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

PRESENTED BY:

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RTI INTERNATIONAL

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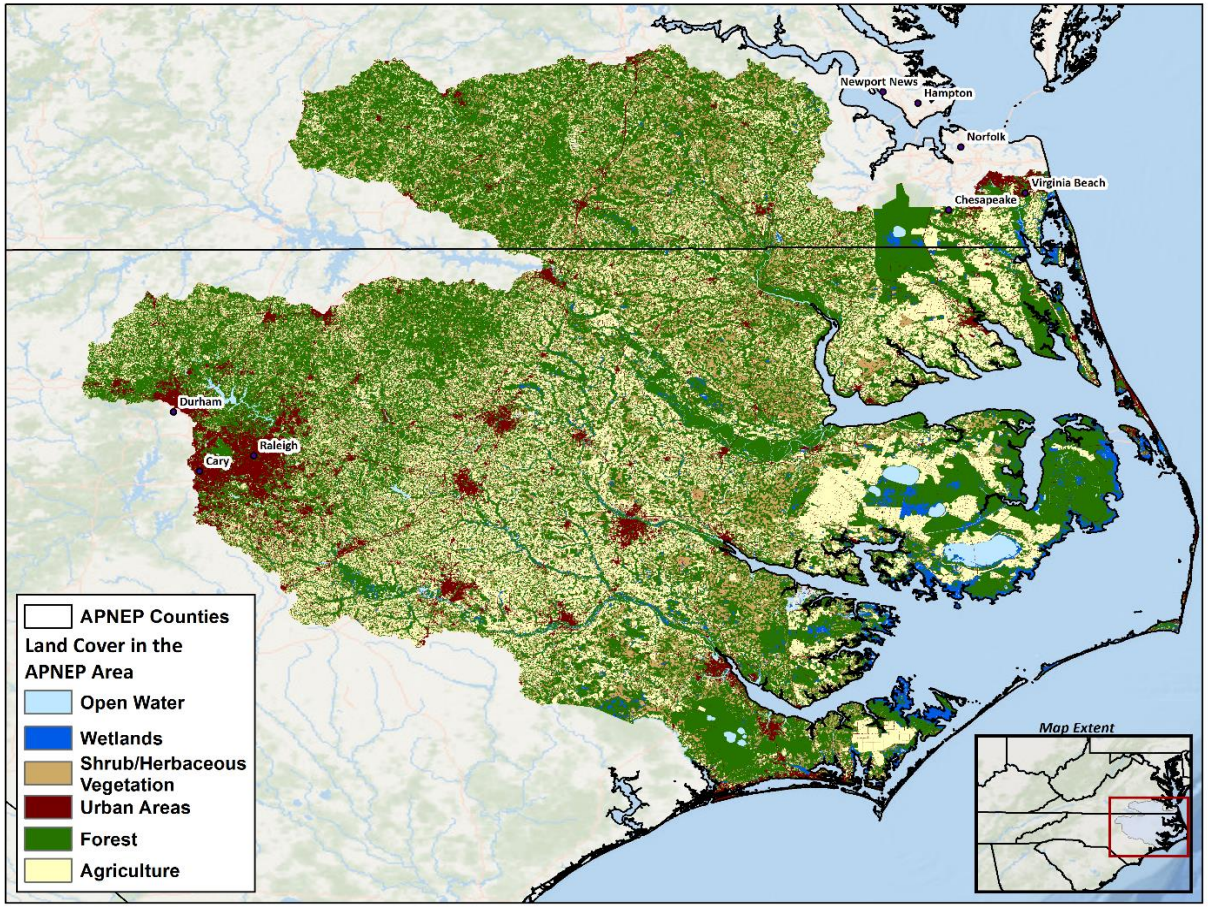
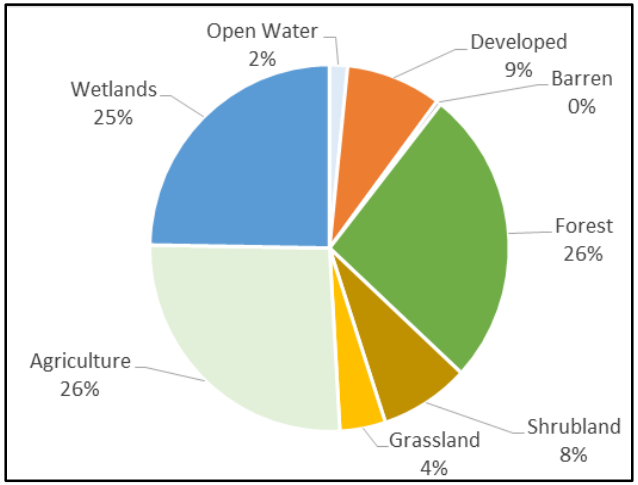
Overview of the Study

- **Main Objective**: Support the Albemarle-Pamlico National Estuary Partnership (APNEP) in measuring and communicating the value of the watershed's natural resources.
- **Two key questions**:
  - What are the main ways in which human populations in and around the watershed 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?

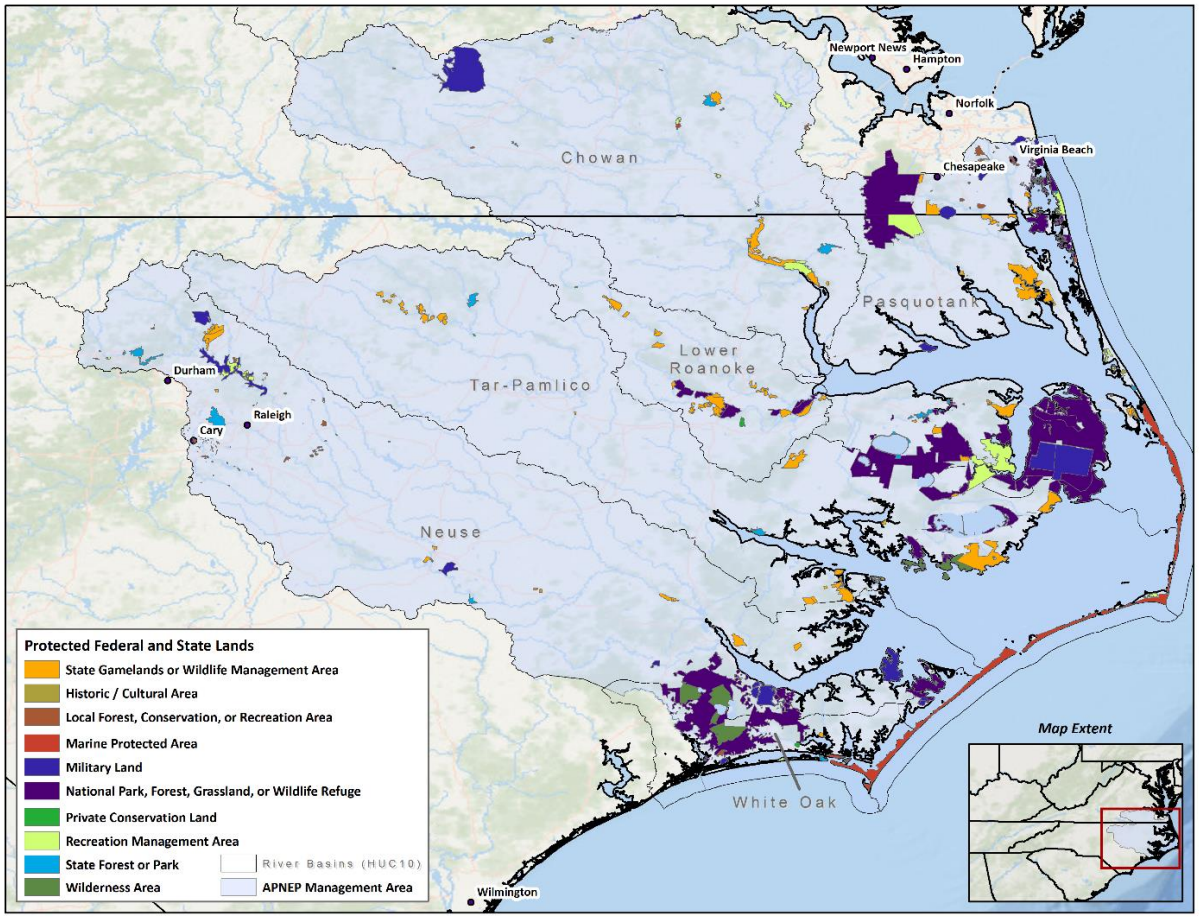
Land Use/Land Cover of A-P Watershed



- ~ 20,000 sq miles draining to the A-P Estuary System
- ~ 3,000 sq miles of open waters in estuary



Basins and Protected Lands in A-P Watershed



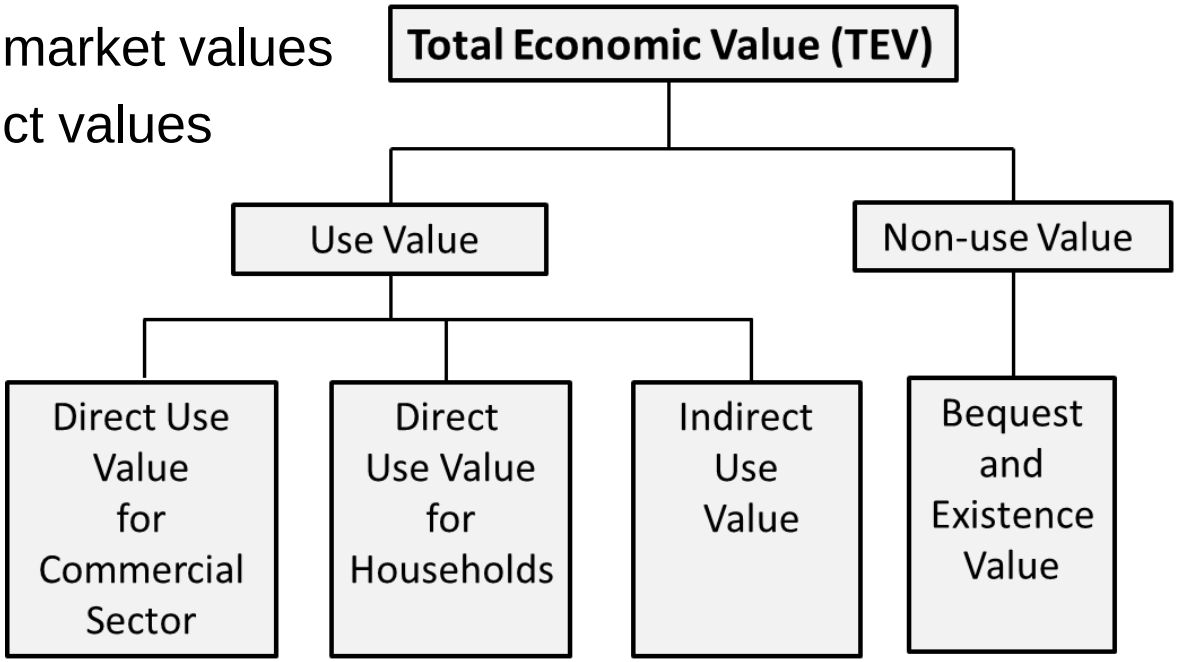
- 6 main HUC 4 river basins
- Over 1 million acres of protected lands including
  - over ½ million acres of national park, forest, and wildlife refuge land
  - almost 200 thousand acres of state game lands, parks, etc.

Conceptual Basis for Economic Value

- Economic value for natural resources must be based on human preferences and the well-being humans derive from these resources
- To measure economic values in monetary terms, economists typically rely on estimates of willingness to pay (WTP) for access to or benefits from natural resources
  - For economic producers WTP is reflected in the producer surplus (profits) they earn from the use of natural resources
  - For households, WTP can also be thought of as the consumer surplus (net benefits) they experience from the resources

Conceptual Framework for Economic Valuation

- TEV provides a comprehensive framework for conceptualizing the links between natural resources and human well-being
  - Use and non-use values
  - Market and non-market values
  - Direct and indirect values



Analytical Approach

- Estimate values for selected components within the TEV framework, using information from existing data and studies
  - Direct use values in selected commercial sectors
  - Selected direct use and non-use values for households
  - Indirect values from selected regulating ecosystem services
- Express values in
  - Average annual terms (dollars per year)
  - Inflation-adjusted terms (2014 dollars)
- In addition, examine how natural resources contribute to employment and to wage income in the watershed
  - Focus on most resource-dependent sectors
  - Estimate direct and indirect contributions to jobs and wages

Direct Use Value to Commercial Sectors

- Focus on “primary sectors” of the economy which depend most directly on natural resource inputs
  - Agriculture, forestry, fishing, aquaculture, and mining
  - Secondary (manufacturing) and tertiary (services) sectors are less directly dependent, and benefit indirectly through inputs from the primary sector
- Do not estimate separate values for different natural resource inputs
  - e.g., agricultural rents/returns reflect combined value of access to land (soils), water (irrigation), and pollination services

Value in Agricultural Production

- Over 3.3 million acres (26% of A-P watershed) is considered agricultural land
  - 80% cropland and 20% pasture/hay
- $4.6 billion in commodity sales in 2012
- Main commodities (by revenue) include grains, tobacco, poultry and eggs, and hog production
- Agricultural withdrawals account for about 17% of total annual water use in A-P watershed (in 2010)
  - 14% for cropland irrigation and 3% for livestock

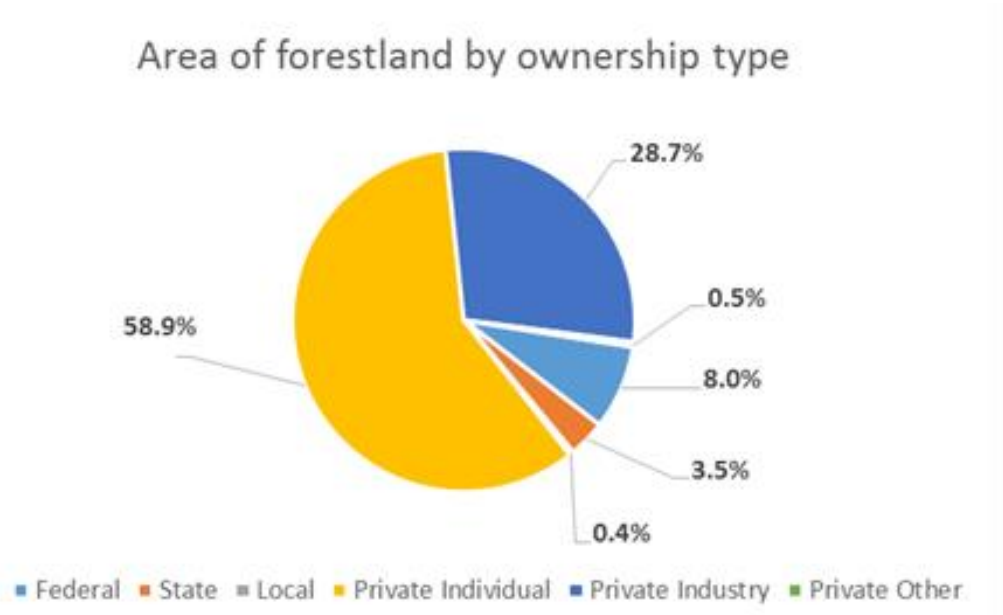
Value in Agricultural Production (Cont'd)

- Applied county-level average annual rental values ($/acre) of cropland and pastureland to approximate *net* returns to agriculture (i.e., producer surplus)

A-P Watershed Region	Farmland in A-P Region (Acres)	A-P Region ($ '000/year)	
		Commodity Total Sales in 2012	Total Rental Value of Cropland and Pastureland
North Carolina	2,773,374	4,252,053	184,660
Virginia Total	531,007	382,756	25,668
A-P Watershed Total	**3,304,381**	**4,634,809**	**210,348**

Value in Forest Production

- Over 3.3 million acres (26%) of A-P watershed is forested land
  - Mainly loblolly-shortleaf pine, oak-gum-cypress, and oak-pine
- Predominantly privately owned lands
  - 59% by individuals and 29% by industry



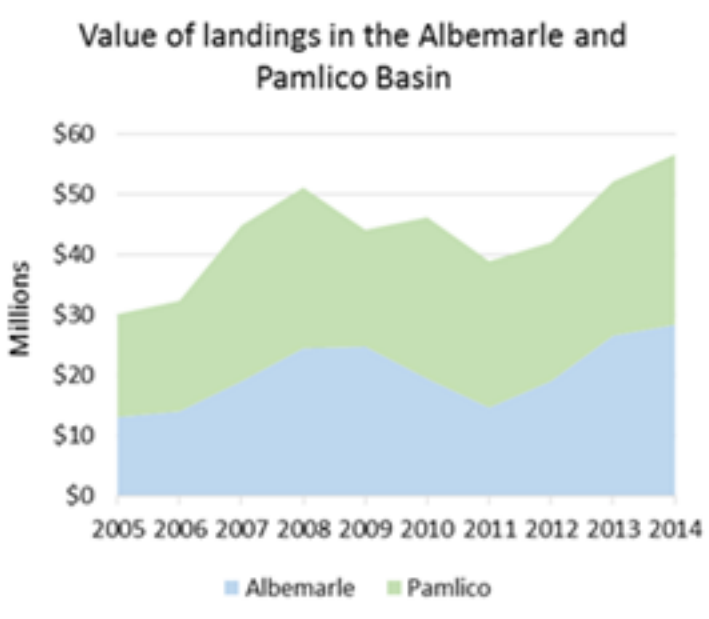
Value in Forest Production (Cont'd)

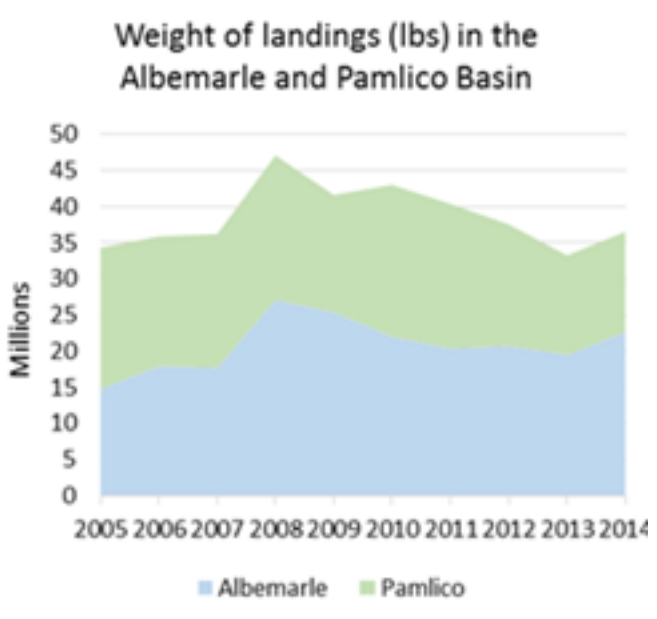
- Estimated average annual revenues based on harvest levels and average stumpage prices for hardwoods and softwoods from 2002-2012
- Estimated costs using average regional per-acre values
  - includes establishment costs (natural regeneration or replanting) and intermediate management costs (for industry-owned forest)

County	Average Annual			
	Harvest Levels (2002–2012) ('000 cubic feet)	Harvest Revenue*	Costs**	Net Revenue
North Carolina Total	317,857	$236,994,990	$58,413,686	$178,531,304
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**

Value in Commercial Fishing

- Revenue estimates based on NC Division of Marine Fisheries (NCDMF) data on landings 2010-2014
  - Blue crab and flounder are most commonly targeted species





Value in Commercial Fishing (Cont'd)

- Annual costs incurred for commercial fishing in the two A-P sounds were estimated by multiplying
  - Average per-trip costs in each sound (based on 2014 NCDMF survey of fishing vessels)
  - Total number of trips per year

	Annual Average (2010-2014)		
	Albemarle Sound	**Pamlico Sound**	**Total A-P System**
Total trips	41,195	54,619	95,814
Total sales ($ millions)	$21.61	$25.62	$47.23
Total costs ($ millions)	$9.12	$17.44	$26.56
Estimated producer surplus ($ millions)	**$12.49**	**$8.18**	**$20.67**

Other Primary Sectors

- Data for other sectors is more limited, particularly for estimating and deducting costs of production
- Annual revenue estimates provide an indicator but not an estimate of natural resource value in these sectors
  - Aquaculture
    - Over 90% of NC freshwater production occurs in A-P watershed
      - NC revenues **~ $18.7 million** in 2014
    - Roughly 80% of NC marine production is in A-P watershed
      - NC revenues **~ $2.3 million** in 2014
  - Non-Fuel Mining
    - Based on % of NC's permitted mining acres that are in A-P region
      - NC revenues **~ $315 million** in 2011

Direct Use and Non-Use Values to Households

- Focus on three main areas
  - Outdoor recreation (use value)
  - Natural and scenic amenities for nearshore residents (use value)
  - Nongame wildlife protection (use and nonuse value)
- Value of water for domestic use is one important natural resource use value that is not estimated
  - Water is essential for survival, so this is different from other WTP trade-off decisions
    - Standard economic valuation methods are not well-suited for this type of value
    - One approach might be to consider costs of transferring water from outside the watershed

Outdoor Recreation Value

- Estimated recreation days in watershed based on existing survey data
- Applied estimates of average consumer surplus per day for selected 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**

Outdoor Recreation Value (Cont'd)

- Alternative approach focused annual visits to state and national parks in the watershed
- Applied estimates of average consumer surplus per day for park visits
- Caution: adding these value estimates to estimates on previous slide would result in double counting of some outdoor recreation activities

Type	Annual Park Recreation Visitation (visits per year) 2013	2014	Annual Visitation Value ($/year; 2013-2014)
State Parks			
North Carolina	6,231,217	6,215,926	$ 414,555,080
Virginia	64,154	65,497	$ 4,318,058
National Park Service Sites	3,342,527	3,279,781	$ 216,116,128
	9,637,898	**9,561,204**	**$ 634,989,266**

Amenity Value to Nearshore Residents

- A-P estuary systems contains over 9,000 miles of estuarine and coastal shoreline
- The natural and aesthetic amenity benefits of living near this shoreline are reflected in higher property values
- Identified 5 hedonic property value studies conducted in NC, which quantify the relationship between value and distance to shoreline
  - Average linear effect: $10.10 decline per additional foot
  - Average percentage effect: 0.004% decline per additional foot
- Applied these average effect size estimates to approximate total annual value of proximity to shoreline for current residents

Amenity Value to Nearshore Residents (Cont'd)

- Used 2010 census housing data to estimate the number and value of nearshore homes
  - Focused on detached units in census blocks bordering A-P shoreline
- Approximated nearshore values by simulating the effect of increasing distance-to-shore for these properties by ½ to 1 mile

A-P Region	Number of Near-Shore Housing Units	Benefit Estimation Method	Annual Benefits (millions $ per year)	
			Δd = 1/2 mile	Δd = 1 mile
All 18 counties bordering estuary or coast	56,455	Linear model	48.0	96.1
		Semi-elasticity model	43.5	87.0

Value of Nongame Wildlife Preservation

- A-P watershed supports diverse habitats and natural communities, including several threatened or endangered species
- Identified 2 stated preference survey studies that estimate households' WTP for programs to protect nongame wildlife in NC
- Multiplied average values by number of NC households to estimate total NC benefits of these programs
  - Most likely includes both use (recreation) and non-use values

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

Values from Regulating/Supporting Ecosystem Services

- Natural systems in the A-P watershed provide indirect benefits to society by regulating climate and environmental quality
- For value estimation, focus on 2 main types of services
  - Carbon storage and sequestration by forests, wetlands, and seagrasses
  - Air pollution regulation by trees
- Other important regulating services that could not be quantified include
  - Flood and storm surge regulation
  - Water quality regulation
  - Natural waste assimilation services

Values from Carbon Storage/Sequestration

- Forest carbon
  - Carbon stocks estimated using USFS's Carbon On-Line Estimator (COLE)
    - provides estimates by forest type in A-P region of (1) total acres and (2) average above and below-ground carbon density (tons/acre),
  - Annual sequestration also estimated with COLE, based on estimates of average age class by forest type (no adjustment for harvesting)
- Emergent wetlands
  - Acres of salt marsh and freshwater marsh estimated using land cover and National Wetlands Inventory (NWI) data
  - Average carbon density (tons/acre) and carbon accrual (tons/acre/year) estimated using literature values from the SE region
- Seagrasses
  - Acres of seagrass taken from APNEP aerial survey (visible acres)
  - Average carbon density (tons/acre) and carbon accrual (tons/acre/year) estimated using literature values from the SE region

Values from Carbon Storage/Sequestration (Cont'd)

- Values estimated using average social cost of carbon (SCC) ($/ton) estimates from US Government Interagency Working Group report (2013)
  - Present value of global damages per ton of carbon released = $152/ton
  - Annualized damage value with 3% discount rate = $4.56/ton

	Area (acres)	Stored Carbon ('000 tons)			Annual Value (millions $/yr)	Annual Carbon Sequestration	
		Above Ground	Below Ground	Total		Total ('000 tons/yr)	Total Value (millions $/yr)
Forest	5,282,282	205,400	194,635	400,035	1,654	6,355	876
Wetland	476,359	1,143	56,529	57,673	263	152	23
Submerged Aquatic Vegetation	70,554	8	1,180	1,188	5	87	13

Values from Air Pollutant Removal by Trees

- Applied USFS's i-Tree Landscape model, which uses
  - geospatial data on forest characteristics (e.g., leaf area, tree cover, percentage of tree population that is evergreen) and air quality grids to determine the change in pollution concentrations
  - epidemiological concentration-response functions to estimate the change in adverse health effects
  - valuation functions to calculate the associated economic values

Annual Value of Avoided Health Effects from Air Pollution ($/year)				
NO_2	Ozone	$PM_{2.5}$	SO_2	Total
$397,823	$26,234,553	$54,563,342	$49,596	$81,245,314

Natural Resource Employment and Wages

- Estimated direct jobs and wages in natural resource dependent sectors using USDA, BLS, and NCDEQ data
- Estimated "indirect and induced" jobs and wages using regional input-output multipliers (by industry)

Sector	Direct		Indirect and Induced	
	Jobs	Wages ($ 000/yr)	Jobs	Wages ($ 000/yr)
Agriculture*	29,132	340,309	68,840	786,624
Commercial fishing (NC only)	2,994	45,347	4,592	76,977
Forestry and logging	1,151	49,337	1,765	83,750
Environmental consulting	1,056	80,191	2,141	131,786
Environmental organizations	72	4,011	146	6,592
Public admin of env programs	1,344	121,019	2,207	170,552
Mining	307	18,893	727	38,714
Recreation	342	12,993	457	22,714
A-P Watershed Total	**36,398**	**672,100**	**80,876**	**1,317,708**

Summary and Conclusions

- Summary of Natural Resource Value Estimates for 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

Summary and Conclusions (Cont'd)

- Combined value of estimated components is roughly $6-7 billion per year, with a large portion derived from outdoor recreation and carbon regulation.
- Caveats:
  - Potential overlaps exist between these components (e.g., wildlife values and recreation values)
  - Does not account for all benefits provided by the watershed's natural resources
    - Benefits from domestic and additional commercial water uses
    - Storm surge, flood control, and water filtration benefits provided by wetlands
    - Waste assimilation benefits provided by land and water resources

Thank you

- Questions?