Mapping Ecosystem Services for Decision Making in Maryland

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ACES 2018

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Natural Resources Benefitting People
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Chesapeake & Coastal Service

MARYLAND DEPARTMENT OF NATURAL RESOURCES

State of Ecosystem Services in Government

- Many federal agencies have efforts to quantify ecosystem services (e.g. EPA's EnviroAtlas, USGS's SoLVES, USDA OEM, NOAA, NESP Guidebook)
- Few states have similar efforts within state government (Oregon's Willamette Partnership)
- Maryland has maintained interest in ES (2011 Ecosystem Service Working Group Report)
- **Charge: Create tool to allow ES to be integrated into State of Maryland decision making**

Integrating Ecosystem Services in the Maryland DNR

Conservation

- Parcel Evaluation Tool on the Maryland GreenPrint Mapper
  - Program Open Space Investments –Totaled >$100 million for FY2018
  - Outreach events to Land Trust Community

Restoration

- Creating a tool to evaluate the ES benefits of ecological restoration
- Help to prioritize restoration opportunities
- Facilitate Green-Grey infrastructure comparisons

Compensation

- Maryland has created a policy to base compensatory fees for impacts on state lands on the ecosystem services lost. The approach has been successfully applied to three natural gas line impacts, with over $500,00 in payments collected.

Valuation Methodology: Eco-Price

- Ecosystem services are paid for in many different ways
- People view responsibility for providing ecosystem services to be a collective obligation
- We look at the many different ways society invests in protecting or replacing the environment
  - In a market
  - Cost of restoration
  - Through mitigation fees
  - Cost to regulate

Assesses the Social Value ≠ Market Value

- We suggest this method is appropriate for influencing government decision making

  (Campbell 2018)

Mapping Ecosystem Services

- ES vary spatially in the biophysical supply of the service, i.e. benefit relevant indicator (e.g. amount of carbon that is sequestered, water being recharged to aquifers)
- ES vary in the way and amount that people benefit (e.g. number of people and value of infrastructure vulnerable to flooding)
- We consider and present both sources of variation when mapping ES in Maryland

Results Presented at 30 m Pixel Scale

- Forest Extent - 1 m LiDAR forest cover (UMD/NASA) downscaled to 30 m
- Wetland Extent- NWI (2006) + MD DNR wetlands, polygons converted to 30 m pixel

Air Pollution

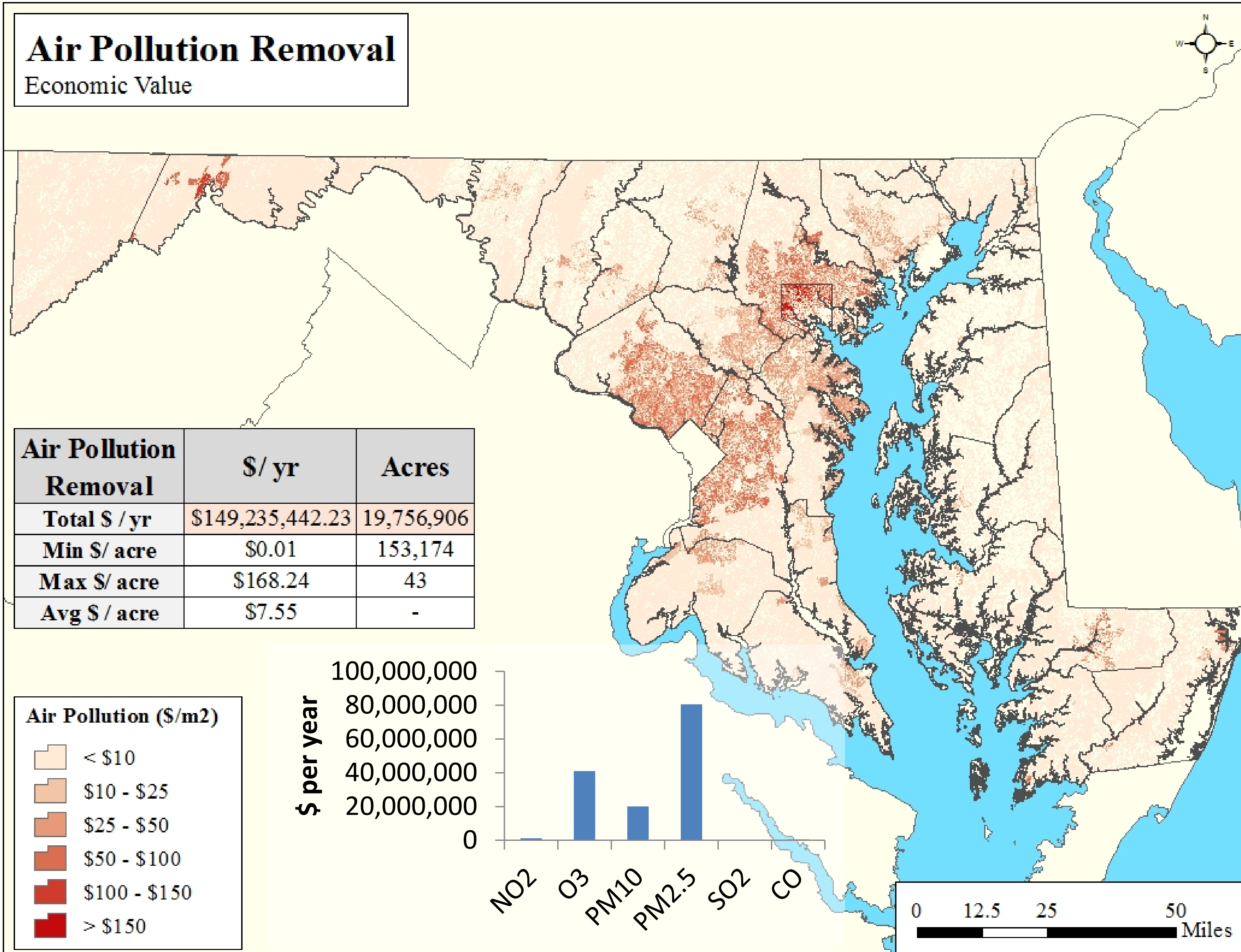
- Used i-Tree Landscape, which models the uptake of 6 atmospheric pollutants:
  - Carbon Monoxide (CO)
  - Nitrogen Dioxide (NO2)
  - Sulfur Dioxide (SO2)
  - Ozone (O3)
  - Particulate Matter 10 (PM 10)
  - Particulate Matter 2.5 (PM 2.5)

- Applied USFS i-Tree Landscape pollution removal coefficients at the Census block group level to updated % tree canopy extent data.

- The amount of pollution removed varies geographically based on the % tree canopy per area, as well as the relative level of the given pollutant in the atmosphere. This effect is typically greater in urban areas, due to higher concentrations of air pollution in urban areas.

i-Tree
Landscape

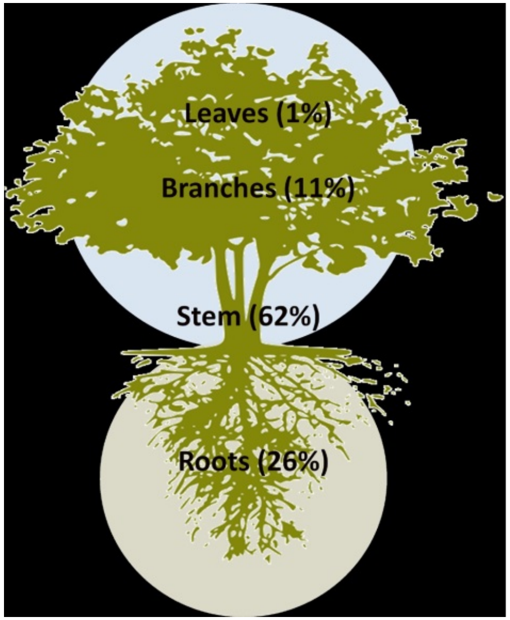
https://landscape.itreetools.org/



Air Pollution Removal	$/ yr	Acres
Total $ / yr	$149,235,442.23	19,756,906
Min $/ acre	$0.01	153,174
Max $/ acre	$168.24	43
Avg $ / acre	$7.55	-

Carbon Sequestration – Forests

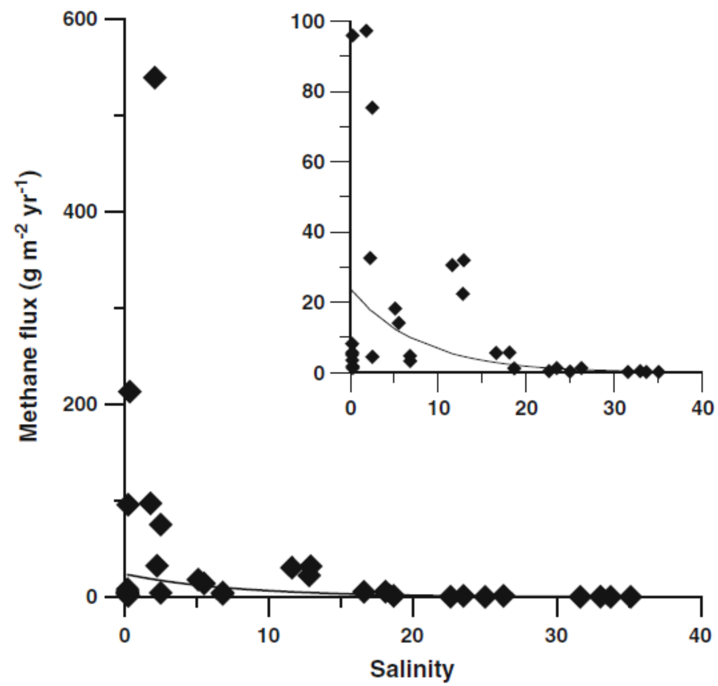
- Built a model of net carbon sequestration in forest and wetland areas across Maryland at the 30m scale.
- Applied USFS i-Tree Landscape carbon sequestration coefficients at the Census block group level to updated % tree canopy extent data.
- The rate and amount of carbon sequestration within forests varies spatially across Maryland. The primary sources of variation in forested areas are tree age and species composition
  - Sequestration increases exponential in the first 30 years, slowing and plateauing as trees reach maturity.
  - Deciduous trees such as oaks and hickories sequestering more carbon than do evergreen trees such as pines and hemlocks.
- Carbon sequestration rates were taken extracted from i-Tree Landscape ranged from 0.4 Mt per ha to 3 Mt per ha



https://landscape.itreetools.org/

Carbon Sequestration – Wetlands

- Developed new model of NET carbon sequestration in wetland areas across the state of Maryland.
- The rate and amount of carbon sequestration and methane emissions within wetlands varies spatially across Maryland, by wetland type and along a gradient of water salinity.
- Derived average rates of carbon sequestration and methane emissions across different wetland types (estuarine and palustrine) and salinity types (fresh, oligohaline, mesohaline) based on field data for the Chesapeake Bay region published in scientific literature. (121 and 34 sites respectively)
- Carbon sequestration rates were taken extracted from iTree Landscape ranged from 0.4 Mt per ha to 3 Mt per ha
- Valued carbon using the US EPA's Social Cost of Carbon, $143 per mt

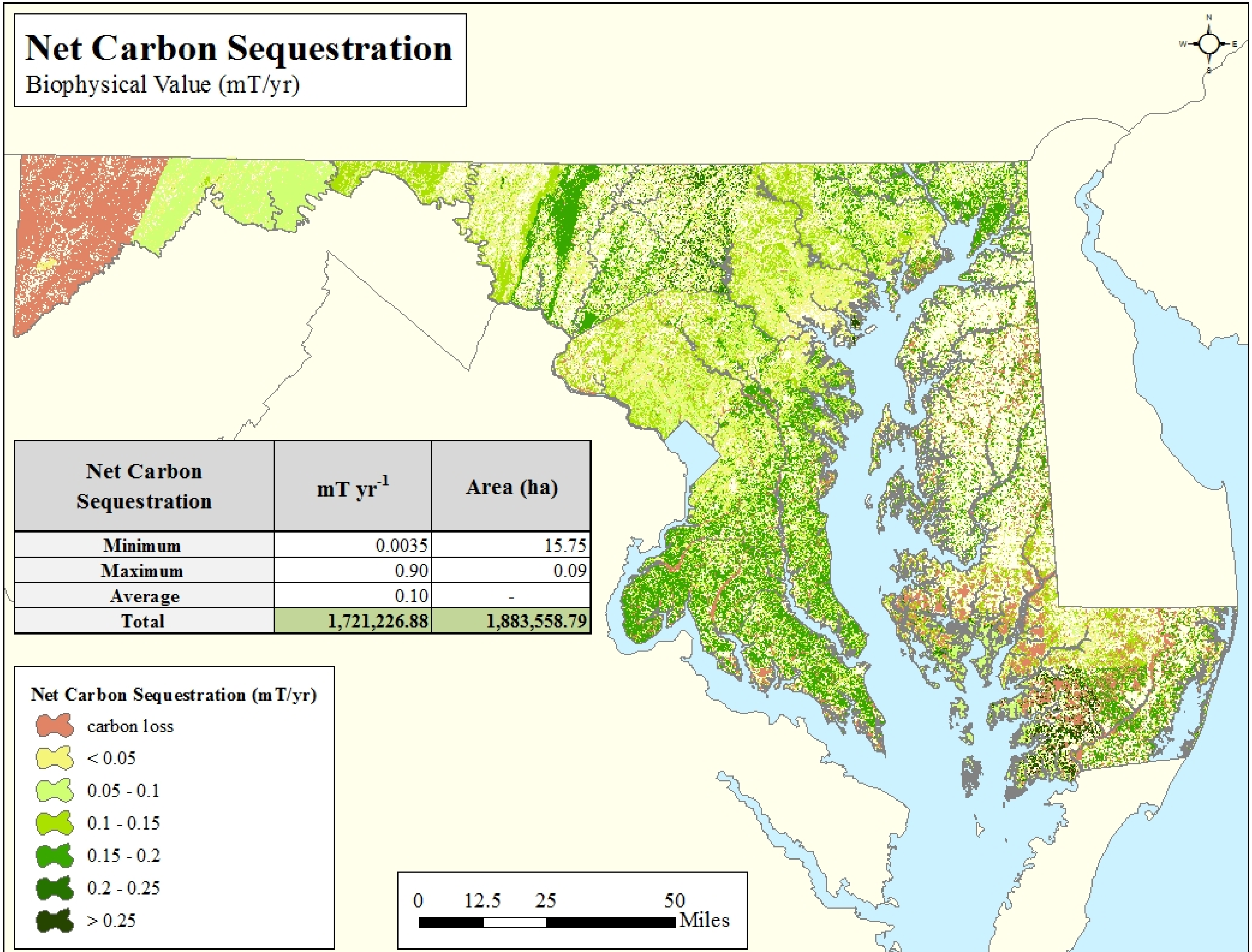


Tidal marsh methane emissions versus salinity from published sources and field sites in Maryland (Poffenbarger, 2011)

Net Carbon Sequestration

Biophysical Value (mT/yr)

Net Carbon Sequestration	$mT\ yr^{-1}$	Area (ha)
Minimum	0.0035	15.75
Maximum	0.90	0.09
Average	0.10	-
Total	1,721,226.88	1,883,558.79



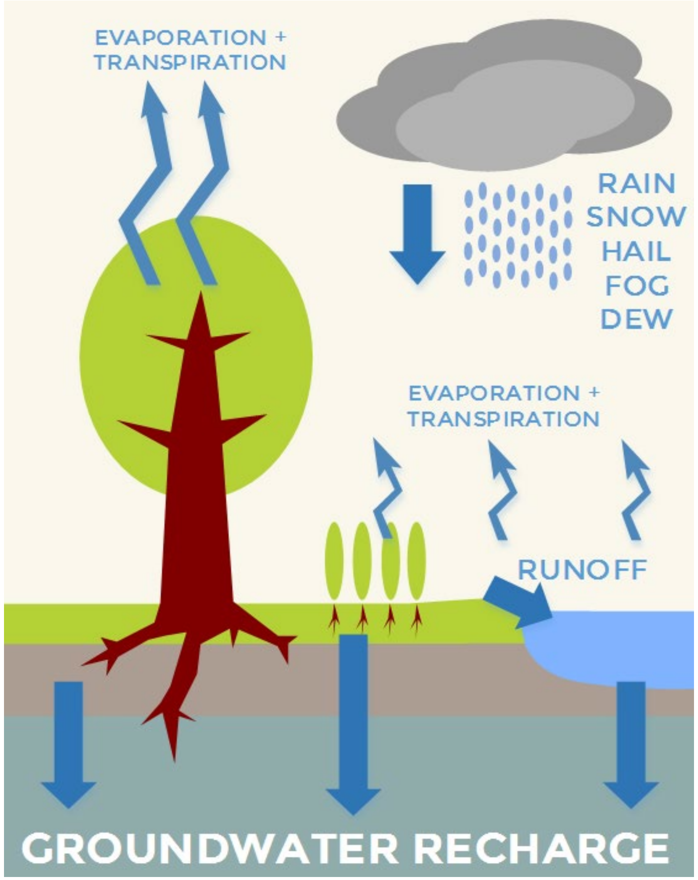
Groundwater Recharge

- Used the “Estimated Mean Annual Natural Groundwater Recharge, 2002” for MRB1 Catchments (mid-Atlantic)

- This layer was specifically created to estimate the mean annual natural groundwater recharge, in millimeters, per watershed catchment segment in the application of the national SPAtially Referenced Regression On Watershed attributes (SPARROW) model.

- Converted groundwater estimates to m^3 per 30m pixel.

- The underlying geology across the landscape is the primary driver of the rate that water enters unconfined and confined aquifers. The amount of impervious surface and soil condition also affect the amount of water reaching aquifers.

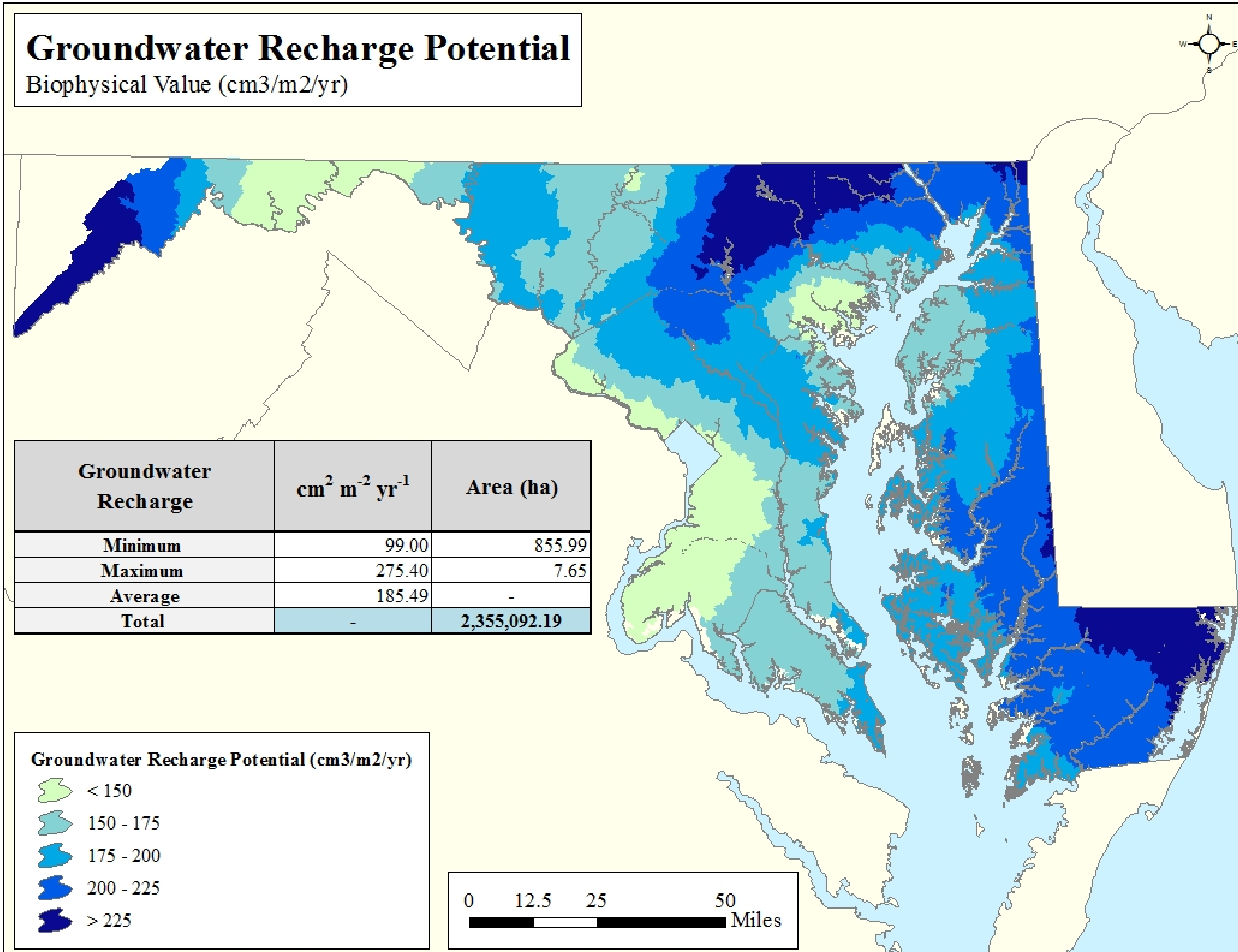


USGS science for a changing world
Water Resources NSDI Node

https://water.usgs.gov/GIS/metadata/usgswrd/XML/mrb_e2rf1_recharge.xml

Groundwater Recharge Potential

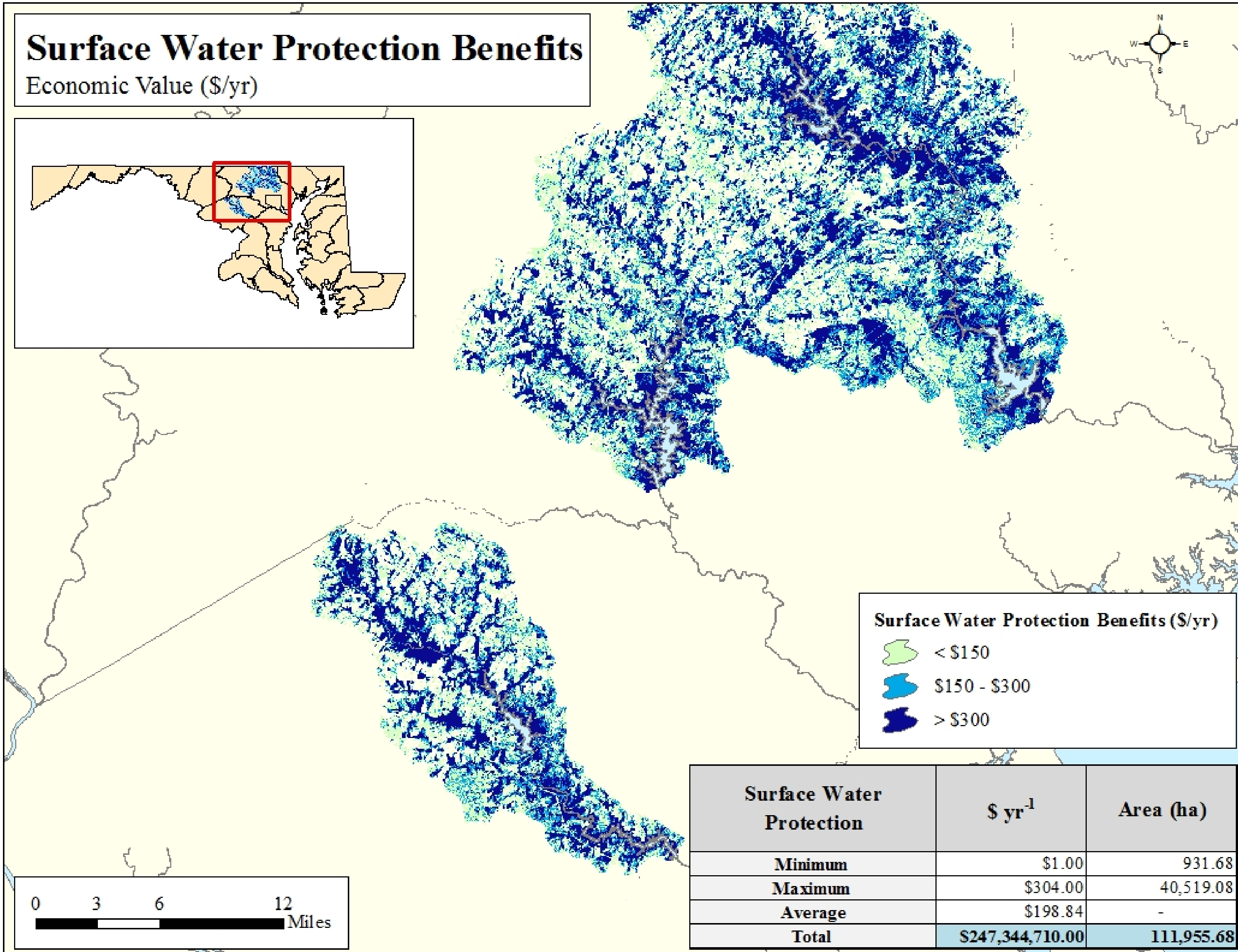
Biophysical Value (cm3/m2/yr)



Groundwater Recharge	$cm^2\ m^{-2}\ yr^{-1}$	Area (ha)
Minimum	99.00	855.99
Maximum	275.40	7.65
Average	185.49	-
Total	-	2,355,092.19

Surface Water Protection

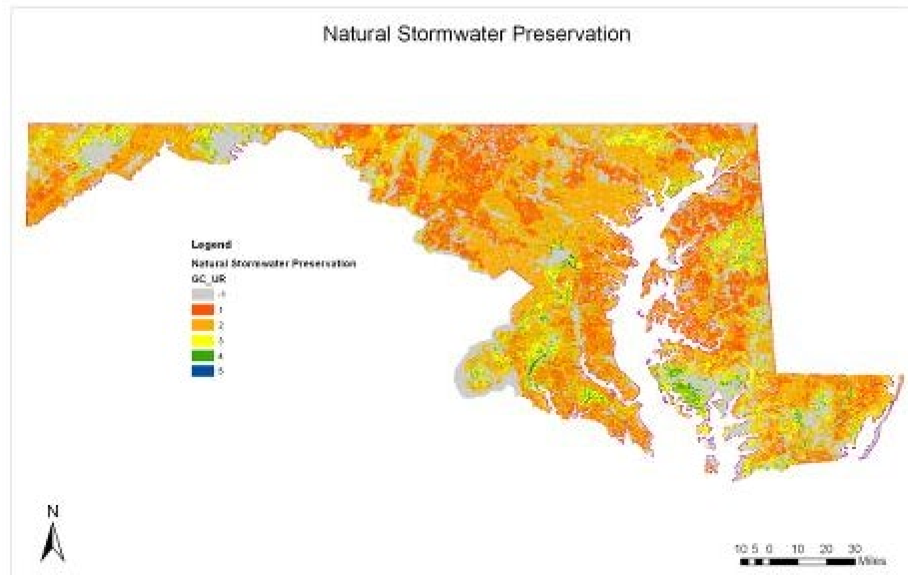
- Half of the water supply in Maryland is sourced from reservoirs.
- Natural lands reduce the cost to treat water from reservoirs to water supply standards
- Five major reservoirs in Maryland: Loch Raven, Liberty, Pretty Boy, Tridelphia, and Rocky Gorge



Surface Water Protection	$ yr^{-1}	Area (ha)
Minimum	$1.00	931.68
Maximum	$304.00	40,519.08
Average	$198.84	-
Total	$247,344,710.00	111,955.68

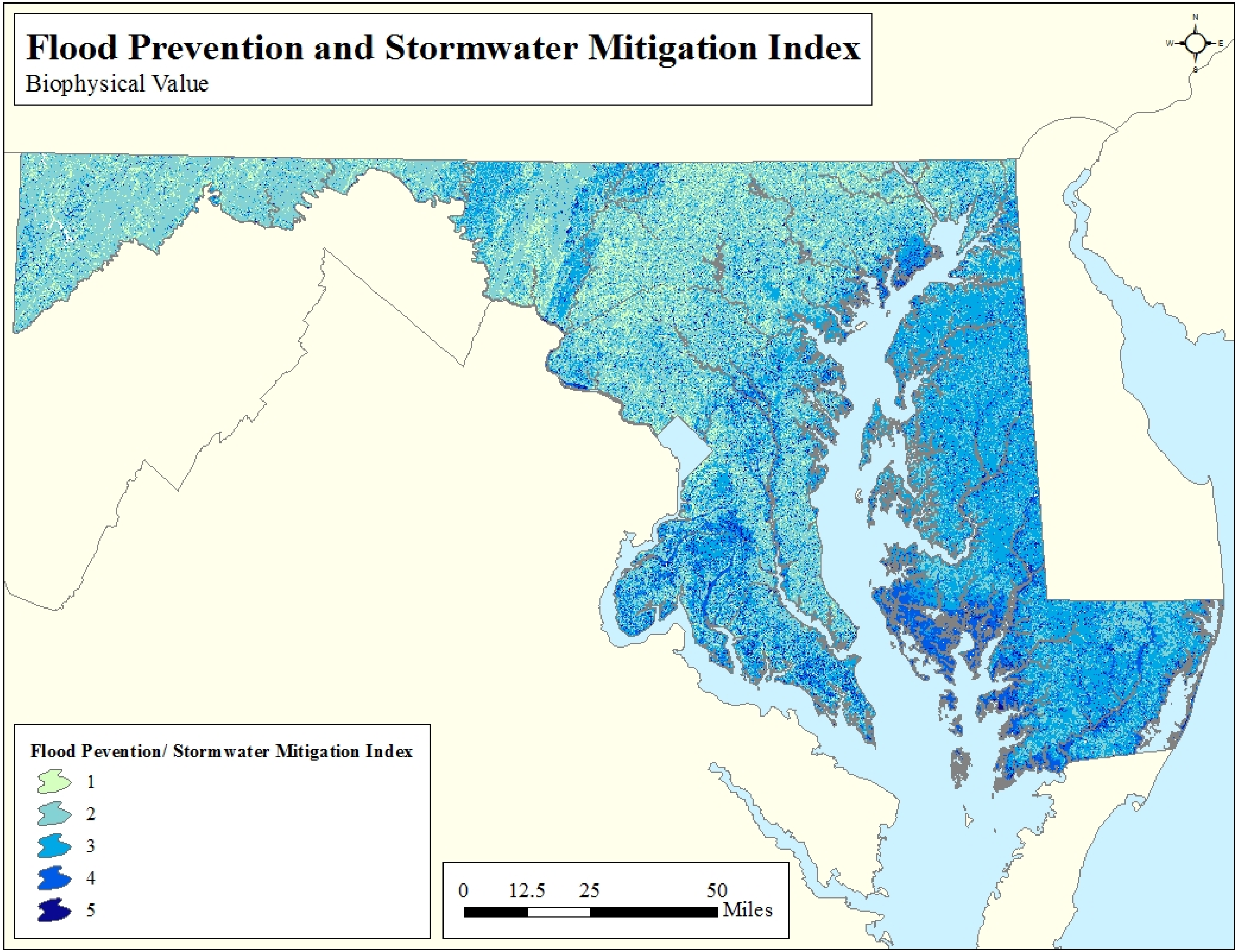
Flood Prevention and Stormwater Mitigation

- Created an index that ranks areas based on the volume of storm water treated.
- Used a modified version of the Watershed Resource Registry Stormwater Preservation model to rank the relative capacity and stormwater load across the landscape from 1-5
- Riparian areas, forests, and wetlands in watersheds with high impervious area upstream receive larger amounts of stormwater runoff. The type of soil, presence of floodplain, whether in a riparian area, type of wetland, and the impervious surface percentage of the surrounding watershed all factor into how much water runs off into the area and the ability of the area to absorb that water.



watershed resources registry

http://watershedresourcesregistry.com/detailsHp.html

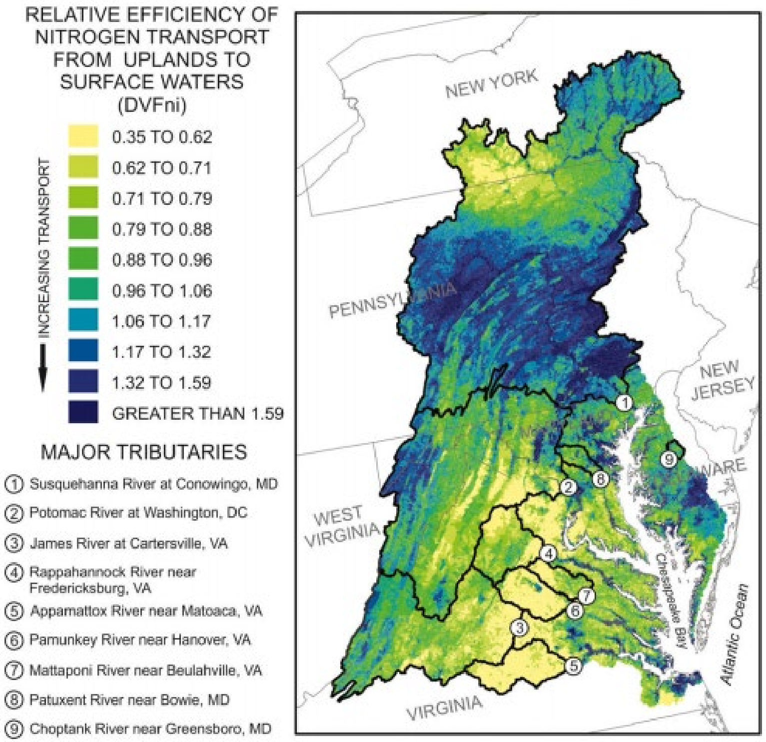

Flood Prevention and Stormwater Mitigation Index
Biophysical Value
N
W
E
S
Flood Pevention/ Stormwater Mitigation Index
1
2
3
4
5
0
12.5
25
50
Miles

Nitrogen Removal

- Used the USGS SPARROW (Spatially Referenced Regression on Watershed Attributes) model, which simulates the loading of nitrogen and phosphorus across the Chesapeake Bay watershed based on land-use, incoming nutrients from other watersheds, and atmospheric deposition.

- Classified catchments as having low, med, or high nitrogen loading.

- Calculated nitrogen uptake rates using average rates for low, medium, and high loading rates and landcover type based on published scientific literature. (Ator, 2011)



Ator and Garcia, 2016

https://water.usgs.gov/nawqa/sparrow/#

Nitrogen Removal

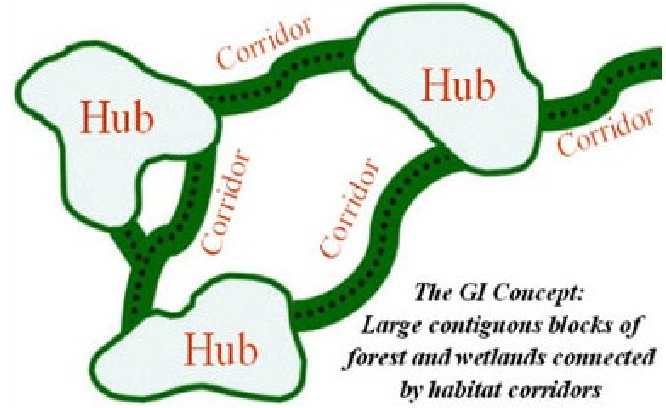
- In palustrine wetlands, floodplains process and store higher quantities of nitrogen than isolated wetlands.

- In estuarine wetlands, salinity is a significant factor in the ability to process and store nitrogen, with more saline wetlands tending to be more efficient in nitrogen removal.

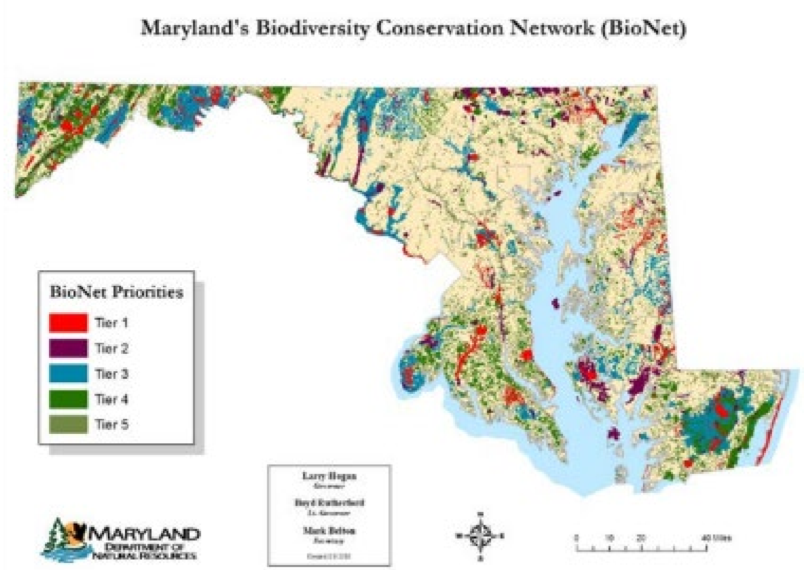
Ecosystem Type	Nitrogen Removal Rate	Reference
	kg/ha/yr	
Forest		
Low N Loading Watershed	5	CBP 2008[54]
Mid N Loading Watershed	10	CBP 2008
High N Loading Watershed	12	CBP 2008
Floodplains Wetlands		
Low N Loading Watershed	30	CBP 2008
Mid N Loading Watershed	80	CBP 2008
High N Loading Watershed	150	CBP 2008
Depressional Wetlands		
Low N Loading Watershed	10	CBP 2008
Mid N Loading Watershed	25	CBP 2008
High N Loading Watershed	50	CBP 2008
Estuarine Wetlands		
Tidal Fresh (0-2.5 ppt)	1750	Merrill & Cornwell 2000[55]
Brackish (2.5-18 ppt)	300	Merrill & Cornwell 2000, Kemp 2006[56]
Salt (18+ ppt)	900	Thomas & Christian 2001[57]

Wildlife Habitat and Biodiversity

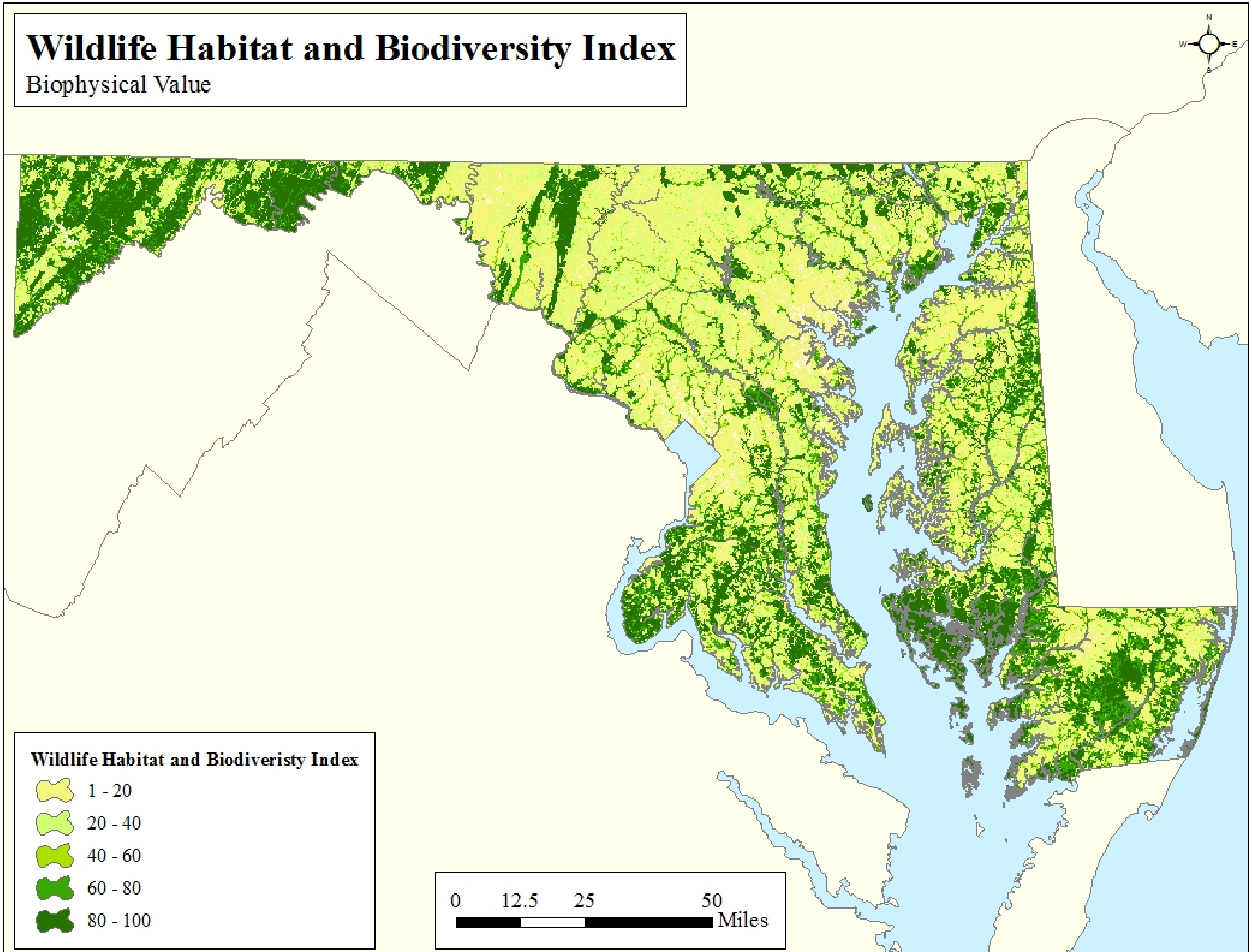
- Created an index showing the wildlife habitat and biodiversity potential of each 30m pixel.
- Considered the size of habitats and the degree of habitat connectivity using the MD Green Infrastructure (GI) Model.
  - Land in the Green Infrastructure was assigned into quintiles based upon their score, and assigned corresponding values.
- Considered the presence of rare species or rare species habitats using the MD BioNet Model.
  - Land in the top two ranks of MD BioNet was assigned the 1st and 2nd quintile of value, respectively.
- Forests and wetlands occurring outside both models were given the lowest quintile value.



http://dnr.maryland.gov/land/Pages/Green-Infrastructure.aspx



http://dnr.maryland.gov/wildlife/Documents/BIONET_FactSheet.pdf

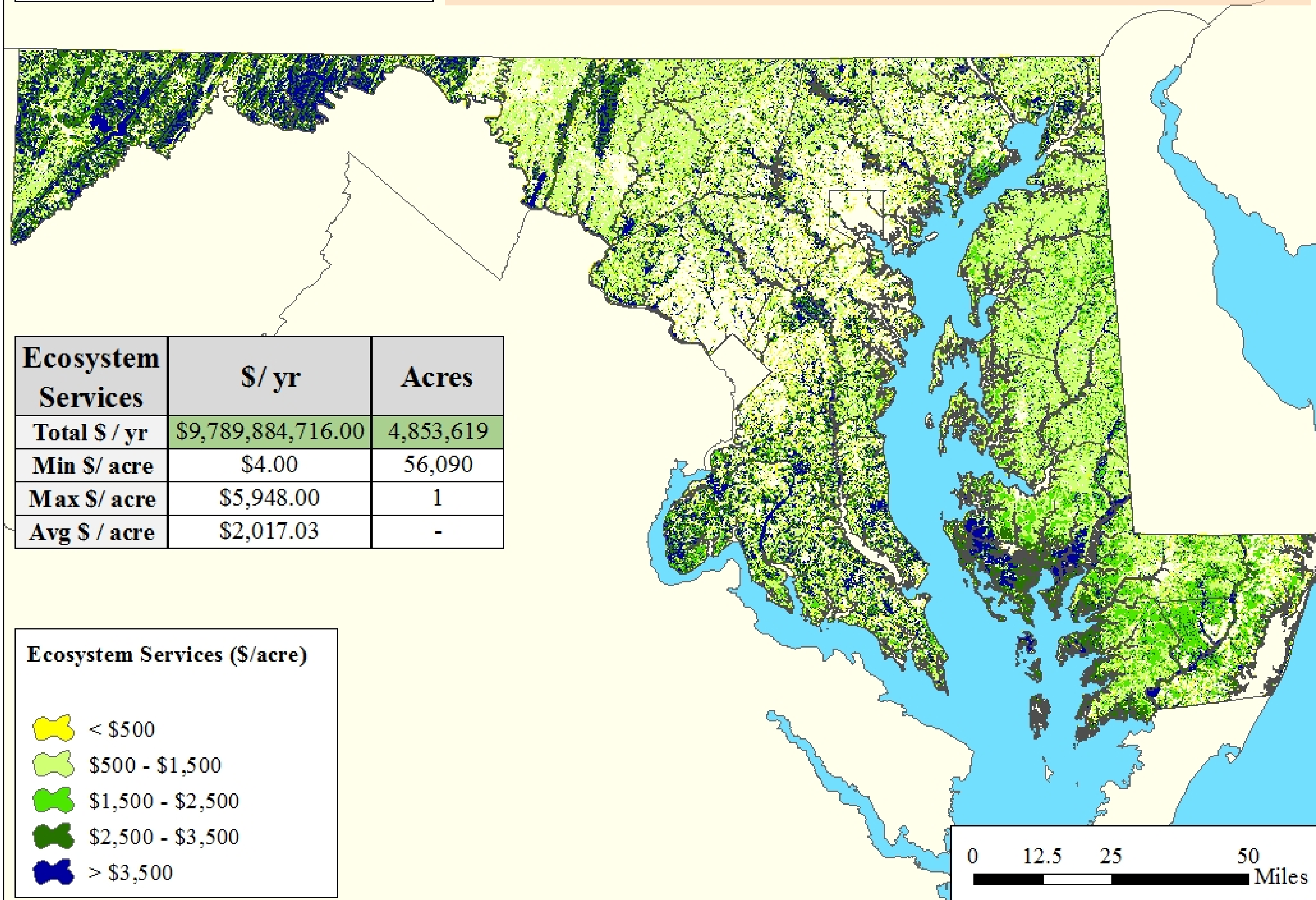

Wildlife Habitat and Biodiversity Index
Biophysical Value
N
W
E
S
Wildlife Habitat and Biodiveristy Index
1 - 20
20 - 40
40 - 60
60 - 80
80 - 100
0
12.5
25
50
Miles

Ecosystem Services

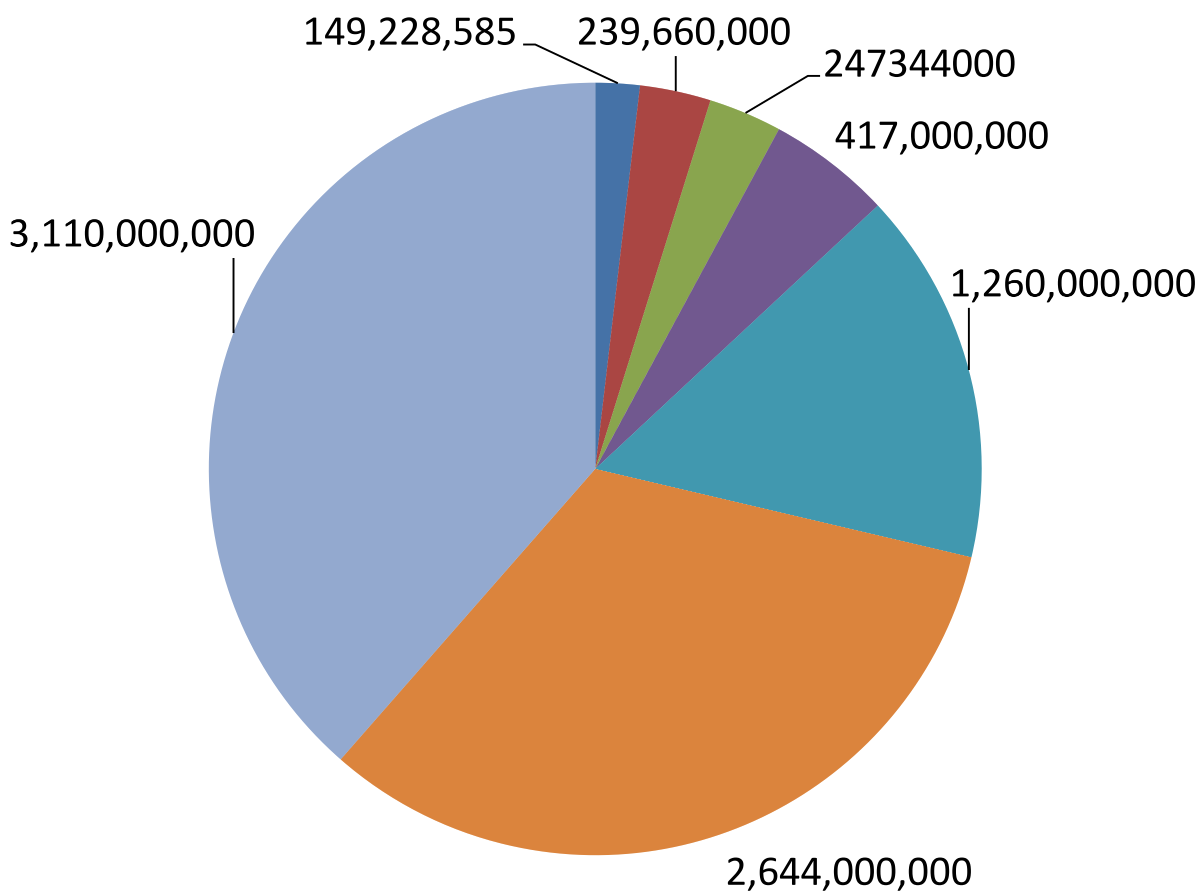
Total Economic Value

$8 billion of ES Benefits per year!

Ecosystem Services	$/ yr	Acres
Total $ / yr	$9,789,884,716.00	4,853,619
Min $/ acre	$4.00	56,090
Max $/ acre	$5,948.00	1
Avg $ / acre	$2,017.03	-



Ecosystem Service Totals



Units= $ per year

Next Steps

- Creating models for ecological restoration
- Include Services from Chesapeake Bay
- Incorporate new data
  - Wetland mapping
  - Higher resolution forest cover
  - New models
  - New eco-prices
- Collaborate with partners- Delaware, Pennsylvania, Chesapeake Bay Program, EPA Reg. 3, counties.

Thank you!

Questions?

Websites:
http://geodata.md.gov/greenprint/
http://dnr.maryland.gov/ccs/Pages/Ecosystem-Services.aspx
NESP Webinar: https://www.youtube.com/watch?v=56mDu3lH0-0

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