Mapping Wetlands of Delaware:

Assessing Spatial and Functional Changes from 2007 to 2017

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Mapping Specifications

Project completed under contract with The Conservation Management Institute at Virginia Polytechnic and State University and funded by EPA grant with State matching funds

Delaware provided 2017 color-infrared/4-band leaf-off imagery (.25 meter) along with previous years imagery (1997, 2002, 2007, 2012 at .25 or 1 meter for reference)

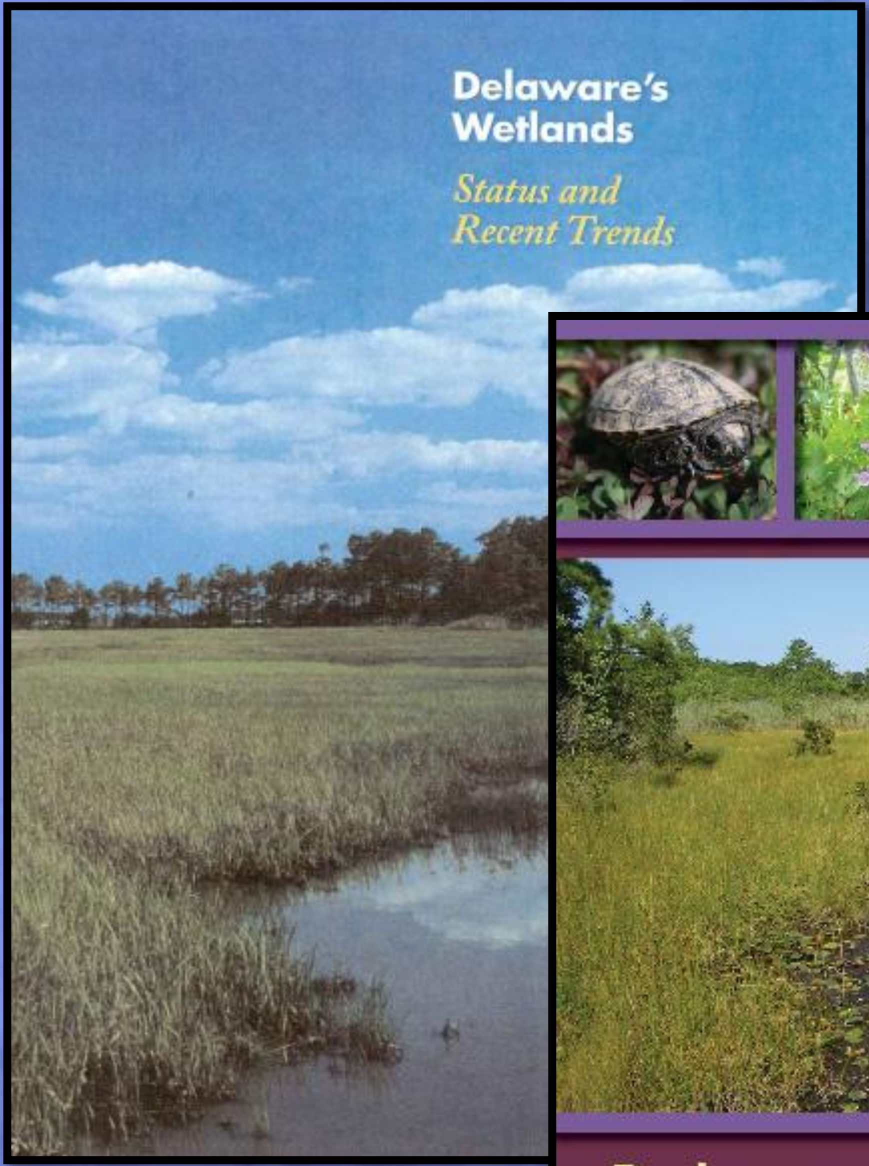
Other spatial data used: 2018 NAIP photography, National Hydrography Dataset (NHD), SSURGO (Hydric Soils only), NRCS Digital Raster Graphic (DRG), Digital Elevation Model (DEM)

53 full or partial 24k quadrangles within mostly Atlantic Coastal Plain and to lesser degree Piedmont physiographic regions

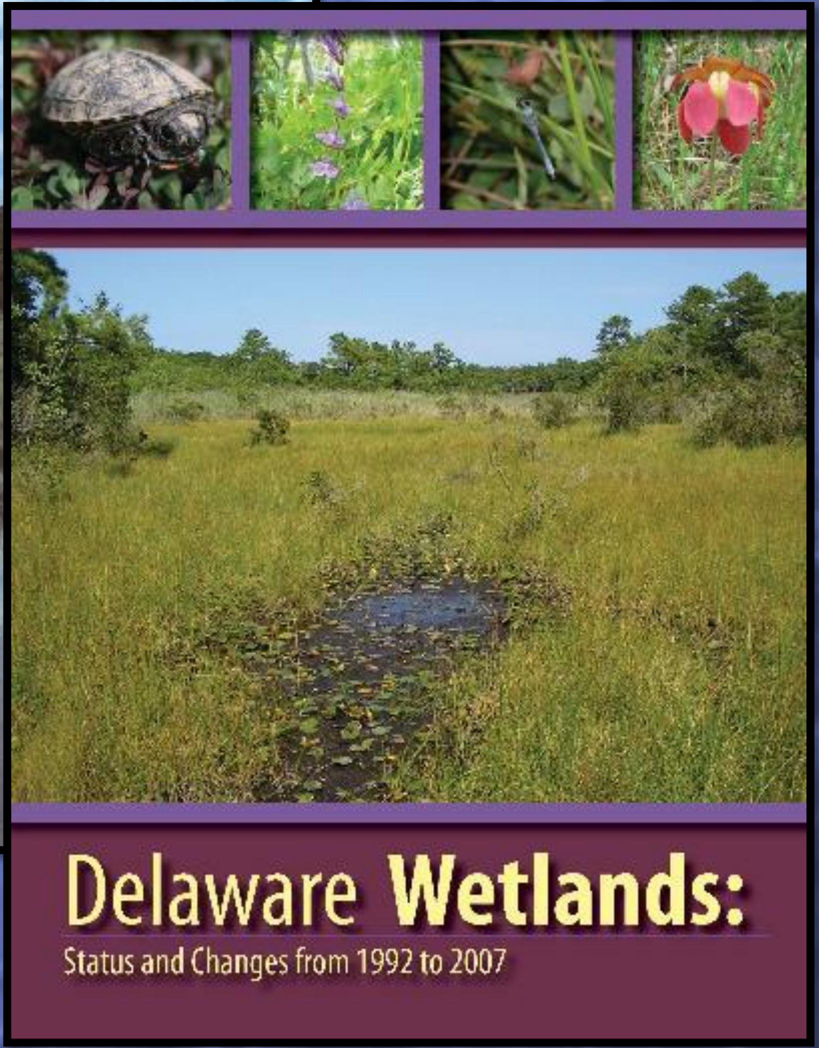
Cowardin et al. classification along with abiotic classification

Minimum mapping unit accuracy at .25 acre with polygons mapped to .10 acre and smaller

2007



1992



This is the fourth statewide wetland mapping effort (1982, 1992, 2007, 2017)

Status and Changes reports (2017 in production)

Ability to track wetland acreage and change in type, gains and losses

Using LLWW, can assess at the landscape level the potential of wetlands to perform certain functions

Notable changes applied in 2017 wetland mapping:

NWI Version 2 methodology (USFWS)

Removal of Hydric Wetland (H-wetland) polygons

Use of QL2 LiDAR and DEMs

Higher resolution imagery (9-inch statewide, 3-inch in State Parks)

* All created significant changes to final data analysis

NWI Version 2 methodology

Mapped wetland and deepwater habitats as in past and applied Cowardin et al. (1979) to all polygonal features

Incorporated hydrography data (NHD) into the mapping for a comprehensive data set of all wetlands and surface waters

Hydrography data became separate polygons (linears buffered)

Allows for more accurate adaptive management, geospatial summaries, and modeling

Removal of Hydric Wetland (H-wetland) polygons

2007 mapping a more conservative effort

Essentially created two sets of data: wetlands polygons and ‘potential’ wetland polygons (H-wetlands)

H-wetlands were areas with hydric soil and natural vegetation but without a visual wet signature on the ground during imagery analysis (~62,000 acres in 2007)

In 2017 either became wetland or not wetland

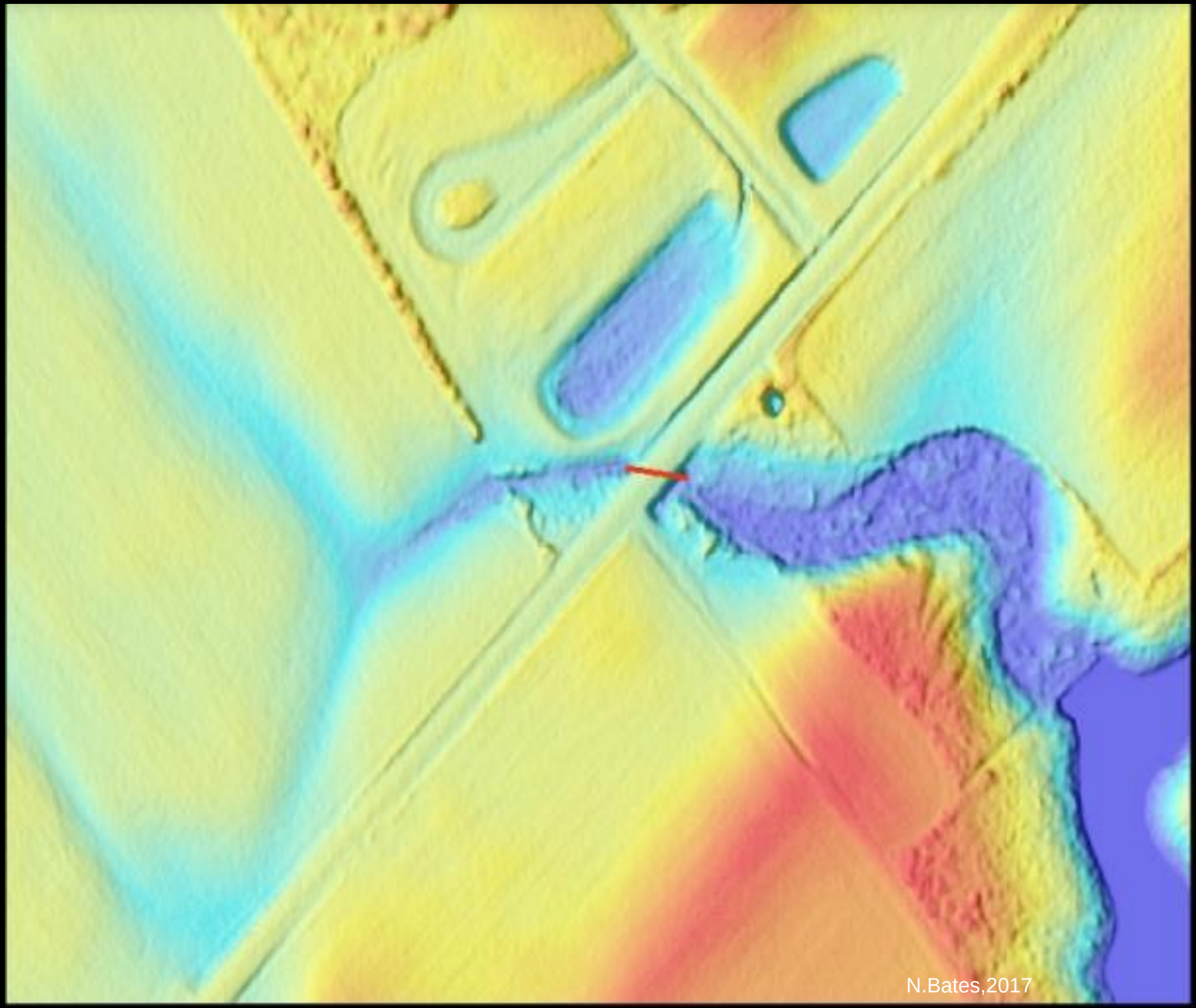
Use of QL2 LiDAR and DEMs

One of five levels of accuracy established by USGS for elevation data

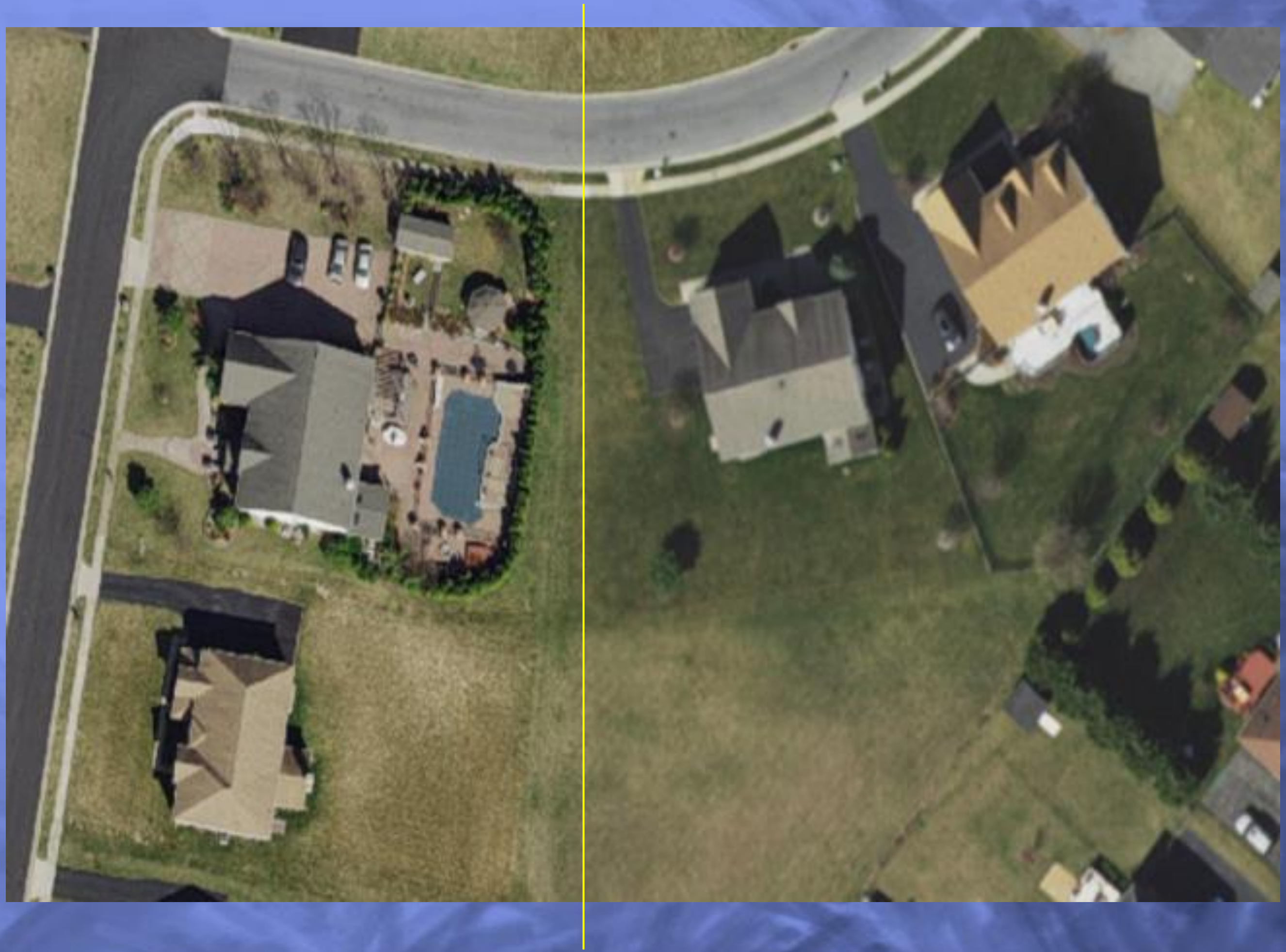
QL2 is the ‘sweet spot’ for level of accuracy and affordability

Delaware was part of the post Hurricane Sandy LiDAR collection

Provide much more specific elevation data to inform wetland polygon boundary mapping



High Resolution Imagery
(9-inch statewide, 3-inch in State Parks)



Best 4-band imagery to date for Delaware

Allowed for better analysis of ground area that may be in shadow (remove consideration as wet signature in processing)

Increased identification and attribution of vegetation types

More accurate depiction of polygonal boundaries

Imagery: Only a snapshot in time – degree of wetness varies

2007

2012

2017

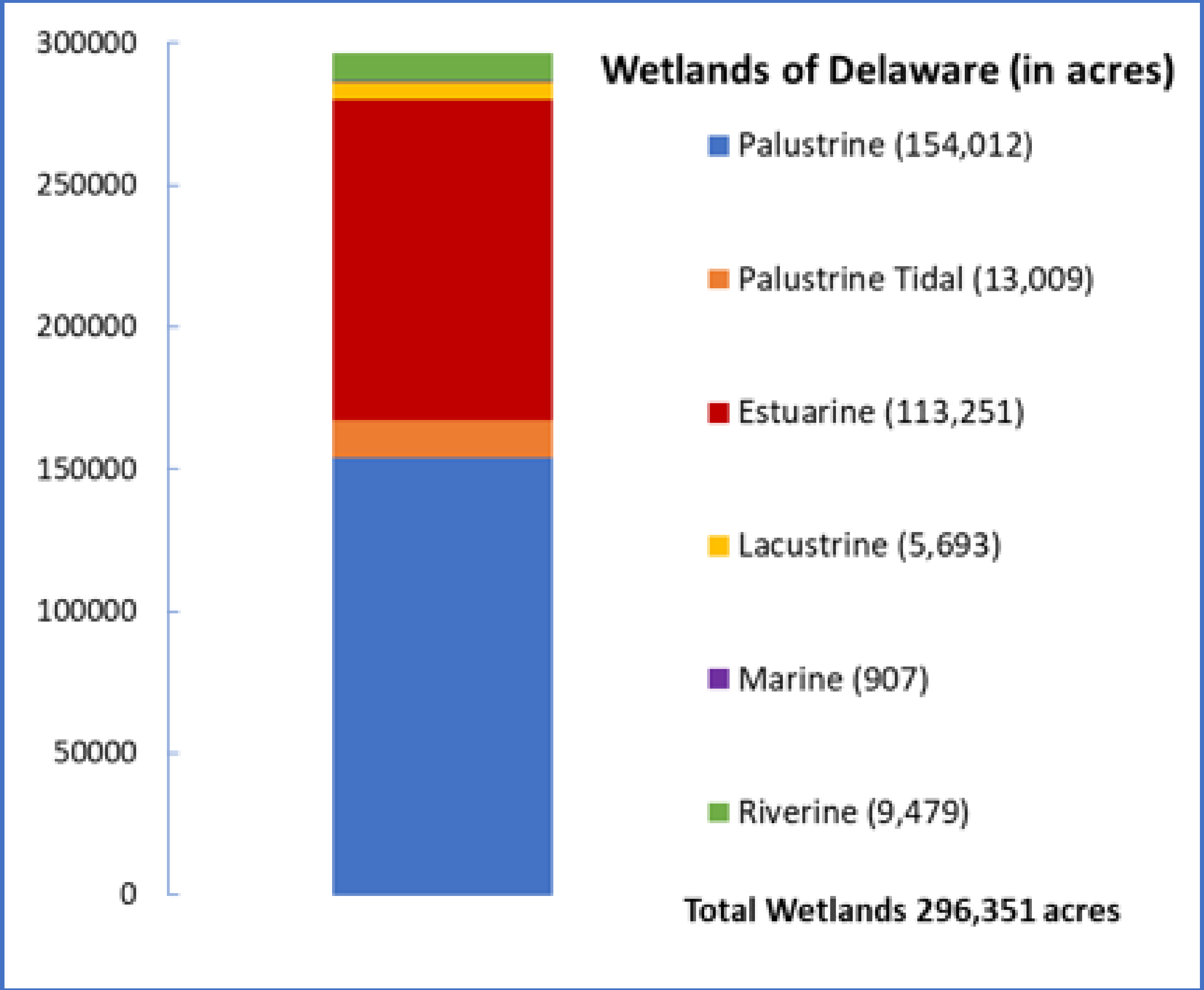
Delaware Wetland Mapping (2017)

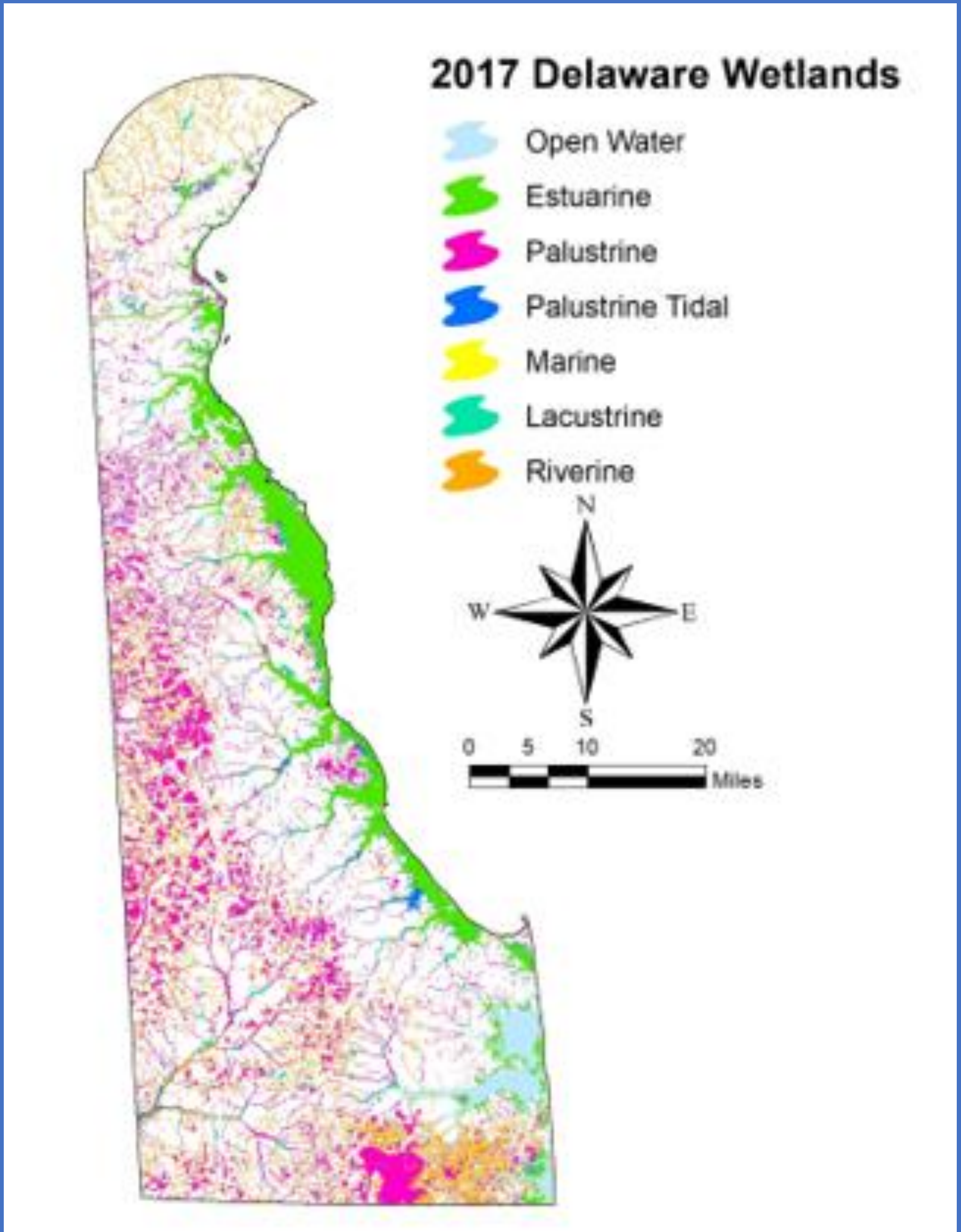
Statewide Totals

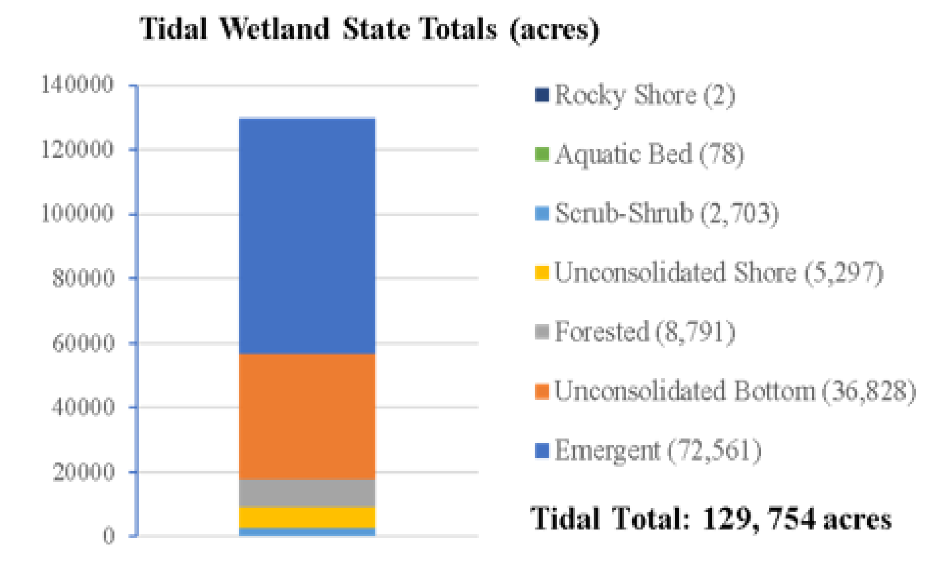
*320,076 acres in 2007

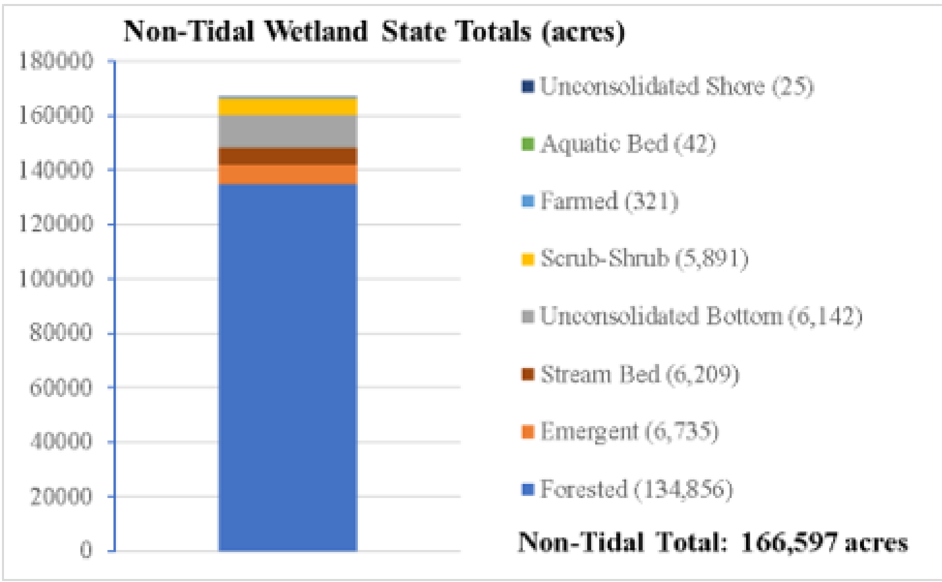
-- H-wetland removal

-- NHD now as polygons




2017 Delaware Wetlands
Open Water
Estuarine
Palustrine
Palustrine Tidal
Marine
Lacustrine
Riverine
N
W
E
S
0
5
10
20
Miles


Tidal Wetland State Totals (acres)
140000
120000
100000
80000
60000
40000
20000
0
Rocky Shore (2)
Aquatic Bed (78)
Scrub-Shrub (2,703)
Unconsolidated Shore (5,297)
Forested (8,791)
Unconsolidated Bottom (36,828)
Emergent (72,561)
Tidal Total: 129, 754 acres


Non-Tidal Wetland State Totals (acres)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Unconsolidated Shore (25)
Aquatic Bed (42)
Farmed (321)
Scrub-Shrub (5,891)
Unconsolidated Bottom (6,142)
Stream Bed (6,209)
Emergent (6,735)
Forested (134,856)
Non-Tidal Total: 166,597 acres

Assessing Wetland Loss, Gain, and Change 2007-2017 (acreage and function)

Mapping provides opportunity to track loss/gain/change over time for spatial extent and functional prediction

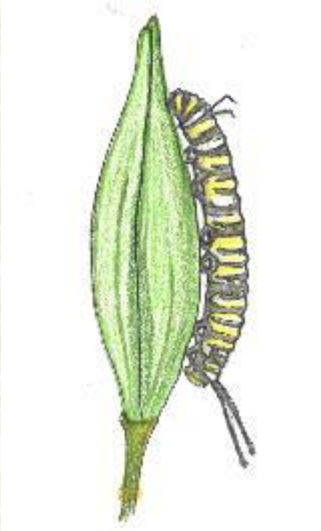
Delaware has three Status and Changes reports

1982-1992 (10 years) – 1,905 acres net vegetated loss
1992-2007 (15 years) -- 3,126 acres net vegetated loss
*2007-2017 (10 years) – 3,011 acres net vegetated loss

Ability to attribute cause of loss/gain/change

* in production

Wetland CHANGE 2007-2017



Swamp Milkweed
(*Asclepias incarnata*)
B.Haywood

Total wetland change 10-year period = 13,822 acres

Change of wetland from one type to another

64% tidal changes from vegetated to intertidal flat or open water
875 acres from tidal palustrine to estuarine
-- clear effects of sea level rise and saltwater intrusion

Majority of nontidal wetland acreage change due to succession or technique improvement

E1UBL (2007) to E2EM1P (2017)

E2EM (2007) to E1UB (2017)

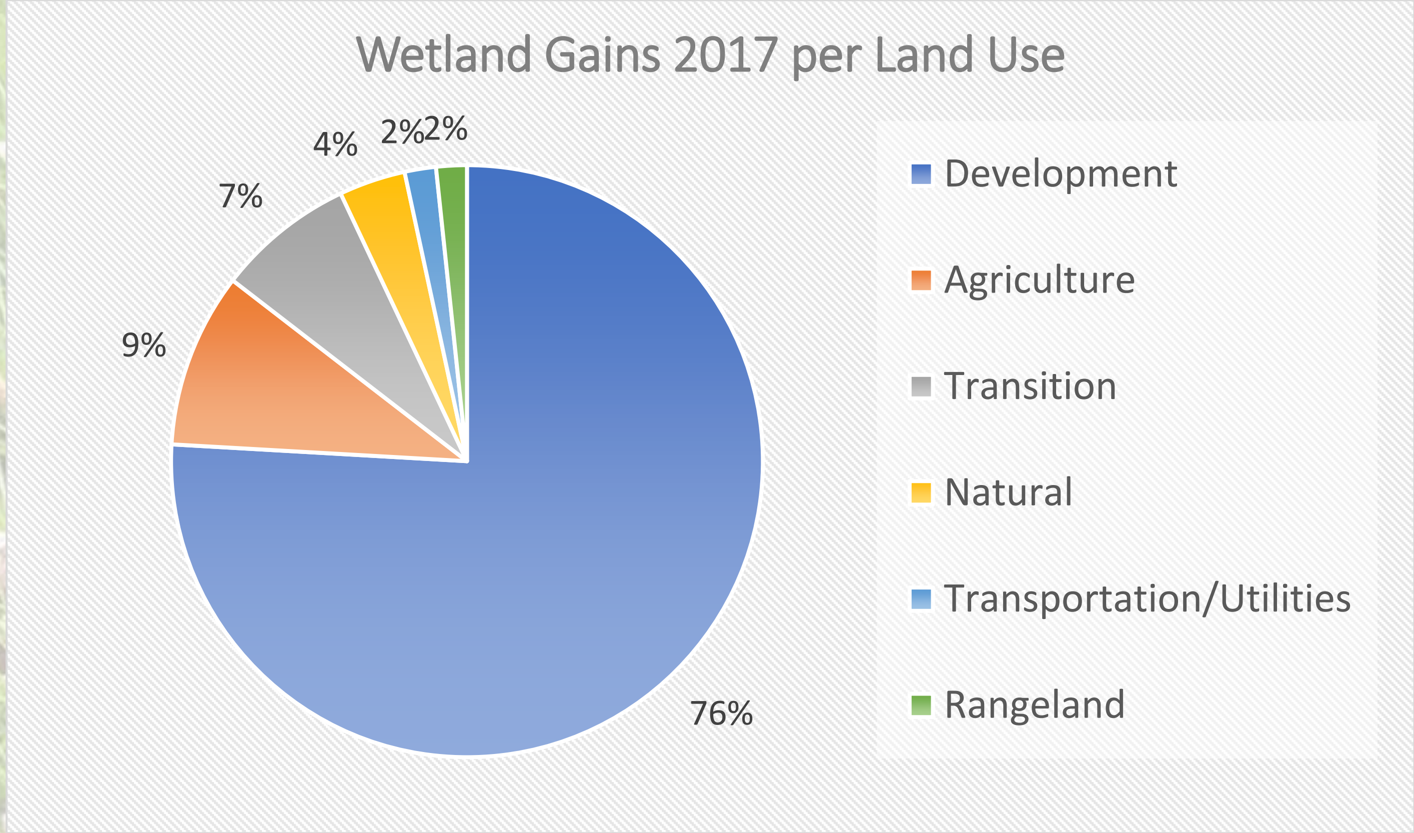
Evidence of sea level rise and saltwater intrusion

Forested in 2007 now mainly emergent with standing dead trees in 2017 (ghost forest)

Wetland CHANGE 2007-2017

Wetland Type	Change Type (2007-2017)	Change Description	Acres
Tidal	Saltwater intrusion:	Tidal palustrine to estuarine	919.3
	Vegetation growth from:	Estuarine unconsolidated bottom	559.2
		Intertidal unconsolidated shore	93.2
		Tidal freshwater ponds/lakes	14.8
	Vegetation loss to:	Intertidal unconsolidated or rocky shore	2,562.0
		Estuarine unconsolidated bottom	1,411.1
		Tidal freshwater ponds/lakes	5.9
	Vegetation changes:	Succession	172.8
		Increased flooding	431.4
	Total Tidal Changes		**6,169.7**
Non-tidal	Tidal regime:	Non-tidal to tidal	1,181.3
	Vegetation growth from:	Non-tidal freshwater ponds/lakes	729.8
	Vegetation loss to:	Freshwater ponds/lakes	266.6
	Vegetation changes:	Succession	2,772.6
		Increased flooding	314.3
		Deforestation	2,387.9
	Total Non-tidal Changes		**7,652.5**

Wetland GAIN 2007-2017



Blackgrass Rush
(*Juncus gerardii*)
B.Haywood

Development	893.274705
Agriculture	112.408322
Transition	88.504761
Natural	42.782315
Transportation/Utilities	20.136748
Rangeland	19.696792
Grand Total	**1176.803643**

(in acres)

Wetland GAIN 2007-2017

Total wetland gain 10-year period = 1,176 acres

Most gains are stormwater ponds from residential development *

Sand/gravel operations

Restoration/mitigation

*stormwater ponds only provide a fraction of wetland functions compared to natural wetlands

LOSS

GAIN

2007

2017

Wetland LOSS 2007-2017

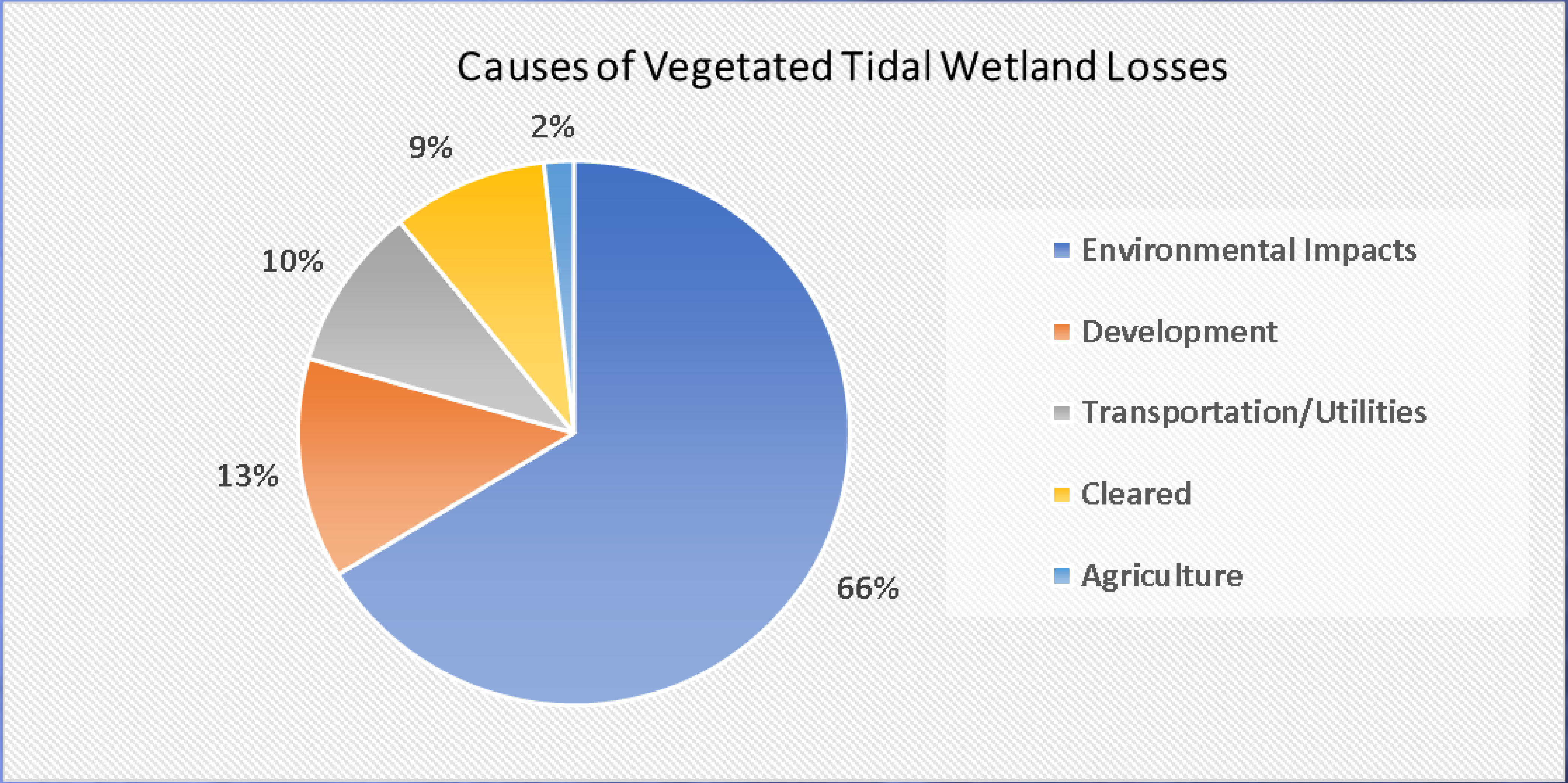
Spotted Water Hemlock
(*Cicuta maculata*)
B.Haywood

Total wetland loss 10-year period = 3,011 acres

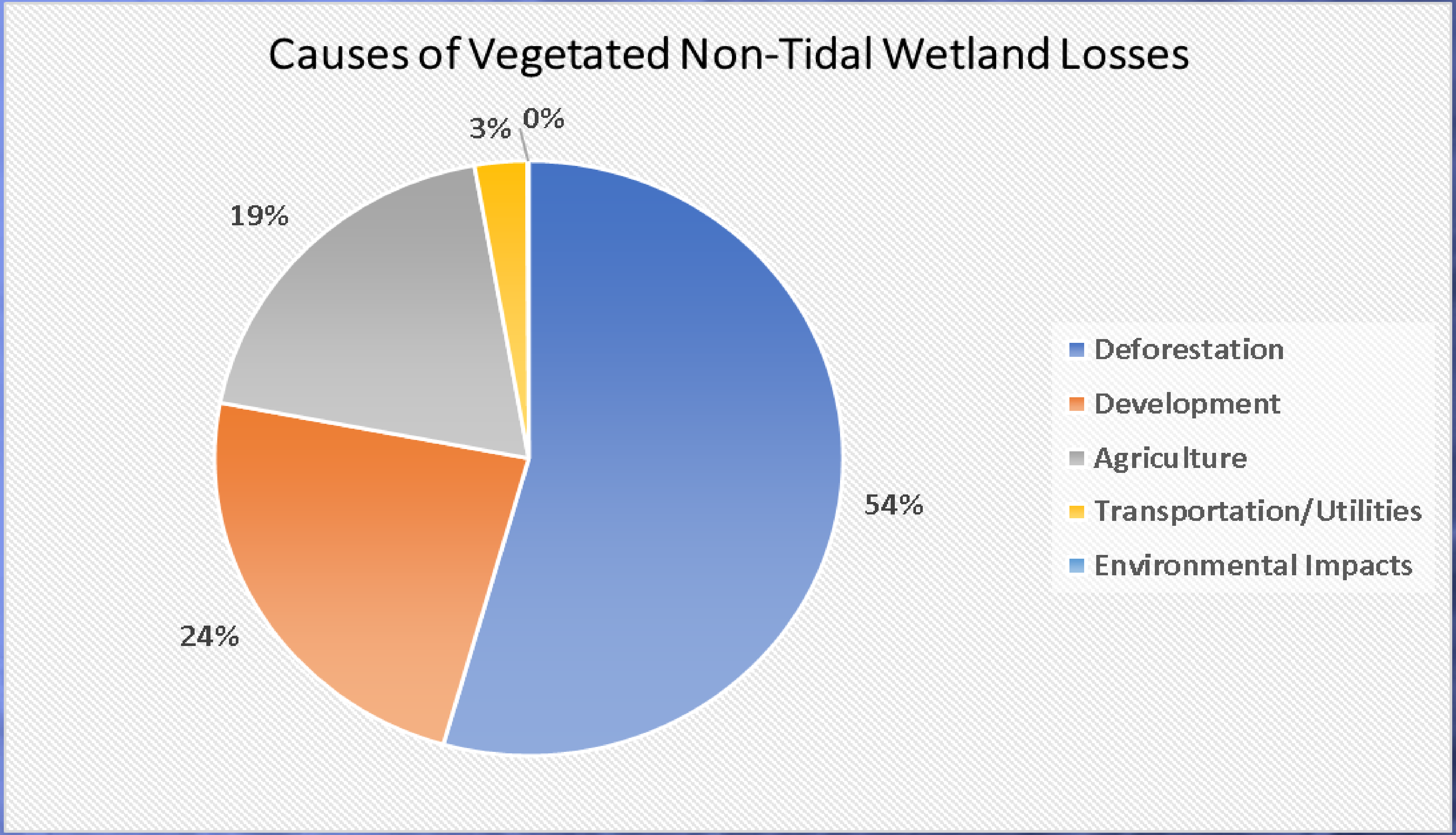
2,773 acres of nontidal wetlands
238 acres to tidal wetlands

Loss to nontidal wetlands is mostly due to human-induced causes

Loss to tidal wetland is mostly due to natural causes



Proportions of vegetated tidal wetland losses from different causes between 2007 and 2017. Only wetlands ≥ 0.25 acres in size were included in calculations of proportions.



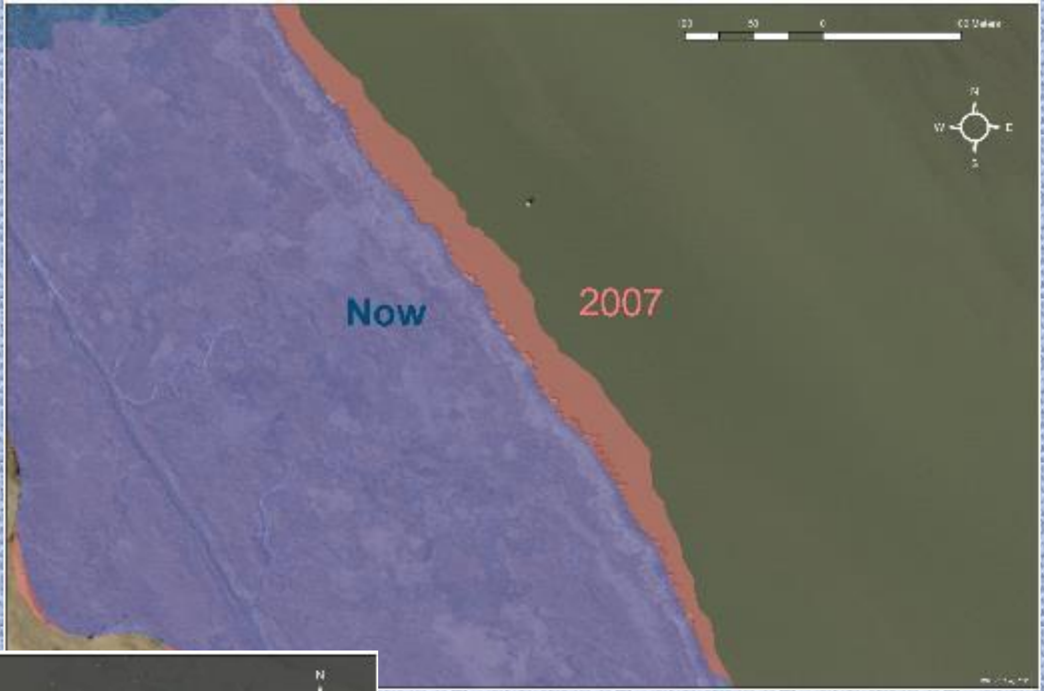
Proportions of vegetated non-tidal wetland losses from different causes between 2007 and 2017. Only wetlands ≥ 0.25 acres in size were included in calculations of proportions.

LOSS to Transportation Projects

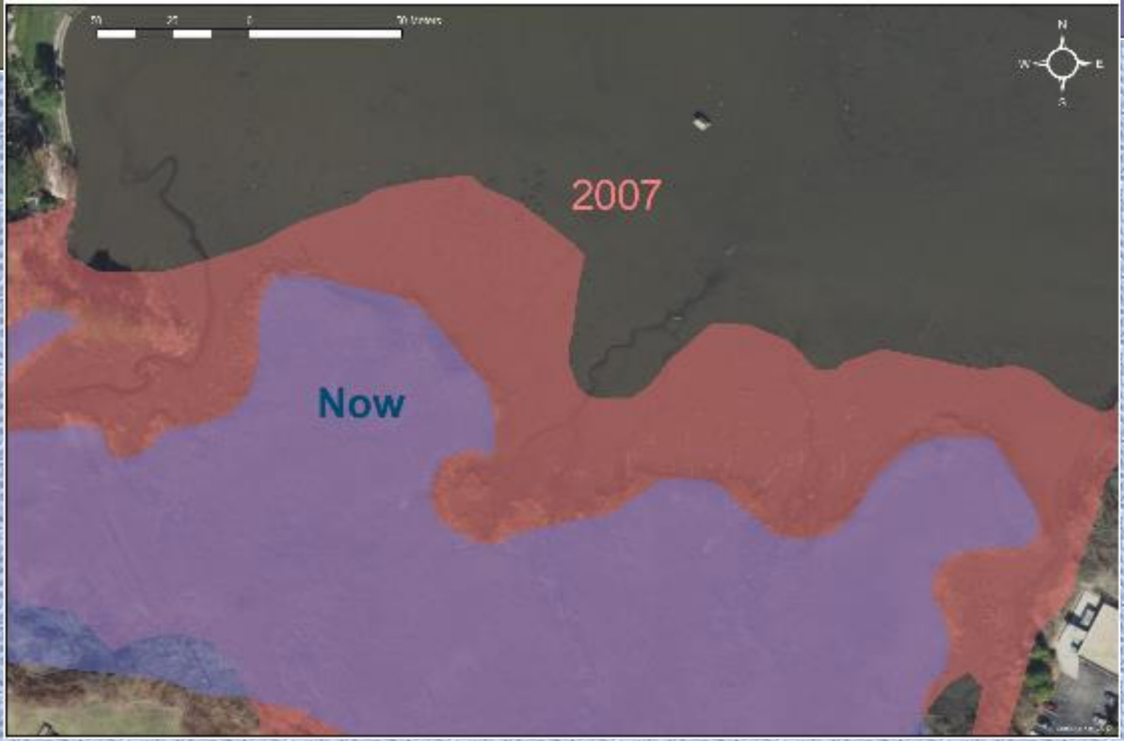
LOSS to Development Projects

LOSS to Natural Causes

Bombay Hook NWR



Cedar Swamp SWA



Millsboro

Prime Hook National Wildlife Refuge and Hurricane Sandy (2012)

Beach dune breached – destroyed one of the most mature freshwater coastal impoundment systems in the Mid-Atlantic region

Has now been successfully restored to tidal marsh system

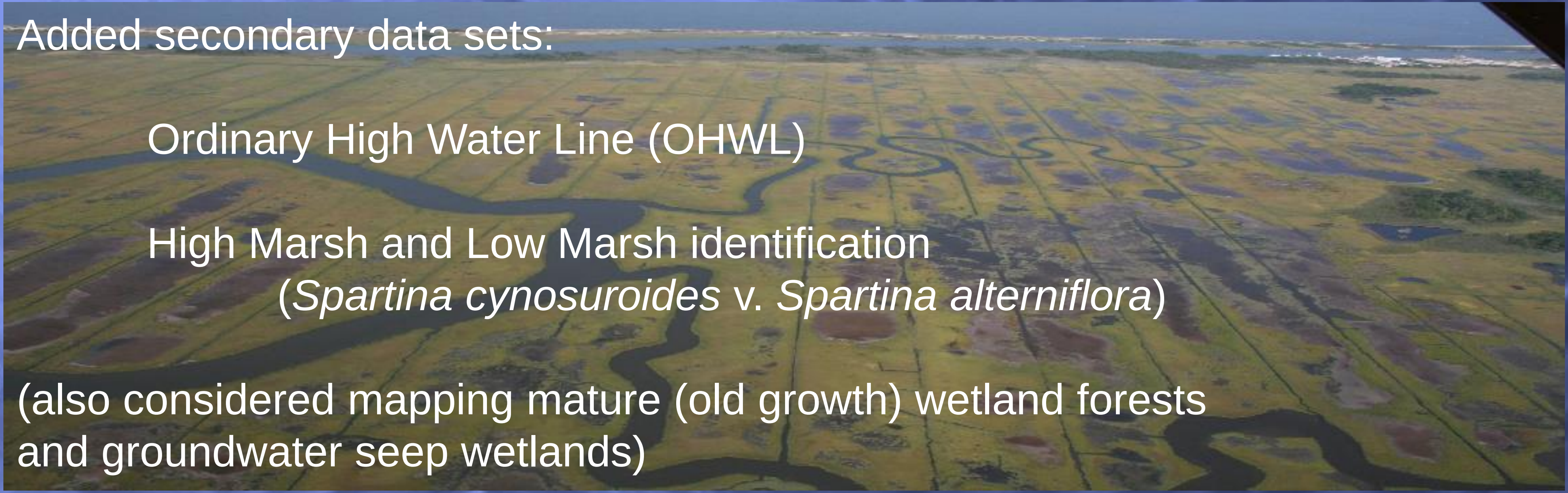
Prime Hook NWR (cont.)

Evidence of forest retreat due to saltwater intrusion from Hurricane Sandy

Opportunities for new wetland-associated spatial data

Increased focus on coastal changes due to sea-level rise and erosion and we've been tracking coastal wetland loss since 1992

Identified need for additional data to precisely understand and track coastal changes over time



Added secondary data sets:

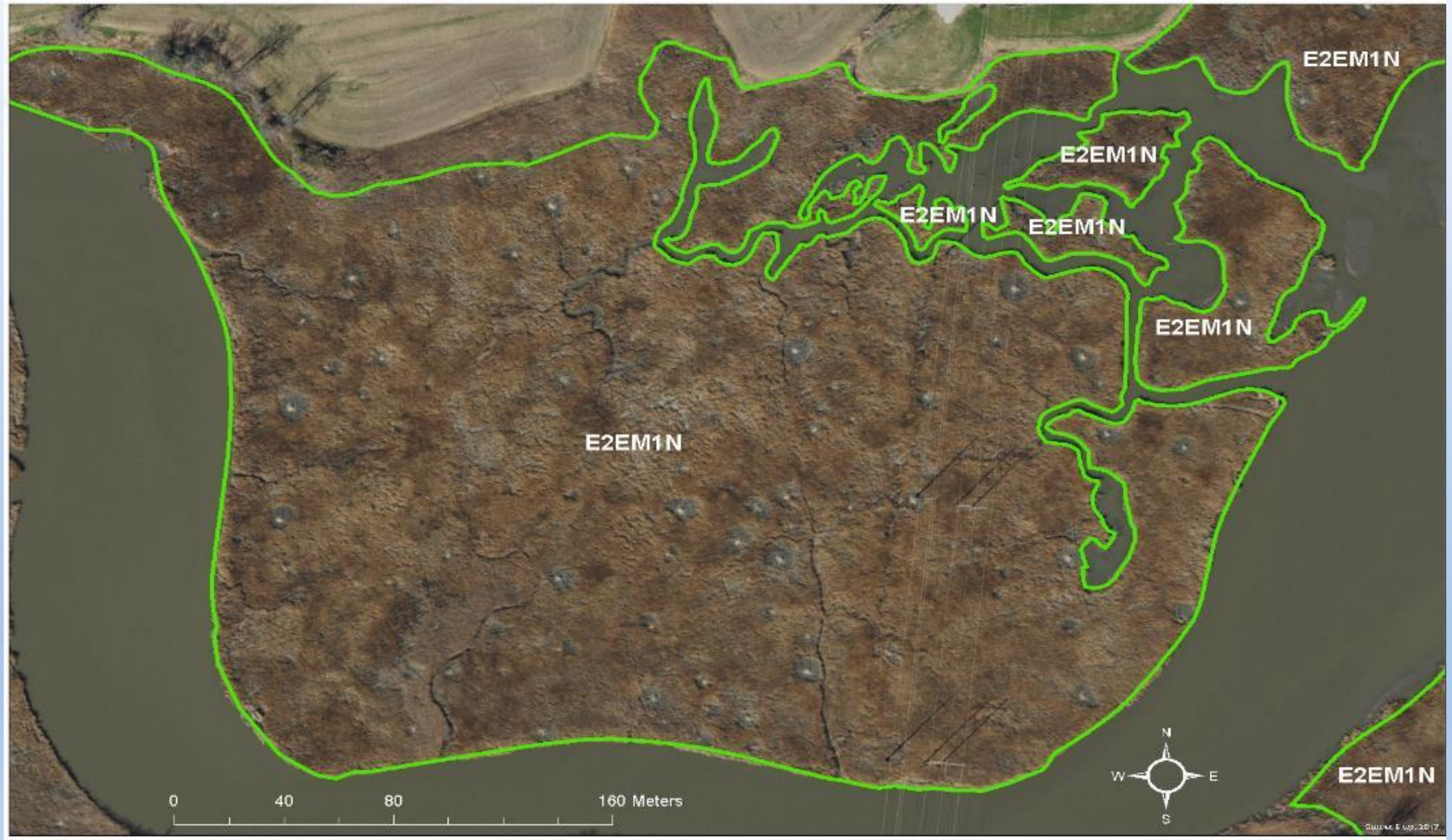
- Ordinary High Water Line (OHWL)
- High Marsh and Low Marsh identification
    - (*Spartina cynosuroides* v. *Spartina alterniflora*)

(also considered mapping mature (old growth) wetland forests and groundwater seep wetlands)

High marsh and low marsh acreage in Delaware based on the 2017 high marsh and low marsh wetland maps.

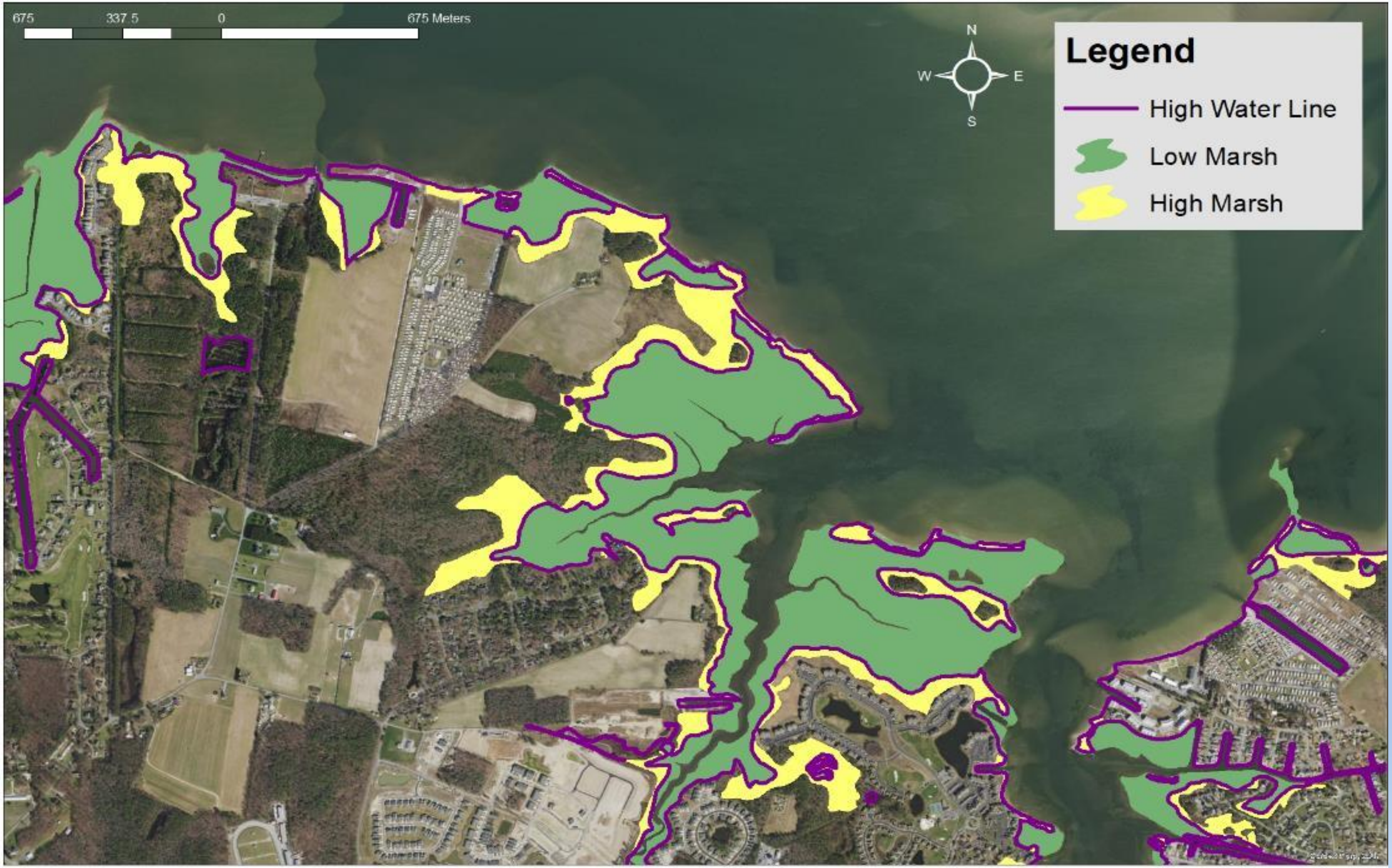
Marsh type	Subsystem	Class	Total Acreage
High marsh	Intertidal		
	Vegetated	Emergent	17,933
		Scrub-shrub	339
		Forested	110
	Nonvegetated	Unconsolidated shore	246
		Rocky shore	2
	Total Mapped		18,630
Low marsh	Intertidal		
	Vegetated	Emergent	52,983
	Nonvegetated	Unconsolidated shore	4,900
	Total Mapped		57,883

Example of Estuarine wetland identified as ‘low-marsh’



Example of Estuarine wetland identified as 'high marsh' (5=*Phragmites australis*)

Example of Ordinary High Water Line


675
337.5
0
675 Meters
N
W
E
S
Legend
High Water Line
Low Marsh
High Marsh

Wetland Functional Analysis

Use of abiotic features to predict wetland functions

LLWW (Tiner, 2003)
Landscape Position, Landform, Water Flow Path, Waterbody Type (derived from HGM classification)

First applied in Delaware as part of the 2007 statewide wetland mapping

Ability to predict at landscape level the potential for wetland types to perform 11 functions at a high or moderate level

Source: USFWS, NWI

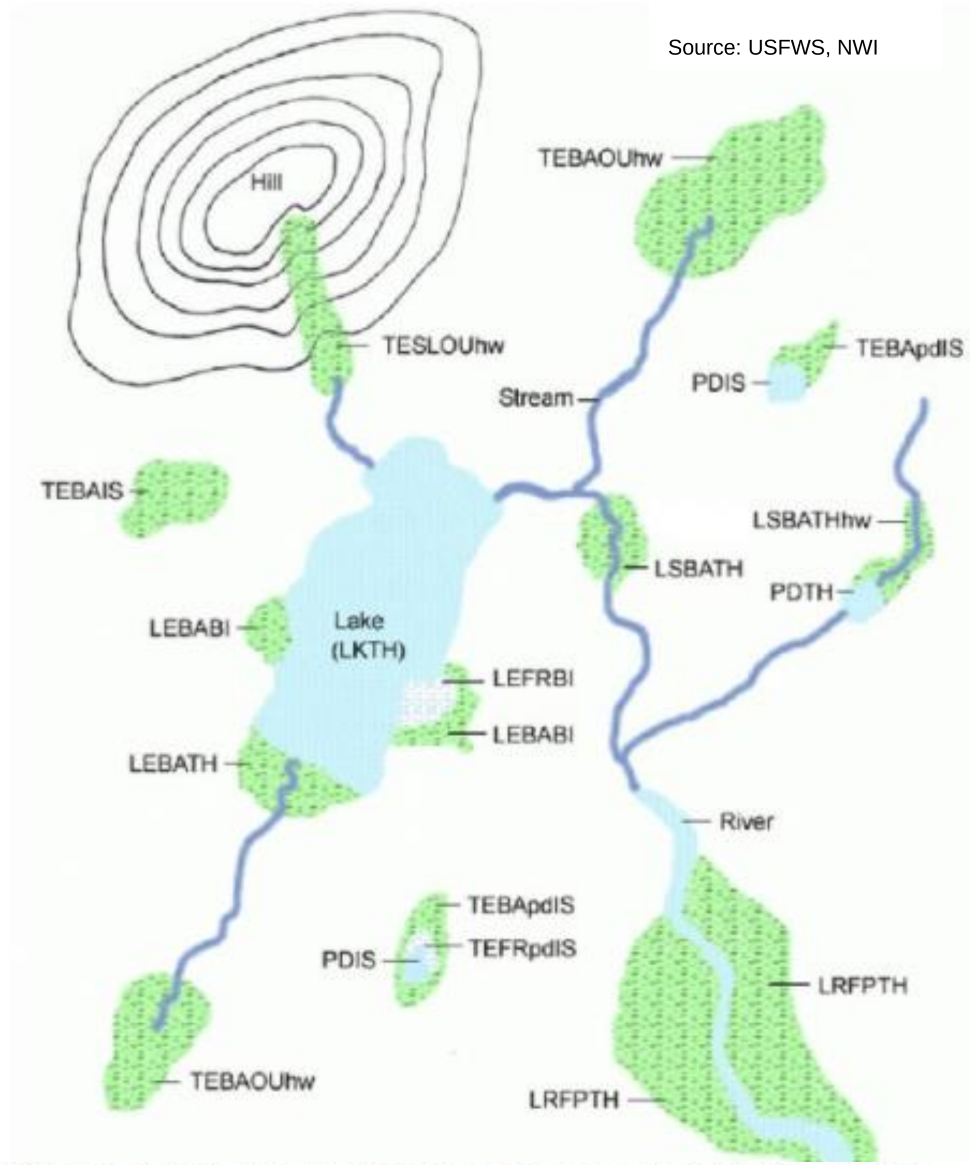


Figure 1. Application of LLWW descriptors to a region with nontidal wetlands. Landscape positions: LR – lotic river, LS – lotic stream, LE – lentic, and TE – terrene; Landforms: BA – basin, FR – fringe, FP – floodplain, SL – Slope; Water flow paths: OU – outflow, IS – isolated, TH – throughflow, BI – bidirectional-nontidal; other descriptors: pd – pond (association), hw – headwater; Waterbodies: PD – pond, LK – lake. Note: Landscape position can be added to lakes and ponds if desirable.

11 Wetland Functions (LLWW)

1. Surface Water Detention (SWD)
2. Coastal Storm Surge Detention (CSS)
3. Streamflow Maintenance (SM)
4. Nutrient Transformation (NT)
5. Sediment Retention (SR)
6. Carbon Sequestration (CAR)
7. Bank and Shoreline Stabilization (BSS)
8. Provision of Habitat for Wildlife (OWH)
9. Provision of Fish and Aquatic Invertebrate Habitat (FAIH)
10. Provision for Waterfowl and Waterbird Habitat (WBIRD)
11. Provision for Unique, Uncommon, or Highly Diverse Wetland Plant Communities (UWPC)

Wetland Function	2017 Acreage	% of DE's Wetlands likely performing at moderate to high levels	2007 Acreage
1. Surface Water Detention (This function is limited to freshwater wetlands; the role of coastal wetlands in water storage is handled by the Coastal Storm Surge Detention function.)	150,203	50.6	171,045
2. Coastal Storm Surge Detention (This function includes tidal wetlands plus contiguous nontidal wetlands subject to flooding during storm	94,096	31.8	85,523
3. Streamflow Maintenance (These wetlands are sources of streams or along first order perennial streams or above.)	112,825	38.1	134,620
4. Nutrient Transformation	261,078	88.0	246,847
5. Carbon Sequestration	256,802	86.6	249,012

Wetland Function	2017 Acreage	% of DE's Wetlands likely performing at moderate to high levels	2007 Acreage
6. Sediment and Other Particulates Retention	149,215	50.3	156,756
7. Bank and Shoreline Stabilization	203,469	68.6	182,105
8. Fish and Aquatic Invertebrate Habitat Stream Shading	136,087 106,349	45.9 35.8	78,230 36,935
9. Waterfowl and Waterbird Habitat Wood Duck	85,691 24,423	29.0 8.2	80,920 25,691
10. Other Wildlife Habitat	230,112	77.6	248,090
11. Unique, Uncommon, or Highly Diverse Wetland Plant Communities (The following types are included in this category: estuarine aquatic beds, regularly flooded salt marsh (low marsh), slightly brackish tidal marshes, tidal freshwater flats (e.g., wild rice beds), marshes and shrub swamps, Atlantic white cedar swamps, bald cypress swamps, and lotic fringe wetlands.)	Did not assess	N/A	54,963

Wetland Functional Trends Assessment

- Significant differences in most functions between 2007 and 2017 that don’t align well with the spatial extent (acreage) differences

- Improved mapping techniques, succession/change in type, gains/losses, and the incorporation of hydrography data as polygons contributed to wide swings in functional prediction

- Some functions increased and some decreased

- Overall accuracy improved which will lead to more concise functional assessment and tracking over time

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Thank you for the opportunity:
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and
Wetland Mapping Consortium

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