April 2016

Economic Valuation of the Albemarle-Pamlico Watershed's Natural Resources

Final Report

Prepared for
Albemarle-Pamlico National Estuary Partnership

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Executive Summary

The Albemarle-Pamlico (A-P) watershed contains a rich and diverse stock of natural resources that are essential for the well-being of the region's residents and economy, and that also provide benefits that are valued outside of the watershed. Of key importance are the land, waters, and ecosystems of the watershed's estuarine system and surrounding coastal plain.

To support the Albemarle-Pamlico National Estuary Partnership (APNEP) in its efforts to measure and communicate the important societal contributions made by natural resources in the A-P watershed, in this study we conduct an economic valuation analysis of these resources. The analysis focuses on two main questions:

- What are the main ways in which the human populations in and around the watershed depend on and benefit from the watershed's land and water resources and related ecosystems?
- How can the benefits they derive each year from their connections to these natural assets and systems be measured and expressed in dollar terms?

We address these questions by applying an economic valuation framework that separates the analysis into three main parts—direct use values to the commercial sector, direct use and non-use values to households, and indirect use values provided through various natural process (referred to in this report as regulating/supporting ecosystem services). For each part, we estimate annual values for key selected benefit categories, based on the availability of data and resources for this study. These selected categories do not cover all types of natural resource values in the A-P watershed, but they are intended to shed light on some of the most significant ones. Our value estimates for these selected categories are summarized in ***Table ES-1***.

Some of the main findings of the analysis include the following:

- The estimated direct value of natural resource inputs to commercial agricultural production in the watershed is $210 million per year. For commercial timber production the estimated direct value is $245 million per year, and $20 million per year in commercial fishing.
- For households engaged in water-based recreation, including fishing, hunting, and wildlife viewing in the watershed, we estimate a total annual value of $3.7 billion. Alternatively, focusing only on visits to national and state parks in the watershed, we estimate an annual value of $640 million. Because of overlaps in the recreation activities covered by these two estimates, the sum of these values ($4.3 billion) can be interpreted as an upper-bound estimate for outdoor recreation.
- For residents living in close proximity to the shorelines of the estuary and coastal waters, we estimate that the annual value of the aesthetic and natural amenities provided by this proximity range between $44 million and $96 million.

- The A-P watershed also provides important habitat for various nongame wildlife species. For North Carolina residents, we estimate that the annual value of preserving this wildlife is in the range of $133 to $202 million per year.

- One of the main regulating ecosystem services offered by natural resources in the A-P watershed is climate regulation through natural storage and sequestration of carbon. We estimate that forests in the watershed currently store over 400 million tons of carbon, providing an annual societal value of $1.7 billion per year. For emergent wetlands, we estimate additional carbon storage of 58 million tons, providing an annual societal value of $263 million. For seagrasses, we estimate additional carbon storage of 1.2 million tons, providing an annual societal value of $5 million.

- The second regulating ecosystem service analyzed in this report is the air pollution removal benefits provided by tree cover in the watershed. By filtering NO_2, ozone, $PM_{2.5}$, and SO_2 from the atmosphere, we estimate that they avoid over $81 million in human health damages each year.

Table ES-1. Natural Resource Value Estimates for the A-P Watershed

Natural Resource Value Category	Annual Value ($ mil)
Direct Use Value to Commercial Sectors	
Agriculture	210
Forestry	245
Commercial Fishing	20
Direct Use and Non-use Values to Households	
Outdoor Recreation	3,668–4,303[a]
Natural and Aesthetic Amenities to Nearshore Residents	44–96
Preservation of Nongame Wildlife Resources	133
Values for Regulating/Supporting Ecosystem Services	
Carbon Storage by Forests, Wetlands, and Seagrasses	1,922
Air Pollutant Removal by Trees	81

[a] Higher value is the sum of recreation activity value estimates and park visit value estimates.

Although it is simple to calculate the sum of these values (i.e., $6.3 billion and $7.1 billion per year), it is also important to be cautious in interpreting the meaning of this summation. First, it cannot be interpreted as the total value of natural resources in the A-P watershed because it only includes values for a selected subset of benefit categories. Other potentially significant benefits that are not included, but that would be good candidates for future research include:

- benefits of groundwater and surface water resources to domestic users;
- water quality regulation and storm surge regulation services provided by riparian buffers and wetlands; and
- natural waste assimilation services provided by land, water, and air resources.

Second, it most likely overstates the combined value of these selected categories because of overlaps between them. In particular, as discussed in the report, some recreation values may be double counted in this summation because they may also be included in the wildlife protection or nearshore amenity value estimates.

In addition to these economic value estimates, we examine the economic contribution of natural resources in the watershed through employment and wages. Focusing on the most resource-dependent sectors, natural resources provide over 36 thousand direct jobs in the watershed, providing over $672 million in wages each year. These direct jobs and wages are estimated to contribute indirectly to an additional 80 thousand jobs and $1.3 billion in annual wages to the region.

Introduction

The Albemarle-Pamlico (A-P) watershed, which drains more than 30,000 square miles of eastern North Carolina and Virginia, contains a rich and diverse stock of natural assets and ecosystems. These natural resources are essential for the well-being of the region's residents and economy, and they also provide services that are valued outside of the watershed. Of key importance are the land, waters, and ecosystems of the watershed's estuarine system and surrounding coastal plain.

To support the Albemarle-Pamlico National Estuary Partnership (APNEP) in measuring and communicating these contributions, this study provides an economic valuation analysis of the watershed's natural resources. This analysis focuses on two main questions:

- What are the main ways in which the human populations in and around the watershed depend on and benefit from the watershed's land and water resources and related ecosystems?
- How can the benefits they derive each year from their connections to these natural systems be measured and expressed in dollar terms?

Importantly, the objective is not simply to measure how much *income* people generate from the watershed's natural resources or to measure how many jobs depend on these resources. Rather, the purpose is much broader. It is to measure (using a monetary equivalent) how much their connections to these natural resources increase their overall *well-being* each year. Due to data and resource limitations, we cannot answer these questions for every human benefit associated with all natural resources in the watershed. However, in this study we examine and assess values for what are arguably some of the most significant natural resource contributions in the region.

To address these questions, we begin in Section 1 by providing an overview of the lands, waters, and protected natural areas of the A-P watershed. In particular, we define the boundaries of the study area and summarize the main land use and land cover categories in this area. We also provide an overview of protected federal and state lands in the watershed. These lands play an important role in conserving and sustaining key natural areas and ecosystems in the region for the benefit of both current and future generations.

In Section 2 we lay the groundwork for the natural resource valuation assessment by describing the conceptual framework that guides our analysis. This section describes the concept of economic value and how it can be applied to the outputs of natural systems. In particular it describes a total economic value (TEV) framework, which defines distinct nonoverlapping categories of natural resource values, including benefits to humans through both market and nonmarket based activities. It also describes the concept of ecosystem services, which are the contributions made by nature to human production processes and human well-being.

Applying the concepts and framework developed in Section 2, the valuation analysis is organized into three sections that separately address the following value categories: direct use values to the commercial sector, direct use and non-use values to households, and indirect values through regulating/ supporting ecosystem services. In each category, we estimate annual values for key selected benefits. Due to data and resource limitation for this study, these estimates do not cover all types of natural resource values in the A-P watershed; however, they are intended to shed light on some of the most significant benefits provided by these resources.

In Section 3, we present our approach and results for estimating direct use values associated with several natural resource based commercial sectors in the watershed. In particular, we estimate the annual benefits to commercial agriculture, forestry, fishing, aquaculture, and mining. In addition to reporting annual revenues for different activities in these sectors, where estimates are available (i.e., the first three sectors) we focus on the *net* returns to these activities, which deduct the annual costs of using and maintaining these resources.

In Section 4, we present our estimation of direct use and non-use values for households (i.e., the nonmarket sector). This section focuses on three main types of benefits. The first are the benefits from outdoor recreation in the watershed, including fishing, hunting, wildlife viewing, and visits to saltwater beaches. The second are the natural and aesthetic amenities enjoyed by residents living near the estuarine and coastal shoreline of the watershed. The third are the benefits from the protection and preservation of nongame wildlife. These benefits include values that not necessarily associated with any direct use of the wildlife resources—that is, the non-use values that households receive just from the knowledge that the wildlife exist and are being protected.

The natural resources of the A-P watershed also provide value to humans through more indirect channels. In particular, by helping to regulate climate and environmental conditions they provide a number of indirect benefits to society. In Section 5, we estimate values for two of these regulating ecosystem services: (1) carbon storage and sequestration by forests and wetland and (2) air pollutant removal by trees.

As previously mentioned, estimating economic values for natural resources is not the same as measuring the incomes generated from activities related to these resources. However, to understand the economic role of natural resources in the watershed, it is useful, as a separate exercise, to examine employment associated with natural resource-based activities. In Section 6, we present estimates of the number of jobs and total wages associated with selected activities in the watershed.

In Section 7, we conclude by summarizing and discussing key findings from the analysis. To assist in interpreting these results, we also point out some of the main limitations and uncertainties associated with the value estimates.

Overview of the A-P Watershed and its Natural Resources

This study focuses on the natural resources of the A-P watershed, which for the purposes of this study are defined by the boundaries of the APNEP management area (as shown in ***Figure 2-1***). This area consists of roughly 20,000 square miles of land draining to the Albemarle-Pamlico Estuary System,[1] plus another 2,900 square miles of open waters that make up the estuary system itself. Located mostly within the Mid-Atlantic Coastal Plain Ecoregion, and to a lesser extent the Piedmont Ecoregion, the A-P watershed includes all or portions of 36 North Carolina counties (making up 79% of the watershed's land area) and 19 Virginia counties.[2]

The drainage area of the A-P watershed includes six main river basins. The four largest basins, which make up over 80% of the watershed are the Neuse, Tar-Pamlico, Chowan, and Pasquotank basins. The other two smaller basins are the White Oak and Lower Roanoke. The natural features of this region include a wide variety of habitat types, including dry coniferous woodlands, pocosin, oak forest, tidal swamp forest, and beach and dune habitats. These habitats support a diversity of game and nongame wildlife, including several threatened and endangered species such as the red cockaded woodpecker, loggerhead turtle, and piping plover.

The main land uses and land cover in the A-P watershed are shown in ***Figures 2-1*** and ***2-2***. According to the most recent National Land Cover Database (NLCD) (Homer et al., 2015), the area primarily consists of pasture/hay and cultivated croplands (26%), evergreen, deciduous, and mixed forest (26%), and woody and emergent herbaceous wetland (25%).[3] Developed lands, which are most highly concentrated in the western portion of the Upper Neuse basin, account for less than 10% of land cover.

[1] This management area does not include the Upper Roanoke Basin, which also drains to the estuary system through the Lower Roanoke Basin that is included. It does include the estuarine areas of the Currituck, Core, Back, and Bogue Sounds and the Back Bay.

[2] Three North Carolina counties—Duplin, Sampson, and Harnett—with less than 1% of their land area in the watershed are not included in this list or this analysis.

[3] The NLCD, produced by the Multi-Resolution Land Characteristics Consortium, provides 16 land cover classifications at a spatial resolution of 30 meters from decadal Landsat satellite imagery.

Figure 2-1. Map of Land Use/Land Cover in the A-P Watershed

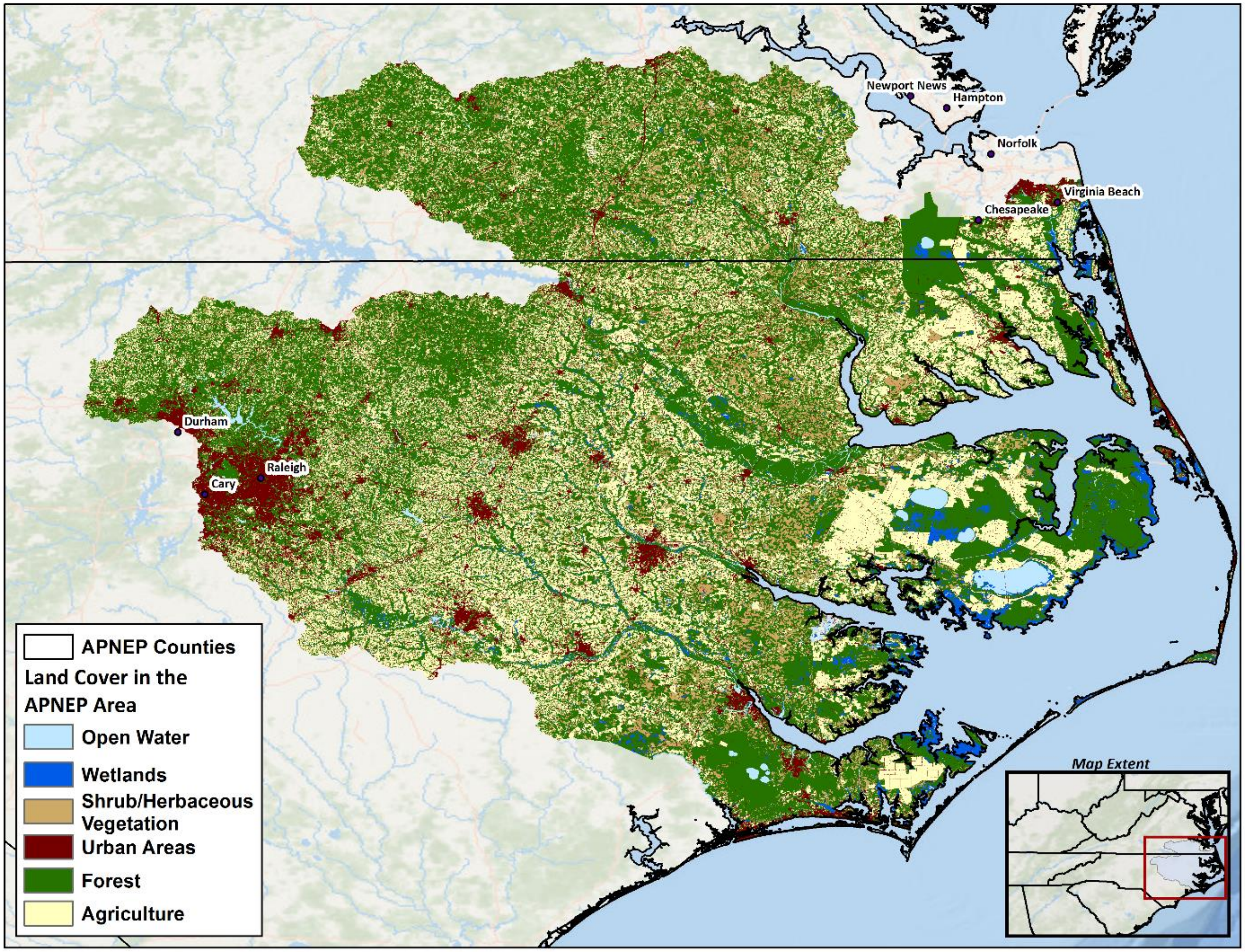
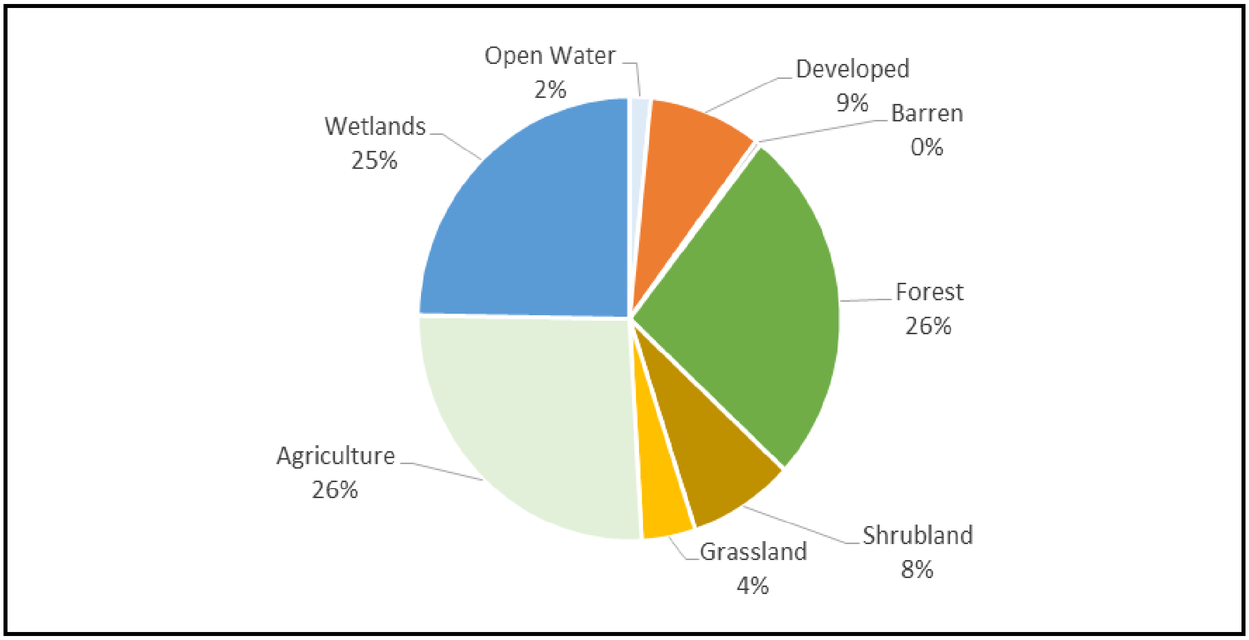
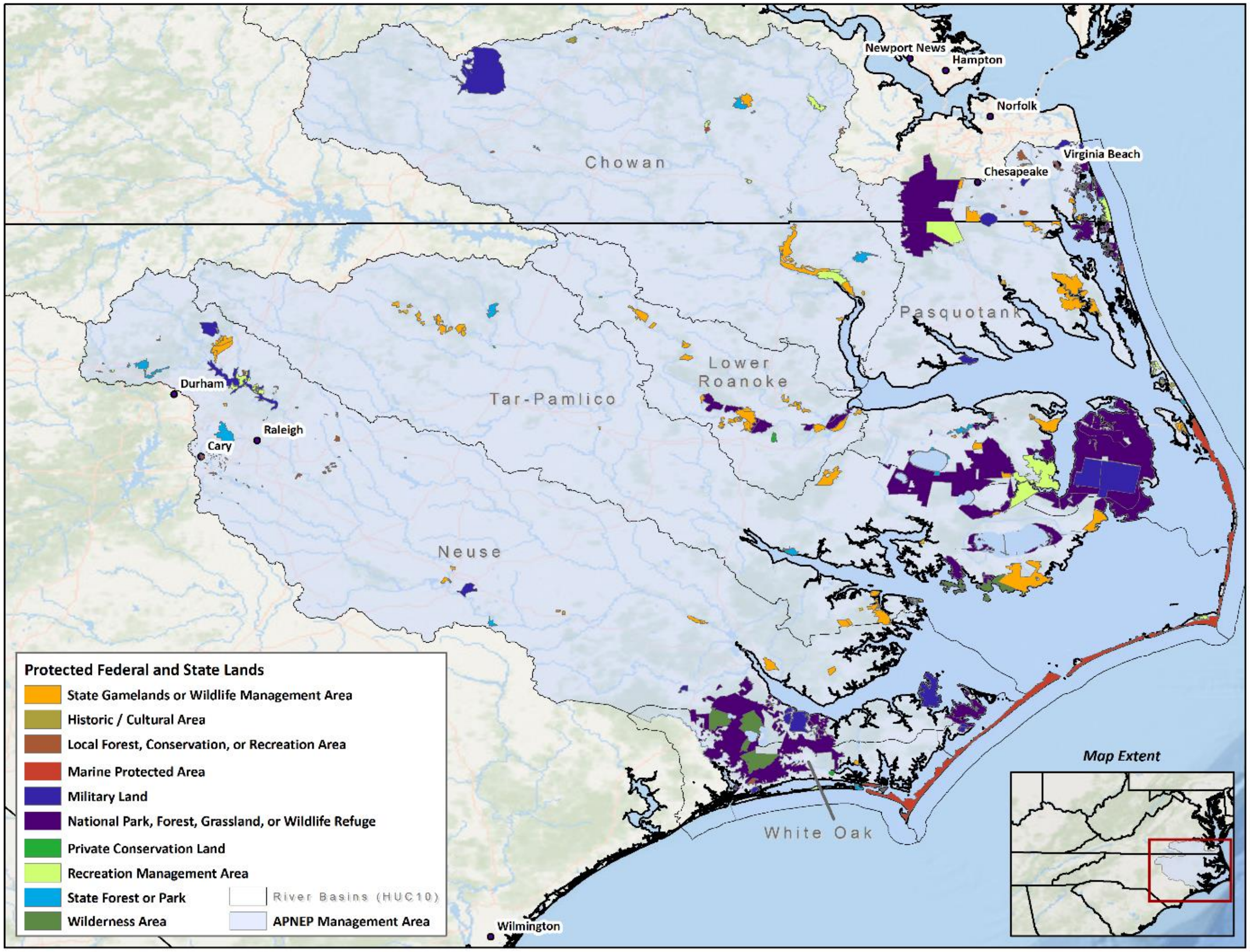


Figure 2-2. Distribution of A-P Watershed Lands by Land Use/Land Cover Category



As a result of various federal, state, and private efforts to conserve its natural lands and resources, the A-P watershed region also contains over 1 million acres of protected lands. As shown in ***Figure 2-3***, these areas include over 0.5 million acres of national forests and wildlife refuge, including the Croatan National Forest, and the Great Dismal Swamp, Alligator River, Pocosin Lakes, and Mattamuskeet National Wildlife Refuges. In addition to iconic National Park Service sites, such as Cape Hatteras and Cape Lookout National Seashores, they also contain 175,000 acres of state game lands, wild management areas, parks, and forests.

Figure 2-3. Map of Protected Lands in the A-P Watershed



3

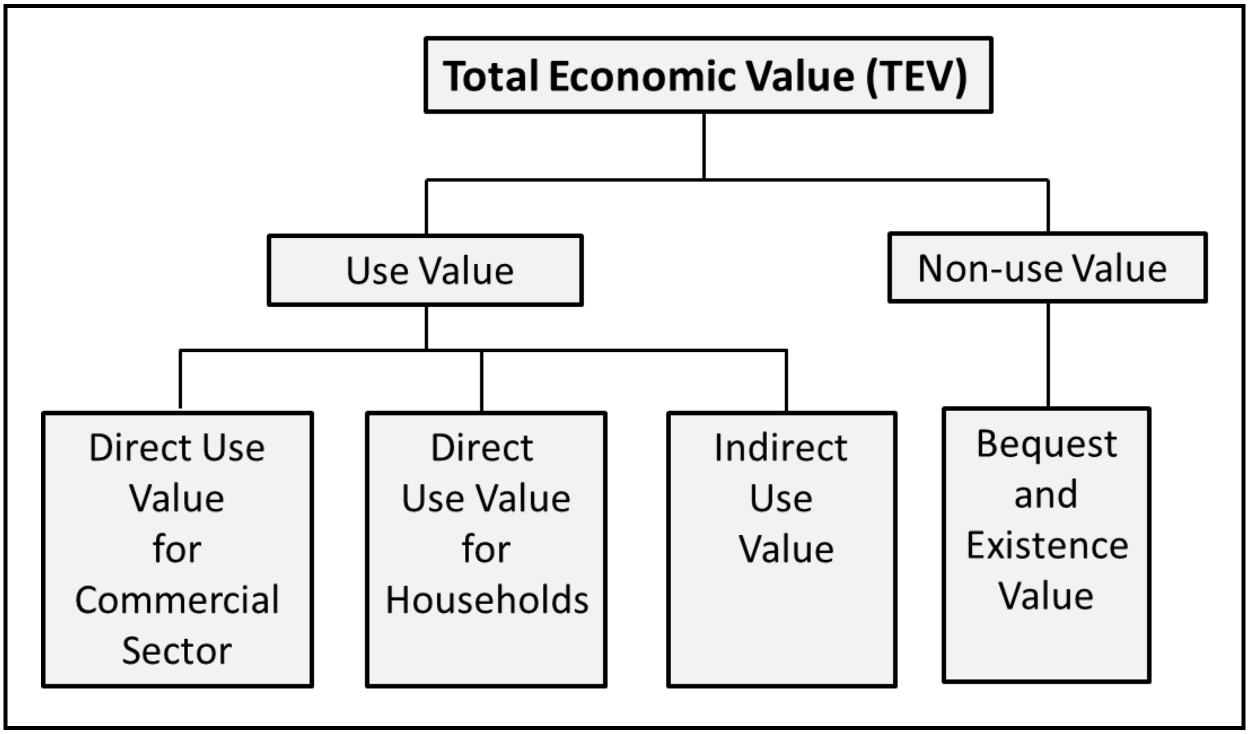
Economic Valuation of Natural Resources: Conceptual Framework and Analytical Approach

The concept of economic value, whether applied to natural resources or any other type of physical asset or commodity, must ultimately be linked to humans' preferences and the well-being they derive from them (Just et al., 2008). In short, resources have economic value to the extent that humans are willing to pay a price for them, rather than living without the resource. For this reason, to measure economic value in dollar terms, economists most commonly rely on the concept of willingness to pay (WTP) (Freeman et al., 2014)—that is, what is the maximum amount of income one would be willing to pay, or forego, for environmental services? For goods and services that are actively traded, WTP can be directly observed in their market prices. In contrast, many of the benefits provided by natural resources are not bought or sold in markets; however, they still provide important economic value. For example, we typically do not have to pay for a natural vista or for a hike in the woods, but they have economic value because there is some amount we would be willing to pay for them if necessary.

To value natural resources, it is also helpful to introduce the concept of ecosystem services. Ecosystem services represent the different ways in which nature contributes to or supports human well-being (MA, 2005; USEPA, 2015a). They include the human benefits derived from extracting and consuming natural resources, such as through timber harvest, as well as those derived from non-extractive activities or appreciation of nature, such as wildlife viewing.

To apply these concepts and account for the many of the different types of benefits provided by the natural resources of the A-P watershed, we use a total economic value (TEV) framework (Plottu & Plottu, 2007). As shown in ***Figure 3-1***, TEV provides a hierarchical system for categorizing distinct types of natural resources values according to how they contribute to human well-being. The first two categories are associated with direct human uses of the resources, either by commercial sectors or by households. In the first case, commercial activities such as agriculture and commercial fishing, use natural resources as inputs to their production processes. In the second case, households derive benefits through their use of and interaction with nature and ecosystems. The third category—indirect use value—represents the ways in which natural resources provide ecosystem services that are indirectly enjoyed by humans. It includes the many natural processes that help to regulate climate and environmental conditions (i.e., "regulating" ecosystem services such as carbon storage and cycling) or that provide inputs to other ecosystem processes (i.e., "supporting" ecosystem services, such as providing forage for wildlife). Humans benefit immensely but indirectly from these processes. The fourth category is non-use value, which recognizes that humans (households) are often willing to pay to preserve and protect natural resources even if they never directly use or see them. They benefit simply from the knowledge that the resources exist or that they will be available for future generations.

Figure 3-1. The Total Economic Value Framework for Valuing Natural Resources



Applying the TEV framework for our analysis is not intended to imply that we capture and estimate *all* of the values associated with natural resources in the A-P watershed. Rather, we use TEV as an organizing framework for the analysis, with the objective of measuring selected benefits within each of the main value categories. Given this objective, the next step is to estimate and express these selected benefits in monetary terms, using WTP as the guiding principle. It is important to emphasize that the A-P watershed would not exist without its natural resources; therefore, at a most comprehensive level, their value could be interpreted as the equivalent of society's WTP to preserve the existence of the watershed as a whole. Rather than trying to address values at this scale, we focus instead on measuring values for selected resources and human uses within each of the TEV categories. In addition to providing more informative value estimates, this selective approach is also based on practical considerations. Due to resource constraints for this study, we must strictly rely on existing data sources and studies to develop these estimates rather than on any extensive primary data collection or analysis.

To estimate direct use values for commercial sectors that directly rely on natural resource inputs—agriculture, forestry, commercial fishing, aquaculture, and mining—we are primarily interested in estimating how much these producers would be willing to pay on an annual basis for access to these resources. The annual revenues generated by these activities provide a rough measure of value; however, a more appropriate measure is *net* revenue (i.e., profit or producer surplus), which deducts the costs of using and maintaining the resources in these productive activities. Moreover, to ensure comparability across annual value estimates, we convert and express all final estimates in 2014 dollars (using a consumer price index adjustment).

Estimating direct use and non-use values for households is in many ways more challenging because these values are not directly linked to observable market transactions and prices. Although numerous methods exist for assessing these types of nonmarket values, applying most these methods requires data and resources that are beyond the scope of this study. Therefore, as a more practical alternative, we apply a "benefit transfer" approach (Boyle & Bergstrom, 1992; Wilson & Hoehn, 2006). That is, we rely on and adapt evidence from existing nonmarket valuation studies that have been conducted for similar natural resources. For example, to value outdoor recreation in the watershed, we use estimates of "consumer surplus" per trip from existing recreation demand studies.[4] These studies use data on recreation behaviors and travel costs to estimate consumer surplus as a measure of WTP per trip. To value the aesthetic amenities provided by shorelines to local residents, we use evidence from property valuation studies. These studies measure the relationship between housing values and distance to shoreline to estimate residents' implicit WTP for shoreline amenities.

Estimating indirect values presents an additional challenge because it requires both an approach for (1) quantifying the impact of natural resources on the "downstream" environments that are directly valued by humans and (2) valuing these impacts. For this analysis, we focus on indirect values for two types of regulating services—carbon and air quality regulation—provided by vegetative cover in the watershed. In both cases we rely on existing modeling approaches that combine quantification of downstream environmental impacts (climate change and air pollution impacts) with benefit transfer methods for valuing these impacts.

It is important to emphasize that the well-being derived from these direct and indirect uses (and non-use)—and therefore the values we estimate for them—depends importantly on the quality of the resources. For example, several activities, including agricultural production, commercial fishing, and water-based recreation depend critically on water quality. As a result, the value contributed by current water quality in these uses is included in our value estimates for these uses. Separately measuring the value contributed by water quality alone would result in double counting of benefits. A separate question is how changes in water quality would affect the values derived from these direct uses; however, that question is beyond the scope of this analysis.[5]

For this analysis, it is also important to distinguish between estimating the economic *value* of natural resources and estimating their economic *impact*. For the latter, conducting an economic impact analysis typically involves measuring how a public or private sector investment affects income, sales, and employment in a regional economy. Although the primary focus of this study is on economic valuation, we also briefly explore economic impacts by estimating the number of jobs and total wages that are directly and indirectly dependent on natural resources in the watershed.

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[4] Consumer surplus is the difference between the total revealed benefits and the travel costs for the recreation trips.

[5] Note that the regulating services analyzed in this report—carbon and air quality regulation—result in improved air quality, and the benefits of these quality improvements are included in our value estimates (e.g., the health benefits from improved air quality provided by trees).

4

Direct Use Value to Commercial Sectors

This section reports annual value estimates for direct use of natural resources in the A-P watershed for five main commercial sectors—agriculture, forestry, fishing, aquaculture, and mining. Together, these sectors comprise the "primary" sector of the economy, which depends most directly on natural resource inputs. Although producers in the secondary (manufacturing) and tertiary (services) sectors also use land and water resources, they usually do so less intensively. Therefore, because most of the direct use value in commercial activities is expected to accrue in the primary sector, and due to data and resource limitations for this study, we do not estimate natural resource values in other sectors. For similar reasons we do not attempt to separately estimate values for different types natural resource inputs. For example, we do not estimate separate values for irrigation water, soils, and natural pollinators in agriculture. Instead we estimate combined direct use values for each primary sector, which include values for water and other natural resources inputs.

4.1 Agriculture

Accounting for over one-quarter of the land area within the A-P watershed, agriculture plays an important role in supporting the local economy and relies heavily on the natural resources within the watershed. On over 3.3 million acres (5,163 square miles) of farmland, farmers in the A-P watershed generated $4.6 billion in commodity sales in 2012, according to the U.S. Department of Agriculture (USDA) Census of Agriculture (2012) estimates. The census is conducted every 5 years and provides comprehensive data on farms and ranches at the state and county level. Commodity sales in the A-P region have increased by 36% since 2007 and 83% since 2002. Sales data reported in the Census include crop, livestock, and aquaculture commodities and are reported at the county level in ***Table 4-2***.

The total farmland in the A-P watershed is approximately 20% pasture/hay area and 80% cultivated crops; however, Virginia has a higher proportion of pasture/hay area (40%) than North Carolina. The main types of commodities produced in the A-P region include grains, tobacco, poultry and eggs, and hogs and pigs. Two North Carolina counties in the A-P region (Wayne and Johnston County) ranked first and second for tobacco value of sales among all U.S. counties in 2012 (USDA, 2012).

Table 4-1 aggregates the total agricultural area and market value by state. Farmland in the A-P region accounts for 20% of the total farmland in North Carolina and Virginia, and 28% of the total market value of farm products sold in 2012. In total, farmland in the A-P region generated over $4.6 billion in commodity sales in 2012.

Table 4-1. Total Value of Agricultural Products Sold in A-P Watershed ($ 2014)

State	State Agricultural Area (Acres)	A-P Watershed Agricultural Area (Acres)	Percent of Agricultural Area in A-P Watershed	State Commodity Sales in 2012 ($ mil)	A-P Watershed Commodity Sales in 2012 ($ mil)	Percent of Commodity Sales in A-P Watershed
North Carolina	8,414,576	2,773,374	33%	12,980	4,252	33%
Virginia	8,302,444	531,3007	6%	3,870	383	10%
Total	**16,717,020**	**3,304,381**	**20%**	**16,850**	**4,635**	**28%**

As discussed in Section 3, total commodity sales are not the best estimate of the economic benefit provided by natural resources to commercial activities such as agriculture in the A-P watershed. Rather, the profits, or producer surplus from those sales more accurately represents the benefits gained from the land and water resources used in producing agriculture products. One proxy for this producer surplus is the rent charged to farmers for land used in agricultural production (Gloy et al., 2011). In essence, the rental value should reflect the profit that tenants expect to earn from using the land and selling their output. As these rental values vary by location, we reviewed the sales and rental value of commodity goods at the county level within the A-P watershed region.

Table 4-2 provides the total farmland in acres, market value of agricultural products sold, and the total rental value of cropland and pastureland by county within the A-P watershed in 2012. Farmland acres include all land designated as pasture, hay, or cultivated land according to the 2011 NLCD. For counties that do not fall entirely within the A-P boundary, we applied a proportion of the farmland area and market value of agricultural products sold. To estimate the area of land attributable to the A-P region for those counties, we calculated the proportion of cultivated and pasture land that falls within the A-P boundary, and then applied that proportion to the total commodity sales by county. Total rental values are calculated by multiplying the county-specific rental value per acre by land type (i.e., irrigated cropland, non-irrigated cropland, and pastureland) by the total acres of land within each type.

In total, North Carolina counties within the A-P region accounted for over $4.6 billion in commodity sales in 2012, with Virginia earning just over $380 million in sales (USDA, 2012). The results indicate that in North Carolina, five counties (Bertie, Greene, Johnston, Lenoir, and Wayne) accounted for over one-third (39%) of the total market value of agricultural products in 2012. In Virginia, the top five counties (Isle of Wight, Southampton, Sussex, Chesapeake City, and Suffolk City) accounted for more than half (58%) of the total market value of agricultural products in 2012.

The total rental value of farmland in 2012 was $185 million and $26 million for North Carolina and Virginia, respectively (USDA, 2012). Total rental value is calculated by multiplying the rental value per acre (which varies based on the type of land, i.e., irrigated versus non-irrigated cropland, pastureland) by the total acres within each land type. Rental values for cultivated crops are approximately double the rental values of pastureland, on a per acre basis. This rental value, which represents over 4% of total commodity sales in the A-P region, serves as a proxy for the profit margin of agricultural goods production, which can be attributed to the ecosystem services that the agricultural land (and air, water, and soil resources) provided to produce these goods.[6]

Table 4-2. Value of Agricultural Commodities Sold in A-P Watershed Counties

County	Farmland in A-P Region (Acres)	Commodity Total Sales in 2012 ($ '000 per year)	Total Rental Value of Cropland and Pastureland ($ '000 per year)
Beaufort	148,140	125,386	12,378
Bertie	90,392	232,171	7,416
Camden	51,979	50,435	4,115
Carteret	56,021	30,116	3,136
Chowan	47,158	72,923	3,732
Craven	71,156	57,233	2,937
Currituck	47,207	26,679	2,509
Dare	5,237	1,163	0
Durham	15,215	9,034	488
Edgecombe	128,991	160,877	6,701
Franklin	79,614	84,001	3,011
Gates	45,175	68,895	3,348
Granville	42,017	16,565	$730
Greene	83,602	282,500	5,496
Halifax	132,025	128,739	11,739
Hertford	53,710	150,925	4,954
Hyde	111,615	137,561	8,589
Johnston	176,872	273,428	8,966
Northampton	102,982	133,936	9,840
Orange	29,335	17,339	466
Pamlico	38,149	36,963	2,347
Pasquotank	79,488	71,172	7,052
Perquimans	79,169	101,879	6,345
Person	28,046	20,353	827
Pitt	158,344	222,624	9,867

(continued)

[6] Although data on the average profitability of farms in the A-P watershed are not available, recent evidence for the United States as a whole indicates that almost 70% of farms had operating profit margins of less than 10% in 2013 (http://www.ers.usda.gov/amber-waves/2015-januaryfebruary/profit-margin-increases-with-farm-size.aspx#.VtSRK6Mo5AH)

Table 4-2. Value of Agricultural Commodities Sold in A-P Watershed Counties (continued)

County	Farmland in A-P Region (Acres)	Commodity Total Sales in 2012 ($ '000 per year)	Total Rental Value of Cropland and Pastureland ($ '000 per year)
Tyrrell	68,477	61,403	7,276
Vance	16,970	10,394	301
Wake	62,369	58,552	1,969
Warren	21,377	14,480	460
Washington	96,232	70,492	7,077
Wayne	139,724	534,124	11,031
Wilson	96,663	185,220	6,994
North Carolina Total	**2,773,374**	**4,252,053**	**184,660**
Brunswick	41,964	23,698	1,311
Charlotte	2,060	737	49
Dinwiddie	46,921	22,233	1,569
Greensville	33,578	21,918	1,917
Isle of Wight	32,545	25,575	1,705
Lunenburg	41,986	19,068	903
Mecklenburg	13,635	7,206	83
Nottoway	14,864	20,987	266
Prince Edward	1,388	573	31
Prince George	15,881	6,505	486
Southampton	106,507	81,627	6,427
Surry	23,528	18,149	2,919
Sussex	49,425	38,437	2,105
Chesapeake City	44,592	37,864	2,843
Emporia City	387	—	—
Franklin City	877	—	—
Petersburg City	447	—	—
Suffolk City	35,499	40,361	2,394
Virginia Beach City	24,924	17,819	910
Virginia Total	**531,007**	**382,756**	**25,668**
A-P Watershed Total	**3,304,381**	**4,634,809**	**210,348**

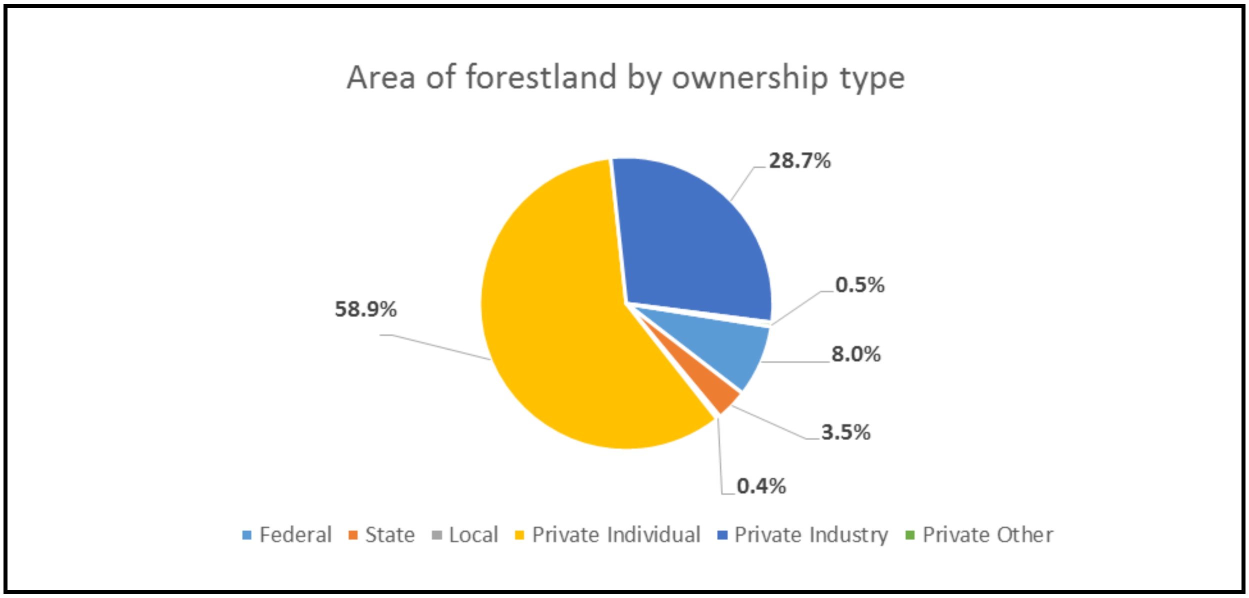
Note: Although commodity total sales include crops, livestock, and aquaculture, rental values are estimated based on the per acre rental value for cropland (irrigated and non-irrigated) and pastureland, and are not available for aquaculture. Therefore, the producer surplus from aquaculture farming is not possible to estimate via the rental value method. See Section 4.4 for further detail on the aquaculture sector in the A-P watershed.

Source: USDA, 2012.

4.2 Forestry

The moderately mild and humid climate in the A-P region supports a strong forestry sector. Just over one-quarter of the land area in the APNEP management boundary, or 3.3 million acres, is covered in evergreen, deciduous, or mixed forests, supporting an active timber industry. Timberland in the region consists primarily of loblolly-shortleaf pine, oak-gum-cypress, and oak-pine forest types. According to the U.S Forest Service, Forest Inventory Analysis (FIA), over three-quarters (86%) of forest land in North Carolina counties, and 94% of forest land in Virginia counties, are privately owned in the A-P watershed. Of this privately owned timberland, approximately one-quarter is corporately owned, with the remainder owned by private individuals (***Figure 4-1***).

Figure 4-1. A-P Watershed Forestland by Ownership Type



To estimate the market value of harvested wood in the A-P region, a number of data sources were compiled. The FIA conducts Timber Products Output (TPO) studies on the status and trends of the nation's forests, including removal volumes by harvest at the county level by species group and product type. According to the most recent studies, counties in the A-P region harvest 436 million cubic feet of roundwood annually. Softwoods (e.g., longleaf pine, loblolly pine) account for over two-thirds of harvests, with hardwoods (e.g., oak, hickory, sweet gum) accounting for the remainder. By applying an average harvest volume per acre, we estimate that over 155,000 acres are harvested for roundwood annually in the A-P region.[7] Forest revenues from these harvests were then estimated using 5-year historic

[7] The North Carolina Harvest and Utilization Study (2007) estimate that in North Carolina, 424,200 acres were harvested between 2002 and 2007, producing over 3.31 thousand cubic feet of roundwood per acre annually.

stumpage (standing timber) prices for roundwood.[8] Similar to value estimates calculated for the agricultural sector for counties that straddle the APNEP management boundary, we applied a proportion of county harvest levels based on the proportion of land area classified as forests according to NLCD that falls within the APNEP boundary. ***Table 4-3*** provides the historic stumpage prices for timber products in Eastern North Carolina.

Table 4-3. Historic Stumpage Prices in Eastern North Carolina (2010–2014)

Timber Product	Eastern NC Price History (5-year average)
Pine Sawtimber ($/mbf)	$225.99
Pine Pulpwood ($/cord)	$23.11
Mixed Hardwood Sawtimber ($/mbf)	$210.15
Hardwood Pulpwood ($/cord)	$14.31

Source: Historic North Carolina Timber Stumpage Prices, 1976–2014. NC Cooperative Extension Resources. Available at http://content.ces.ncsu.edu/historic-north-carolina-timber-stumpage-prices-1976-2014. (Note: mbf= thousand board feet). Prices reported are in 2014 dollars.

We use these historic stumpage prices and harvest levels to estimate the average annual revenue from forest harvests by county in the A-P region. However, the costs associated with managing and treating the land for harvest must be subtracted to estimate the net revenue, or profit, generated from these harvests. The profit generated from forest harvests represents the value received from natural resource inputs in the forestry sector. The forestry costs, however, can vary substantially as landowners can choose to allow land to naturally regenerate with minimal costs, or replant following a harvest, which incurs substantial site-preparation and planting costs. According to a recent study, these costs can range from $42 per acre to naturally regenerate (i.e., establish) hardwoods to $384 per acre to replant hardwoods following a harvest (Bair et al., 2006). In addition to establishment costs, landowners may choose between various intermediate treatments to maintain productivity, including designing management plans, fire protection, and surveying. ***Table 4-4*** reports these establishment and management costs as estimated for the Southeast.

Studies have estimated that over half of timberland in southern forests is naturally regenerated, with the remainder undergoing replanting of the deforested land (Blair & Alig, 2006). For the purposes of estimating management costs associated with regeneration of forestland, we also assume that one-half of the harvested acres (calculated using an average harvest volume per acre) in the A-P region undergo more management-intensive replanting costs, and one-half are naturally regenerated. It is also assumed that all industry-owned forestland undergo intermediate management costs, and these costs are applied to all private industrial acres in the A-P region. ***Table 4-5*** summarizes these harvests, revenue, costs, and net

[8] Historic North Carolina Timber Stumpage Prices, 1976–2014. Eastern North Carolina price history was used for pine sawtimber, pine pulpwood, mixed hardwood sawtimber, and hardwood pulpwood to estimate the stumpage value of harvests in the A-P region.

revenue by county in the A-P region. In total, we estimate that forests in A-P counties generate over $245 million in net revenue, or producer surplus, annually in marketable goods.

Table 4-4. Stand Establishment, Planting, and Management Costs in the Southeast ($ 2014)

Timber Activity	Hardwood	Softwood
Establishment via natural regeneration ($ per acre)	42.11	59.22
Establishment via replanting (site preparation and planting) ($ per acre)	383.59	253.07
Intermediate management activities ($ per acre per year)	11.84	15.79

Source: Blair & Alig, 2006.

Table 4-5 Average Annual Harvest Levels, Revenue, and Costs in the A-P Region ($ 2014)

	Average Annual			
County	Harvest Levels (2002–2012) ('000 cubic feet)	Harvest Revenue*	Costs**	Net Revenue
Beaufort	35,238	$30,259,680	$7,358,415	$22,901,265
Bertie	22,139	$14,490,286	$5,558,189	$8,932,097
Camden	2,757	$1,507,659	$334,398	$1,173,261
Carteret	4,632	$4,559,053	$1,702,978	$2,856,075
Chowan	4,480	$3,031,014	$446,025	$2,584,989
Craven	17,109	$17,389,535	$5,012,766	$12,376,769
Currituck	1,761	$841,206	$102,063	$739,143
Dare	123	$126,189	$16,245	$109,944
Durham	2,376	$2,124,200	$309,035	$1,815,165
Edgecombe	7,933	$5,025,685	$1,543,674	$3,482,011
Franklin	8,256	$6,633,809	$763,986	$5,869,822
Gates	10,783	$8,991,205	$1,880,891	$7,110,314
Granville	6,590	$4,877,288	$885,545	$3,991,743
Greene	6,666	$2,992,593	$922,173	$2,070,420
Halifax	17,526	$12,472,485	$2,498,923	$9,973,562
Hertford	13,268	$9,758,267	$1,787,415	$7,970,852
Hyde	3,302	$2,318,415	$2,601,987	-$283,571
Johnston	7,978	$6,308,439	$1,398,576	$4,909,863
Jones	9,757	$7,302,251	$2,590,929	$4,711,322
Lenoir	6,331	$4,118,106	$849,177	$3,268,928

(continued)

Table 4-5 Average Annual Harvest Levels, Revenue, and Costs in the A-P Region (2014 dollars) (continued)

County	Average Annual			
	Harvest Levels (2002–2012) ('000 cubic feet)	Harvest Revenue*	Costs**	Net Revenue
Martin	16,136	$11,466,723	$2,956,131	$8,510,591
Nash	8,462	$7,004,157	$1,527,106	$5,477,051
Northampton	14,558	$9,192,857	$2,534,337	$6,658,520
Orange	2,045	$1,827,602	$146,266	$1,681,336
Pamlico	8,989	$7,421,275	$406,606	$7,014,670
Pasquotank	4,298	$2,674,533	$481,548	$2,192,985
Perquimans	6,725	$4,964,635	$496,112	$4,468,523
Person	3,511	$1,773,234	$236,216	$1,537,018
Pitt	11,627	$7,087,323	$2,527,780	$4,559,543
Tyrrell	3,699	$2,085,415	$1,327,320	$758,095
Vance	2,517	$2,004,356	$308,465	$1,695,891
Wake	8,158	$6,813,622	$2,046,299	$4,767,323
Warren	14,950	$8,530,673	$1,358,443	$7,172,230
Washington	$5,952,294	$1,432,768	$4,519,526	$5,952,294
Wayne	$8,441,557	$1,629,363	$6,812,194	$8,441,557
Wilson	$4,577,370	$435,535	$4,141,835	$4,577,370
North Carolina Total	**317,857**	**$236,994,990**	**$58,413,686**	**$178,531,304**
Brunswick	17,722	$12,174,012	$2,041,635	$10,132,377
Charlotte	673	$384,884	$69,354	$315,530
Chesapeake	1,374	$692,077	$214,378	$477,699
Dinwiddie	11,925	$8,802,405	$1,701,578	$7,100,827
Franklin City	8,042	$7,211,869	$449,084	$6,762,785
Greensville	12,768	$6,433,506	$1,258,807	$5,174,698
Isle Of Wight	3,257	$2,196,290	$289,662	$1,906,628
Lunenburg	12,074	$7,029,936	$1,960,432	$5,069,504
Mecklenburg	558	$316,269	$167,010	$149,259
Nottoway	3,359	$2,636,889	$427,642	$2,209,247
Prince Edward	372	$144,323	$48,770	$95,553
Prince George	3,276	$2,673,823	$718,661	$1,955,162
Southampton	21,482	$14,596,050	$2,374,458	$12,221,591
Suffolk	5,362	$3,440,486	$876,444	$2,564,042
Surry	2,135	$2,176,508	$638,171	$1,538,337

(continued)

Table 4-5 Average Annual Harvest Levels, Revenue, and Costs in the A-P Region (2014 dollars) (continued)

County	Average Annual			
	Harvest Levels (2002–2012) ('000 cubic feet)	Harvest Revenue*	Costs**	Net Revenue
Sussex	13,659	$11,120,042	$2,189,986	$8,930,056
Virginia Beach	243	$50,465	$14,471	$35,994
Virginia Total	**118,280**	**$82,079,833**	**$15,440,543**	**$66,639,290**
A-P Watershed Total	**436,137**	**$319,024,822**	**$73,854,229**	**$245,170,594**

* Based on 2010–2014 average stumpage prices for Eastern NC.

** Includes establishment, replanting, and intermediate management costs. Assumes that one-half of harvested acres are naturally regenerated and one-half are replanted.

4.3 Commercial Fishing

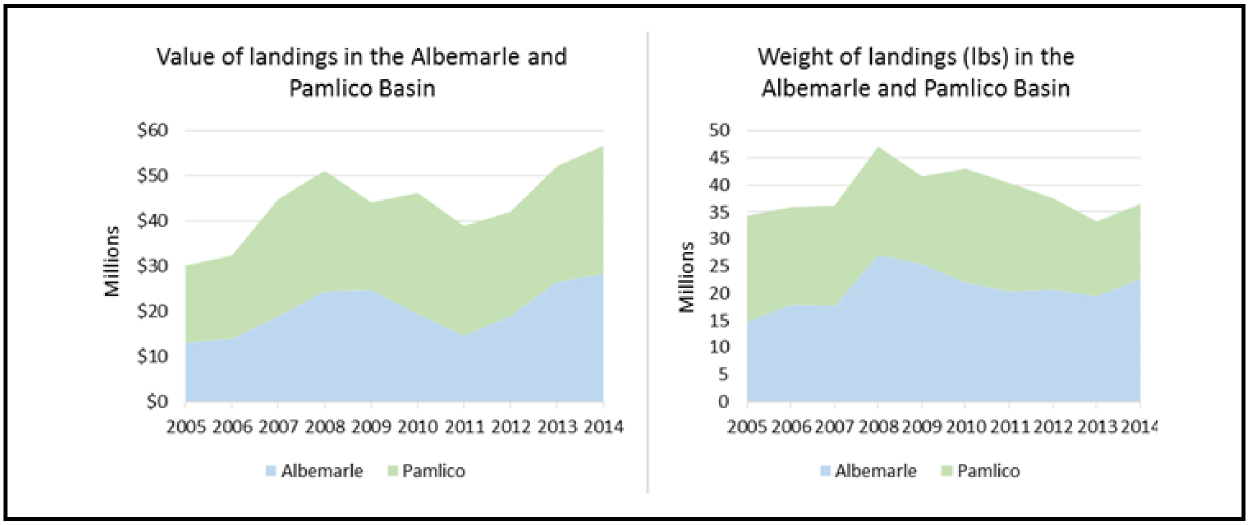
Fisheries resources play an important role in supporting the economy in the A-P region. In the U.S., the A-P estuary is second in size only to the Chesapeake Bay, with roughly 3,000 square miles of open water (Giordano & Holloman, 2001). Twenty water bodies are contained within the estuary, including eight sounds and twelve major rivers. The A-P estuary provides critical habitat and spawning grounds for many fish species important to the commercial fisheries sector. It has in fact been estimated that over 75% of all commercial fisheries catch have spent some time in estuaries (USEPA, n.d.).

A variety of species are targeted among commercial fishermen in the A-P estuary. A survey conducted by the North Carolina Department Division of Marine Fisheries in 2014 revealed that two-thirds of commercial fishermen target blue crabs, followed by nearly one-half targeting flounder (Hadley & Wiegand, 2014). Other popular species include white perch, striped bass, shad, catfish, peeler crabs, striped mullet, speckled trout, croaker, oysters, and soft shelled blue crabs.

As shown in ***Figure 4-2***, the value of landings in the A-P basin in 2014 was just under $60 million with a catch of over 36 million pounds, up from $42 million in 2012. Landing values are approximately equal for water bodies in the Albemarle and Pamlico estuaries, with on average slightly higher landing values from the Pamlico estuary.

Commercial fishers incur substantial trip costs, however, when operating their fishing vessels, which varies depending on the size of the fishing vessel. The NC Division of Marine Fisheries captured trip expenditures by vessel size in both the Albemarle and Pamlico Sounds through a survey of fishermen in 2014 (Hadley & Wiegand, 2014). The survey found that trip costs can range from just over $100 per trip in small vessels (defined as less than 19 feet) to over $2,000 per trip for large vessels (defined as greater than 38 feet). Fuel and oil account for the greatest share of trip expenditures, at 30%–50% of the total cost in small- and medium-size vessels, and over 80% in large vessels. Other expenses include bait, ice, and groceries. The finding of this survey allow us to estimate the trip costs of commercial fishers in the A-P estuary by applying these cost estimates to the total number of trips in the region. By subtracting these costs from the value of commercial landings, we estimate the profit, or producer surplus, of fishing activities. This value can be attributed to the natural resources and ecosystem services provided by the estuary. ***Table 4-6*** summarizes these costs and benefits from 2010–2014. As shown, commercial fisheries generated over $30 million in producer surplus in 2014, up from $17 million in 2012. On average, $20 million in producer surplus is generated in the A-P region each year.

Figure 4-2. Value and Weight of Landings in the A-P Basin



Source: North Carolina Division of Marine Fisheries.

Table 4-6. Total Producer Surplus in the Albemarle and Pamlico Sounds ($ values in millions per year, 2014 dollars)

	2010	2011	2012	2013	2014	2010–2014 Average
Albemarle						
Total trips	41,668	34,732	41,020	45,312	43,242	41,195
Total sales	$19.43	$14.62	$19.03	$26.58	$28.39	$21.61
Total costs	$9.22	$7.69	$9.08	$10.03	$9.57	$9.12
Estimated producer surplus	**$10.21**	**$6.93**	**$9.95**	**$16.55**	**$18.82**	**$12**
Pamlico						
Total trips	63,637	57,354	50,607	51,172	50,323	54,619
Total sales	$26.83	$24.34	$23.07	$25.61	$28.28	$25.62
Total costs	$20.32	$18.32	$16.16	$16.34	$16.07	$17.44
Estimated producer surplus	**$6.50**	**$6.02**	**$6.91**	**$9.27**	**$12.21**	**$8**

4.4 Aquaculture

North Carolina and Virginia have abundant water resources that support a robust and fast-growing aquaculture sector. In 2012, 228 aquaculture operations existed in North Carolina, supporting a sales and distribution value of over $23 million, an increase of 32% since 2002. Food fish (e.g., catfish, trout, perch, bass) account for most (95%) of aquaculture sales in North Carolina, with catfish and trout contributing over half of the values of sales and distribution in 2012 (USDA, 2012). Other species farmed in North Carolina include prawns, clams, and oysters, although these account for a small proportion of sales. In Virginia, 160 operations generated a sales and distribution value of over $54 million in 2012, up from $20 million in 2002. Over 90% of Virginia's aquaculture value is generated from clam and oyster farming, with nominal sales in trout, catfish, and crustaceans (USDA, 2012). According to a recent survey conducted by the Virginia Sea Grant Program, Virginia shellfish farmers sold nearly $60 million in oysters and clams in 2014, leading the nation in hard clam production and boasting the highest sales of oysters along the East Coast (Hudson & Murray, 2015). ***Table 4-7*** provides the total number of operations and value by state for the three most recent USDA Censuses of Agriculture.

Table 4-7. Aquaculture Sales and Operations in North Carolina and Virginia, 2002–2012

State	2002		2007		2012	
	Number of Operations	Total Sales and Distribution Value ($)	Number of Operations	Total Sales and Distribution Value ($)	Number of Operations	Total Sales and Distribution Value ($)
North Carolina	202	17,669,000	311	32,175,000	228	23,365,000
Virginia	182	19,945,000	182	53,032,000	160	54,665,000

Source: USDA, 2012.

Detailed information on aquaculture sales at the county level, however, is not available through the censuses due to the limited number of operations and nondisclosure requirements. Therefore, to estimate the size and value of both freshwater and marine aquaculture markets in A-P watershed counties, we derived estimates based on information and guidance from the NC Sea Grant and NC Department of Agriculture (NCDA, 2015; P. Anderson, personal communication, January 21, 2016).

Marine aquaculture in North Carolina consists of clam, oyster, and soft crab farming. As shown in ***Table 4-8***, the total statewide farm gate value of marine aquaculture was $2.81 million in 2014. Accounting only for those leases and permits that fall within A-P watershed counties, we estimate that marine aquaculture in the watershed produced $2.32 million in farm gate value in 2014, accounting for over 80% of the total production value in the state.

Table 4-8. Marine Aquaculture Statistics in North Carolina (2014)

	Statewide		% of Leases/Permits in A-P Watershed counties	Estimated Farm Gate Value in A-P Watershed (million)
	Production	Farm Gate Value (million)		
Clam	3,955 bushels	$0.22	52	$0.12
Oyster	21,157 bushels	$0.45	52	$0.24
Blue Crab	367,277 lbs	$2.14	92	$1.97
Total	—	$2.81	—	$2.32

Source: North Carolina Department of Agriculture and Consumer Services

Freshwater aquaculture production in North Carolina includes trout, catfish, hybrid striped bass, tilapia, prawns, crawfish, and sturgeon. According to the NC Department of Agriculture, over 90% of the catfish, hybrid striped bass, and tilapia production occurs within A-P counties (P. Anderson, personal communication, January 21, 2016). Therefore, this proportion was applied to the total statewide production value to estimate the farm gate value of freshwater aquaculture goods in A-P watershed counties in North Carolina. As shown in ***Table 4-9***, combined catfish, hybrid striped bass, and tilapia production in the watershed was estimated to be roughly 15 million pounds with a farm gate value $18.7 million in 2014.

Table 4-9. Freshwater Aquaculture Statistics in North Carolina (2014)

	Statewide		A-P Watershed (90% of Statewide Production)	
	Production (million lbs)	Farmgate Value ($ million)	Production (million lbs)	Farmgate value ($ million)
Catfish				
Food fish	4.20	$4.96	3.78	$4.46
Fingerlings	3.50	$0.35	3.15	$0.32
Hybrid Striped Bass				
Food fish	2.81	$11.10	2.53	$9.99
Fingerlings	3.00	$0.72	2.70	$0.65
Tilapia				
Food fish	1.43	$3.28	1.28	$2.95
Fingerlings	1.86	$0.32	1.67	$0.29
TOTAL	**16.80**	**$20.73**	**15.12**	**$18.66**

Source: North Carolina Department of Agriculture and Consumer Services.

In total, we estimate that A-P watershed counties in North Carolina generated nearly $21 million in revenue in 2014 from freshwater and marine aquaculture. It is important to note that, due to data and resource limitations, this figure does not include aquaculture production in Virginia, nor does it account for the costs of aquaculture practices. Therefore, it only provides a rough indicator of the watershed's natural resource values in aquaculture production.

4.5 Non-Fuel Mining

Rich mineral deposits support a large mining economy in Virginia and North Carolina. Combined, Virginia and North Carolina produced over 100,000 metric tons[9] of non-fuel raw minerals in 2009, valued at over $1.7 billion (DOI, 2015). The predominant commodity mined in the region is crushed stone, accounting for over 50% of total production value. Other minerals mined in the region include sand and gravel, feldspar, olivine, mica, and phosphate rock.

North Carolina has over 123,000 acres under active permits, with over one-third (35%) located within A-P watershed counties. The state continues to rank second out of four states with phosphate rock production. Beaufort County in the Tar-Pamlico river basin (an area within the A-P boundary) contains the only active mining permit for phosphate rock in the region, covering over 14,000 acres of permitted land. In Virginia, 18% of the 74,000 permitted acres lie within the A-P watershed counties, accounting for 8 billion tons (12%) of the total production quantity in 2014 (VA DMM, 2015). Over 95 of these permitted acres are for titanium, granite, sand, and gravel mining.

Although annual estimates of the production quantity and value of non-fuel raw minerals exist at the state level, there is sparse data available at the river basin or county level to specifically estimate the value of mining activities within the A-P watershed. Moreover, with even less data available on the costs of these activities in the watershed, we are not able to estimate producer surplus values. In 2011, North Carolina's nonfuel mineral production was $0.84 billion, down from $0.88 billion in 2010 and $0.85 billion in 2009 (DOI, 2015). If we approximate the portion of these values that are attributable to the A-P watershed based on permitted acres, over one-third of the total production value in North Carolina is mined in the A-P region. This accounts for $360 million in revenues in 2010, and $315 million in 2011.

In Virginia, due to data limitations, it was not possible to reasonably estimate the production value attributable to counties the A-P region.[10] However, the available data suggest that only a small proportion of the total production value in Virginia can be attributable to the A-P region. In total, $1.2 billion of nonfuel raw mineral revenues were generated in 2011, up from $0.9 billion in 2009. Crushed stone continues to be Virginia's leading non-fuel mineral commodity by sales value, accounting for nearly 60% of the total value in 2009–2011. The primary commodities mined in areas within the

[9] This estimate does not include production quantities from withheld entities and therefore represents the lower bound estimate of production quantities.

[10] The aggregate classification of production value by commodity was not easily overlaid with the disaggregated classification of acres by commodity, thus estimating the production value of commodities mined in A-P counties was not possible.

APNEP boundary, however, include sand and gravel, titanium, and granite, which make up a smaller proportion of the total production quantity and value in Virginia.

As with the aquaculture estimates, it is important to emphasize that these estimates do not account of the costs of mining operations. Therefore, they only provide rough indicators of natural resource values in mining activities.

5

Direct Use and Non-use Values to Households

In addition to providing key inputs for market sector production activities, the natural resources of the A-P watershed also provide ecosystems services to the nonmarket sector by directly supporting the activities and well-being of households. This section reports annual value estimates associated with three important direct sources of natural resource benefits to households: outdoor recreation, natural and scenic amenities for nearshore residents, and nongame wildlife protection.

One important source of direct use value for households *not* included in this section are the benefits associated with water withdrawals for domestic use. Based on 2010 county-level data on water withdrawals (Maupin et al., 2014) over one-third of total withdrawals in the A-P watershed are for domestic use. Clearly, this is a very high-valued use of groundwater and surface water resources in the region. However, one of the main challenges in estimating the *total* value of this water use is precisely because of its fundamental importance to humans—that is, some amount of water is essential for human survival. Therefore, unless households' water needs can be met by transferring water from other locations outside the watershed, valuing domestic water use is equivalent to measuring the value of human survival in the watershed. Unfortunately, standard economic valuation methods, which focus on household-level and firm-level decisions and trade-offs, are not well-suited for addressing these types of changes (Hammitt, 2000).

5.1 Outdoor Recreation

Among the most visible and widely appreciated nonmarket uses of the land and water resources in the A-P watershed are a wide variety of outdoor recreation activities. The Outer Banks barrier islands alone extend for roughly 200 miles and are amongst the most popular East Coast destinations for beach recreation and saltwater fishing. The Albemarle and Pamlico Sounds together provide about 2,500 square miles of shallow estuarine waters, which are also popular destinations for fishing, boating, and other water-based recreational activities. Meanwhile, the inland portion of the A-P watershed covers roughly 20,000 square miles, which includes nine state parks and recreation areas, over 1 million acres of protected lands and wilderness areas, and over 6,000 miles of rivers and streams. These areas support a wide range of freshwater recreation, hunting, and other wildlife-related recreation activities.

Although detailed data are not specifically collected or available for outdoor recreation activities in the A-P watershed, a number of data sources can be used to approximate the extent and overall value of these activities in the watershed. In particular, the U.S. Fish and Wildlife Service's (USFWS) National Survey of Fishing, Hunting, and Wildlife Associated Recreation (FHWAR) (USFWS, 2011) provides a rich source of data on selected recreation activities in the United States. Conducted every 5 years, FHWAR provides state-level estimates of annual participation in freshwater and saltwater fishing, hunting, and wildlife viewing activities, most recently for 2011. However, due to the sample size and design of the survey, the results are only reported at a state-level and they are only available for these activities.

To approximate participation levels only within the A-P watershed and to include other recreation activities, we supplemented the FHWAR with data from other sources, in particular the U.S. Forest Service's National Survey on Recreation and the Environment (NSRE). The sample sizes for the NSRE are considerably smaller than for the FHWAR; however, the NSRE contains more detailed information about the destination of recreation trips for a number of water-based recreation activities. Using data from the 2000 and 2009 surveys, we estimated the portion of annual freshwater and saltwater fishing trips in North Carolina and Virginia that were to sites in the A-P watershed. We applied these percentages to the state-level fishing activity days reported in FHWAR to estimate freshwater and saltwater fishing days. For hunting and wildlife viewing days in the A-P watershed, we assumed that they occurred in proportion to the percentage of each state's land area that falls within the watershed. For each state, the NSRE data also provide estimates of the total annual number of saltwater beach visits, the portion of total saltwater recreation trips to A-P region sites, and the portion of annual freshwater recreation trips that are primarily for non-fishing activities. We applied these estimates to approximate total saltwater beach and non-fishing freshwater recreation days.

The resulting annual outdoor recreation activity estimates for the A-P watershed are shown in ***Table 5-1***. Saltwater beach recreation and non-fishing freshwater recreation (e.g., swimming, boating, water-skiing, and other water-based activities) account for roughly two-thirds of the over 50 million estimated annual recreations days. Freshwater and saltwater fishing account for 13% and 7% of these days, respectively.

Table 5-1. Annual Value Estimates for Selected Outdoor Recreational Activities

Recreational Activity	Estimated Annual Activity Days in A-P Watershed ('000 Days/Year)			Average Per-Day Value ($/day)	Total Annual Value ($ million/year)
	NC	VA	Total		
Fishing					
Freshwater	6,130	452	6,582	99.60	655.6
Saltwater	3,003	489	3,492	99.60	347.8
Hunting	2,401	1,049	3,449	44.46	153.4
Wildlife viewing	2,884	475	3,358	50.42	169.3
Saltwater beach visits	15,165	3,024	18,189	41.64	757.4
Other freshwater recreation	14,231	1,054	15,285	103.65	1,584.3
Total	**43,814**	**6,542**	**50,356**		**3,667.8**

To estimate the annual value of these outdoor recreation days in the A-P watershed, we applied estimates of the average consumer surplus (CS) per recreation day from the existing recreation demand literature. In particular, we drew from the Kaval and Loomis (2003) summary of the literature, which reports average CS values by U.S. region for selected activities including fishing, hunting, wildlife viewing, beach visits, and several other water-based recreation activities. The inflation-adjusted estimates (in 2014 dollars) of these average CS values are also reported in Table 5-1. For the other (i.e., non-fishing) freshwater recreation category, the per-day value is calculated as an average of CS per-day estimates for three activities—non-motorized boating, motorized boating, and swimming.

Applying the average per-day values to the recreation day visits, Table 5-1 also reports estimates of the total annual value of the selected outdoor recreation activities in the A-P watershed. The combined annual value for the six selected outdoor recreation activities is estimated to be $3.7 billion per year. Freshwater-based recreation, including fishing and other activities, accounts for 61% of this estimate, and saltwater-based activities, including fishing and beach visits accounts for 30%.

An alternative approach for assessing the annual value of outdoor recreation in the A-P watershed is to examine visitation at popular recreation sites in the region. One advantage of this approach is that it should capture a broader range of outdoor recreation activities than the six activity categories included in Table 5-1. The main limitation of this approach is that annual visitation statistics are not collected or available for all sites visited in the watershed. Annual recreation values based on this approach are reported in ***Table 5-2***, which includes 2013 and 2014 visitation estimates for 12 state parks and recreation areas and four federal (National Park Service) sites. Total annual visitation for these sites is about 9.6 million per year, which is less than 20 percent of the total recreation days that were estimated using the activity categories reported in Table 5-1. The most visited site in this group is Cape Hatteras National Seashore, with roughly 2.2 million visits per year. The most visited state parks are William B. Umstead State Park near Raleigh, NC and Fort Macon State Park near Atlantic Beach, NC, with roughly 1.2 million visits per year to each site.

To estimate the annual value of these park visits, we again rely on average CS per day values reported in the Kaval and Loomis (2003) summary. In this case, we use the summary values for visits to selected recreation areas. For state parks visits we apply the average Southeast region value for state and city lands ($67 per day converted to 2014 dollars). For national parks we use the national average CS value of $65 per day, because the sample size of CS estimates for just the Southeast region is small.

Using this approach, the annual value of outdoor recreation to the selected sites in the A-P watershed is estimated to be roughly $635 million per year. It is important to emphasize that there is likely to be a significant amount of overlap between the recreational activities included in the two tables. In other words, adding the two estimates would result in double counting a portion of the recreation day values.

Table 5-2. Annual Value Estimates for State and National Park Visits

Type	Name	Annual Park Recreation Visitation (visits per year)		Annual Average Visitation Value ($ million/year; 2013–2014)
		2013	2014	
State Parks				
North Carolina				
	Dismal Swamp State Park	127,090	125,026	8.4
	Merchants Millpond State Park	247,952	283,270	17.7
	Jockey's Ridge State Park	1,185,745	1,237,276	80.7
	Pettigrew State Park	80,114	72,251	5.1
	Goose Creek State Park	266,582	255,107	17.3
	Fort Macon State Park	1,191,942	1,190,134	79.3
	Cliffs of the Neuse State Park	194,583	177,224	12.3
	Medoc Mountain State Park	97,140	109,573	6.9
	Falls Lake State Recreation Area	1,045,882	1,080,730	70.8
	Eno River State Park	501,124	530,703	34.4
	William B. Umstead State Park	1,293,063	1,154,632	81.5
Virginia				
	False Cape State Park	64,154	65,497	4.3
National Park Service Sites				
	Cape Hatteras National Seashore	2,214,565	2,153,350	142.5
	Cape Lookout National Seashore	416,568	430,927	27.7
	Fort Raleigh National Historic Site	263,598	264,987	17.3
	Wright Brothers National Memorial	447,796	430,517	28.7
Total		**9,637,898**	**9,561,204**	**635.0**

5.2 Natural and Aesthetic Amenities to Nearshore Residents

One of the most notable natural features of the A-P estuary system, including the Outer Banks barrier islands, is its over 9,000 of miles of estuarine and coastal shoreline. In addition to providing extensive habitat for various animal and plant communities, these shoreline miles provide valuable natural amenities for people living in or visiting the region. In particular, they provide areas of natural beauty with specific and highly appreciated aesthetic qualities.

To estimate the value of these natural and aesthetic amenities, we focus on benefits to nearshore residents. The estimation approach involves the following main steps. First, to quantify the average effect of nearby shorelines on residents' home values, we use evidence from economic studies measuring how proximity to shoreline waters affects the value of residential properties. Based on a review of the literature, we identified five studies in particular that were conducted in the A-P region.[11] These studies use different modeling approaches, but in each case the results can be expressed as either a linear estimate (dollar per foot) or a "semi-elasticity" estimate (percent change per foot). Averaging across studies (weighted by each study's sample size), the linear estimates imply that property values decrease by an average of $10.10 (in 2014 dollars) for each additional foot of distance from the shoreline. The semi-elasticity estimates imply that property values decrease by an average of 0.004 percent for each additional foot of distance.

Second, we use U.S. 2010 census data to estimate the number and value of existing nearshore residential properties in the A-P region. For the purposes of this analysis, to define "nearshore" we focus on census blocks that border the A-P shoreline and that have a geographic centroid located within at most one mile from the shoreline. Using census housing data, we estimate (1) the number of single detached units (rental and owner-occupied) in each selected census block and (2) the average value of these units for each block. Based on this approach, the total estimated number of nearshore housing units in the A-P region is 56,455. As shown in ***Table 5-3***, Carteret County and Dare County account for the largest portions (26% and 21% respectively) of these units. At a block group level, the average values for these units vary between $95 thousand and $550 thousand.

Table 5-3. Annual Value Estimates for Natural and Aesthetic Amenities to Near-Shore Residents

County	Number of Near-Shore Housing Units	Benefit Estimation Method	Annual Benefits (millions $ per year)	
			Δd = 1/2 mile	Δd = 1 mile
Beaufort	5,551	Linear model	4.6	9.1
		Semi-elasticity model	4.1	8.2
Bertie	207	Linear model	0.2	0.3
		Semi-elasticity model	0.2	0.3
Camden	1,061	Linear model	0.9	1.7
		Semi-elasticity model	0.8	1.6
Carteret	14,577	Linear model	12.0	23.9
		Semi-elasticity model	10.8	21.7
Chowan	2,456	Linear model	2.2	4.4
		Semi-elasticity model	2.0	4.0
Craven	4,982	Linear model	4.9	9.9
		Semi-elasticity model	4.5	9.0
Currituck	4,317	Linear model	3.8	7.7
		Semi-elasticity model	3.5	6.9

(continued)

[11] Bin, Kruse et al. (2008); Bin, Crawford et al. (2008); Bin et al. (2010); Gopalakrishnan et al. (2010); Landry & Allen (2014).

Table 5-3. Annual Value Estimates for Natural and Aesthetic Amenities to Near-Shore Residents (continued)

County	Number of Near-Shore Housing Units	Benefit Estimation Method	Annual Benefits (millions $ per year)	
			Δd = 1/2 mile	Δd = 1 mile
Dare	12,056	Linear model	9.9	19.8
		Semi-elasticity model	9.0	17.9
Hertford	56	Linear model	0.0	0.0
		Semi-elasticity model	0.0	0.0
Hyde	670	Linear model	0.0	0.1
		Semi-elasticity model	0.0	0.1
Onslow	709	Linear model	0.5	1.1
		Semi-elasticity model	0.5	1.0
Pamlico	2,418	Linear model	0.7	1.5
		Semi-elasticity model	0.7	1.3
Pasquotank	2,796	Linear model	2.0	4.0
		Semi-elasticity model	1.8	3.6
Perquimans	2,556	Linear model	2.3	4.6
		Semi-elasticity model	2.1	4.2
Tyrrell	638	Linear model	2.4	4.7
		Semi-elasticity model	2.1	4.3
Virginia Beach	1,170	Linear model	0.5	1.0
		Semi-elasticity model	0.5	0.9
Washington	233	Linear model	1.1	2.2
		Semi-elasticity model	1.0	2.0
All 18 counties	**56,455**	**Linear model**	**48.0**	**96.1**
		Semi-elasticity model	**43.5**	**87.0**

Third, we approximate the benefits to nearshore residents of living near the A-P region's shoreline. We do this by asking the following hypothetical question: *how much would the value of their property decline if the only thing that changed was their proximity to the shoreline?* To address this question we must define what is meant by a loss in proximity. For the purpose of this analysis, we represent a loss in proximity using two alternative hypothetical increases in distance (Δd) from the shoreline: Δd=½ mile and Δd=1 mile. To estimate the change in value for these two distance increments, we also use two alternative approaches. One approach is to apply the linear estimate from step one ($10.10 per foot) to all of the units identified in step two. Using this approach, the total effect on property values (summed across all units) ranges from $1.57 billion to $3.13 billion. The alternative approach is to use the semi-elasticity estimate from step one, which reduces the average home value by 0.004 percent per foot of distance. Using this approach, the total effect on property values ranges from $1.42 billion to $2.84 billion. Converting these estimates to *annual* benefits, assuming a 3% discount rate (i.e., multiplying by 0.03), the total annual benefits of nearshore amenities to local residents are shown in

Table 5-3. These annual benefit estimates range from \$44–\$48 million per year for Δd=½ mile to \$87–\$96 million per year for Δd=1 mile.

5.3 Preservation of Nongame Wildlife Resources

Although predominantly located within the Mid-Atlantic Coastal Plain ecoregion, the A-P watershed is home to a wide variety of terrestrial and aquatic habitats and diverse natural communities. In addition to supporting recreational, commercial, and other human uses, these natural systems provide ecosystem services and value to local populations which are not necessarily tied to specific uses. In particular, they support and protect wildlife species that are increasingly under threat from environmental and human development pressures. For example, the sub-basins within the watershed provide habitat for 14 state-listed threatened or endangered aquatic (fish and mussels) species, such as the shortnose sturgeon in the Chowan basin (NCWRC, 2005, Wildlife Action Plan). The coastal flood plain forest and the beach and dune terrestrial habitats support an additional 10 state-listed threatened or endangered (bird, mammal, and reptile) species, such as the piping plover and the loggerhead sea turtle. Due in part to their high-risk status, these species are often valued by humans for their existence rather than for any direct use.

To assess the value of protecting and preserving nongame wildlife resources in the A-P watershed, in particular species that are at relatively high risk of extinction, we use results from two main valuation studies. The results are summarized in ***Table 5-4***. Several U.S. studies have used stated preference surveys to elicit respondents' values for threatened, endangered, or rare species (Richardson & Loomis, 2009); however, two studies in particular have focused on nongame wildlife protection in North Carolina. The first study was conducted in 1991 based on a telephone survey of NC residents (Whitehead, 1993). The survey included a question eliciting respondents' WTP for a nongame wildlife preservation program for all threatened and endangered species in coastal North Carolina. Half of respondents were asked to assume that the program would avoid extinction for all protected species in the next 25 years. The remaining respondents were asked to assume that the program would provide a specific reduction in the probability of extinction. Based on the analysis in the study, we estimate that the average WTP for a program that would fully protect coastal species that would otherwise become extinct would be \$51 per household per year (converted to 2014 dollars). Multiplying this value by the number of households in NC, we estimate the total annual benefits to this population of preserving nongame coastal species in their state would be \$201.7 million per year.

Table 5-4. Annual Value Estimates for Nongame Wildlife Preservation

Wildlife Protection Program (Study)	Average Value ($/NC HH/year)	Total Benefits ($000/year)
Coastal nongame wildlife protection in NC (Whitehead, 1993)	51.31	201,662
Nongame wildlife protection in all of NC (Dalrymple et al., 2012)	107.26	133,034

The second study we use was based on a mail survey of NC residents conducted in 2010 (Dalrymple et al., 2012). This survey also elicited respondents' WTP for a nongame conservation program in North Carolina. However, in contrast to the earlier study, (1) it was less specific about the exact outcomes that the proposed program would achieve (or avoid) for at-risk wildlife, and (2) it proposed a program for the entire state rather than just for coastal wildlife. The resulting average WTP estimate from this study was $107 per household per year (converted to 2014 dollars). Aggregating this estimate over all NC households provides a total annual benefit of over $421 million per year. To approximate the portion of these benefits that would specifically apply to wildlife resources in the A-P watershed, we assumed that it would be in proportion to the percentage of the state's land area that falls within the A-P watershed (i.e., 31.6%). The resulting estimate of the total annual benefits to NC households of nongame conservation in the A-P watershed is $133 million per year.

Taken together these studies suggest that the total annual benefits of preserving at-risk wildlife species in the North Carolina portion of the A-P watershed are in the range of $133 million to $202 million per year. It should be noted that the higher value does not include protection of non-coastal species in the A-P watershed, but it does include species protection in NC coastal areas outside of the watershed. Also, because no comparable valuation studies were identified for Virginia, the estimated values exclude the benefits of wildlife protection for Virginia households or for the VA portion of the A-P watershed.

Values from Regulating/Supporting Ecosystem Services

In addition to providing direct benefits to businesses and households in the region, the natural resources and ecosystems of the A-P watershed also provide indirect benefits to society through their roles in regulating climatic conditions and environmental quality.

This section reports annual value estimates associated with two main types of services: (1) carbon and climate regulation by forests, wetland, and seagrasses; and (2) air pollution regulation by trees. These services were selected based on the availability of data and methods for estimating their values and the expectation that the magnitude of these values is significant.

It is important to emphasize that many other types of regulating services are also provided by natural resources in the watershed; however, estimating values for these other services was not feasible within the scope and resources of this study. These services include, for example, the water quality regulation and storm surge regulation provided by riparian buffers and wetlands. They also include natural waste assimilation services provided by land, water, and air resources, such as the biodegradation of solid waste provided by land-based disposal systems and wastewater assimilation provided by soil and water resources. These processes provide significant benefits to humans by reducing environmental damages from human waste flows and by providing natural and often relatively low-cost alternatives to manmade waste treatment technologies.

6.1 Carbon Storage and Sequestration

6.1.1 Forests

As atmospheric carbon levels and average temperatures continue to rise around the world, increasing concerns about the pace and consequences of climate change, there is also growing recognition of the critical role that forests can play in mitigating climate change. In particular, as forest ecosystems grow, they sequester carbon from the atmosphere and provide natural long-term storage for carbon. Therefore, the forested lands of the A-P watershed contribute to a valuable global ecosystem service by helping to mitigate damages due to climate change. As discussed in Section 2, roughly one quarter of the A-P watershed is classified as forest land, and additional tree cover exists in several other land use categories including wetlands and developed lands.

To estimate the value of A-P watershed forests in this role, we first used the conterminous U.S. (CONUS) data from USDA Forest Service's (USFS) Forest Inventory and Analysis (FIA) database, combined with the NLCD land cover data, to estimate the number of watershed acres in different forest cover categories. As shown in ***Table 6-1***, forested lands in the watershed fall into six main forest group categories, which can be further subdivided into a total of 22 forest type categories. The most prevalent type is loblolly pine forest, which by itself accounts for roughly 60% of the total forested acres in the watershed. The oak/gum/cypress group accounts for about 15%.

Next, we estimated the above- and below-ground carbon stocks for each forest type within the watershed using the National Council for Air and Stream Improvement (NCASI) and USFS's Carbon On-Line Estimator (COLE) tool. Specifying the 59 A-P watershed counties as the study area, COLE provides estimates of the average per-acre above and below-ground carbon pools by forest type. Multiplying these values by the watershed acreage in each forest type provides estimates of the total carbon storage, which are reported in Table 6-1. In total, we estimate that 400 million tons of carbon are stored in the forest lands of the A-P watershed, with just over half of this value accounted for by above-ground storage.

To estimate the annualized value of carbon stored in A-P watershed forests, we apply estimates of the social cost of carbon (SCC) drawn from the United States Government's Interagency Working Group on Social Cost of Carbon (2013). Using this approach, each ton of stored carbon is assumed to avoid the global climate change damages to society that would on average be caused by a ton of carbon in the atmosphere. According to the SCC report, the expected present value of future social costs per additional metric ton of carbon in the atmosphere in 2014 would be about $152, assuming a 3% annual discount rate and adjusting for inflation. On a permanent annualized basis, this estimate translates to $4.56 in damages per metric ton per year. Applying this SCC value, we estimate that the annual value of carbon stored by forests in the A-P watershed is $1.7 billion per year.

The COLE tool also provides information that allows us to estimate the annual increase in forest carbon stocks (i.e., carbon sequestration) in the study area. In particular, COLE results allow us to approximate the average age class by forest type (for 13 of the 22 types), and the average above-ground net accrual of carbon (in tons per acre per year) corresponding to that age category.[12] For forest type categories lacking sufficient data on age and/or accrual, we used the average net accrual from the other forest types (with data) in the same forest group category. Using this approach, we estimate that forests in the A-P watershed are currently sequestering 6.4 million tons of carbon per year. To estimate the value of this sequestered carbon, we again apply the SCC estimate of $152 per metric ton. We estimate that the annual value of carbon sequestered by forests in the A-P watershed is $876 million per year.

One important caveat about these carbon sequestration estimates is that they tend to overestimate annual carbon accrual because they do not account for carbon released to the atmosphere as a result of annual timber harvests. Based on the average annual harvest estimates reported in Section 4, we estimate that roughly 4.7 million tons of carbon are contained in these harvested volumes. Although harvesting does not release all of this carbon to the atmosphere, it does offset some of the estimated sequestration reported in Table 6-1.

[12] Net above-ground accrual accounts for changes in carbon stocks in live trees, dead trees, under story, down dead wood and forest floor.

Table 6-1. Benefits of Carbon Storage and Sequestration by Forests in the A-P Watershed

Forest Type	Forest Area (acres)	Stored Carbon ('000 tons)			Annual Value (millions $/yr)	Annual Carbon Sequestration		
		Above Ground	Below Ground	Total		Average (tons/acre/yr)	Total ('000 tons/yr)	Total Value (millions $/yr)
Loblolly/Shortleaf Pine Group								
Loblolly pine	3,190,354	117,128	104,291	221,419	915.3	1.52	4,838.8	666.7
Pond pine	195,629	6,781	6,364	13,145	54.3	0.45	87.3	12.0
Virginia pine	3,091	180	112	292	1.2	*0.98*	3.0	0.4
Shortleaf pine	3,209	194	105	300	1.2	*0.98*	3.1	0.4
Oak/Pine Group								
Loblolly pine/hardwood	548,042	20,512	15,070	35,581	147.1	1.20	660.1	91.0
other pine/hardwood	7,322	166	201	367	1.5	0.67	4.9	0.7
Longleaf pine/oak	22	0	1	1	0.0	*0.94*	0.0	0.0
Shortleaf pine/oak	332	16	9	25	0.1	*0.94*	0.3	0.0
Virginia pine/southern red oak	2,546	102	71	173	0.7	*0.94*	2.4	0.3
Longleaf/Slash Pine Group								
Longleaf pine	22,833	665	1,105	1,770	7.3	n/a	-	-
Slash pine	700	37	34	71	0.3	n/a	-	-
Oak/Hickory Group								
White oak/red oak/hickory	79,460	4,328	1,604	5,932	24.5	0.31	24.8	3.4
Yellow-poplar/white oak	47,545	2,161	960	3,121	12.9	0.54	25.5	3.5
Sweetgum/yellow-poplar	305,976	12,039	6,213	18,252	75.4	0.76	232.0	32.0
Mixed upland hardwoods	58,371	2,127	1,178	3,306	13.7	0.54	31.2	4.3
Post oak/blackjack oak	298	10	6	16	0.1	*0.54*	0.2	0.0
Oak/Gum/Cypress Group								
Sweetgum/nuttall oak/willow oak	209,212	7,737	14,747	22,483	92.9	0.76	158.7	21.9
Bald cypress/water tupelo	235,889	17,405	16,973	34,378	142.1	0.36	84.2	11.6
Sweetbay/swamp tupelo/red maple	348,466	12,949	24,562	37,511	155.1	0.54	186.5	25.7
Swamp chestnut oak/cherrybark oak	1,350	89	91	180	0.7	*0.55*	0.7	0.1
Elm/Ash/Cottonwood								
River birch/sycamore	10,750	372	459	831	3.4	0.22	2.4	0.3
Sugarberry/hackberry/elm/green ash	10,885	402	479	881	3.6	0.76	8.3	1.1
Total	5,282,282	205,400	194,635	400,035	1,653.6		6,354.5	875.6

6.1.2 Emergent Wetlands

In addition to forests (including forested wetlands), emergent wetlands in the A-P watershed (i.e., those dominated by emergent vegetation such as grasses, reeds, and shrubs that grow in water) also provide valuable climate-related ecosystems services by storing and sequestering carbon. Emergent wetlands trap sediments including carbon from terrestrial sources. Anaerobic soil conditions often found in emergent wetlands prevents decomposition of plant biomass. Consequently, plant biomass accumulates within wetland soils sequestering the carbon from the environment. Both of these factors enable emergent wetlands to store carbon. Roughly 3% of the A-P watershed area is classified as emergent wetlands. Wetlands are able to sequester much more carbon in below-ground stores relative to above-ground stores compared to forested lands.

To determine the value of emergent wetlands in the A-P watershed, we used NLCD to estimate the area of emergent wetlands. Studies have shown that freshwater emergent wetlands are capable of storing up to 18% carbon than estuarine wetlands (Schmidt et al., 2013). Therefore, we used the National Wetlands Inventory (NWI) to classify emergent marshes as salt marsh or freshwater marsh. As shown in ***Table 6-2***, there are almost twice as many freshwater wetland acres compared to salt marsh acres in the A-P watershed.

Table 6-2. Benefits of Carbon Storage and Sequestration by Emergent Wetlands in the A-P Watershed

Wetland		Stored Carbon ('000 tons)			Annual Value (millions $/yr)	Annual Carbon Sequestration		
Type	Area (acres)	Above Ground	Below Ground	Total		Average (tons/acre/yr)	Total ('000 tons/yr)	Total Value (millions $/yr)
Salt Marsh	169,419	407	23,380	23,786	108	0.32	54.2	8.23
Freshwater Marsh	306,940	737	33,150	33,886	154	0.3	98.2	14.92
Total	**476,359**	**1,143**	**56,529**	**57,673**	**263**		**152.4**	**23.2**

Because specific empirical data for A-P watershed wetlands are unavailable, we rely on values of carbon stores found in the literature from similar wetlands in Virginia, North Carolina, South Carolina and Georgia. Most of the carbon in emergent wetlands is stored below ground as dead biomass and soil, but above-ground biomass also contributes to the overall carbon stores. We used the above-ground and below-ground biomass carbon stores for salt marshes summarized in the North American Blue Carbon Scoping Study (CEC, 2013). Based on the study by Schmidt et al. 2013, we assumed that carbon stores for freshwater marshes are 18% higher than salt marshes. Based on these assumptions, we estimate that 58 million tons of carbon are stored in emergent marshes of the A-P watershed, with a majority of the carbon below the ground. To assess the economic value of this storage we use the same approach as we applied for forest carbon storage. Applying the annualized SCC value, we estimate that the annual value of carbon stored by emergent wetlands in the A-P watershed is $263 million per year.

Like forests, emergent wetlands also sequester carbon. Annual rates of carbon sequestration in marshes are mainly associated with rates of sediment accretion, which depend on sediment input and sea level rise. Several studies have shown that sediment accretion rates will likely keep pace with sea level rise, as long as the rise occurs at current or slightly higher levels (Kirwan & Mudd, 2012; Currin et al., 2015). For this analysis, we assume that freshwater and salt marshes have similar accretions of 0.32 tons/ac/year, based on the average of two North Carolina Studies reported by Sifleet et al. (2011). Using this approach, we estimate that emergent wetlands in the A-P watershed are currently sequestering 0.15 million tons of carbon per year. Applying the SCC value, we estimate that the total value of this rate of annual sequestration is roughly $23 million.

6.1.2 Seagrasses

Seagrass communities in the A-P estuary—also known as submerged aquatic vegetation (SAV)—also provide valuable climate-related ecosystems services by storing and sequestering carbon. Although these systems have relatively low above-ground biomass compared to forests and emergent wetlands, they often have deep root structures, forming mattes of sediments that are capable of storing and sequestering large quantities of carbon.

To estimate the spatial extent of SAV in the estuary, we used summary data from APNEP's 2011 aerial survey of North Carolina's sounds (http://portal.ncdenr.org/web/apnep/sav-map). This survey identified roughly 138,000 visible acres in the A-P estuary system, of which over 70,000 were considered to contain "dense" communities of SAV (with the remaining acres being "patchy"). For estimating carbon in these systems, we focused on these dense SAV acres. It is important to emphasize, however, that this is a conservative (i.e., low) estimate of total SAV acres because it only includes those that are visible from the air.

Using a similar approach to the one used for emergent wetlands, we separately estimate stored carbon in above- and below-ground systems. For carbon stored in above-ground SAV biomass, we use estimates of average tons of carbon per acre reported in Fourqurean et al. (2012) for 18 sites in North Carolina and Virginia. The median from these estimates is 0.11 tons of carbon per acre. For carbon stored in seagrass sediments, we multiply estimates of average carbon density (tons of carbon per acre per unit of depth) by estimates of the average depth of seagrass sediments. The density estimates are based on 11 observations from two studies conducted in Virginia (Buzzelli, 1998; McGlathery et al., 2012) and the depth estimates are assumed to 1 meter (Campbell et al., 2013). The results are summarized in ***Table 6-3***. We estimate a total of 1.2 million tons of carbon stored in the dense SAV, with a large majority of this carbon stored in sediments. To assess the economic value of this storage, we use the same approach we applied for forest and wetland carbon storage. Applying the annualized SCC value, we estimate that the annual value of carbon stored by dense seagrass systems in the North Carolina portion of the A-P watershed is $5 million per year.

To estimate annual carbon sequestration by these seagrass communities in the A-P watershed, we used estimates of average annual seagrass sequestration rates (per acre) from studies conducted in North Carolina and Virginia (Cebrian, 2002; Duarte et al., 2010). Across 22 observations from these studies, the median rate is 1.26 tons of carbon per acre per year. Multiplying by the number of dense SAV acres, we estimate annual sequestration of 87 thousand tons per year. Applying the SCC value, we estimate that the total value of this rate of annual sequestration is roughly $13 million.

Table 6-3. Benefits of Carbon Storage and Sequestration by Seagrasses in the A-P Watershed

SAV Area (acres)	Stored Carbon			Annual Value (millions $/yr)	Carbon Sequestration	
	Above Ground ('000 tons)	In Seagrass Sediment ('000 tons)	Total ('000 tons)		Total ('000 tons/yr)	Total Value (millions $/yr)
70,554	8	1,180	1,188	5.4	87	13

6.2 Air Pollutant Removal by Trees

One of the many beneficial ecological functions performed by trees is that they are capable of removing pollutants from the air. Through this process they can mitigate various harmful health impacts on humans that are caused or exacerbated by air pollution. With a human population of almost 3 million in the A-P watershed and forest cover accounting for over a quarter of its land area, we posit that the trees in the region can provide significant health benefits to local populations.

To quantify and value these health benefits we use the i-Tree Landscape v1.0.2 beta model, which is part of a suite of software tools developed by the USDA Forest Service to analyze the benefits of forests, particularly in urban landscapes. Similar analyses focusing on the health benefits of trees have been conducted by i-Tree developers for areas across the country (Nowak et al, 2014).

The i-Tree Landscape model is run at a county-level. To calculate improvements in air quality for each specified county, it uses geospatial data on forest, climate, demographic, and environmental characteristics such as leaf area, tree cover, percentage of tree population that is evergreen, population size, weather, and air pollution. The model uses air quality grids to determine the change in pollution concentrations, epidemiological concentration-response functions to estimate the change in adverse health effects, and valuation functions to calculate the associated economic values. These functions and values are themselves drawn from the U.S. Environmental Protection Agency's BenMAP program. (USEPA, 2015b).

Table 6-4 summarizes the results of our analysis. We ran i-TREE Landscape for the each of the 58 counties in the A-P watershed. For counties that are only partially within the region, we adjusted the benefit estimates by multiplying them by the share of the county's population living within the A-P region. Health benefits were separately estimated for removal of four air pollutants—fine particulates ($PM_{2.5}$) ozone, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). These estimates include values for several health endpoints, including avoided premature deaths and various respiratory and cardiovascular illnesses.

Table 6-4. Estimated Annual Value of Health Benefits due to Air Pollutant Removal by Trees

County	Dollar ($)				
	NO_2	Ozone	$PM_{2.5}$	SO_2	Total
North Carolina Counties					
Beaufort	10,916	1,104,308	2,245,981	1,235	3,362,440
Bertie	6,157	660,643	1,107,703	414	1,774,917
Camden	1,683	202,399	819,263	693	1,024,038
Carteret	15,533	1,880,796	3,986,407	2,064	5,884,800
Chowan	2,771	312,044	587,993	169	902,977
Craven	13,504	709,411	2,223,715	1,522	2,948,152
Currituck	5,235	594,416	2,812,005	2,131	3,413,787
Dare	10,847	1,721,172	2,748,218	1,965	4,482,202
Durham	30,753	1,208,672	2,646,482	2,358	3,888,264
Edgecombe	5,516	446,774	720,423	479	1,173,192
Franklin	10,174	754,106	1,267,852	1,596	2,033,728
Gates	3,753	344,580	687,018	979	1,036,330
Granville	8,160	495,026	777,292	859	1,281,336
Greene	2,875	194,762	308,016	221	505,874
Halifax	7,219	621,572	981,098	652	1,610,542
Hertford	5,162	509,748	821,731	334	1,336,975
Hyde	3,115	774,819	1,270,695	690	2,049,319
Johnston	19,250	654,759	1,044,334	1,836	1,720,180
Jones	3,540	158,948	309,365	390	472,243
Lenoir	8,769	353,536	600,696	1,107	964,108
Martin	7,169	563,790	572,283	479	1,143,721
Nash	9,331	822,685	1,237,360	1,513	2,070,889
Northampton	3,672	499,100	701,797	318	1,204,888
Orange	1,975	100,870	147,751	158	250,754
Pamlico	6,375	689,594	1,493,610	710	2,190,289
Pasquotank	2,516	281,975	1,034,757	1,212	1,320,460
Perquimans	3,349	363,125	675,037	225	1,041,736
Person	3,180	211,137	356,550	368	571,235
Pitt	8,698	624,414	602,571	466	1,236,149

(continued)

Table 6-4. Estimated Annual Value of Health Benefits due to Air Pollutant Removal by Trees (continued)

County	Dollar ($)				
	NO_2	Ozone	$PM_{2.5}$	SO_2	Total
Tyrrell	1,707	328,288	510,637	169	840,801
Vance	3,834	331,575	530,412	614	866,435
Wake	120,048	3,826,447	11,540,296	9,683	15,496,474
Warren	2,634	324,150	485,283	414	812,480
Washington	2,551	256,428	452,498	163	711,640
Wayne	7,941	445,713	1,476,430	1,206	1,931,290
Wilson	6,880	512,654	823,133	815	1,343,482
Virginia Counties/Cities					
Brunswick	2,847	291,576	465,123	1,016	760,562
Charlotte	387	32,299	49,043	50	81,779
Chesapeake City	957	68,136	138,053	473	207,618
Dinwiddie	2,361	181,586	368,652	726	553,326
Emporia City	725	87,695	98,260	292	186,972
Franklin City	1,435	117,531	157,612	682	277,260
Greensville	2,198	234,890	298,374	776	536,238
Isle of Wight	1,047	63,056	98,231	457	162,792
Lunenburg	5,000	295,819	440,487	879	742,185
Mecklenburg	2,564	149,464	246,659	251	398,937
Nottoway	1,280	70,719	131,469	231	203,698
Petersburg	1,009	96,186	243,079	346	340,620
Prince Edward	85	4,915	7,207	15	12,223
Prince George	1,442	58,508	86,325	397	146,672
Southampton	3,137	262,618	376,918	983	643,656
Suffolk City	533	28,822	46,361	231	75,947
Surry	802	38,428	60,346	338	99,914
Sussex	2,217	196,682	324,671	750	524,320
Virginia Beach City	1,004	71,186	319,778	498	392,467
Total	**397,823**	**26,234,553**	**54,563,342**	**49,596**	**81,245,314**

The total benefits due to avoided health impacts in the entire region is estimated to be over $81 million per year with the largest share of these benefits (almost $55 million) due to removal of $PM_{2.5}$. Trees in Wake County in North Carolina account for almost 20 percent of these total annual benefits.

Natural Resource Employment and Wages

The A-P watershed region supports a large number of jobs in sectors reliant on the natural resources found in the area, including agriculture, fishing, mining, water transportation, recreation, and tourism. The jobs and wages generated from these industries also indirectly support the region by adding value throughout the supply chain and contributions resulting from household spending.

The Bureau of Labor Statistics publishes the Quarterly Census of Employment and Wages (QCEW) on employment and wages at the county level according to NAICS industries. However, much of the data is suppressed to prevent disclosure of business statistics. Therefore, additional sources of employment statistics were also used to estimate jobs and wages in the A-P region, including farm labor from the USDA Census of Agriculture and commercial fishing statistics from the NC Department of Natural Resources. In order to estimate the indirect contributions from these jobs and wages, we applied the regional input-output multipliers as estimated by the Bureau of Economic Analysis for North Carolina. These multipliers are industry specific and calculated for earnings and employment and range from 1.3 to 2.5.

Table 7-1 provides estimates of the direct and indirect jobs and wages in the A-P watershed for selected industries reliant on the natural resources of the watershed. Particularly for employment information as reported in the Bureau of Labor Statistics QCEW, this represents the lower-bound estimation, as only disclosed data is reported here. Based on most recent employment data,[13] over 36 thousand jobs in the selected industries are directly supported by the natural resources of the A-P watershed, providing over $672 million in wages. Based on regional input-output multipliers, these direct jobs and wages are estimated to support an additional 80 thousand jobs and $1.3 billion in wages in the region, through indirect and induced employment.[14]

[13] Employment data for agriculture and commercial fishing is from 2012, all other sectors from 2014.

[14] Regional multipliers used in this analysis come from the Regional Input-Output Modeling System (RIMS II), Regional Product Division, Bureau of Economic Analysis (2010). The jobs multiplier represents “the total change in number of jobs in all industries for each additional job in the industry,” therefore capturing indirectly related and induced employment supported by the directly related jobs. The wages multiplier represents “the total dollar change in earnings of households employed by all industries for each additional dollar of earnings paid directly to households employed by the industry.” These multipliers vary by industry.

Table 7-1. Jobs and Wages in Natural Resource Dependent Sectors in the A-P Watershed and Indirectly Related Jobs and Wages

Sector	Direct		Indirect and Induced		Source
	Jobs	Wages ($ 000/yr)	Jobs	Wages ($ 000/yr)	
Agriculture*	29,132	340,309	68,840	786,624	USDA Census of Agriculture (2012)
Commercial fishing (North Carolina only)	2,994	45,347	4,592	76,977	NC DENR–Division of Marine Fisheries (2012)
Forestry and logging	1,151	49,337	1,765	83,750	U.S. Bureau of Labor Statistics (2014)
Environmental consulting	1,056	80,191	2,141	131,786	U.S. Bureau of Labor Statistics (2014)
Environmental organizations	72	4,011	146	6,592	U.S. Bureau of Labor Statistics (2014)
Public Administration of Environmental Programs**	1,344	121,019	2,207	170,552	U.S. Bureau of Labor Statistics (2014)
Mining	307	18,893	727	38,714	U.S. Bureau of Labor Statistics (2014)
Recreation***	342	12,993	457	22,714	U.S. Bureau of Labor Statistics (2014)
A-P Watershed Total	**36,398**	**672,100**	**80,876**	**1,317,708**	

* Includes crop, livestock, and aquaculture production

** Includes state and federal employees

*** Includes scenic water transportation, tour operators, recreational goods rentals, and nature parks

Conclusion

To support APNEP in its efforts to measure and communicate the important societal contributions made by natural resources in the A-P watershed, in this study we conduct an economic valuation analysis of these resources. As discussed in the introduction, this analysis focuses on two main questions

- What are the main ways in which citizens in and around the watershed depend on and benefit from the watershed's land and water resources and related ecosystems?
- How can the benefits citizens derive each year from their connections to natural systems be measured and expressed in dollar terms?

We address these questions by applying a TEV framework and separating the analysis into three main parts—direct use value to the commercial sector, direct use and non-use to households, and indirect values through regulating ecosystem services. For each part, we estimate annual values for key selected benefit categories, based on the availability of data and resources for this study. These selected categories do not cover all types of natural resource values in the A-P watershed, but they are intended to shed light on some of the most significant ones.

Some of main findings and caveats from these estimates include the following:

- To assess the economic value contributed by natural resource inputs to agricultural production, we focus on land rental values. Using this approach, we estimate that the direct value of these resources to agricultural production are $210 million per year.
- For the commercial forestry sector, we use estimates of producer surplus for timber productions and harvesting to assess the direct values. Accounting for timber management and replanting costs, these estimates are $245 million per year.
- Using a similar approach for the commercial fishing sector, we estimate that fishery resources support an average of approximately $20 million in producer surplus each year.
- Due to data and resource limitations, we are unable to estimate producer surplus estimates for the aquaculture and mining sectors; however, we estimate that recent annual revenues have been $21 million for aquaculture and $315 to $360 million for mining activities for North Carolina counties in the watershed.
- To assess economic value to households from outdoor recreation in the watershed, we combine estimates of annual recreation days with consumer surplus estimates drawn from the recreation demand literature. Because data are limited for recreation activities in the watershed we use two alternative approaches. Focusing on water-based recreation, hunting and wildlife viewing, we estimate a total annual value of $3.7 billion. Alternatively, focusing only on visits to national and state parks in the watershed we estimate an annual value of $640 million; however, due to overlaps in activities between these two estimates, summation of these values will result in some double counting of benefits.

- For residents living close to the shorelines of the estuary and coastal waters, we estimate that the annual value of the aesthetic and natural amenities provided by this proximity are in a range between $44 million to $96 million. It is important to note that these benefit estimates are likely to include values for easy access to outdoor recreational activities near the shore; therefore, there may be significant overlap with the previously described recreation values.

- The A-P watershed also provides important habitat for various nongame wildlife species. Using available survey-based studies of North Carolina residents, we estimate that the annual value of preserving this wildlife is in the range of $133 - $202 million per year. Unfortunately similar valuation studies are not available for Virginia; therefore this range of estimates represents a lower bound estimate for the watershed as a whole. It is also important to acknowledge that these value estimates are likely to include some benefits for wildlife-recreational uses (e.g., for wildlife viewing); therefore, adding them to the recreation benefits summarized above would most likely result in some double counting of values.

- One of the main regulating ecosystem services offered by natural resources in A-P watershed is climate regulation through natural storage and sequestration of carbon. We estimate that forests in the watershed currently store over 400 million tons of carbon, providing an annual societal value of $1.7 billion per year. We also estimate that, each year, forests sequester roughly an additional 6 million tons with a total social value of $876 million. It is important to emphasize that these benefit estimates are based on avoided *global* damages from climate change and not just benefits to residents in the region. For emergent wetland we estimate carbon storage of 58 million tons, providing an annual societal value of $263 million, and annual sequestration of 152 thousand tons, with a total societal value of $23 million. For seagrasses we estimate additional carbon storage of 952 thousand tons, providing an annual societal value of $5 million, and annual sequestration of 87 thousand tons, with a total societal value of $13 million. These carbon estimates for seagrasses are conservative because they only include SAV beds in North Carolina that are visible from the air and that contain dense submerged vegetation.

- The second regulating ecosystem service analyzed in this report is the air pollution removal benefits provided by tree cover in the watershed. By filtering NO_2, ozone, $PM_{2.5}$ and SO_2 from the atmosphere, we estimate that tree cover reduces human health damages by over $81 million per year.

Although it is simple to calculate the sum of these values (i.e., $6.3 billion to $7.1 billion per year), it is also important to be cautious in interpreting the meaning of this summation. First, it cannot be interpreted as the total value of natural resources in the A-P watershed because it only includes values for a selected subset of benefit categories. Other potentially significant benefits that are not included, but that would be good candidates for future research include:

- benefits of groundwater and surface water resources to domestic users;

- water quality regulation and storm surge regulation services provided by riparian buffers and wetlands; and

- natural waste assimilation services provided by land, water, and air resources.

Second, it most likely overstates the combined value of these selected categories because of overlaps between them. In particular, as discussed in the report, some recreation values may be double counted in this summation because they may also be included in the wildlife protection or nearshore amenity value estimates.

In addition to these economic value estimates, we examine the economic contribution of natural resources in the watershed through employment and wages. Although all of the jobs in the watershed depend to some extent on its natural resources, we focus our analysis on employment in sectors that are arguably most resource dependent (including the commercial sectors analyzed in Section 4). We find that there are over 36 thousand jobs in these selected sectors, providing over $672 million in wages each year. These direct jobs and wages are estimated to contribute indirectly to an additional 80 thousand jobs and $1.3 billion in wages in the region.

References

Bair, L. S., & Alig, R. J. (2006). Regional cost information for private timberland conversion and management. Gen. Tech. Rep. PNW-GTR-684. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Bin, O., Crawford, T. W., Kruse, J. B., & Landry, C. E. (2008). Viewscapes and flood hazard: Coastal housing market response to amenities and risk. *Land Economics, 84*(3), 434–448.

Bin, O., Kruse, J. B., and Landry, C. E. (2008). Flood hazards, insurance rates, and amenities: Evidence from the coastal housing market. *Journal of Risk and Insurance, 75*(1), 63–82.

Bin, O., Poulter, B., Dumas, C. F., & Whitehead, J. C. (2011). Measuring the impact of sea-level rise on coastal real estate: A hedonic property model approach. *Journal of Regional Science, 51*(4), 751–767.

Boyle, K. J. & Bergstrom, J. C. (1992). Benefit transfer studies: myths, pragmatism, and idealism. *Water Resources Research*, *28*(3), 657–663.

Buzzelli, C. P. (1998). Dynamic simulation of littoral zone habitats in lower Chesapeake Bay. I. Ecosystem characterization related to model development. *Estuaries*, 21, 659–672.

Campbell, J. E., Lacey, E. A., Decker, R. A., Crooks, S., & Fourqurean, J. W. (2015). Carbon storage in seagrass beds of Abu Dhabi, United Arab Emirates. *Estuaries and Coasts*, *38*(1), 242–251.

Cebrian, J. (2002). Variability and control of carbon consumption, export, and accumulation in marine communities. *Limnology and Oceanography, 47*(1), 11–22.

Commission for Environmental Cooperation (CEC). 2013. North American blue carbon scoping study. Montreal, Canada: Commission for Environmental Cooperation. 49pp. http://www3.cec.org/islandora/en/item/11368-north-american-blue-carbon-scoping-study-en.pdf

Currin, C., Davis, J., Baron, L. C., Malhotra, A., & Fonseca, M. (2015). Shoreline Change in the New River Estuary, North Carolina: Rates and Consequences. *Journal of Coastal Research*, *31*(5), 1069-1077.

Dalrymple, C. J., Peterson, M. N., Cobb, D. T., Sills, E. O., Bondell, H. D. and Dalrymple, D. J. (2012). Estimating public willingness to fund nongame conservation through state tax initiatives. *Wildlife Society Bulletin*, *36*(3), 483–491.

Department of Interior, U.S. Geological Survey (2015). Minerals yearbook, volume II. Area reports: Domestic. Available at: http://minerals.usgs.gov/minerals/pubs/state/

Duarte, C. M., Marbà, N., Gacia, E., Fourqurean, J. W., Beggins, J., Barrón, C., & Apostolaki, E. T. (2010). Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. *Global Biogeochemical Cycles*, *24*(4).

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A & Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience*, *5*(7), 505–509.

Freeman III, A. M., Herriges, J. A., & Kling, C. L. (2014). *The measurement of environmental and resource values: Theory and methods*. New York: RFP Press.

Giordano, J., & Holloman, J. (2001). Taking control of nonpoint source pollution. Albemarle-Pamlico Estuary Program, 1-4. Retrieved from the United States Environmental Protection Agency website: http://tinyurl.com/oop4lwg.

Gloy, B. A., Boehlje, M. D., Dobbins, C. L., Hurt, C., & Baker, T. G. (2011). Are economic fundamentals driving farmland values? *Choices*. Quarter 2. Retrieved from: http://www.choicesmagazine.org/choices-magazine/theme-articles/farmland-values/are-economic-fundamentals-driving-farmland-values

Gopalakrishnan, S., Smith, M. D., Slott, J. M., & Murray, A. B. (2011). The value of disappearing beaches: A hedonic pricing model with endogenous beach width. *Journal of Environmental Economics and Management*, *61*(3), 297–310.

Hadley, J., & Wiegand, C. (2014). An economic and social analysis of commercial fisheries in North Carolina: Albemarle Sound and Pamlico Sound. NC Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC. Atlantic Coastal Fisheries Cooperative Management Act, National Oceanic and Atmospheric Administration Award No. NA08NMF4740476.

Hammitt, J. K. (2000). Valuing mortality risk: Theory and practice. *Environmental Science & Technology*, *34*(8), 1396–1400.

Homer, C. G., Dewitz, J. A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N. D., Wickham, J. D., & Megown, K. (2015). Completion of the 2011 National Land Cover Database for the conterminous United States—Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing*, *81*(5), 345–354.

Hudson, K., & Murray, T. (2015). Virginia shellfish aquaculture situation and outlook report. Results of the 2014 Virginia Shellfish Aquaculture Crop Reporting Survey. Retrieved from: http://www.vims.edu/research/units/centerspartners/map/aquaculture/docs_aqua/2015_shellfish_aq_report.pdf

Just, R. E., Hueth, D. L., & Schmitz, A. (2008). *Applied welfare economics*. Cheltenham, UK: Edward Elgar Publishing, Ltd.

Kaval, P., & Loomis, J. (2003, October). Updated outdoor recreation use values with emphasis on National Park recreation. Final report, Cooperative Agreement 1200–99-009. National Park Service. Retrieved from http://www.nature.nps.gov/protectingrestoring/damageassessmentandrestoration/pdf/Benefitstransfer.pdf

Kirwan, M. L., & Mudd, S. M. (2012). Response of salt-marsh carbon accumulation to climate change. *Nature*, *489*(7417), 550-553

Landry, C. E., & Allen, T. (2014). Hedonic property prices and coastal beach width. Available at SSRN, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2474276

Maupin, M. A., Kenny, J. F., Hutson, S. S., Lovelace, J. K., Barber, N. L., & Linsey, K. S. (2014). Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p.

McGlathery, K. J., Reynolds, L. K., Cole, L. W., Orth, R. J., Marion, S. R., & Schwarzschild, A. (2012). Recovery trajectories during state change from bare sediment to eelgrass dominance. *Marine Ecology Progress Series*, *448*, 209-221.

Millennium Ecosystem Assessment (MA). (2005). *Ecosystems and human well-being: Synthesis*. Island Press: Washington, DC

North Carolina Department of Agriculture & Consumer Services, 2015. North Carolina aquaculture update; 2014 licensing, production, and processing data. Available at: http://www.ncagr.gov/markets/aquaculture/documents/2015NCADCUpdateMASTER.pdf.

North Carolina Wildlife Resources Commission (NCWRC). 2005. *North Carolina Wildlife Action Plan*. Raleigh, NC.

Nowak, D. J., Hirabayashi, S. Bodine, A., & Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. *Environmental Pollution, 193,* 119–129

Patton, D., Bergstrom, J. J., Moore, R., & Covich, A. P. (2015). Economic value of carbon storage in U.S. National Wildlife Refuge wetland ecosystems. *Ecosystem Services, 16,* 94–104.

Plottu, E. & Plottu, B. (2007). The concept of Total Economic Value of environment: A reconsideration within a hierarchical rationality. *Ecological Economics*, *61*(1), 52–61.

Richardson, L., & Loomis, J. (2009). The total economic value of threatened, endangered and rare species: An updated meta-analysis. *Ecological Economics, 68*(5), 1535–1548.

Schmidt, J.P., Moore, R., & Alber, M. (2013). Integrating ecosystem services and local government finances into land use planning: A case study from Georgia. *Landscape and Urban Planning, 122,* 56–67.

Sifleet, S., Pendleton, L., & Murray, B. C. (2011). State of the science on coastal blue carbon: A summary for policy makers. 43 pp. https://nicholasinstitute.duke.edu/sites/default/files/publications/state-of-science-coastal-blue-carbon-paper.pdf

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). (2012). Census of agriculture. Available at: http://www.agcensus.usda.gov/Publications/2012/.

U.S. Environmental Protection Agency (USEPA). (n.d.). Wetland functions and values. United States Environmental Protection Agency Distance Learning Modules on Watershed Management, 11. Retrieved from http://cfpub.epa.gov/watertrain/pdf/modules/WetlandsFunctions.pdf.

U.S. Environmental Protection Agency (USEPA). (2015a). National Ecosystem Services Classification System (NESCS): Framework design and policy application. EPA-800-R-15-002. Washington, DC: United States Environmental Protection Agency.

U.S. Environmental Protection Agency (USEPA). (2015b). Environmental Benefits Mapping and Analysis Program (BenMAP). Retrieved from http://www.epa.gov/benmap (last accessed December 2015).

U.S. Fish and Wildlife Service (USFWS) (2011). 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau.

United States Government, Interagency Working Group on Social Cost of Carbon. (2013, May). Technical support document: Technical update of the social cost of carbon for regulatory impact analysis—Under Executive Order 12866. Washington, DC.

Virginia Department of Mines, Minerals and Energy (VA DMM) (2014). Comparison of annually reported tonnage data. Available at: https://www.dmme.virginia.gov/dmm/divisionmineralmining.shtml.

Whitehead, J. C. (1993). Total economic values for coastal and marine wildlife: Specification, validity, and valuation issues. *Marine Resource Economics*, *8*(2), 119–132.

Wilson, M. A., & Hoehn, J. P. (2006). Valuing environmental goods and services using benefit transfer: The state-of-the art and science. *Ecological Economics*, *60*(2), 335–342.