Creek (47,662) to mid-Atlantic region population.

State Parks

There are no state parks within the Red Clay Creek watershed.

Agriculture

In 2007, the USDA National Agricultural Statistics Service (2009) estimated the annual market value of agricultural products sold in Chester County, PA and New Castle County, DE was \$599 million. Scaling by the area of farmland in the Red Clay Creek watershed, the value of crops in the watershed is \$39 million (Table 23).

Table 16. Value of Cropland and Agriculture in the Red Clay Creek watershed

County	Farmland by County ¹ (ac)	2007 Value by County ¹ in (\$ million)	Farmland in Watershed ² (ac)	2007 Value in Watershed in (\$ million)
Chester	117,145	553.3		
New Castle	51,913	45.7		
Total	169,058	599	10,880	\$39

1. USDA 2009. 2. NOAA CSC 2006

Forests

The U.S. Forest Service (Nowak et al. 2008) estimated that forests 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, 13,440 acres (21 mi²) of forests in the Red Clay Creek watershed have benefits of carbon storage (\$11.1 million), carbon sequestration (\$0.39 million), air-pollution removal (\$3.6 million), and building-energy savings (\$0.75 million). Forests in the Red Clay Creek watershed provide environmental benefits by regulating climate change, cooling, and air-emissions control including 537,600 tons of carbon-storage capacity, 18,816 tons of carbon sequestration, 538 tons of air-pollution removal, and 1,882 tons of avoided carbon-emissions capacity (Table 17).

Table 17. Forest benefits in the Red Clay Creek watershed

Forest Benefits	Forests New Castle County ¹		Forests Red Clay Creek ²	
	Environmental (tons/acre)	Economic (\$/acre)	Environmental (tons)	Economic (\$)
Carbon Storage	40	827	537,600	11,114,880
Carbon Sequestration	1.4	29	18,816	389,760
Air Pollution Control	0.04	266	538	3,575,040
Energy Savings		56	0	752,640
Avoided Carbon Emissions	0.14	3	1,882	40,320
Total				15,872,640

1. Nowak et al. (2008).

2. Computed for 13,440 acres of forest in the Red Clay Creek 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), 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 benefits transfer, the 815 acres of public parks within the Red Clay Creek watershed (Table 20) provide health benefits (\$7.9 million), community cohesion benefits (\$1.9 million), clean-water benefits (\$750,000), and air-pollution-mitigation value (\$72,000) for a total of \$10.7 million.

Table 18. Value of public parks in the Red Clay Creek watershed

State	Parks in Watershed (acres)	Health Benefits (\$9,734/acre)	Community Cohesion (\$2,383/acre)	Stormwater Benefits (\$921/acre)	Air Pollution (\$88/acre)	Total (\$)
PA	221	2,147,807	525,809	203,219	19,417	2,896,473
DE	595	5,789,589	1,417,361	547,792	52,341	7,807,678
Total	815	7,937,396	1,943,170	751,011	71,758	10,704,150

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 Brandywine Creek 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. 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. 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 19 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 19. 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 Red Clay Creek watershed using the NJDEP and USDA farm-good values are worth \$84.3 million (2010 dollars) or and net present value (NPV) of \$2.7 billion, which are conservatively in the lower end of the range (Table 20). If lower per-acre estimates of ecosystem services from other studies were used instead of the NJDEP values, ecosystem services in the Red Clay Creek watershed would be \$30.8 million or NPV = \$1.0 billion (Table 21). If higher per-acre estimates from other studies were used, the value of ecosystems in the Red Clay Creek watershed would be \$303.2 million or NPV = \$9.9 billion (Table 22).

<u>Estimate</u>	<u>PV (\$ million)</u>	<u>NPV (\$ million)</u>
Low	30.8	1,000
NJDEP	84.3	2,700

High

303.2

9,900

Table 20. Value of Ecosystem Goods and Services in the Red Clay Creek watershed

Ecosystem	Area (acres)	\$/acre/yr	PV \$	NPV \$
Freshwater wetlands	697	13,621	9,487,729	308,351,190
Marine	0	10,006	0	0
Farmland	10,686	4,124	44,264,788	1,438,605,597
Forest land	13,537	1,978	26,778,652	870,306,187
Saltwater wetland	0	7,235	3,352	108,943
Barren land	13	0	0	0
Urban	9,428	342	3,220,587	104,669,065
Beach/dune	2	48,644	86,544	2,812,669
Open water	210	1,946	409,361	13,304,238
Total	34,573	2,437	84,251,012	2,738,157,889

Table 21. Low range of ecosystem services in the Red Clay Creek watershed

Ecosystem	Area (acres)	\$/acre/year	PV (\$)	NPV (\$)
Freshwater wetlands	697	6,268	4,366,093	141,898,014
Marine	0	8,670	0	0
Farmland	10,686	1,387	14,820,865	481,678,121
Forest land	13,537	641	8,677,472	282,017,848
Saltwater wetland	0	6,269	2,905	94,396
Barren land	13	0	0	0
Urban	9,428	296	2,790,566	90,693,394
Beach/dune	2	42,149	74,988	2,437,114
Open water	210	217	45,653	1,483,712
Total	34,573	890	30,778,542	1,000,302,600

Table 22. High range of ecosystem services in the Red Clay Creek watershed

Ecosystem	Area (acres)	\$/acre/year	PV (\$)	NPV (\$)
Freshwater wetlands	697	43,685	30,429,605	988,962,151
Marine	0	8,670	0	0
Farmland	10,686	9,979	106,631,157	3,465,512,592
Forest land	13,537	12,033	162,895,513	5,294,104,161
Saltwater wetland	0	28,146	13,040	423,813
Barren land	13	0	0	0
Urban	9,428	296	2,790,566	90,693,394
Beach/dune	2	42,149	74,988	2,437,114
Open water	210	1,686	354,702	11,527,824
Total	34,573	8,770	303,189,571	9,853,661,050

Ecosystem-services areas within the Red Clay Creek watershed comprise forests (39%), farmland (31%), freshwater wetlands (2%), and open water (1%). More than one quarter of the land in the Red Clay Creek watershed is urban (Figure 6).

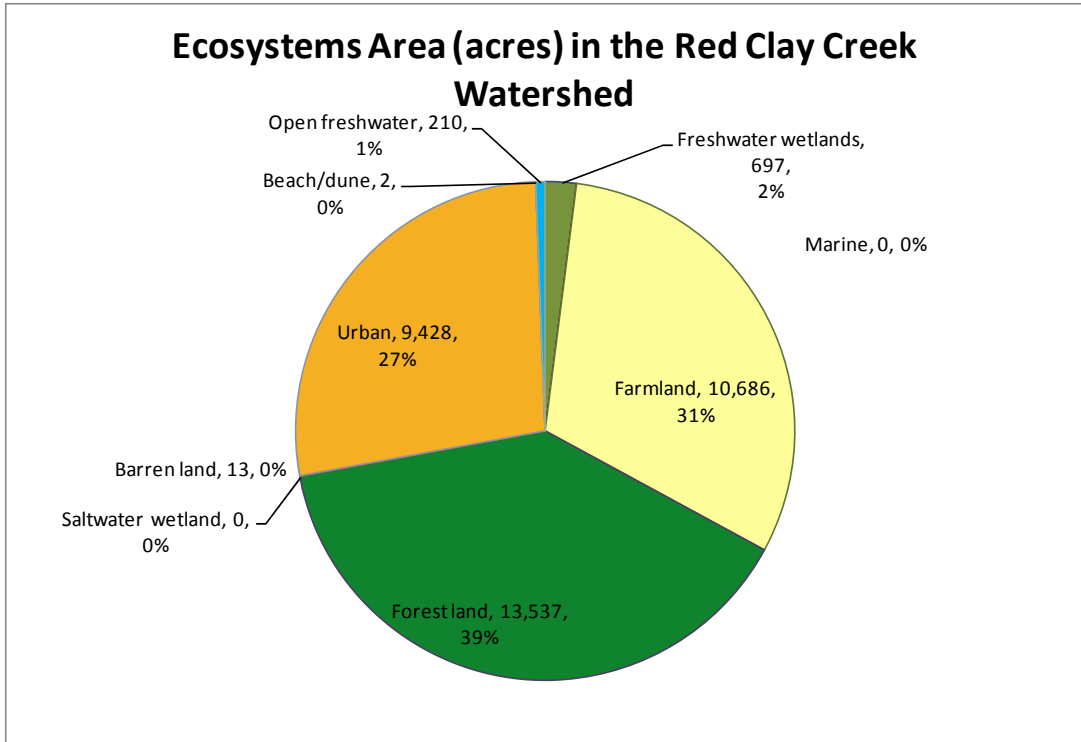


Figure 6. Ecosystem Service Areas in the Red Clay Creek Watershed

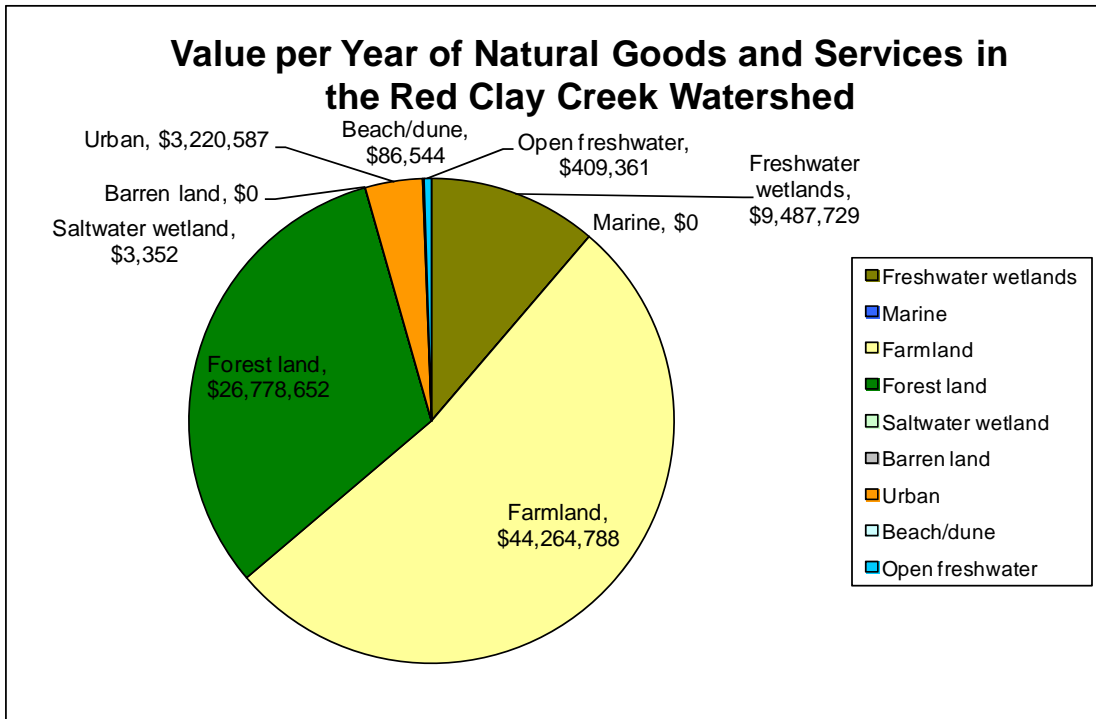


Figure 7. Value of Natural Goods and Services by Ecosystem in the Red Clay

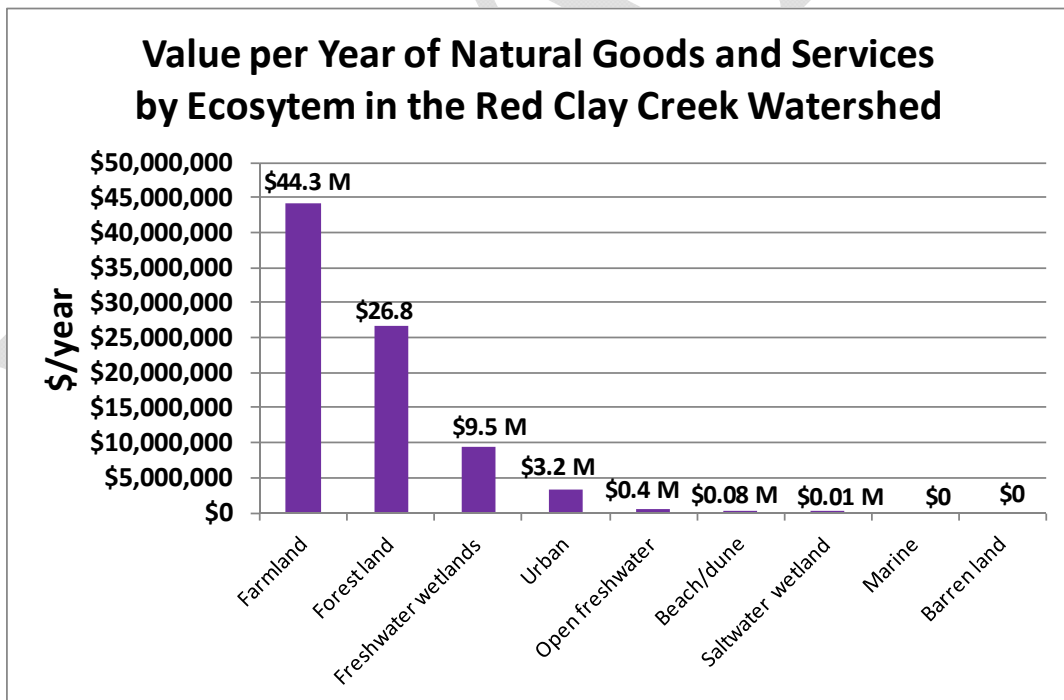


Figure 8. Ecosystem Service Value (2010 dollars) in the Red Clay Creek watershed

5. Jobs and Wages

The Red Clay Creek watershed contains water resources and habitats that support over 9,900 direct and indirect jobs and over \$27.3 million in annual wages in the coastal, farm, fishing/hunting/birding, watershed organization, and water supply/wastewater industries (Table 23).

Table 23. Jobs and wages directly and indirectly related to the Red Clay Creek watershed

Sector	Jobs	Wages (\$)	Data Source
Direct Watershed-Related	4,361	216,525	U.S. Census Bureau (2010)
Indirect Watershed-Related	5,233	173,220	U.S. Census Bureau (2010)
Coastal	436	8,717,875	National Coastal Econ. Program (2009)
Farm	411	416,279	U.S. Dept. of Agriculture., (2007)
Fishing/Hunting/Birding	204	6,691,214	U.S. Fish and Wildlife Service (2008)
Outdoor Recreation	252	8,276,436	
Watershed Organizations	116	5,568,000	WRA and DRBC (2010)
Water Supply Utilities	0	0	Delaware Tourism Office (2008)
Public Wells	2	110,814	WRA and DRBC (2010)
Wastewater Utilities	5	212,000	WRA and DRBC (2010)
Total	>9,900	>27,300,000	

Direct and indirect jobs and wages in the Red Clay Creek watershed were obtained from U.S. Census Bureau (2010) databases. 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, watershed-related jobs are likely undercounted. Red Clay Creek watershed-related jobs are tabulated for three categories: (1) total jobs in the Red Clay Creek watershed, (2) direct Red Clay Creek watershed jobs, and indirect watershed jobs. To avoid double counting between sectors and NAICS data, the total value of jobs and wages for the watershed is estimated by discounting the sum of all sectors by 10%.

The U.S. Census Bureau (2010) indicates there were 23,490 nonfarm jobs in the Red Clay Creek watershed (Table 24).

Table 24. Employment in the Red Clay Creek Watershed in 2010

County	County ¹ Population	Watershed ¹ Population	County ² Employment	Watershed ³ Employment
Chester County	498,886	23,579	249,515	11,793
New Castle County	538,479	24,083	261,530	11,697
Total	1,037,365	47,662	511,045	23,490

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

Direct Red Clay Creek 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 in the Red Clay Creek watershed. Industries directly associated with the Red Clay Creek watershed (such as water/sewer construction, water utilities, fishing, recreation, tourism, and transportation) employed 4,361 people with over \$216.5 million in wages (Table 25).

Indirect jobs and wages funded by purchases 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 Programme (2011) estimates each tourism job generates 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 5,233 people with over \$173.2 million in wages (Table 25).

Table 25. Direct and indirect watershed-related jobs in the Red Clay Creek 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 construction	23711	17	1,004	21	803
Living Resources	Agriculture and forestry	115	22	779	26	623
	Wineries	31213				
	Fish and seafood wholesalers	42446				
	Nursery, garden center, farm	44422	22	729	26	583
	Fish and seafood markets	44522	1	25	1	20
	Fruit and vegetable markets	44523	3	57	3	46
Minerals	Mining, quarrying, extraction	21	4	296	5	237
	Electric power generation	2211				
Tourism/ Recreation	Sporting/recreational goods	42391	3	154	4	124
	Sporting goods stores	45111	38	757	46	605
	Recreational goods rental	532292				
	Commercial water transport.	532411				
	Recreational vehicle dealers	44121				
	Boat dealers	441222	5	177	5	142
	Museums, historical sites	712	33	984	40	787
	Amusement parks and arcades	7131	5	41	6	33
	Amusement arcades	71312	4	27	5	21
	Amusement/recreation	7139	280	4,909	336	3,927
	Golf courses/country clubs	71391	80	2,364	96	1,891
	Marinas	71393		31		25
	Fitness/recreational sports	71394	175	2,057	210	1,646
	Amusement/recreation	71399	6	309	7	247
	Accommodation	721	127	2,668	152	2,135
	Hotels (except casino hotels) and motels	72111	119	2,470	143	1,976
	Bed-and-breakfast inns	721191				
	Recreational vehicle, camps	7212	2	89	3	71
	Full-service restaurants	7221	721	10,946	865	8,757
	Limited-service restaurants	722211	429	5,287	515	4,229
	Snack/beverage bars	722213	66	919	80	735
Food service contractors	72231	138	3,336	166	2,669	
Caterers	722320	30	662	36	530	
Transportation	Water transportation	483		849		680
	Inland water transportation	4832				
	Scenic and sightseeing transportation	487	1	37	1	30
	Scenic and sightseeing transportation, water	4872	1	37	1	30
	Support activities for water transportation	4883	23	956	28	764
	Marine cargo handling	488320	20	778	24	623
Environmental	Architectural, engineering	541	1,860	166,164	2,232	132,931
	Environmental, conservation	813211	7	708	9	566
	Civic and social organizations	8134	26	984	32	787
Water/Wastewater	Water, sewage systems	2213	15	1,066	18	852
	Waste management services	562	77	3,870	92	3,096
SUM OF ALL INDUSTRIES			4,361	216,525	5,233	173,220

1. Direct jobs/wages are those directly related to the Red Clay 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.

US Census Bureau 2010

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 Red Clay Creek watershed contributed 436 coastal jobs, representing over \$8.7 million in annual wages and \$16.7 million toward the state GDP (Table 26).

Table 26. Coastal employment in the Red Clay Creek watershed

Economic Sector	Establishments	Employment	Wages	GDP
Construction	1	5	\$254,892	\$415,360
Living Resources	1	5	\$177,775	\$405,319
Minerals	D	D	D	D
Ship & Boat Building	D	D	D	D
Tourism & Recreation	22	374	\$5,982,417	\$12,454,103
Transportation	1	50	\$2,226,901	\$3,224,722
All Ocean Sectors	25	436	\$8,717,875	\$16,752,010

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 411 farm jobs in the Red Clay Creek watershed and over \$416,000 in wages (Table 27).

Table 27. Jobs from farms in the Red Clay Creek Watershed

Region	Farmland (ac)	Farm Jobs	Wages
PENNSYLVANIA			
Chester County	166,891	7,708	\$5,047,000
Red Clay Creek Portion	8,509	393	\$257,331
DELAWARE			
New Castle County	66,981	565	\$4,892,000
Red Clay Creek Portion	2,176	18	\$158,948
Watershed Total	10,686	411	\$416,279

USDA 2007

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 204 jobs, a value of \$6.7 million in annual economic activity in 2010 dollars (Table 28). 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 Red Clay Creek watershed.

Table 28. Jobs from wildlife recreation in the Red Clay Creek watershed

Recreation Activity	Recreation Value ¹ (\$2010)	Jobs ² in 2010 Dollars
Fishing	\$2,193,637	67
Hunting	\$1,770,703	54
Wildlife/Birding	\$2,726,875	83
Total	\$6,691,214	204

1. USFWS 2008
2. Scaled by the percentage of each state that is in the Red Clay Creek watershed (0.0007 PA and 0.0108 DE)
3. Jobs estimated at \$32,843 average salary.

Outdoor Recreation

The Outdoor Industry Foundation (2006) concluded that 16.3 million people participated 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), contributing to 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 Red Clay Creek watershed (population 47,662) contributes 252 jobs and \$8.3 million in wages (Table 29).

Table 29. Outdoor recreation jobs in the Red Clay Creek watershed

Activity	Mid-Atlantic Region ¹	Red Clay Creek ²	Total Wages ³ Earned (\$)
Bicycling	40,121	47	1,543,621
Camping	89,384	104	3,415,672
Fishing	17,195	20	656,860
Hunting	7,234	8	262,744
Paddling	9,331	11	361,273
Hiking	28,686	33	1,083,819
Wildlife Viewing	24,445	28	919,604
Total	216,396	252	8,276,436

1. Outdoor Recreation Foundation 2006.
2. Scaled by population of watershed to Mid-Atlantic region population.
Red Clay Creek: 47,662
3. Based on the average \$32,843 salary from NJDEP in the Fishing/Hunting/Bird and Wildlife Jobs section

Watershed Organization Jobs

Fifteen nonprofit watershed and environmental organizations employ at least 116 staff to work on programs to protect the Red Clay Creek watershed (Table 30). Assuming that the average salary of an environmental scientist/specialist is \$61,700 (Bureau of Labor Statistics), these watershed organization jobs account for \$5.57 million in annual wages.

Table 30. Watershed organization jobs in the Red Clay Creek watershed

Watershed Organization	Town	Jobs	Salaries
PENNSYLVANIA			
Delaware Nature Society	Hockessin	20	\$960,000
Red Clay Valley Association	West Chester	1	\$48,000
Stroud Water Research Center	Avondale	45	\$2,160,000
Total for Pennsylvania	3	66	\$3,168,000
DELAWARE			
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
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
Widener Environmental and Natural Resources Law Clinic ²	Wilmington	1	\$48,000
Total for Delaware	12	50	\$2,400,000
Total for Watershed		116	\$5,568,000

Water Supply Jobs

There are no public water withdrawals in the Red Clay Creek watershed.

Wastewater Utility Jobs

Three wastewater utilities discharge over 1.3 million gallons per day of treated wastewater to the Red Clay Creek watershed. The wage information is computed using the assumption that the average wastewater utility salary is \$40,000/year. These wastewater utilities employ 5 employees who earn over \$212,000 in wages annually (Table 31).

Table 31. Wastewater treatment jobs in the Red Clay Creek watershed

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	Jobs	Salaries
<i>Main Stem</i>				
PA0055107	East Marlborough Township STP TB-EB Red Clay Creek Municipal Large STP	0.15	1	\$40,000
DE0021709	Greenville Country Club	0.015	1	\$40,000
<i>West Branch</i>				
PA0024058	Kennett Square Boro. WWTP WB Red Clay Creek Municipal Large STP	1.1	3	\$132,000
Total for watershed		1.265	5	\$212,000

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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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