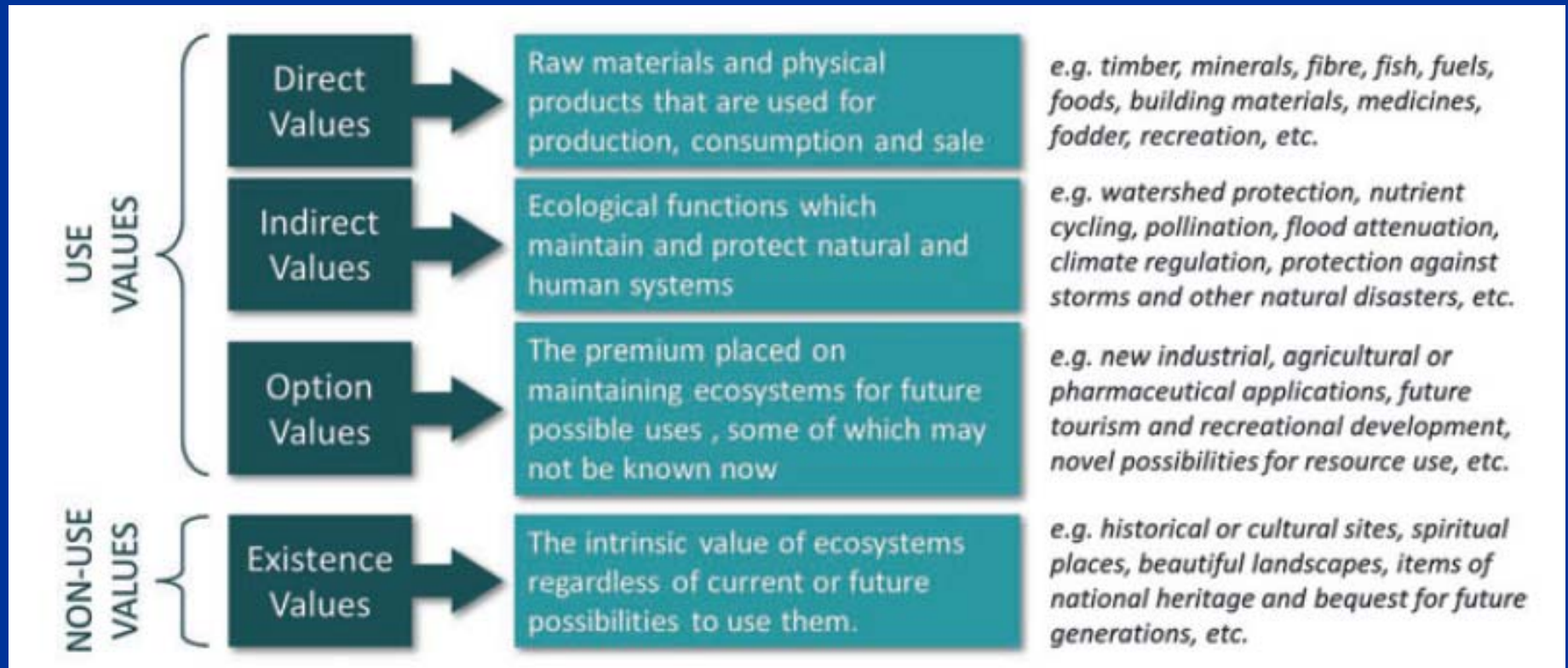


Socioeconomic Value of Delaware Wetlands

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Total economic value of wetland ecosystems
(Emerton and Bos 2004)

Wetlands: Most productive ecosystems on Earth

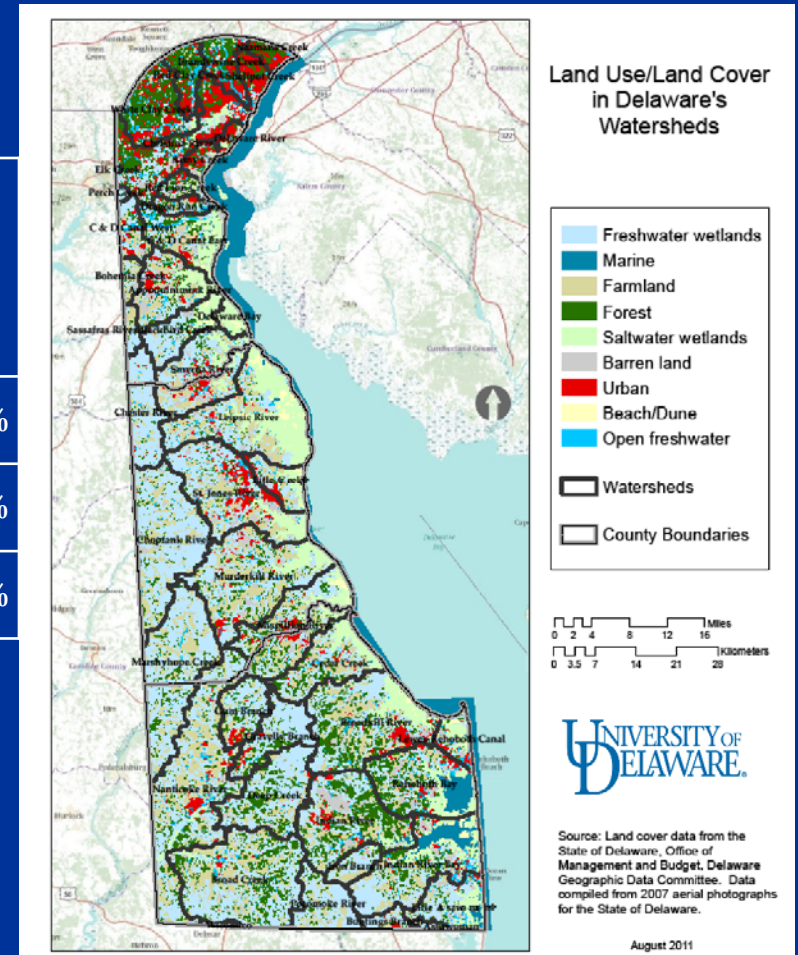
- “the kidneys of the landscape” and “biological supermarkets” (Barbier, Acreman, and Knowler 1997).
- Wetlands cover 6% of the Earth, home to 40% of world’s plant species, 12% of animal species (Brander & Schuyt 2004).
- Coastal marshes provide a commercial/recreational fishery economy worth billions of dollars. (NWCA, EPA 2016).
- Wetlands cover 5% of lower 48 states, habitat for 1/3 of threatened/endangered species, 31% of plant species (EPA 2006).

Estimates of economic value of wetlands

Source	Wetland Function	Wetland Value (\$)
Costanza et al. 1997	Global value of wetlands	\$15 trillion
Boutwell and Westra 2015	Hurricane protection in US	\$23 billion/yr
Brander and Schuyt 2010	8.5 million acres world-wide	\$3.4 billion/yr
Narayan et al. 2017	Superstorm Sandy damage protection	\$625 million

20% of Delaware are covered by wetlands

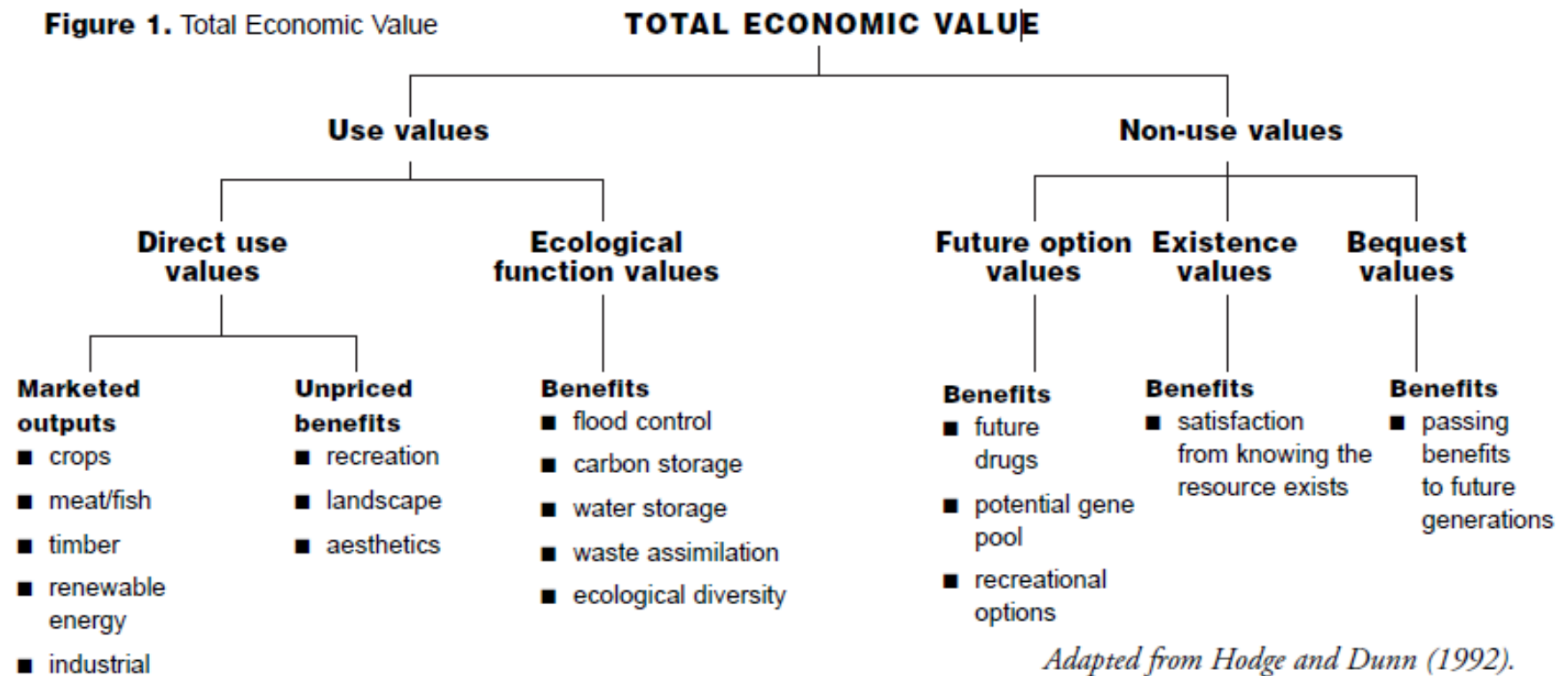
Ecosystem	Piedmont (ac)	Delaware Estuary (ac)	Chesapeake Bay (ac)	Inland Bays/ Atlantic Ocean (ac)	Total (ac)
Freshwater wetlands	4.1%	9.3%	18.1%	10.6%	11.8%
Saltwater wetlands	0.8%	9.9%	0.1%	2.5%	4.7%
Open freshwater	0.5%	2.2%	0.4%	9.8%	3.2%



Delaware Population

State/county	Pop. 2000	Pop. 2010	Projected Pop. 2030
New Castle	500,265	538,479	589,267
Kent	126,697	162,310	192,853
Sussex	156,638	197,145	272,511
Delaware	783,600	897,934	1,054,631

Figure 1. Total Economic Value

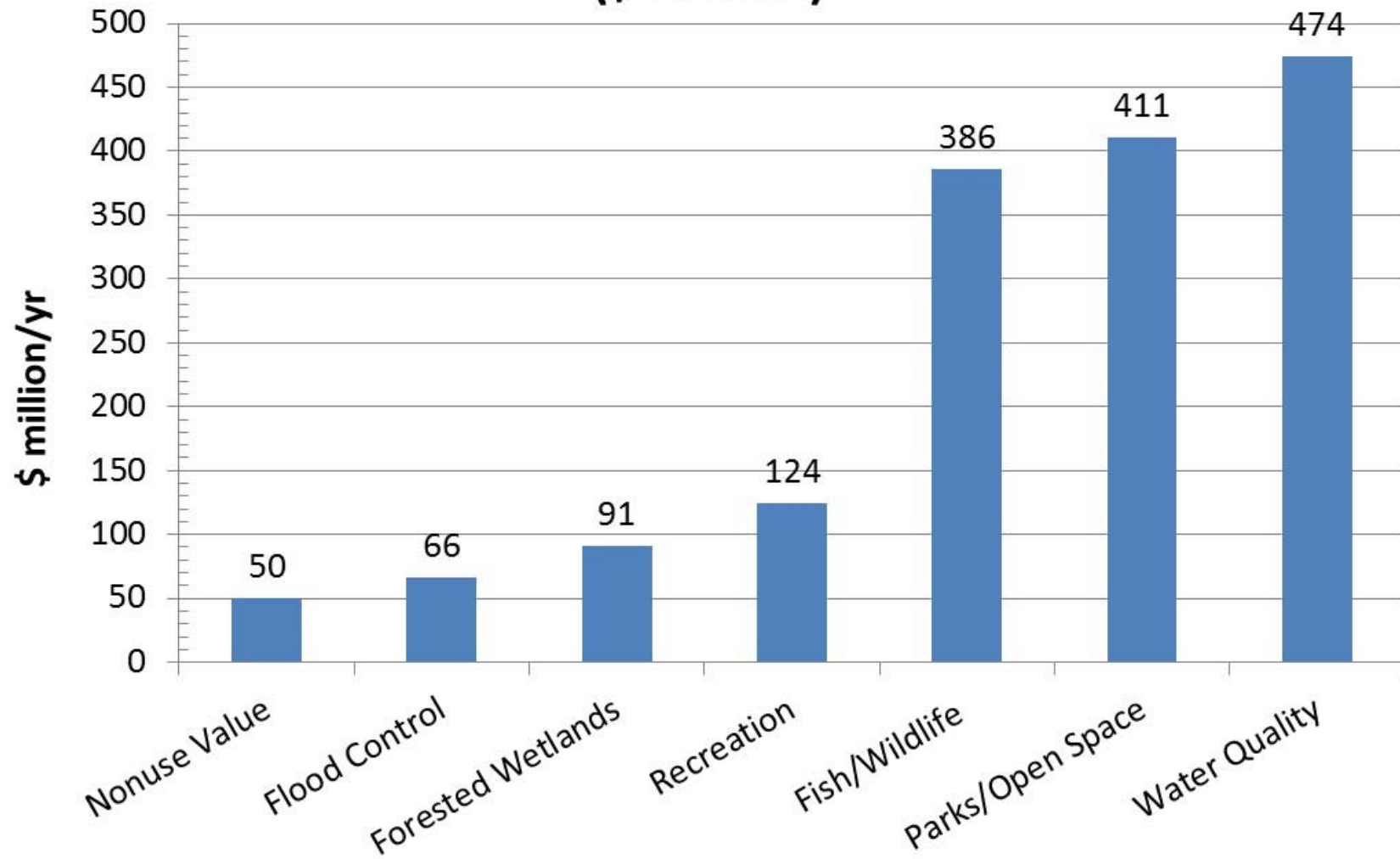


Delaware Wetlands

Annual Economic Activity

• Water Quality	\$474 million
• Flood Control	\$66 million
• Parks/Open Space	\$411 million
• Fish/Wildlife	\$386 million
• Recreation	\$124 million
• Forested Wetlands	\$91 million
• Nonuse Value	\$50 million
Total	>\$1 billion

Annual Economic Value of Delaware Wetlands (\$ million)



Water Quality

Water Treatment: Industrial Economics Inc. (2011), 1.2% decrease (3,132 ac) in wetlands in Delaware (2007 to 2022), increased water treatment costs \$9.67 million (\$770,000/yr).

Wastewater Treatment: Greeley-Polhemus Group (1993), Delaware Estuary supported wetlands wastewater treatment of \$638 million. Wetlands in Delaware cover 120,000 ac (26% of Delaware Estuary wetlands), then wastewater value in Delaware was \$166 million.

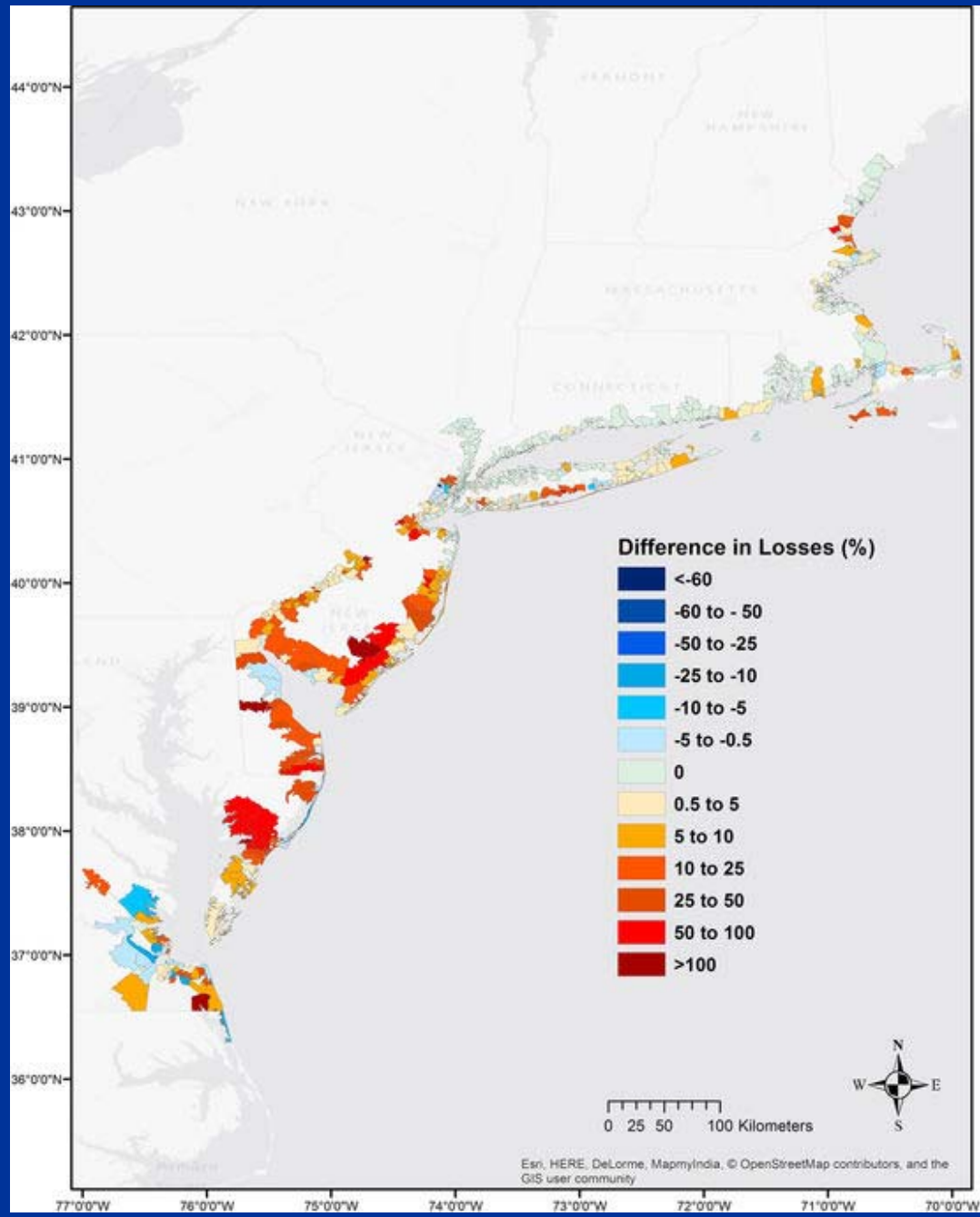
Wastewater Assimilation: DeLorme and Wood (1976), 463,000 acres wetlands in Delaware Estuary capacity to treat 1.6 million lb waste/day. At \$2.00/lb BOD removal, Estuary wetlands had replacement value of \$1.18 billion/yr (\$255/acre). Annual wetland replacement value wastewater assimilation in Delaware is \$307 million.

Flood Control

Stormwater Detention: Braden and Johnston (2004), stormwater detention provides flood/water quality protection services 2% to 5% of property value in floodplain. If 211,840 acres (17%) of Delaware's land mass is in the 100-year floodplain covered mostly by wetlands with value of floodplain land \$10,000/acre, then total value of floodplain land in Delaware is \$2.1 billion. At 2%-5%, stormwater detention from floodplains/wetlands provides \$42 to \$105 million in economic benefits in Delaware.

Flood Protection: "Scientific Reports", coastal marshes/wetlands in 12 mid-Atlantic states (i.e. Delaware) prevented \$625 million in flood damages during Superstorm Sandy in October 2012 (Narayan et al. 2017). Delaware, (1/5 is wetlands, coastal marshes reduced flood damages during Sandy by 10% (\$24 million.

State	Damages: Wetlands Present (\$)	Damages: Wetlands Lost (\$)	Difference (\$)	% Difference (total damages)
Connecticut	2,180,600,000	2,181,000,000	400,000	0.02
Delaware	228,100,000	251,900,000	23,800,000	10.43
Massachusetts	1,452,300,000	1,458,600,000	6,300,000	0.43
Maryland	15,500,000	20,000,000	4,500,000	29.03
Maine	17,600,000	17,603,000	3,000	0.02
North Carolina	9,400,000	8,800,000	-615,000	-6.47
New Hampshire	29,600,000	30,500,000	900,000	3.04
New Jersey	14,014,600,000	14,443,300,000	428,700,000	3.06
New York	32,314,600,000	32,452,800,000	138,200,000	0.43
Pennsylvania	174,400,000	188,100,000	13,600,000	7.86
Rhode Island	72,100,000	72,400,000	300,000	0.42
Virginia	195,400,000	205,300,000	9,900,000	5.07



Parks/Open Space

State Parks: Delaware state parks are covered in large part by tidal and freshwater wetlands that provide recreational and wildlife habitat benefits. Rockport Analytics (2017) reported that the economic impact of the Delaware State Park System was \$390 million/yr in 2017-2017 from spending by 1.6 million visitors.

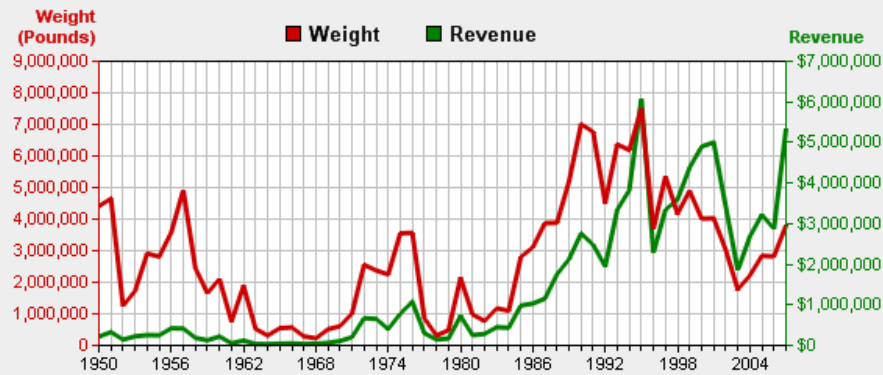
National Wildlife Refuge: The Bombay Hook and Prime Hook National Wildlife Refuges (NWR) on the Delaware Bay marshes contributed over \$21 million to the Delaware economy from 390,000 annual visitors and supported over 200 jobs with \$6 million in wages. The U.S. Fish and Wildlife Service reported that the 16,000-acre Bombay Hook National Wildlife Refuge in Delaware was the 4th most visited refuge in the nation with nearly 271,000 recreational visits in 2006 (Carver and Caudill 2007). The Bombay Hook NWR is the 6th most valuable refuge in the U.S. contributed \$20.2 million to the economy from food, lodging, equipment, transportation expenditures (\$13.4 million bird watching) and supported 198 jobs with \$5.5 million in annual income.

State Park	Attendance	Visitors	Spending (\$)	% Spending	Rank
Delaware Seashore S.P.	1,055,759	588,906	\$172,984,023	44.4%	1
Cape Henlopen State Park	1,276,040	591,141	\$128,481,875	33.0%	2
Fenwick Island State Park	232,832	115,909	\$60,032,326	15.4%	3
Lums Pond State Park	316,253	71,726	\$7,323,283	1.9%	4
Killens Pond State Park	260,959	93,698	\$6,548,569	1.7%	5
Bellevue State Park	351,235	30,230	\$4,236,074	1.1%	6
Trap Pond State Park	116,626	51,050	\$3,512,408	0.9%	7
White Clay Creek State Park	175,076	15,068	\$2,111,508	0.5%	8
Brandywine Creek State Park	129,006	11,103	\$1,555,877	0.4%	9
Alapocas Run State Park	109,229	9,401	\$1,317,356	0.3%	10
Brandywine Zoo	97,686	8,408	\$1,178,060	0.3%	11
First State Heritage Park, Dover	18,878	1,625	\$227,662	0.1%	12
Fort Delaware State Park	14,128	1,216	\$170,379	0.0%	13
Holts Landing State Park	8,592	739	\$103,621	0.0%	14
Fort DuPont State Park	5,485	472	\$66,148	0.0%	15
Auburn Heights Preserve	3,188	274	\$38,443	0.0%	16
All State Parks	4,170,969	1,590,967	\$389,887,614		

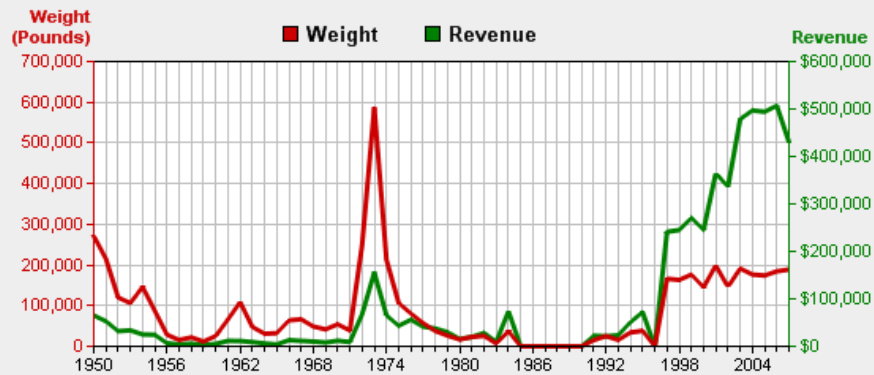
Fish/Wildlife

Recreation Activity	Value¹ (\$2011 million)	Participants
Fishing	\$104.4	166,000 anglers
Trip-related	\$48.7	
Equipment/Other	\$55.6	
Hunting	\$40.8	23,000 hunters
Trip-related	\$5.4	
Equipment/Other	\$35.3	
Wildlife/Birding	\$169.8	243,000 viewers
Trip-related	\$36.1	
Equipment/Other	\$133.7	
Total	\$315.0	

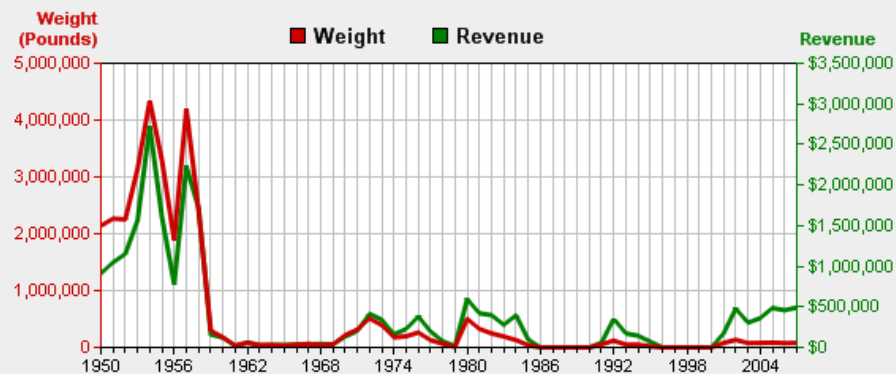
Delaware 'crab, blue' Harvests



Delaware 'bass, striped' Harvests



Delaware 'oyster, eastern' Harvests



Value of commercial fish harvests in Delaware (NMFS and NOEP 2007)

Species	Pounds (2007)	Landed Value (2007 dollars) ²	Landed Value (2010 dollars) ²
Blue Crab	3,799,820	\$5,329,182	\$5,823,341
Eastern Oyster	79,933	\$490,465	\$535,944
Knobbed Whelk	260,078	\$456,368	\$498,686
Striped Bass	188,671	\$429,994	\$469,866
American Eel	139,648	\$315,094	\$344,312
Black Sea Bass	72,675	\$200,902	\$219,531
Northern Quahog Clam	44,618	\$181,350	\$198,166
Spot	128,209	\$99,995	\$109,267
Shellfish	30,130	\$76,119	\$83,177
Channeled Whelk	17,139	\$54,804	\$59,886
Horseshoe Crab	229,602	\$48,978	\$53,520
White Perch	55,973	\$46,865	\$51,211
American Shad	71,445	\$42,408	\$46,340
Weakfish	24,604	\$36,177	\$39,532
Total	5,327,115	\$7,894,099	\$8,626,096

Recreation

Economic Activity	Outdoor Recreation Delaware ¹	Paddling Delaware ²
Consumer Spending	\$3.1 billion	\$124 million
Participants	467,000	18,680
Jobs	29,000	1,160
Wages	\$959 million	\$38.4 million

Benefits	Forests New Castle County ¹		Forested Wetlands In Delaware ²	
	Environmental (tons/acre)	Economic (\$/acre)	Environmental (tons)	Economic (\$)
Carbon Storage	40.00	\$827	3,072,000	63,513,600
Carbon Sequestration	1.40	\$29	107,520	2,227,200
Air Pollution Control	0.04	\$266	3,072	20,428,800
Energy Savings		\$56	0	4,300,800
Avoided Carbon Emissions	0.14	\$3	10,752	230,400

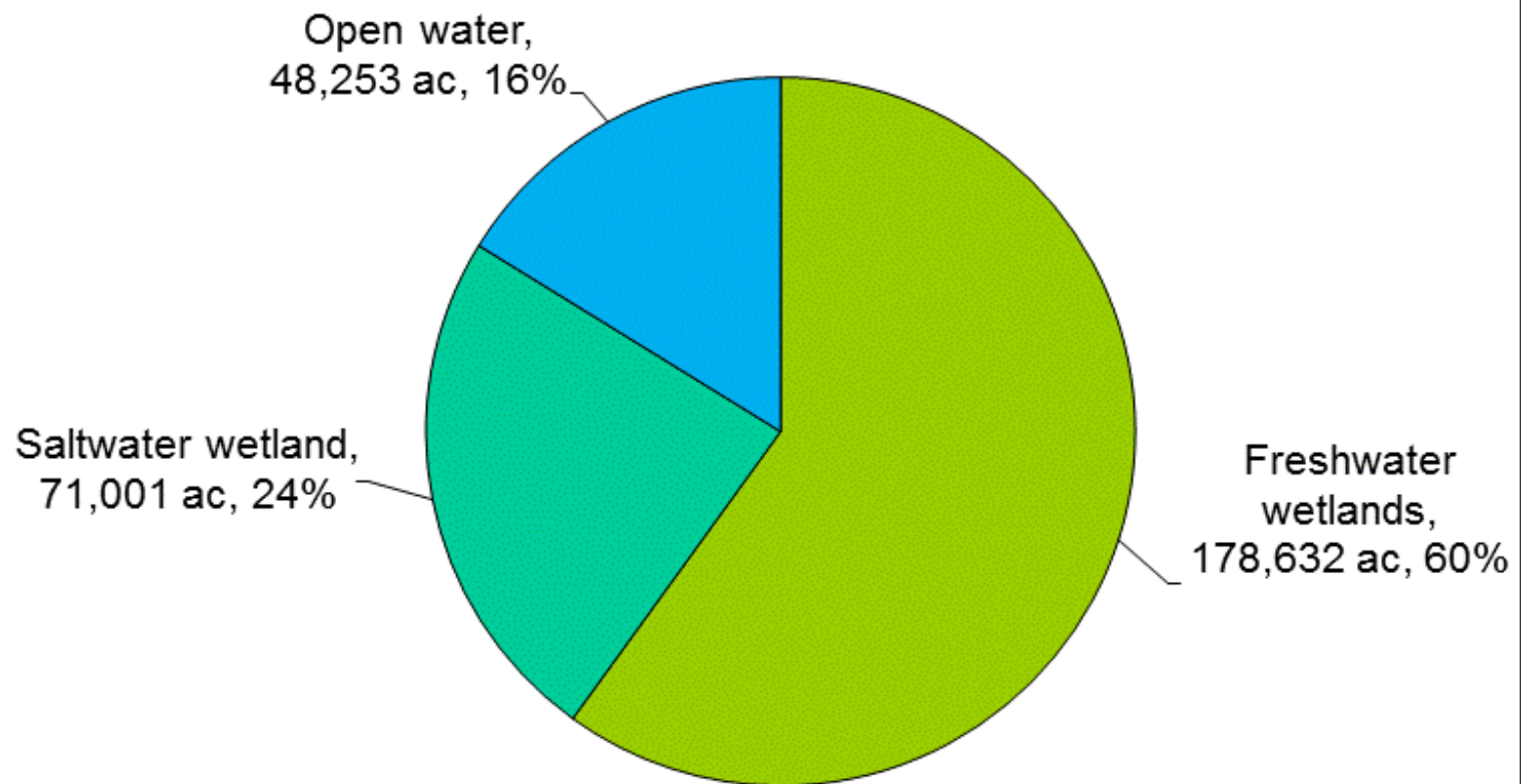
1. Nowak et al. 2008. 2. Computed for 76,800 acres of forested wetlands in Delaware

Nonuse Value

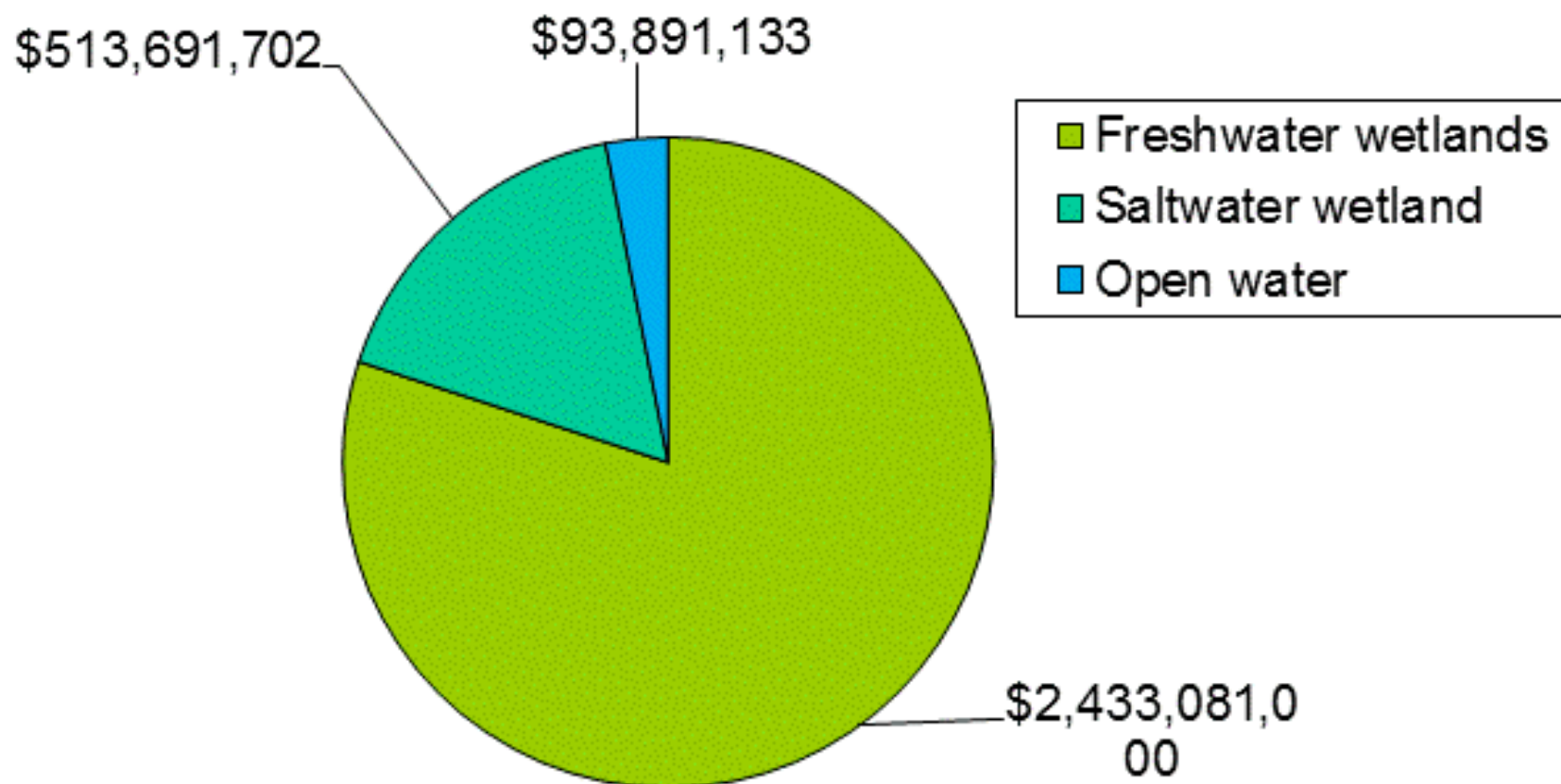
Willingness to Pay: Delaware residents are willing to pay between \$16 to \$84 million per year in increased taxes and fees for wetland protection and management programs on 320,000 wetland acres where 25% are tidal (Santoni, Arvay, and Scarborough 2017).

Ecosystem Goods and Services

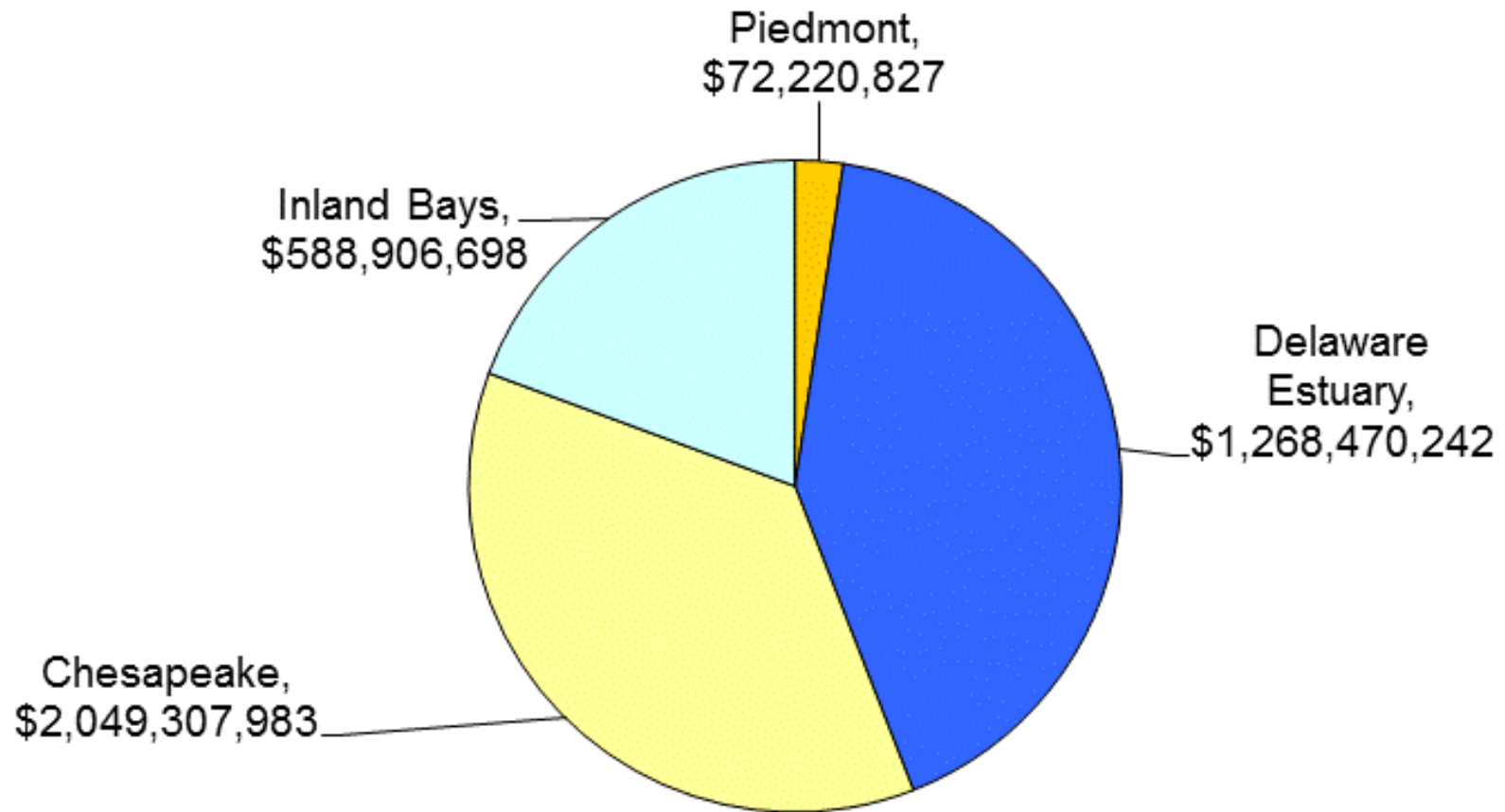
**Wetland Ecosystems Area (acres)
in Delaware, 2007**



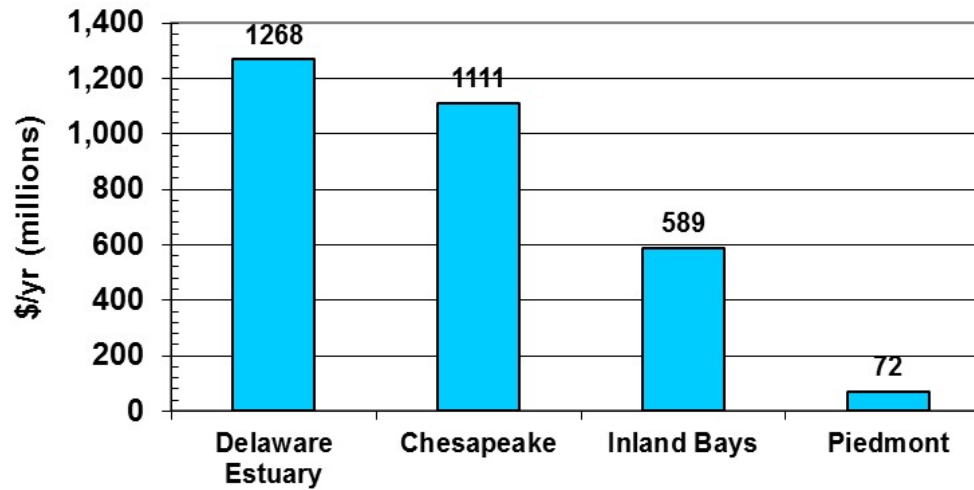
Value of Natural Goods and Services by Wetland Ecosystem in Delaware



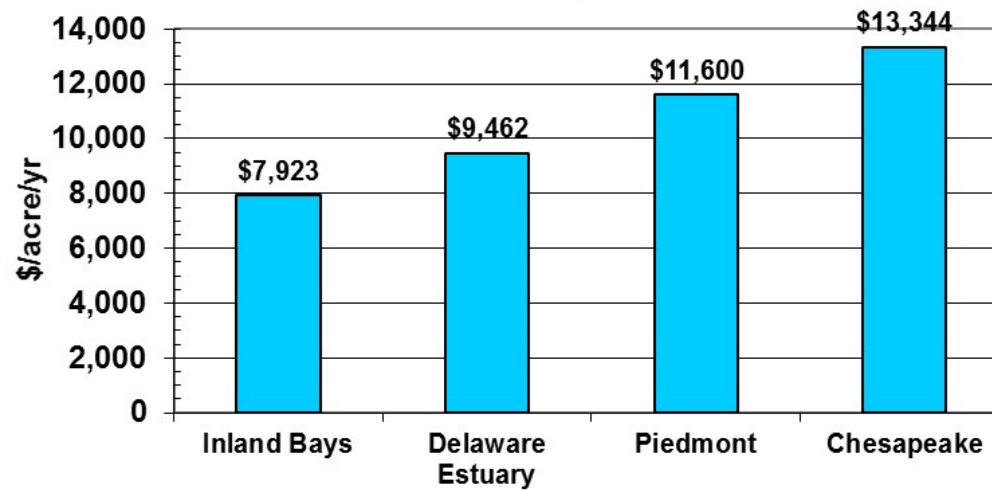
Ecosystem Services Value of Delaware Wetlands by Watershed



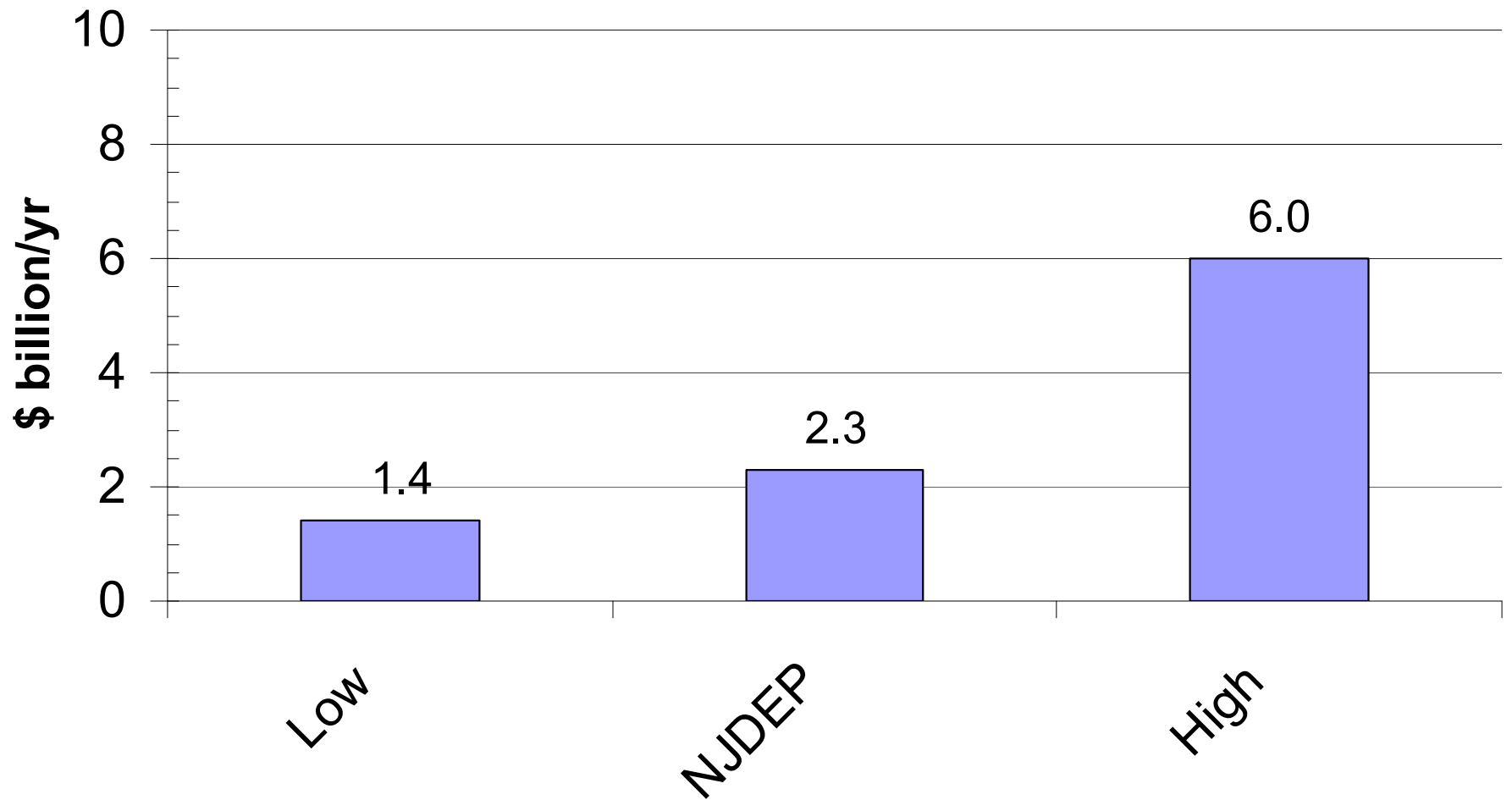
Value of Natural Goods and Services (\$2010) in Delaware Wetlands by Watershed



Value of Natural Goods & Services (\$2010 per acre) in Delaware Wetlands by Watershed



Range of Ecosystem Services Value Estimates Barnegat Bay Watershed



Present value of wetland ecosystem services in Delaware

Range	PV (\$B)	NPV (\$B)
Low	1.6	51.2
Mid-range (NJDEP)	3.0	98.8
High	9.9	321.2

Ecosystem	Area (acres)	\$/acre/year	PV (\$/yr)	NPV (\$)
Low Range	297,885		1,575,236,043	51,195,171,401
Freshwater wetlands	178,632	6,268	1,119,662,818	36,389,041,588
Saltwater wetland	71,001	6,269	445,102,324	14,465,825,530
Open water	48,253	217	10,470,901	340,304,283
Mid Range (NJDEP)	297,885	10,208	3,040,663,834	98,821,574,614
Freshwater wetlands	178,632	13,621	2,433,081,000	79,075,132,489
Saltwater wetland	71,001	7,235	513,691,702	16,694,980,313
Open water	48,253	1,946	93,891,133	3,051,461,812
High Range	297,885		9,883,256,574	321,205,838,669
Freshwater wetlands	178,632	43,685	7,803,521,093	253,614,435,509
Saltwater wetland	71,001	28,146	1,998,380,924	64,947,380,025
Open water	48,253	1,686	81,354,558	2,644,023,135

Table 19. Jobs and wages directly and indirectly related to Delaware wetlands

Sector	Jobs	Wages (\$M)	Data Source
Living Marine Resources	442	10	National Coastal Economics Program (2009)
Tourism & Recreation	12,997	188	National Coastal Economics Program (2009)
Fishing/Hunting/Birding	9,591	315	U.S. Fish and Wildlife Service (2008)
National Wildlife Refuges	200	6	Carver and Caudill (2007)
Outdoor Recreation	1,160	38	Outdoor Industry Association (2016)
Wetland Organizations	115	6	
Wetlands	496	5	NOAA Coastal Services Center (2011)
Delaware Wetlands	25,000	\$568 million	

Coastal employment, wages, and GDP related to wetlands in Delaware

Sector	Employment	Wages (\$ million)	GDP (\$ million)
Living Marine Resources	442	10.3	19.2
Tourism & Recreation	12,997	188.5	373.9
Delaware wetlands	13,439	198.8	393.1

Table 21. Jobs from fishing, hunting, and wildlife recreation in Delaware wetlands

1. USFWS 2014. 2. Jobs based on \$32,843 average salary.

Recreation Activity	Economic Activity¹ (\$2011 million)	Delaware Recreation Jobs²
Fishing	\$104.4	3,179
Trip-Related	\$48.7	
Equipment/other	\$55.6	
Hunting	\$40.8	1,242
Trip-Related	\$5.4	
Equipment/other	\$35.3	
Wildlife/Birding	\$169.8	5,170
Trip-Related	\$36.1	
Equipment/other	\$133.7	
Total	\$315.0	9,591

National Wildlife Refuge

The Bombay Hook and Prime Hook National Wildlife Refuges (NWR) on the Delaware Bay marshes contributed over \$21 million to the Delaware economy from 390,000 annual visitors and supported over 200 jobs with \$6 million in wages (Carver and Caudill 2007).

Outdoor Recreation

The Outdoor Industry Association (2016) concluded 467,000 people in Delaware participated in recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing that supported 29,000 jobs with \$959 million in wages to the regional economy. If paddling related to wetlands and marshes in Delaware is 4% of the outdoor recreation economy, then paddling (by 18,680 paddlers) supported 1,160 jobs with \$38 million in wages.

Wetland Organization Jobs

More than 20 nonprofit watershed and environmental organizations employ at least 115 staff to work on programs to protect the land and waters that flow into Delaware wetlands (Table 22). Assuming that the average salary is \$48,000/person working in a wetland-organization job in Delaware, these jobs account for \$5.5 million in annual wages.

Wetland Jobs (NOAA CSC 2011)

County	Wetland Area (ac)	Wetland Area (%)	Jobs	Business Output (\$)	Self Employed Revenue (\$)
New Castle	37,568	13%	191	\$1,500,000	\$4,300,000
Kent	91,974	24%	176	\$443,000	\$2,000,000
Sussex	128,926	21%	129	\$3,100,000	\$3,100,000
State	258,468	21%	496	\$5,043,000	\$9,400,000

Freshwater and saltwater wetlands in Delaware contribute:

1. **>\$1 billion** in annual economic value from water quality, flood control, parks/open space, fish/wildlife, recreation, forest/carbon storage, and nonuse value (willingness to pay) functions.
2. Ecosystem goods and services worth **\$3 billion** per year, net present value (NPV) = **\$99 billion**.
- 3. **25,000** jobs with **\$568 million** in wages in the marine resources, tourism/recreation, fishing/hunting/birding, and wetland organization sectors.