Benefit-Cost Analysis of Improved Water Quality in the Delaware Basin

Delaware Estuary Summit
Cape May, NJ
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Jerry Kauffman
University of Delaware
Newark, Del.

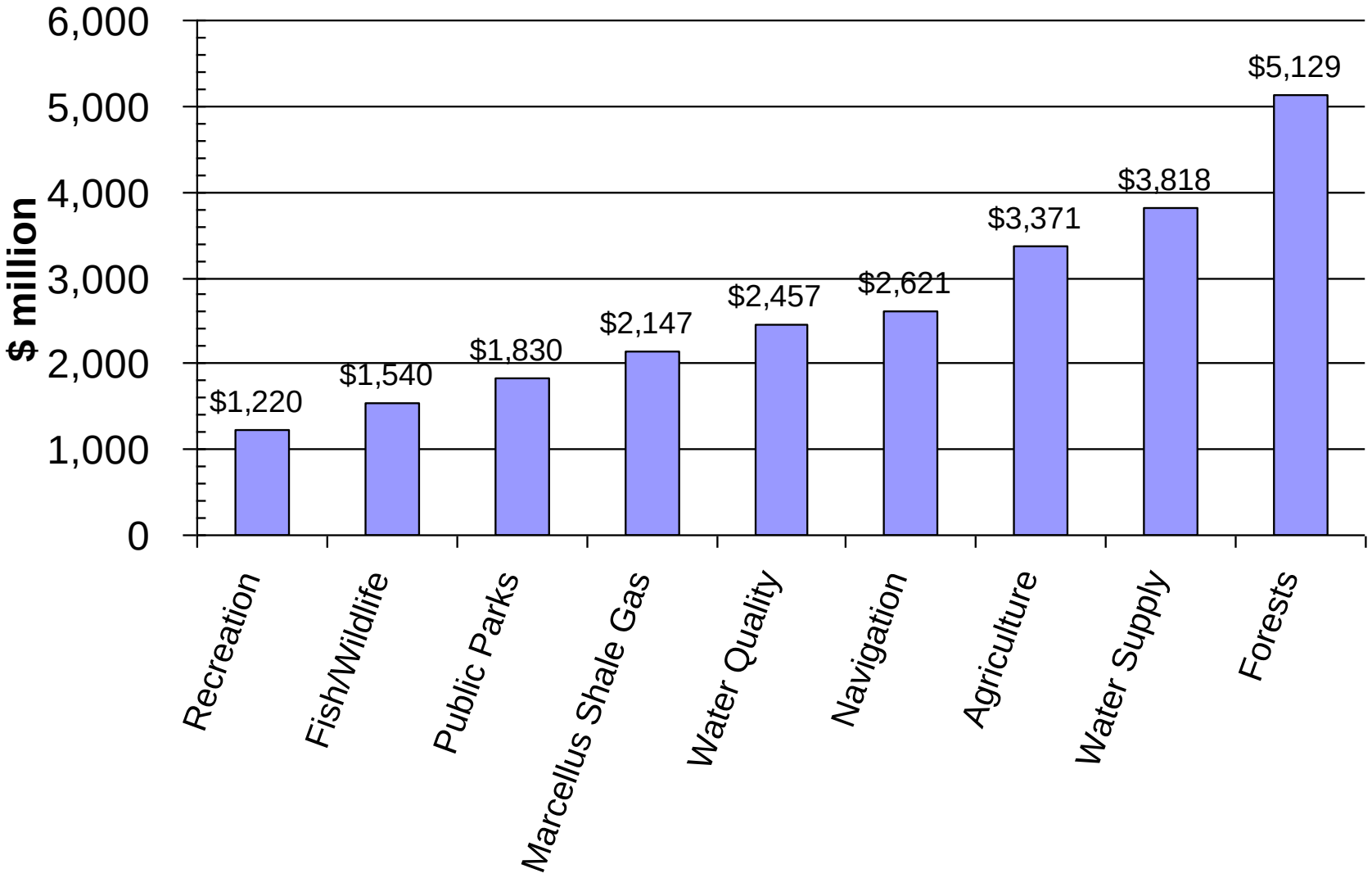
The Delaware River Basin in Del., NJ, NY, and Pa. contributes:

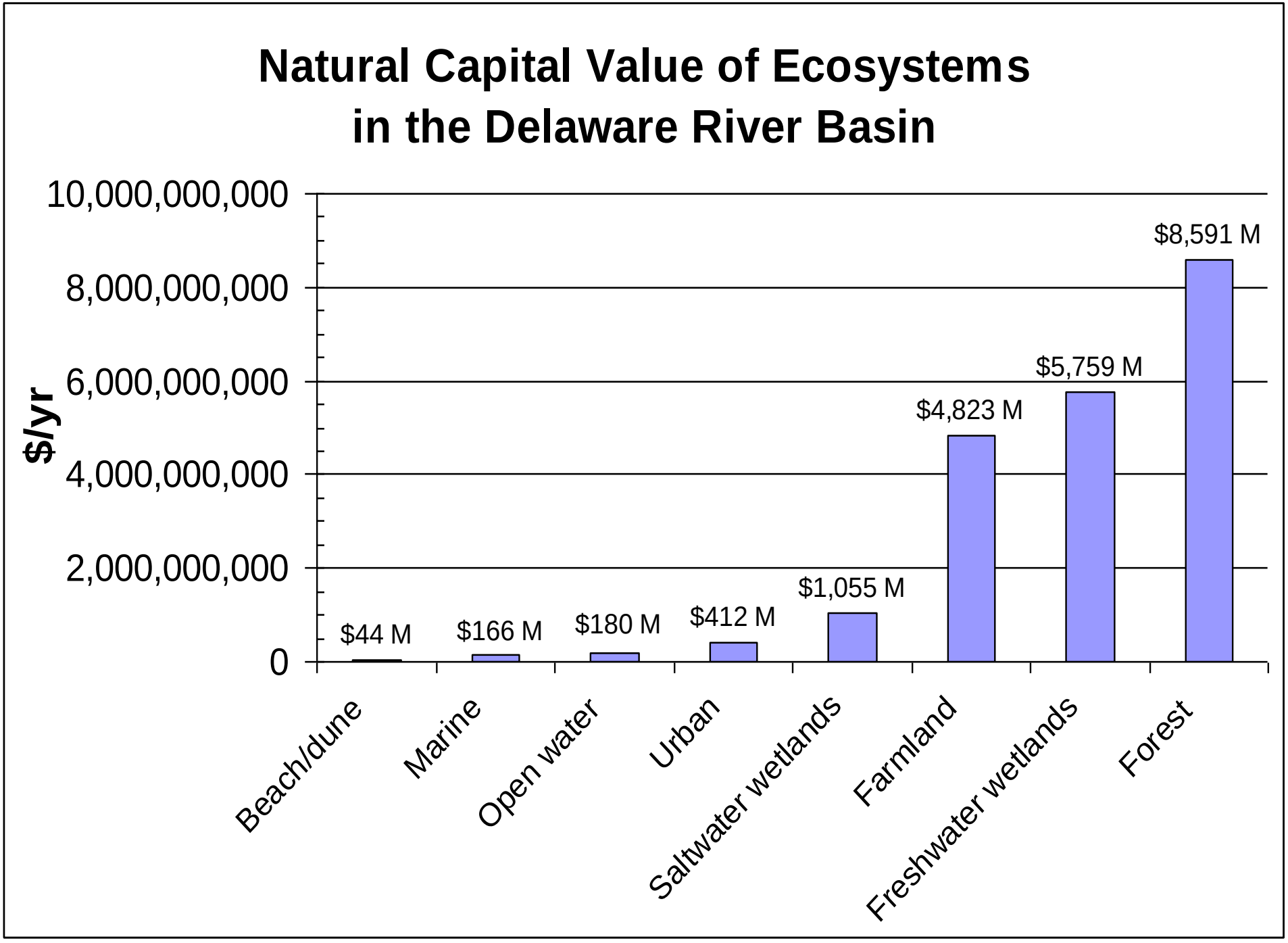
1. **$25 billion** in annual economic value from recreation, water quality, water supply, ecotourism, forest, agriculture, open space, and port benefits.

2. Ecosystem goods and services worth **$21 billion** per year, net present value (NPV) = **$683 billion**.

3. Over **600,000 jobs** with **$10 billion** in wages.

Annual Economic Benefits
Delaware River Basin




Natural Capital Value of Ecosystems in the Delaware River Basin
$/yr
10,000,000,000
8,000,000,000
6,000,000,000
4,000,000,000
2,000,000,000
0
$44 M
$166 M
$180 M
$412 M
$1,055 M
$4,823 M
$5,759 M
$8,591 M
Beach/dune
Marine
Open water
Urban
Saltwater wetlands
Farmland
Freshwater wetlands
Forest

>600,000 jobs ($10 billion in wages)

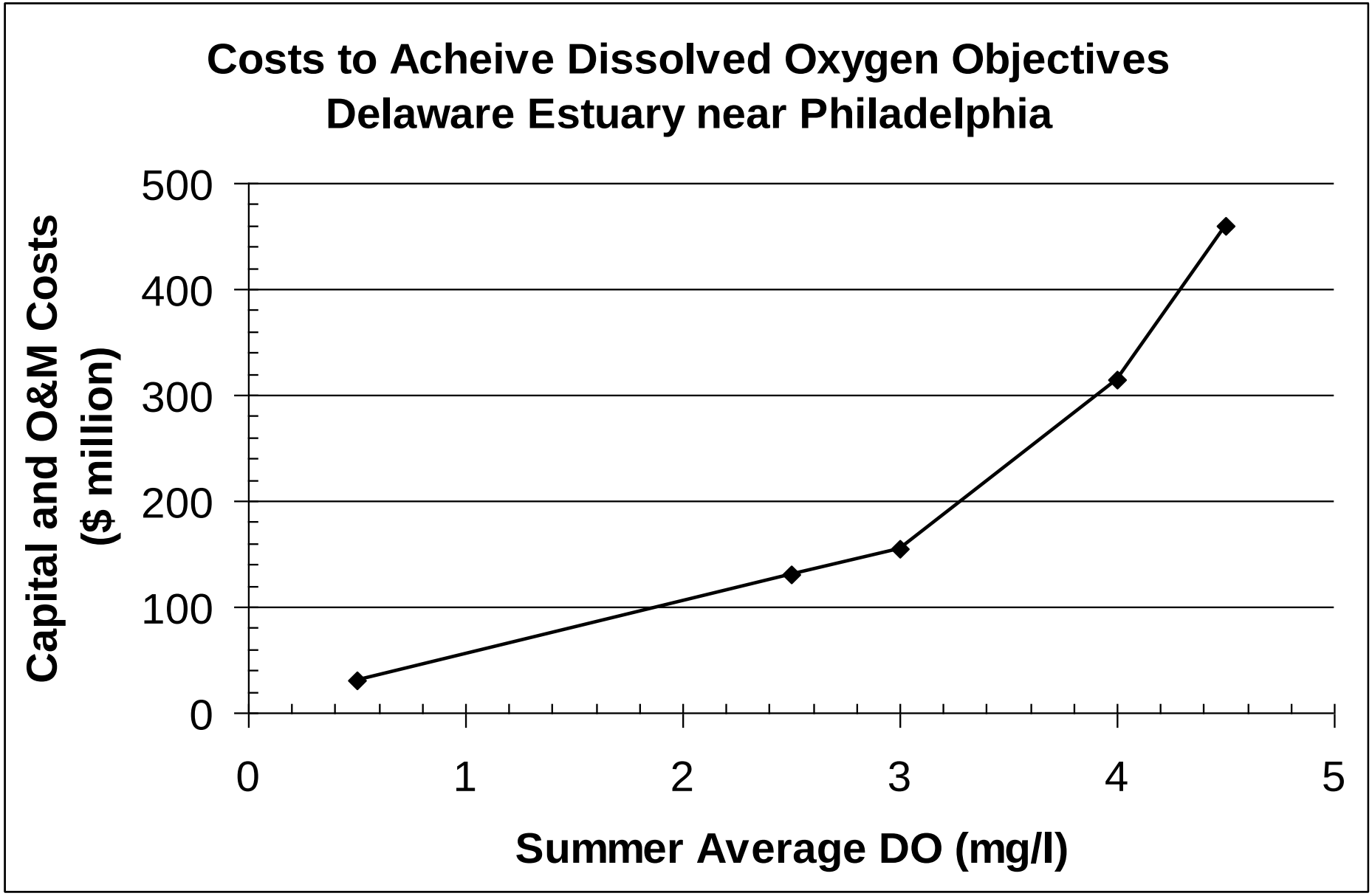
- Marine & Water Supply Construction
- Fishing & Aquaculture
- Ship/Boat Building
- Tourism/Recreation
- Marine Transportation
- Hunting/Fishing/Wildlife
- Farming
- Water/Wastewater Utility
- Ports
- Watershed Protection

Delaware River Basin

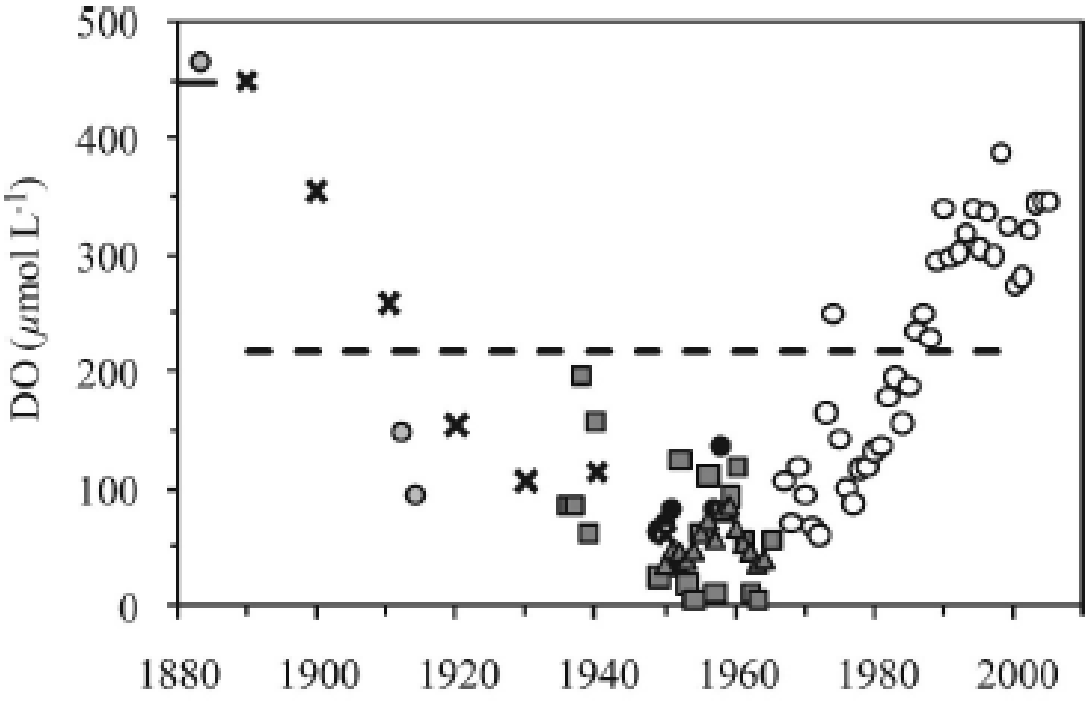
- Federalist model of shared power in water management
- 1961 DRBC Compact manages “without regard to political boundaries.”
- Global model of efficient watershed governance.
- 4 states, 24 counties, and 838 municipalities
- 8 Senators, 25 Members of HR
- 19 federal, 43 state, 14 interstate agencies
- Use charges on water allocations ($0.08/1000 gal.).

Background

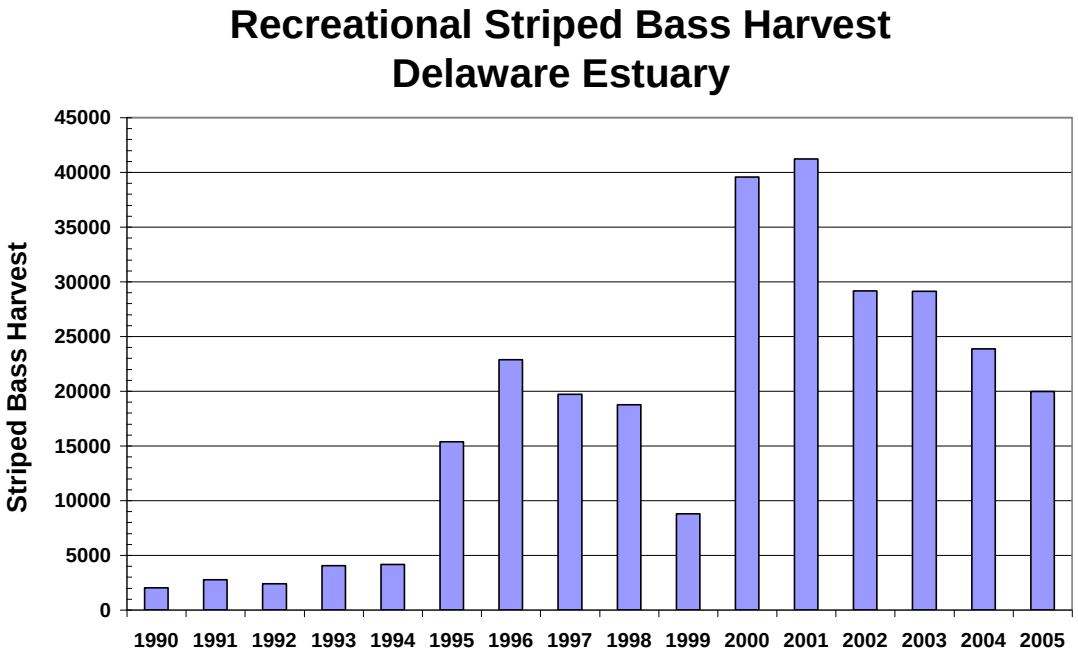
- Since 1961, water quality has improved in tidal Delaware River.
- Yet, DO doesn’t fully meet fishable standard (3.5 mg/l) in summer.
- American shad/striped bass abundance increasing in river.
- In 2011, EPA advised states to adopt numeric nutrient standards
- In 2012, NOAA placed Atlantic sturgeon on Endangered Species list
- Atmospheric warming and sea level rise (increased salinity) may decrease DO saturation.
- Considering more protective DO criteria to 4.0 or 5.0 mg/l?



Costs to achieve DO objectives along Delaware Estuary in 1967 (Kneese and Bower 1984)



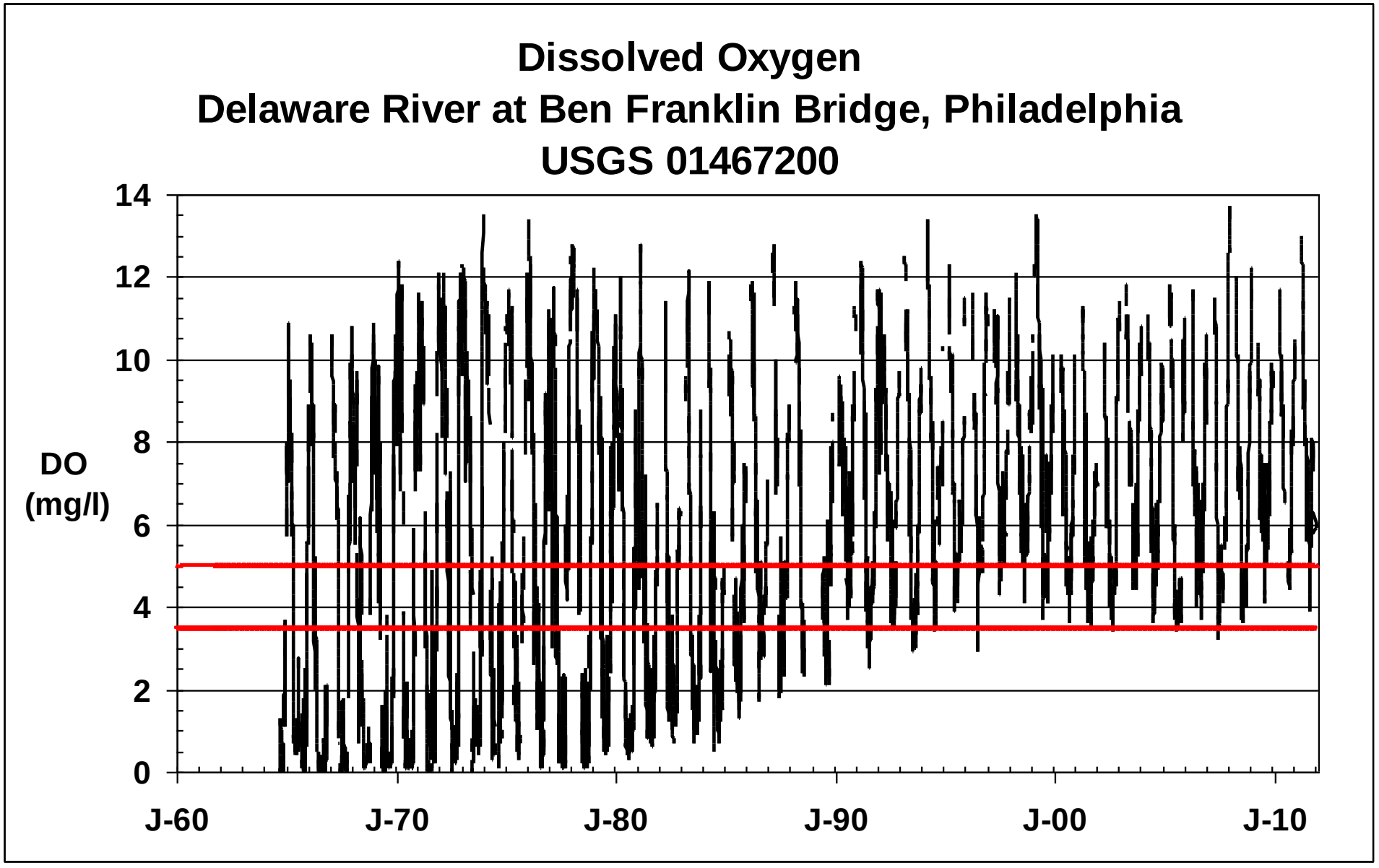
Water quality has improved in the Delaware River (Sharpe 2011).



Fish abundance has increased in the Delaware River (DNREC 2005).

Objective

Based on benefit-cost analyses, what are optimal costs to achieve improved water quality in the tidal Delaware River?


Dissolved Oxygen
Delaware River at Ben Franklin Bridge, Philadelphia
USGS 01467200
DO
(mg/l)
14
12
10
8
6
4
2
0
J-60
J-70
J-80
J-90
J-00
J-10

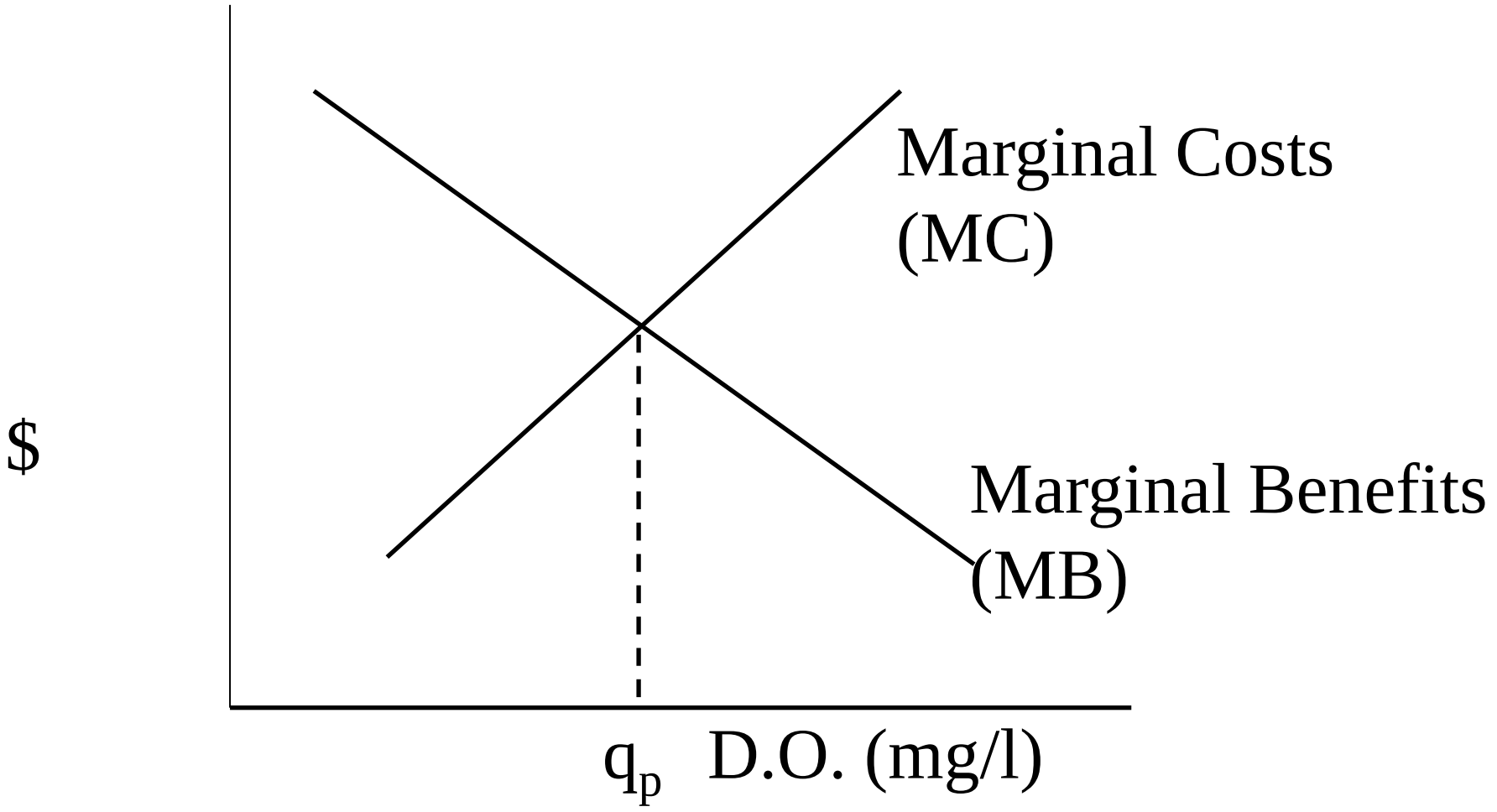
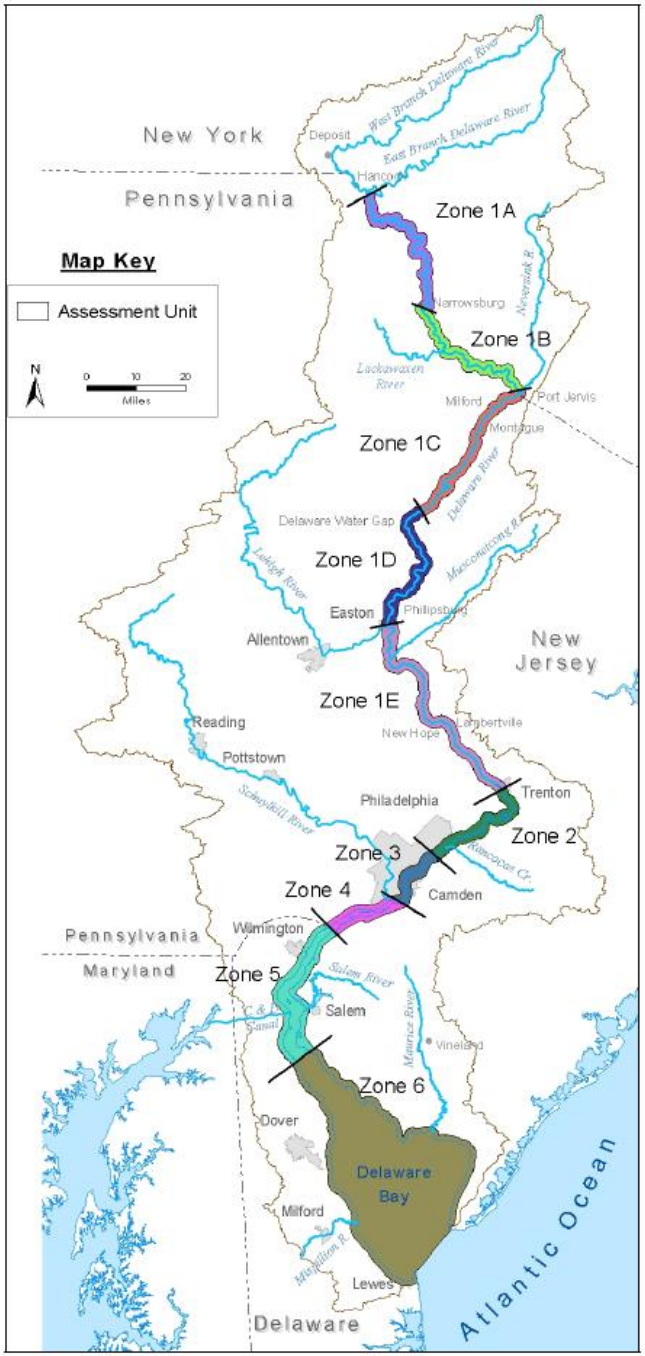
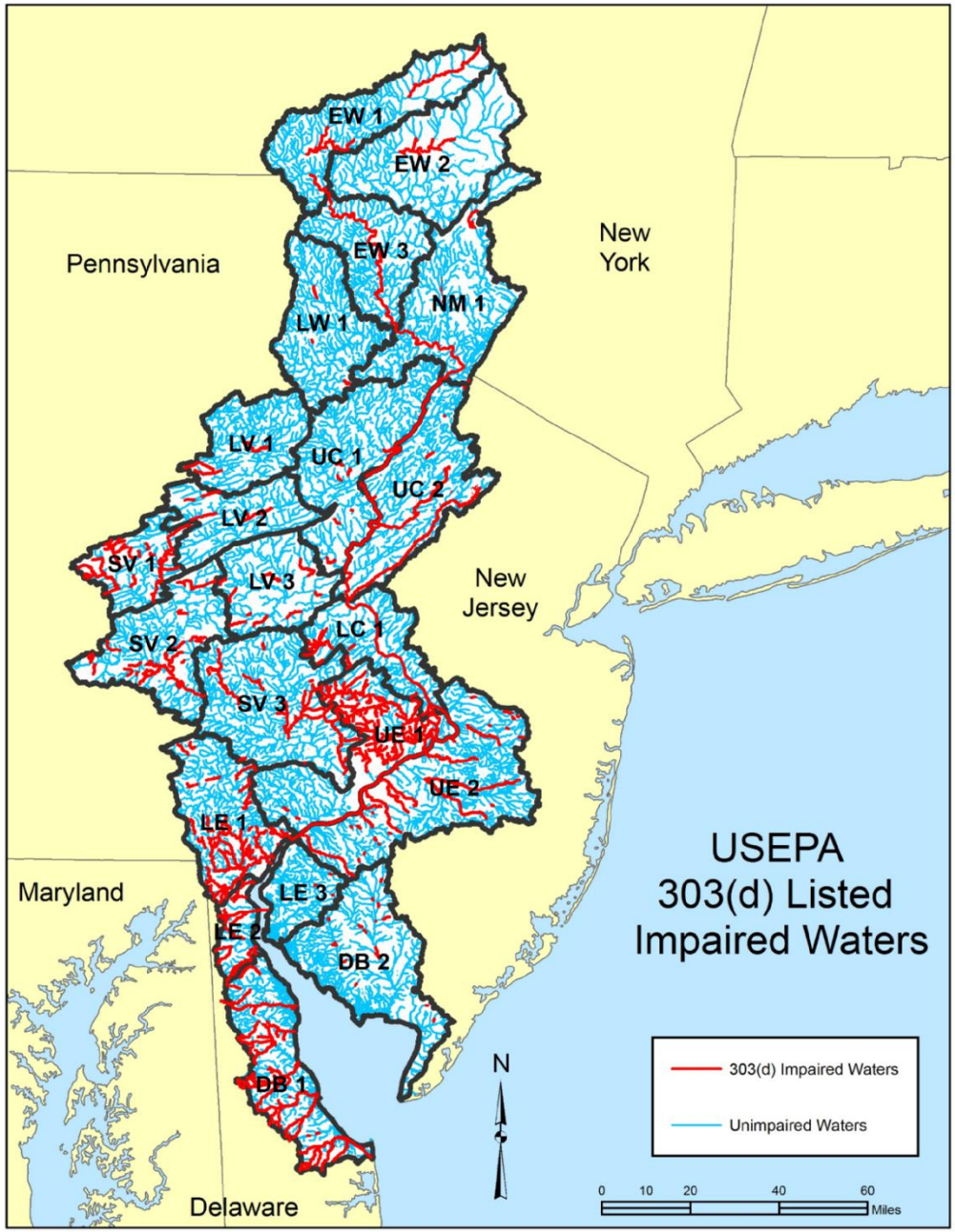

$
Marginal Costs
(MC)
Marginal Benefits
(MB)
q_p
D.O. (mg/l)

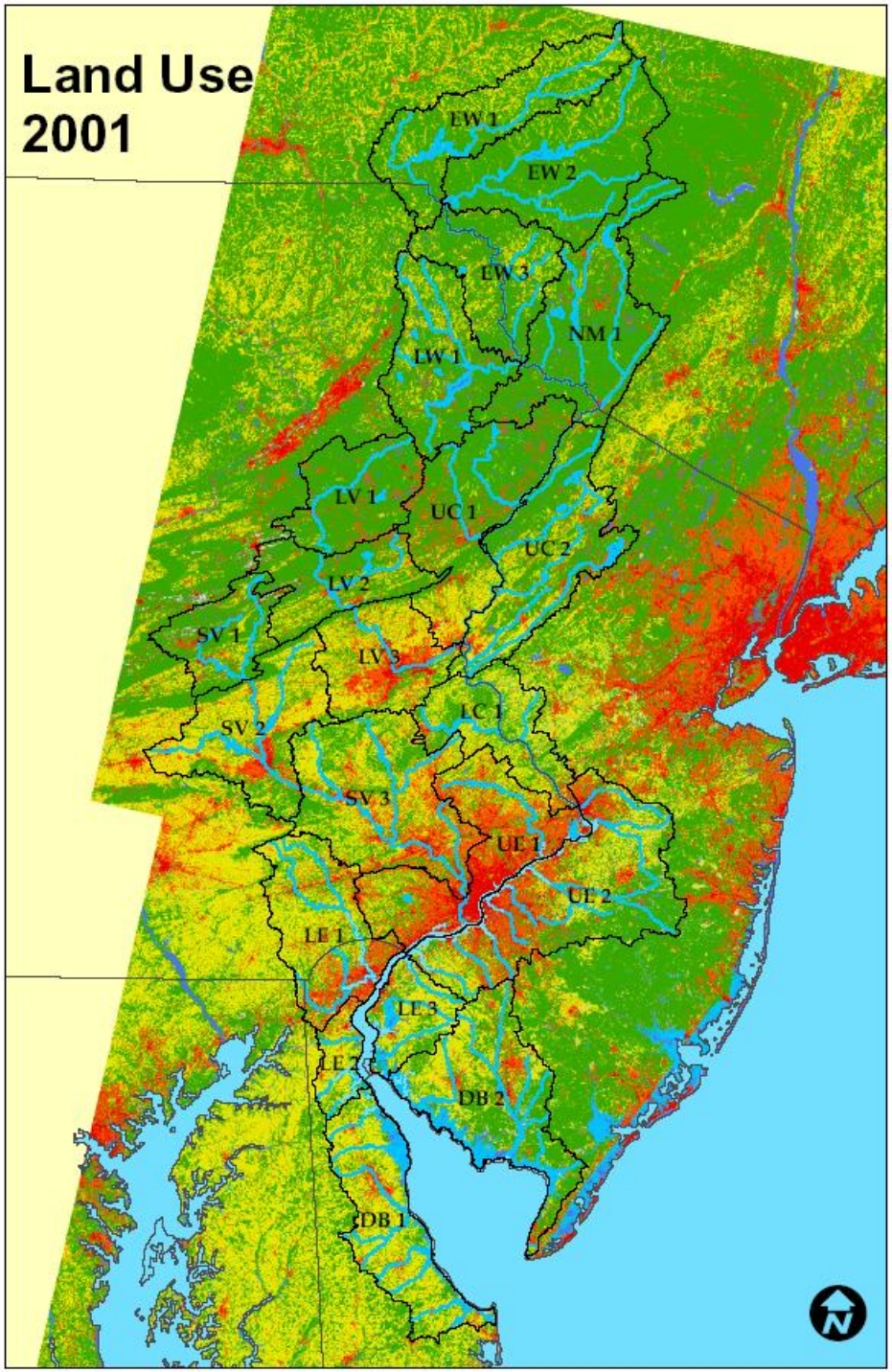
Figure 2: Delaware River Water Quality Management Zones / Assessment Units





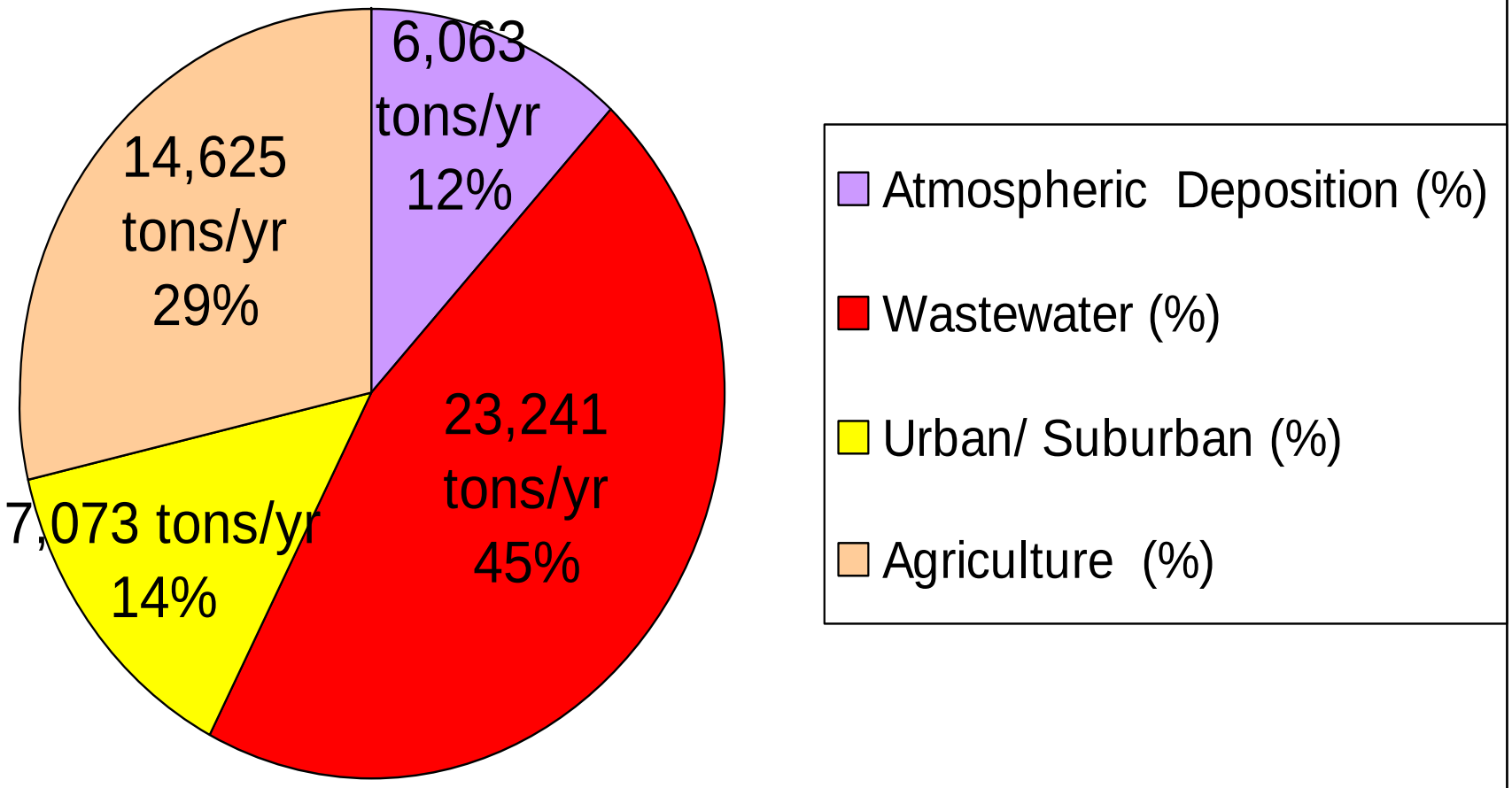
Costs

1. Estimate nutrient loads from USGS SPARROW model for the Delaware Basin (Moore et al. 2011).
2. Utilize TMDL models to estimate reductions based on 25^{th} percentile, median, and 75^{th} percentile confidence intervals.
3. Estimate costs of nitrogen reduction ($/lb N) from PS and NPS best management practices.
4. Calculate costs to improve water quality to future DO standard (4.0 - 5.0 mg/l) by multiplying N load reductions (lb/yr) by unit costs of PS/NPS BMPs ($/lb N).
5. Define nitrogen marginal abatement cost (MAC) curve.

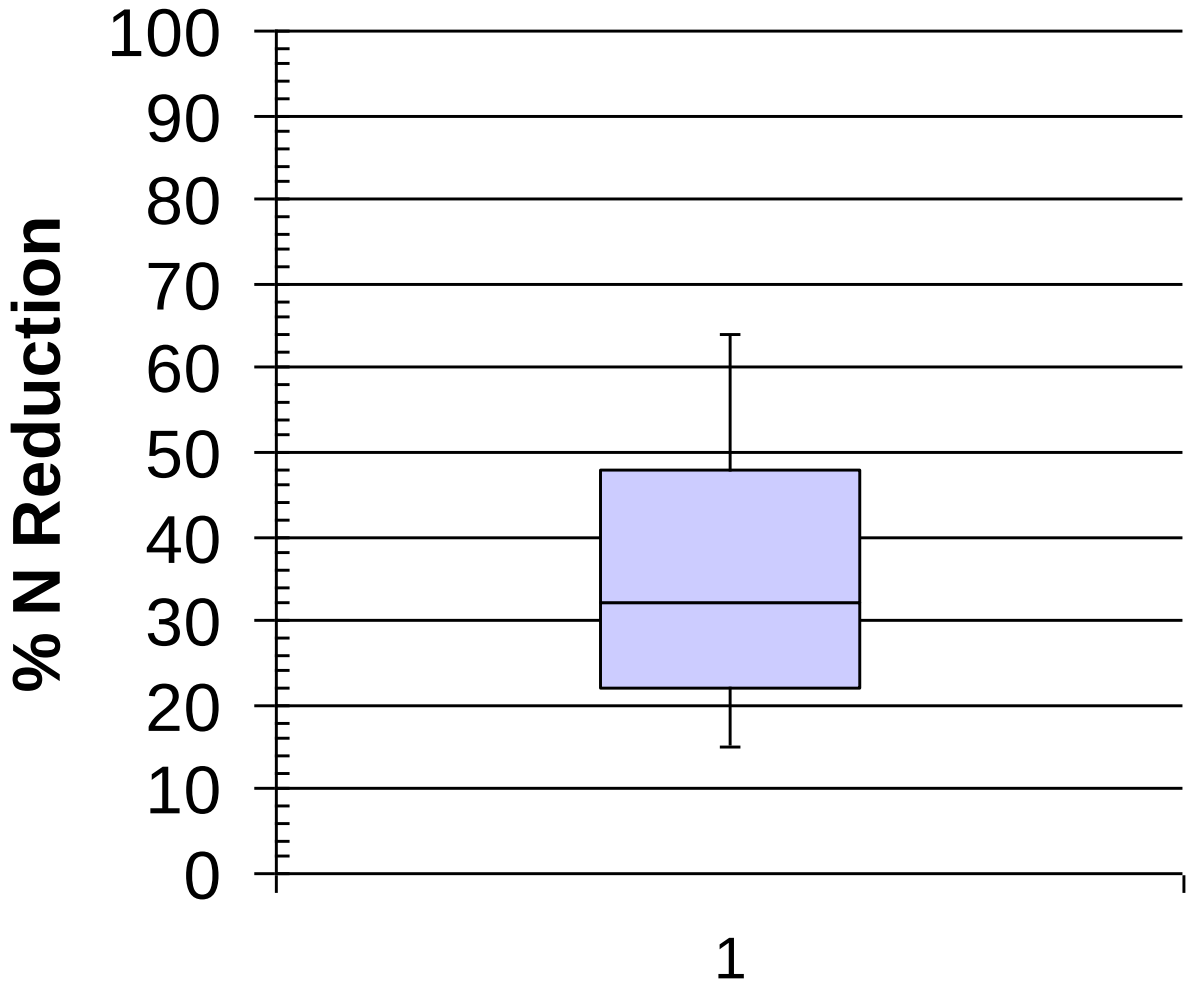


State	Urban (%)	Ag (%)	Forest (%)
NY	2%	11%	87%
PA	23%	20%	57%
NJ	17%	29%	54%
DE	25%	28%	46%
DRB	17%	20%	62%

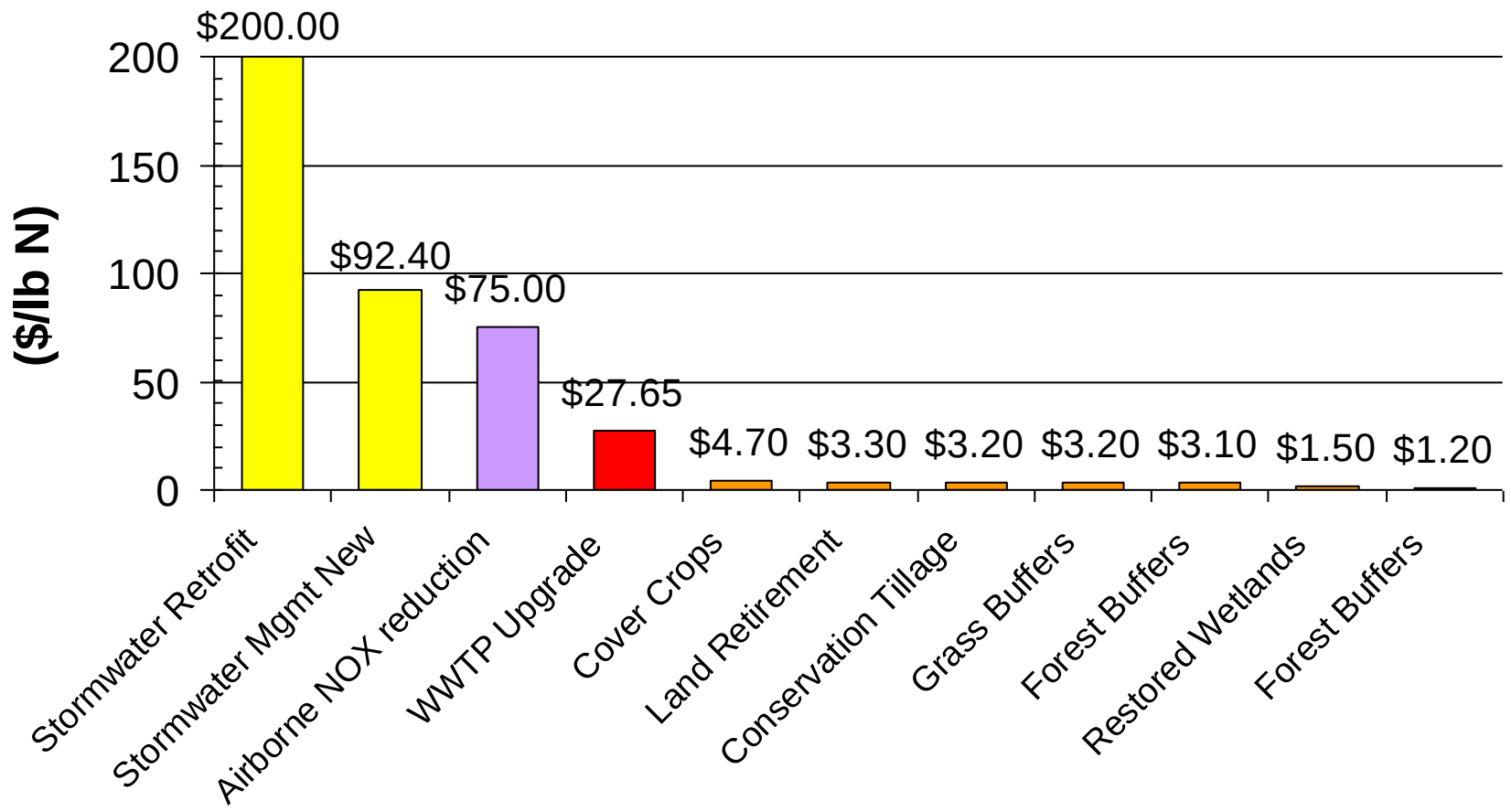
Nitrogen Loads Delaware Basin (USGS SPARROW)



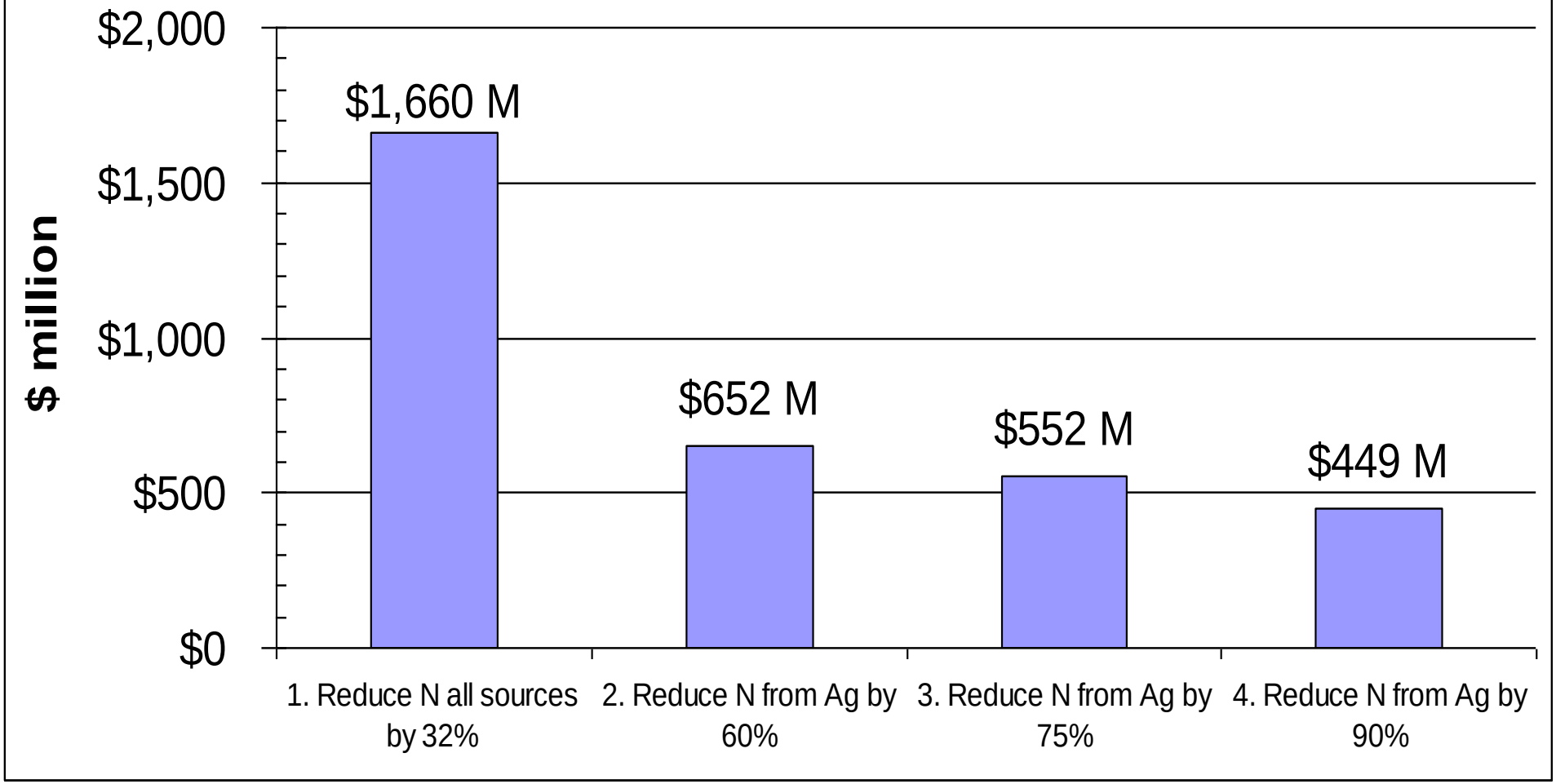
Nitrogen Reduction from TMDLs
Lower Delaware River



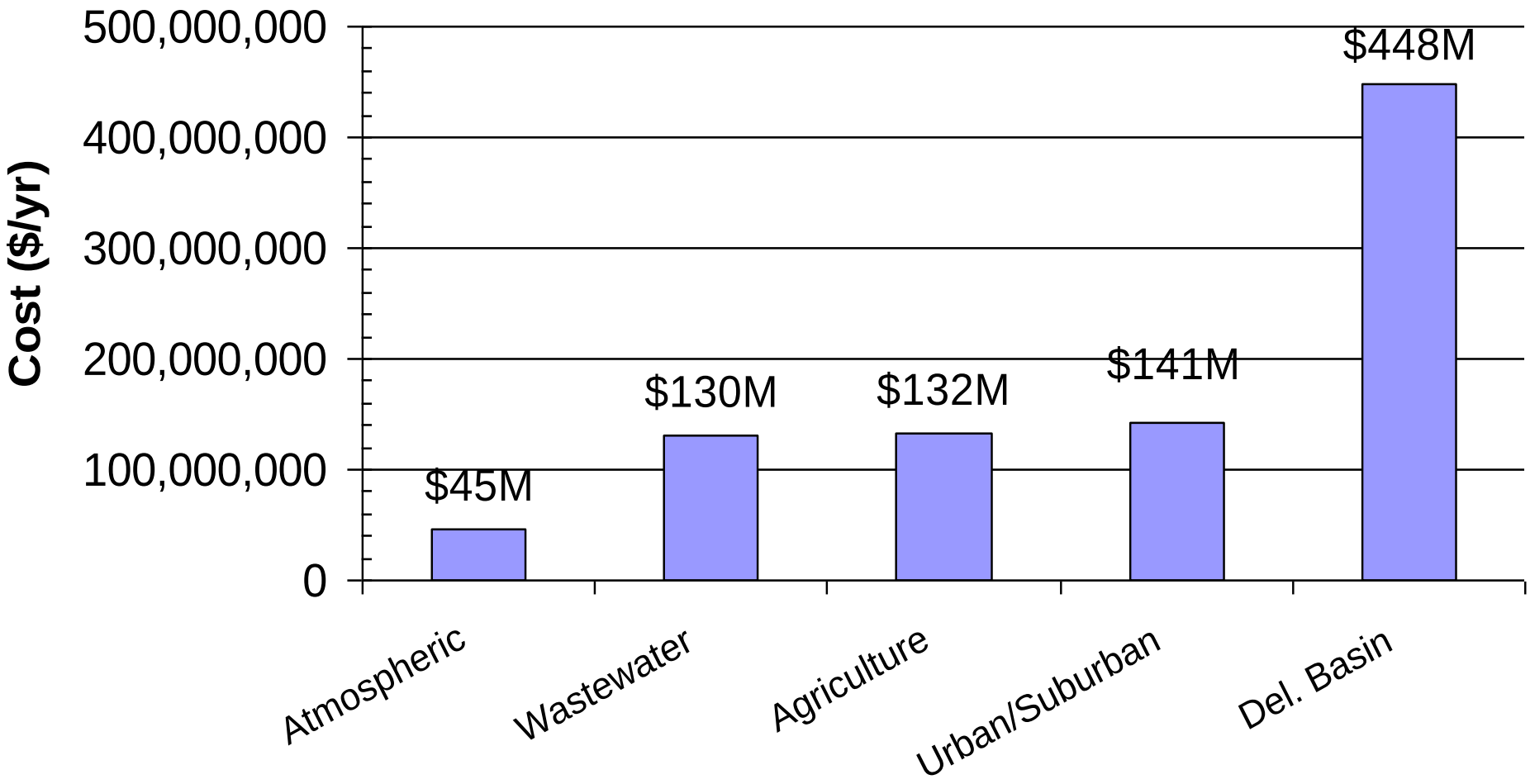
Per-Pound Costs of Reducing Nitrogen Pollution in the Chesapeake Bay Region



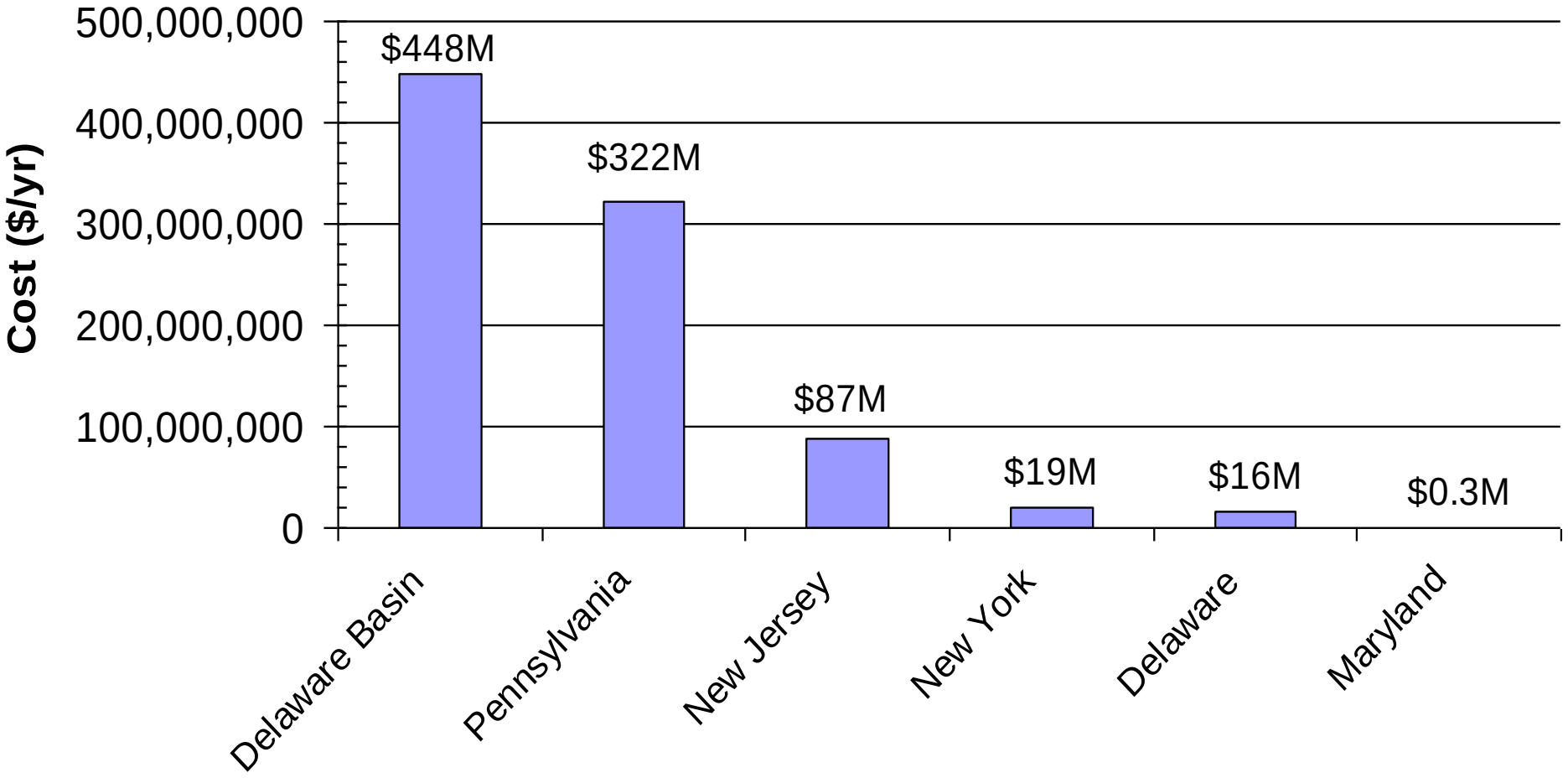
Costs of Nitrogen Reduction by 32%
Delaware River Basin



Cost by Source for 32% Nitrogen Reduction Delaware Basin



Cost by State for 32% Nitrogen Reduction
Delaware River Basin



Nitrogen Marginal Abatement Cost Curve
Delaware Basin

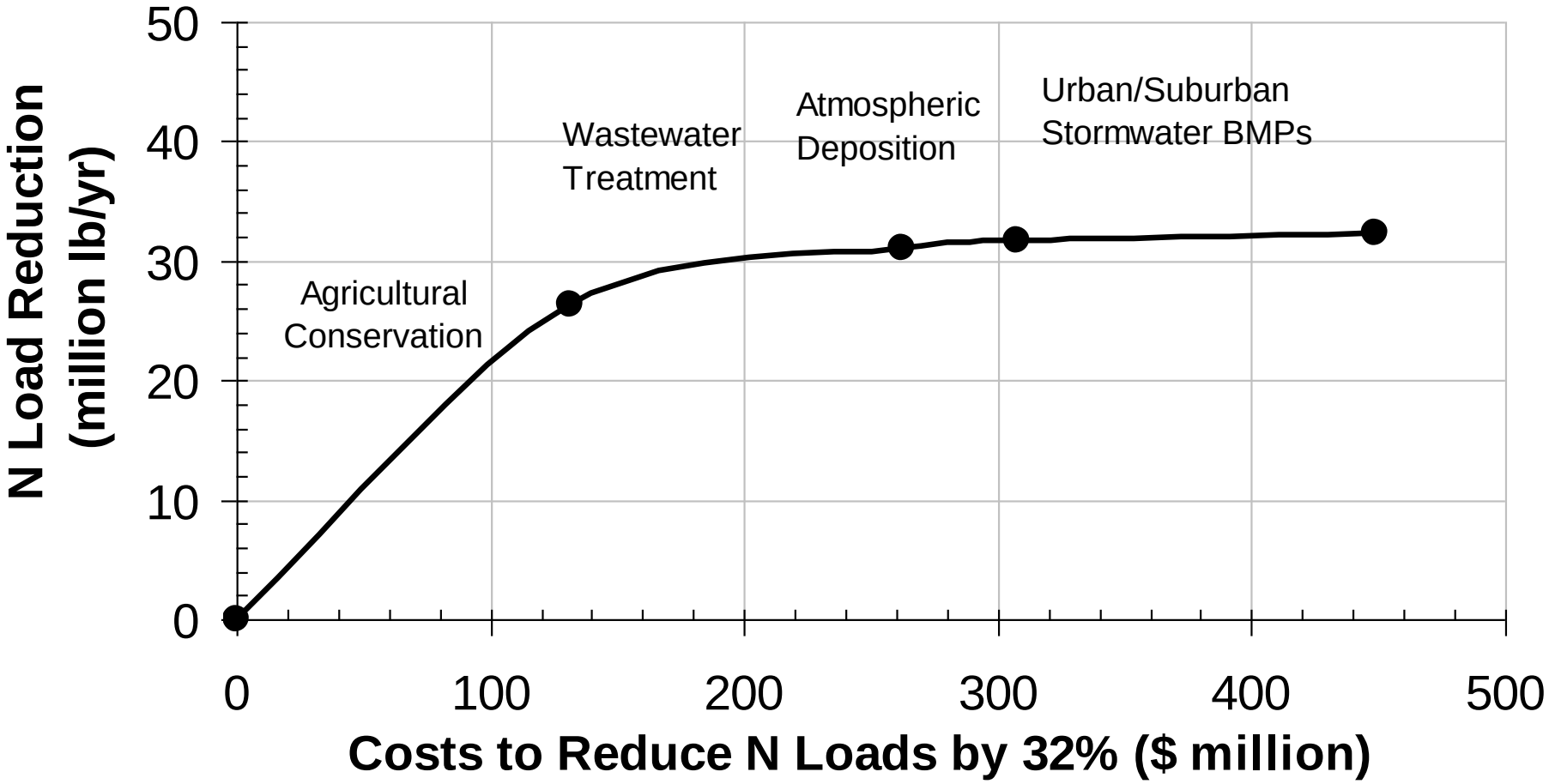
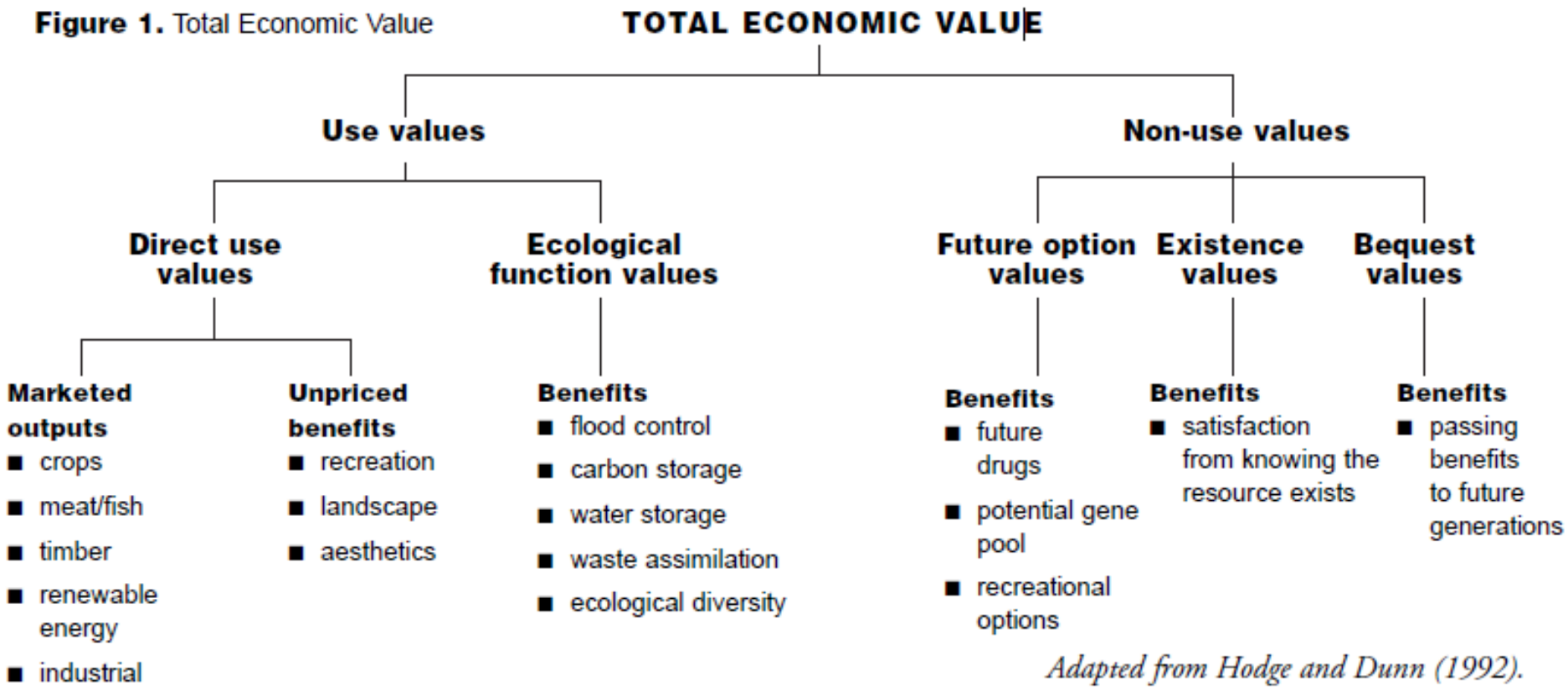


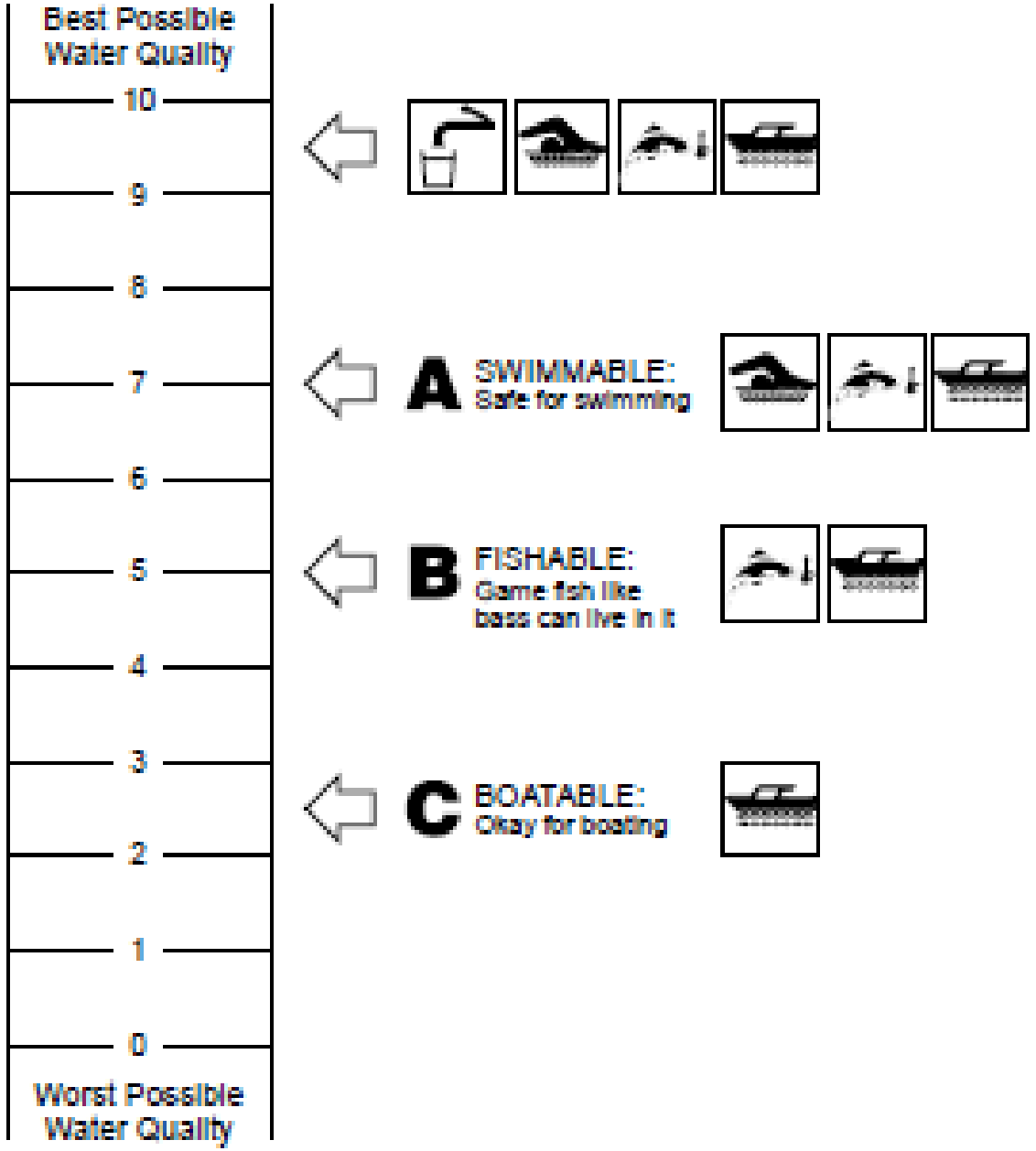
Figure 1. Total Economic Value



Adapted from Hodge and Dunn (1992).

Nonuse Benefits

1. Estimate adult population who would benefit from improved water quality.
2. Estimate WTP for incremental water quality improvements from nonsupport to viewing to boatable to fishable uses
3. Estimate annual benefits to meet improved water quality by multiplying population by individual WTP.



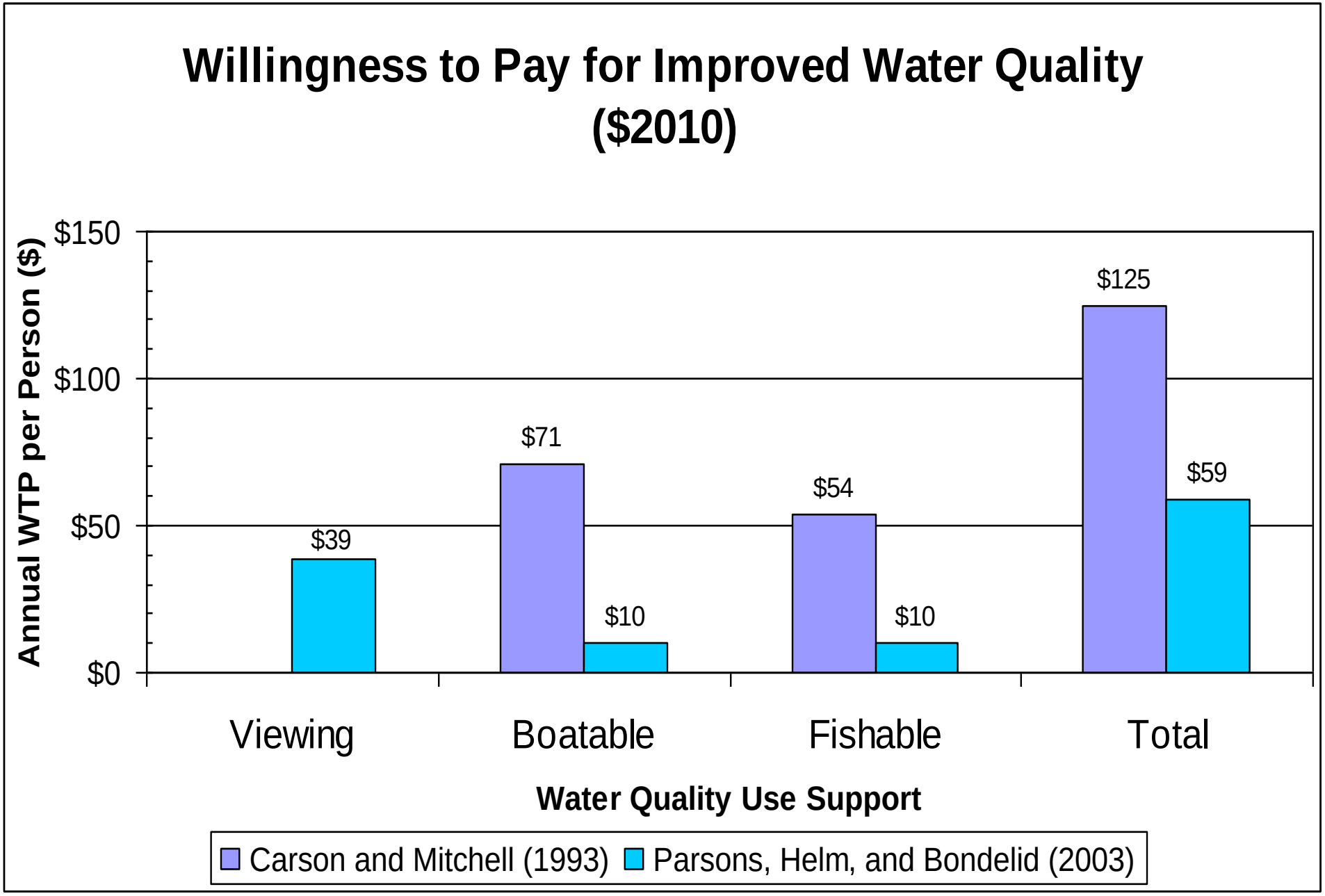
Resources for the Future water quality ladder (Carson and Mitchell 1993)

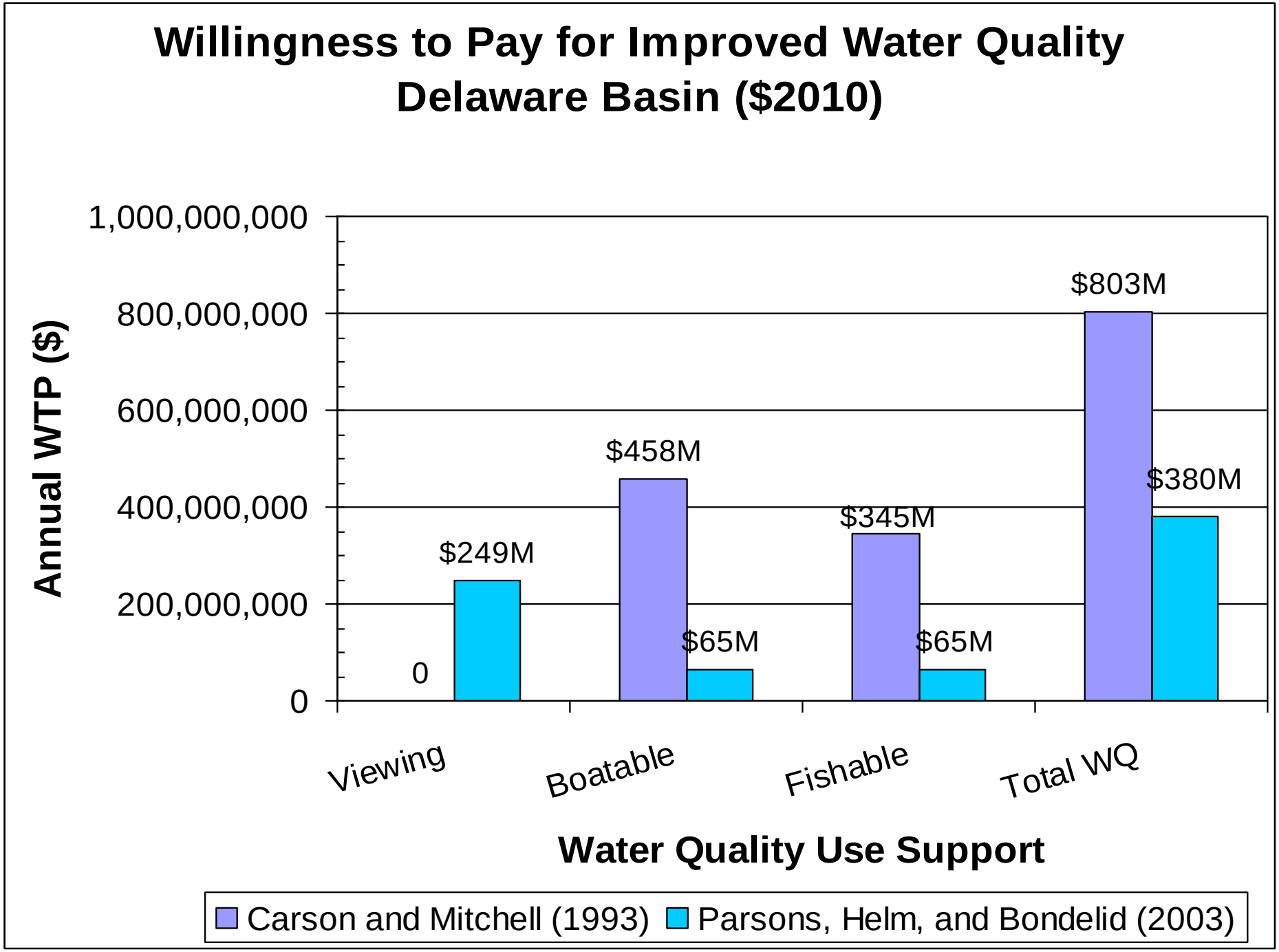
Table XX. Benefits of improved water quality along the Delaware River and Bay

Benefit	Category	Activity	2010 Benefits ($ million/yr)	
			Low Bound	High Bound
Use				
Instream	Recreation	Boating		
		Fishing		
		Bird/Wildlife Watching		
	Commercial	Fishing		
		Navigation		
Withdrawal	Water Supply	Municipal (Drinking Water)		
		Agriculture (irrigation)		
		Industrial/Commercial		
Viewing/Aesthetic	Near water	Hiking, picnicking, photography		
		Commuting, office/home views		
Ecosystem		Hunting/bird watching		
Nonuse				
Vicarious		Significant others (relatives, friends)		
		American public		
Stewardship		Inherent (preserving remote wetlands)		
		Bequest (family, future generations)		
Total				

Table 35. Summary of benefits from improved water quality (Carson and Mitchell 1993, EPA 2002, WBCSD 2011)

Benefit	Category	Examples	Benefits Methods
Use	Recreation	Boating, fishing, swimming	Willingness to Pay
	Aesthetic/Viewing	Commuting, office/home views hiking, picnicking, photography,	Willingness to Pay
	Fishing	Commercial Recreation	Qualitative Discussion
	Water Supply	Municipal, agriculture, industrial, commercial	Avoided Cost of Water Treatment
	Property Ownership	Increased river-side property value	Benefits Transfer
	Ecosystem	Hunting/fishing/bird watching	Benefits Transfer
Nonuse	Vicarious	Significant others (relatives, friends), American public	Benefits Transfer
	Stewardship	Inherent and bequest (family, future generations)	Benefits Transfer


Willingness to Pay for Improved Water Quality ($2010)
Annual WTP per Person ($)
$150
$100
$50
$0
$39
$71
$10
$54
$10
$125
$59
Viewing
Boatable
Fishable
Total
Water Quality Use Support
Carson and Mitchell (1993)
Parsons, Helm, and Bondelid (2003)


Willingness to Pay for Improved Water Quality
Delaware Basin ($2010)
Annual WTP ($)
1,000,000,000
800,000,000
600,000,000
400,000,000
200,000,000
0
$803M
$458M
$380M
$345M
$249M
$65M
$65M
0
Viewing
Boatable
Fishable
Total WQ
Water Quality Use Support
Carson and Mitchell (1993)
Parsons, Helm, and Bondelid (2003)

Benefits (Use)

Category	Lower ($M)	Upper ($M)
Boating	39	72
Fishing (Rec.)	27	47
Fishing (Com.)	1	3
Swimming	0	0
Wildlife Viewing	15	32
Drinking Water	51	105
Industrial	37	54
Property Value	16	34
Total	186	347

Benefits (WTP, Nonuse)

WQ Support	Lower ($M)	Upper ($M)
Viewing	249	
Boatable	65	458
Fishable	65	345
Total	380	803

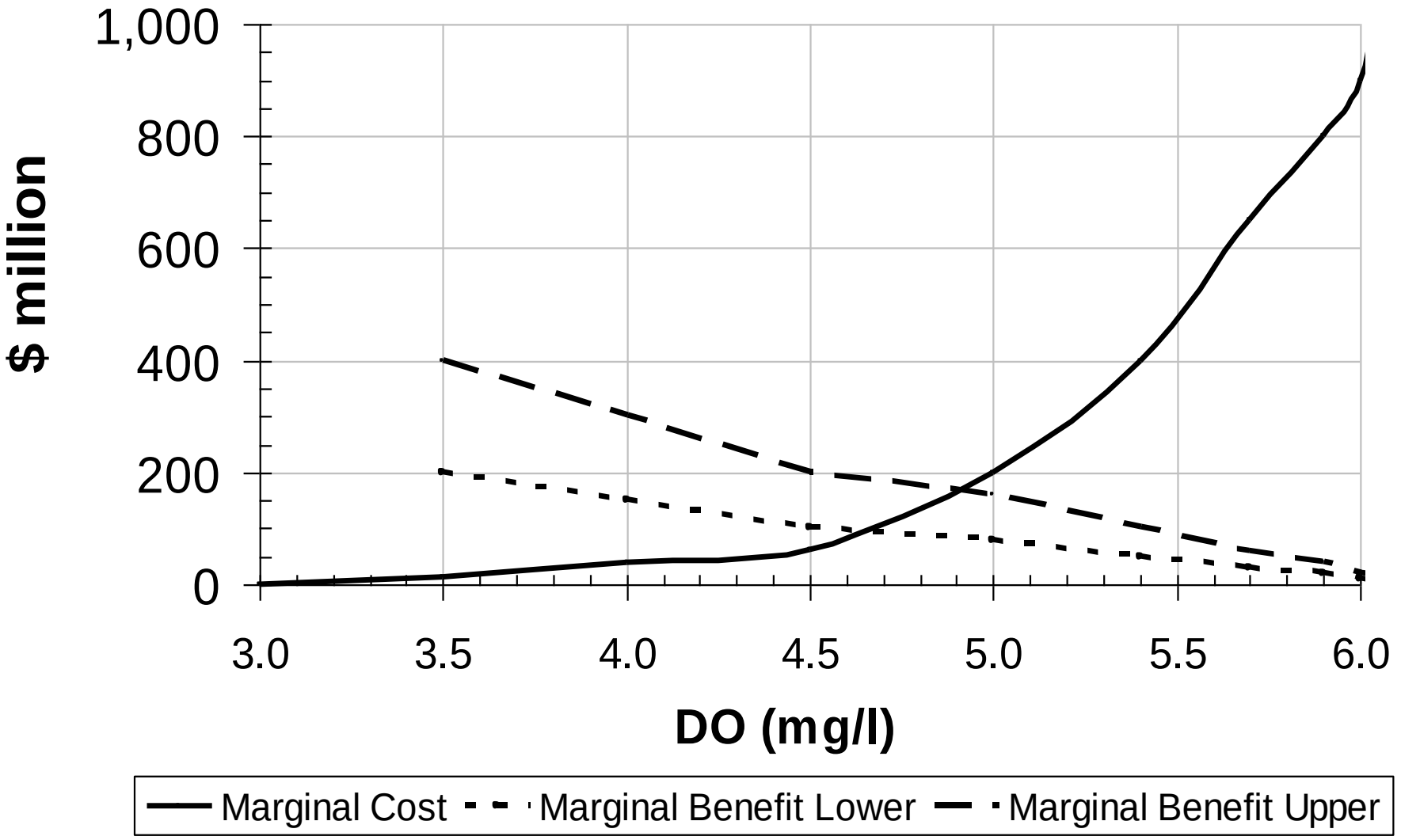
Benefits

Category	Lower ($M)	Upper ($M)
Use	186	347
Nonuse	380	803
Total	566	1,150

BCA

Estimate	Benefit ($M)	Cost ($M)	Net Benefit ($M)	B/C ($M)
Lower	566	448	118	1.2
Upper	1,150	448	702	2.5

Optimal Water Quality
Delaware Basin



Funding Vehicles

- Prioritize Existing Watershed Programs
- Water Quality Trading
- User Fee
- Emissions Charge

Prioritize Existing Watershed Programs

Program	Contracts (2002-2008)	Payments (2002-2008)
WRP	5,007	$1,721,339,753
AMA	2,694	$35,112,081
EQUIP	276,893	$2,901,739,523
CSP	21,258	$483,866,003
CRP	4,870,811	$12,772,019
EPA 319	7,171	$1,524,800,000
Drinking Water		$1,674,143,000
Total	5,183,833	$8,353,772,379

Kneese and Bower, Resources for the Future (1984)

- River basin firm internalizes the externalities
- Effluent charges should be seriously considered as a method for attaining water quality improvement.
- Effluent charge of $0.10/lb of BOD, agency would collect $7 million/yr (rent on river's assimilative capacity).
- A charge of $0.08 to $0.10/lb of oxygen-demanding material produces large increases in DO levels;

Water Quality Trading

Watershed	Location	Pollutant	Reductions (lb)	($2008)
Bear Creek	CO	P	137	6,197
Long Island Sound	CT	N	7,300,000	8,806,500
Great Miami River	OH	N	318,031	591,970
Neuse River Basin	NC	N	5,906	207,886
Red Cedar River	MN	P	12,091	14,908
So. MN Beet Sugar	MN	P	10,633	425,320
South Nation River	ON	P	1,157	20,822

User/Emissions Charges

- **France:** *Agencies de L'eau* collect user charges (*redevance)* from dischargers. Water parliaments advise on water use fees.
- **Germany:** Ruhr Water Associations (*Genossenschaften*) financed by user charges.
- **Mexico:** National Water Commission oversees 25 river basin councils and 6 basin commissions funded by user fees.
- **Portugal:** 15 river basin authorities funded by user (withdrawal) and polluter (discharger) pays principles.
- **Australia:** In 1985, Murray Darling Basin Ministerial Council organized. Funded by user/discharge fees and water trade market.

Questions?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