Monitoring and Assessment of Coastal Wetlands in Representative Estuaries of the Mid-Atlantic

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PARTNERSHIP FOR THE DELAWARE ESTUARY, INC

BARNEGAT BAY PARTNERSHIP
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Tidal Wetlands

A Hallmark of the Delaware Estuary

Near Contiguous Band

Diverse: *Freshwater Tidal Marshes*

Brackish Marshes

Salt Marshes

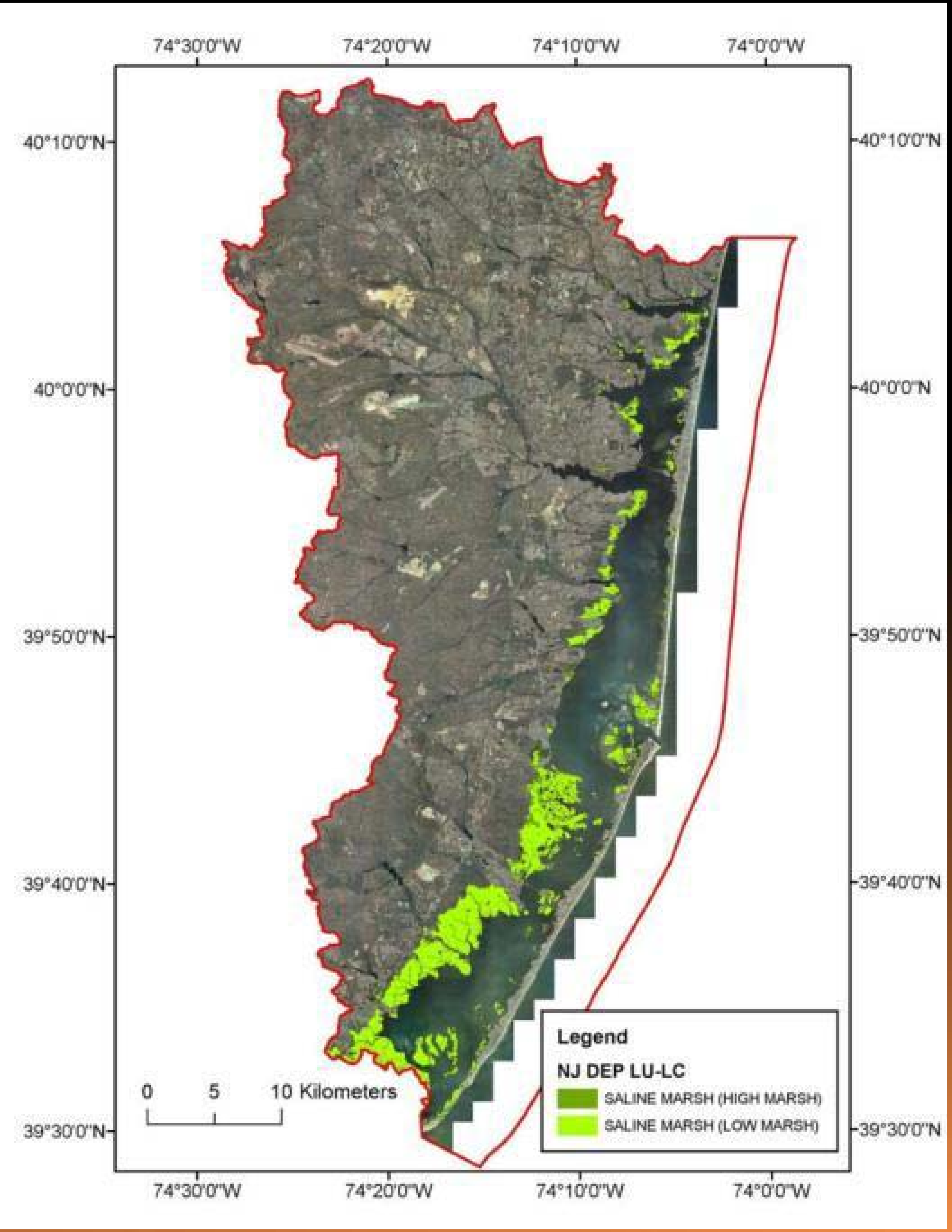
<u>Nature's Benefits</u>

- Flood Protection
- Fish and Wildlife
- Natural Areas
- Carbon Sequestration
- Water Quality

Barnegat Bay

mainly salt marshes

High Salt Marsh	
Low Salt Marsh	



Coastal wetland monitoring and assessment:
Why it is important for your state or organization?

Coastal wetlands are:

- a hallmark feature of the Delaware and Barnegat Estuaries
- critical for sustaining fish and wildlife, preserving water quality, and protecting against flooding *(especially post-Sandy!)*
- one of the most degraded habitats due to past land use practices and degradation
- increasingly threatened by increasing sea level, salinity, storms

Tracking and understanding the health and acreage of coastal wetlands is a top priority for the National Estuary Programs and coastal managers

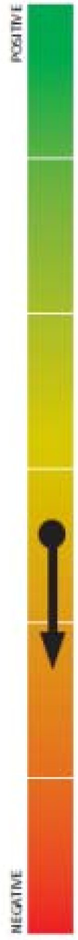
State of the Estuary Report 2008

We were seeing declines but significant data gaps

<u>Acreage</u>?
no recent, consistent, high resolution data across the estuary

<u>Condition</u>?
no data

Tidal Wetlands



INDICATOR DESCRIPTION: Coastal wetlands are one of the Delaware Estuary's most important and characteristic habitats, and they are a premier environmental indicator for the area's ecosystem. The Estuary has one of the largest freshwater tidal prisms in the world running from Trenton, New Jersey, to approximately Wilmington, Delaware. The gradual transition from fresh to salt water allows for abundant and rare freshwater tidal wetlands in the Upper Estuary, brackish marshes in the Middle Estuary, and salt marshes surrounding Delaware Bay. Together, these marshes form a nearly continuous perimeter fringing the tidal system. Tidal wetlands furnish essential spawning, foraging, and nesting habitat for fish, birds, and other wildlife. These wetlands are considered by many scientists to function like the ecosystem's "kidneys," absorbing contaminants, nutrients, and suspended sediments. Other scientists regard them as "fish factories" that are crucial to the success of important finfisheries. They also provide a first line of defense against storm surge and flooding. Acre for acre, tidal wetlands likely provide more ecosystem services than any other habitat type in the region.

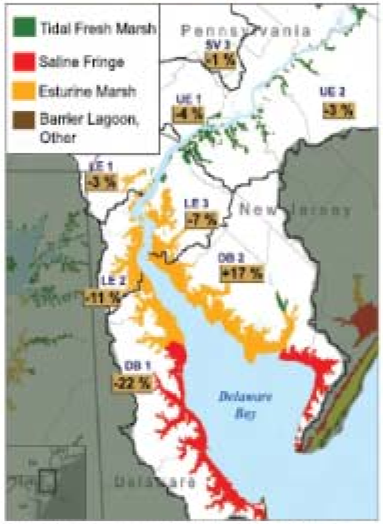
STATUS: A 1992 to 2001 land cover data comparison (for both tidal and non-tidal wetlands combined) showed wetland loss throughout the Estuary, except along the New Jersey side of Delaware Bay where extensive marsh restoration may have offset this trend (see map). During the preceding decade, a more in-depth analysis showed that Delaware's tidal marshes dropped by 12 percent and the proportion of marshes with degraded conditions almost doubled.

TRENDS: For over 300 years, the extent and integrity of tidal wetlands has been under assault across the Estuary. Perhaps 50 percent of the natural marshes have been lost to development, conversion, or degradation associated with human activities. Losses have been most severe in the urban corridor where perhaps only five percent of pre-settlement acreage of the nationally rare freshwater tidal marsh remains. Despite proactive laws protecting marshes, a growing awareness of their ecological value, and mounting restoration attention, marsh acreage and condition are still lost from human-caused impairments, land uses, and sea level rise.

ACTIONS AND NEEDS: Tidal wetlands are a hallmark feature of our watershed that suffer continued losses of both area and condition. Coordinated monitoring and assessment programs are urgently needed to regularly and carefully track tidal marsh extent and condition across the three Estuary states. A better scientific understanding is also needed of the factors that govern wetland well-being, such as sediment supply, water quality, and ecology. Studies of their ecosystem services and natural capital value would benefit land-use and regional-restoration planning.

A coconut fiber log is deployed along the edge of a tidal marsh in Bivalve, New Jersey, in an effort to establish a "living-shoreline" reef that may soon protect against erosion.

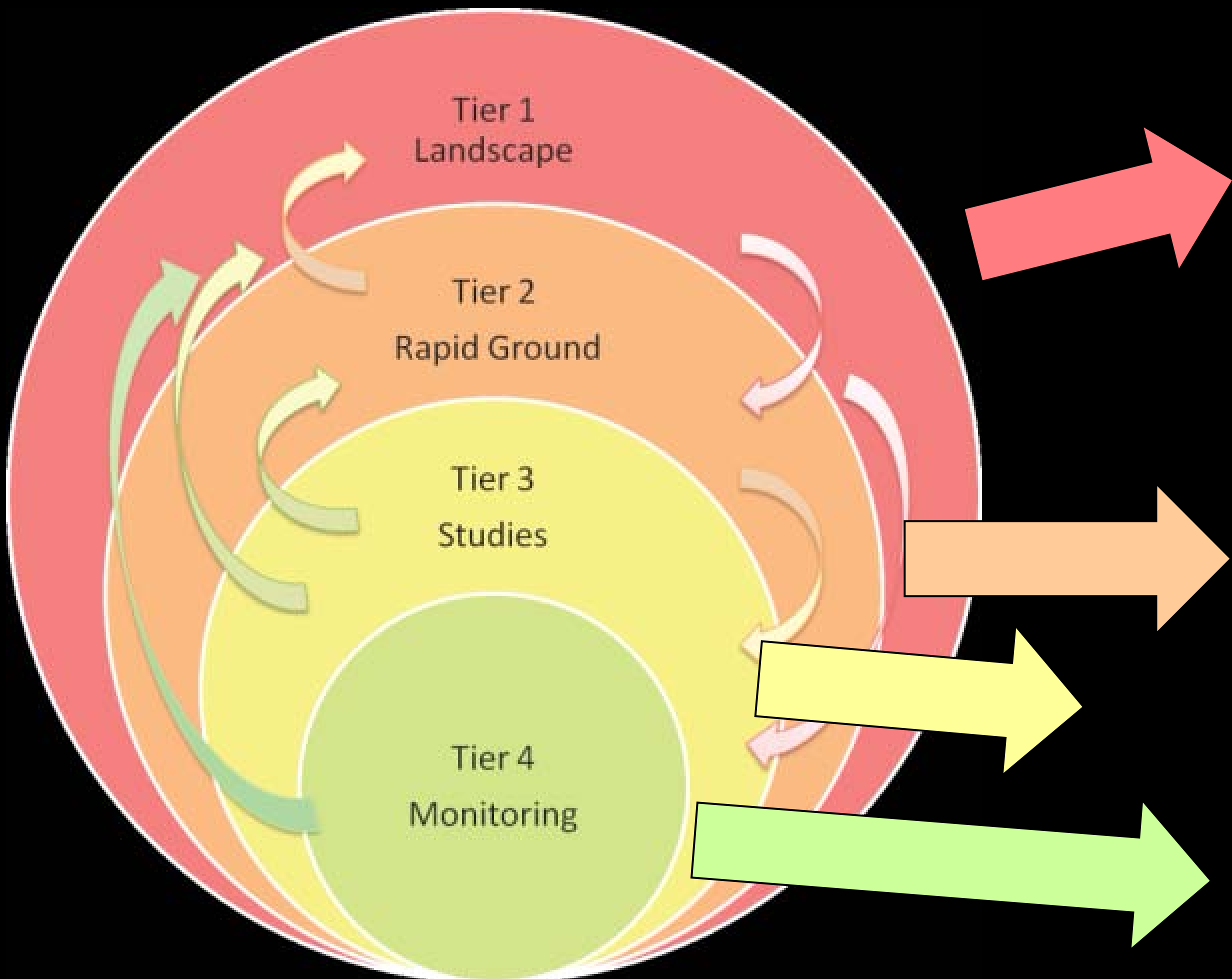
Relative Change in Wetland Acreage 1992-2001



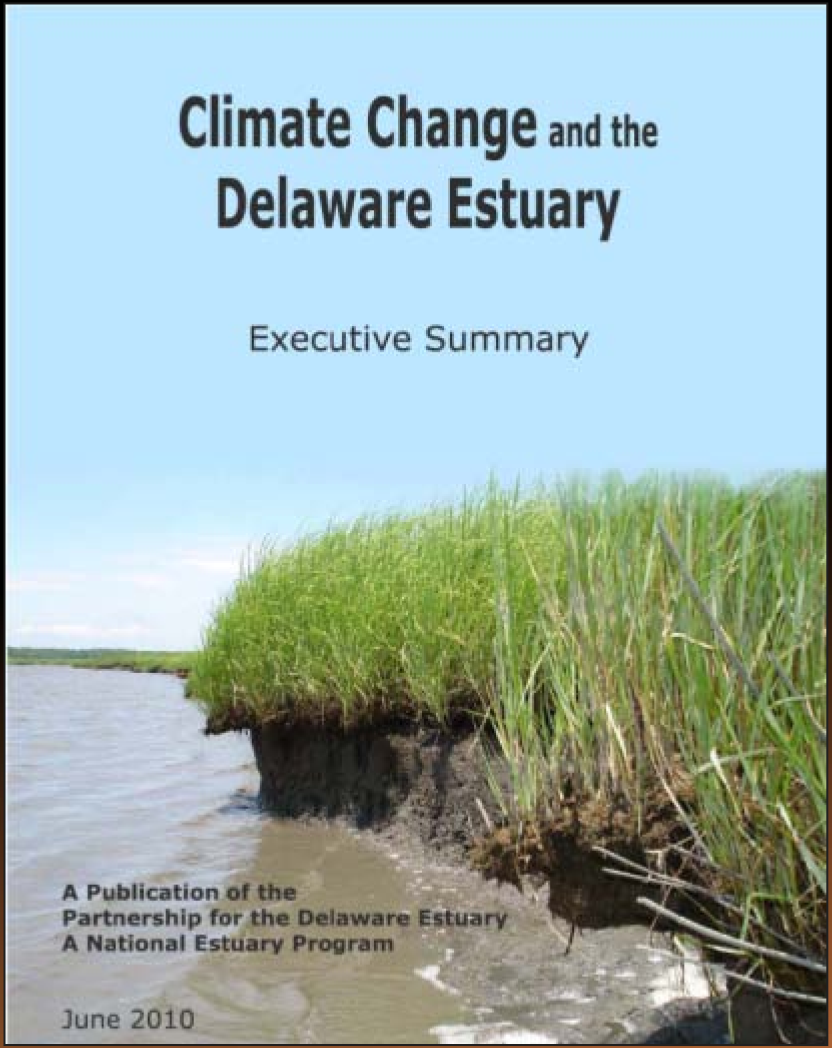
Please refer to the map on page 31 to view the full range of each region.

Response: The Mid-Atlantic Coastal Wetland Assessment:

Integrated Monitoring of Tidal Wetlands for Water Quality/Habitat Management and Climate/Restoration Planning



Response: Wetland Case Study in Climate Planning



case studies

Climate Predictions

↓

Resources Vulnerability

↓

Predicted Resource Changes

↓

Adaptation Options

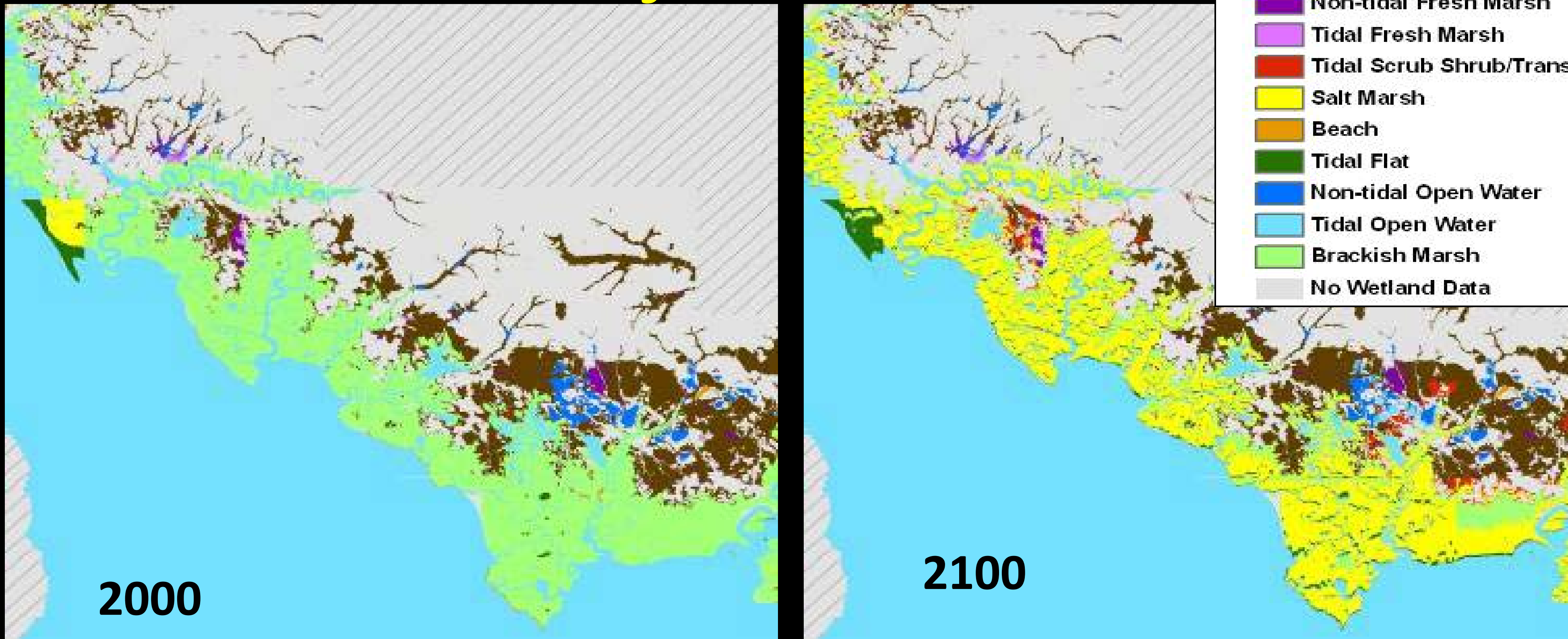
↓

Adaptation Strategy

CLIMATE READY ESTUARIES

http://delawareestuary.org/climate-change

Tidal Wetland Projections

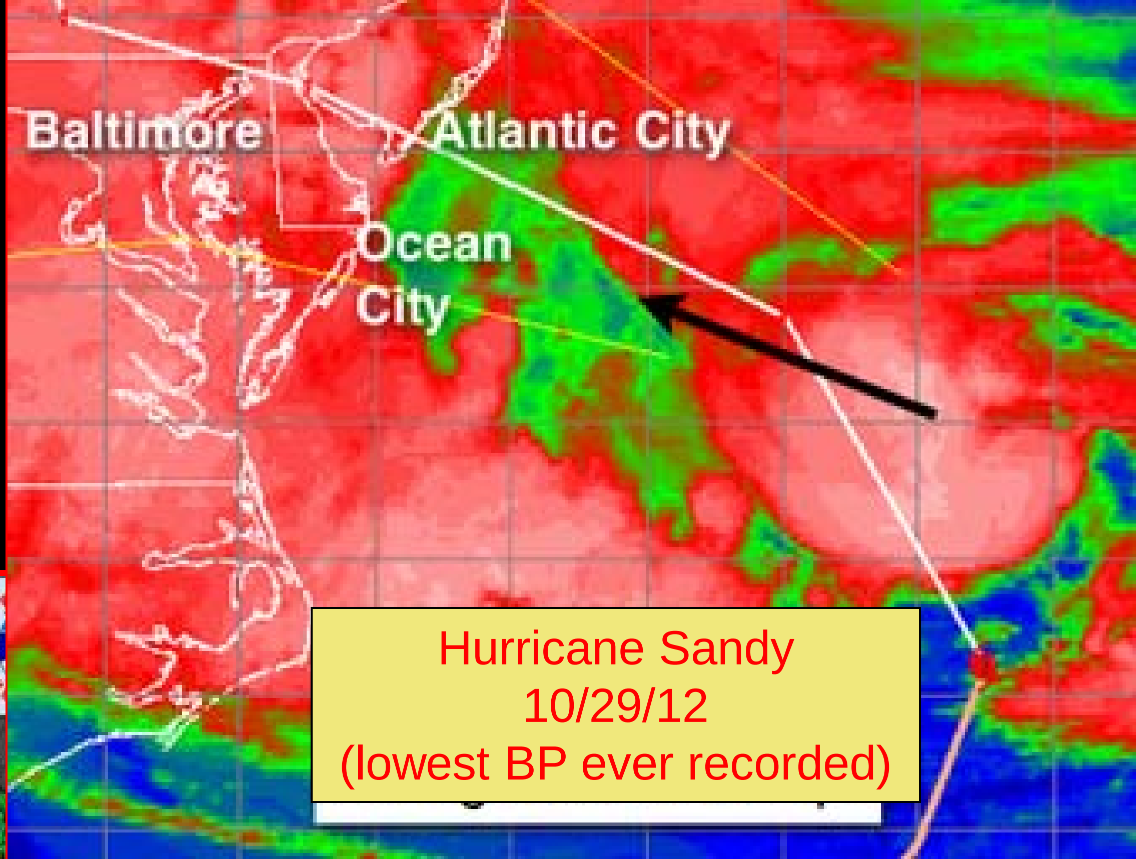


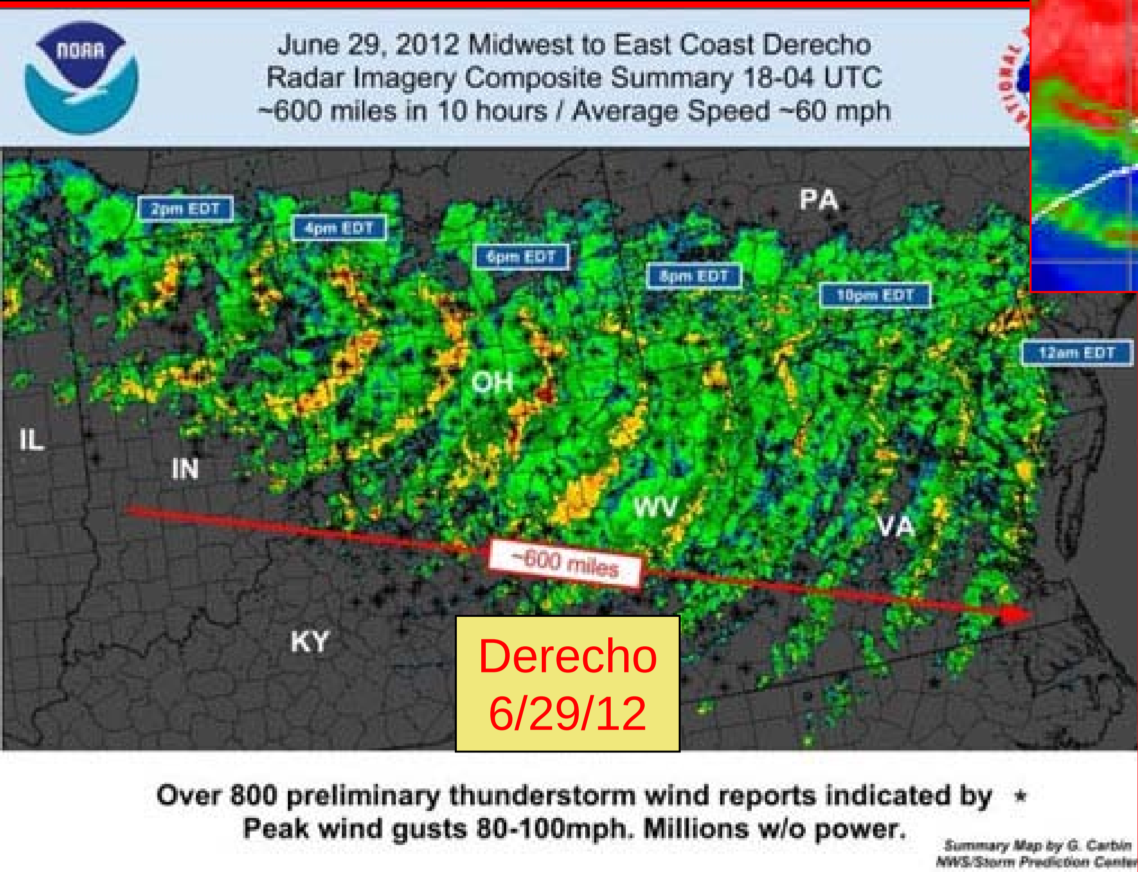
by 2100:

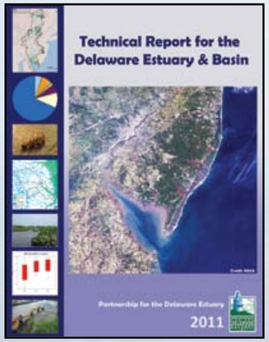
- loss of 50,236 acres of uplands and non-tidal wetlands
- gain of 106,529 acres of open water and tidal flats
- 26% net loss of 42,558 acres of tidal wetlands
- net loss of >60,000 metric tons/year of primary production

Emerging Threats

Frequent Bigger Storms
Saltwater and Sea Level Rise
Flooding (amid Droughts)







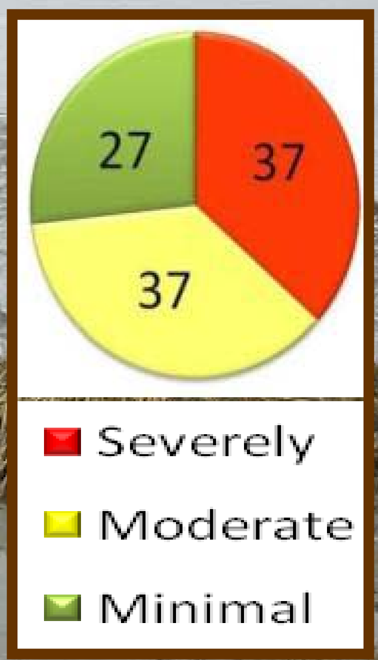
2012 State of the Estuary Report

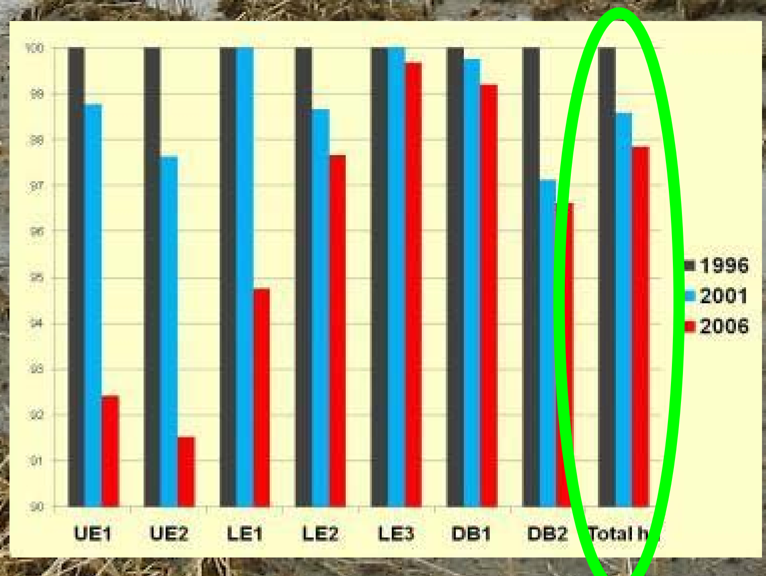
Rapid loss of acreage and degraded wetland health

Losing an acre per day (1996-2006)

Most tidal wetlands are moderately or severely stressed

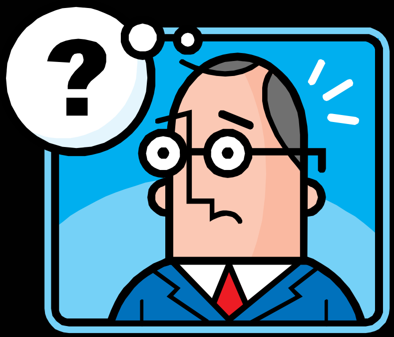
Future scenarios are worrisome





http://delawareestuary.org/technical-report-delaware-estuary-basin

Example Questions from Managers



Are wetlands keeping pace with sea level rise?

How are wetlands responding to stressors, such as pollution?

Are wetlands as healthy and productive as they can be?

Where will wetlands likely survive in the future?

What actions or tactics will work best to sustain the greatest functional wetland acreage in the future?

What are the unique aspects of coastal wetland monitoring?

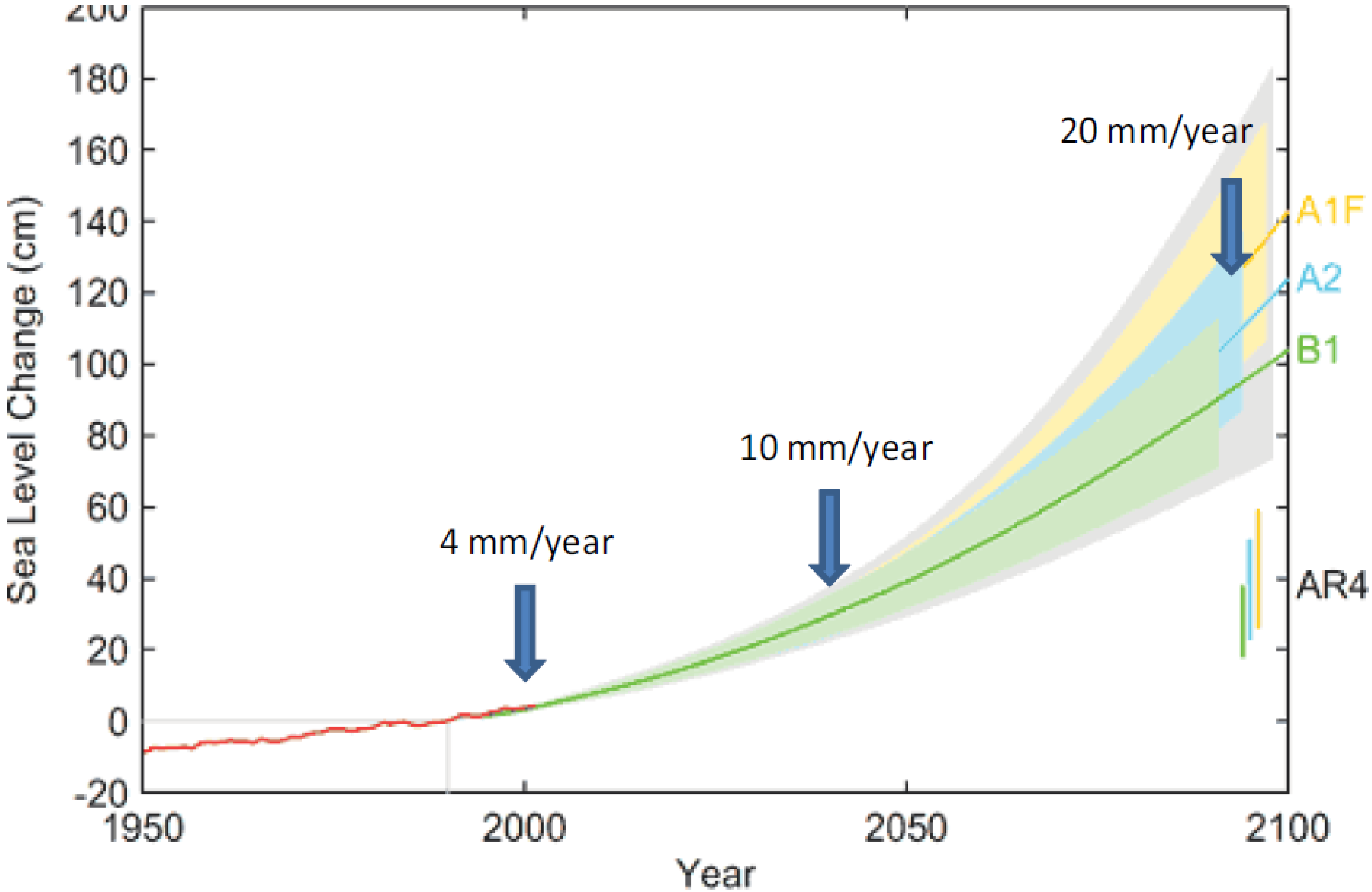
Coastal wetlands are:

- ✓ Situated at land-sea interface, filled and confined by development
  - near head of tide where early settlers established ports
  - 50% of US population now lives in coastal zone

- ✓ Affected by system manipulation and changes
  - altered sediment budgets
  - increased nutrients, altered stoichiometry
  - diking and tidal restrictions for farming and waterfowl
  - ditching for mosquito control
  - insufficient enforcement of wetland protections

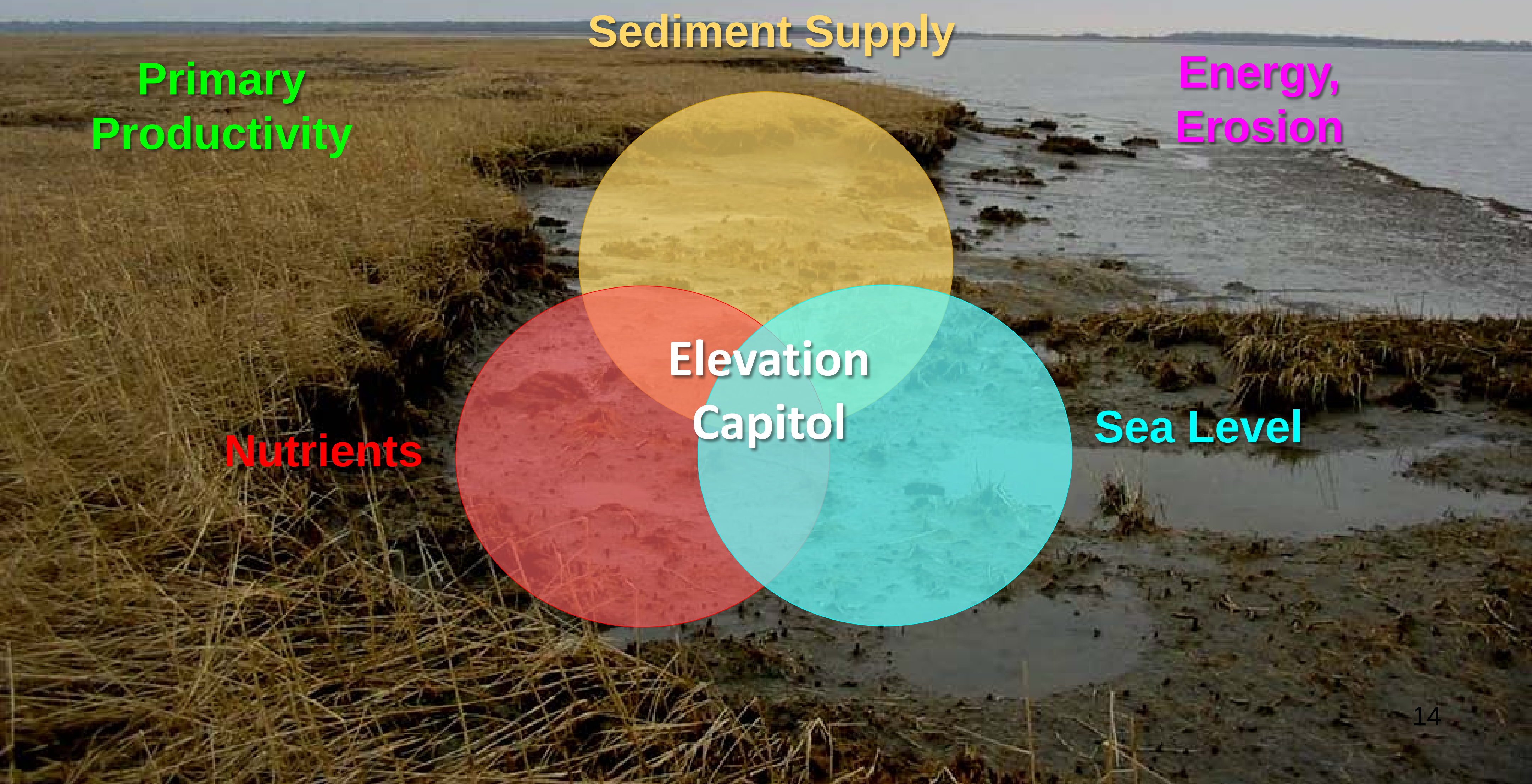
- ✓ Increasingly vulnerable to climate changes
  - sea level rise, tidal range
  - salinity rise
  - storm intensity and frequency

Many Tidal Marshes Cannot Survive When Sea Levels Rise >1 cm Per Year



INFORMATION

Will Tidal Wetlands Keep Pace with SLR?



Management Needs

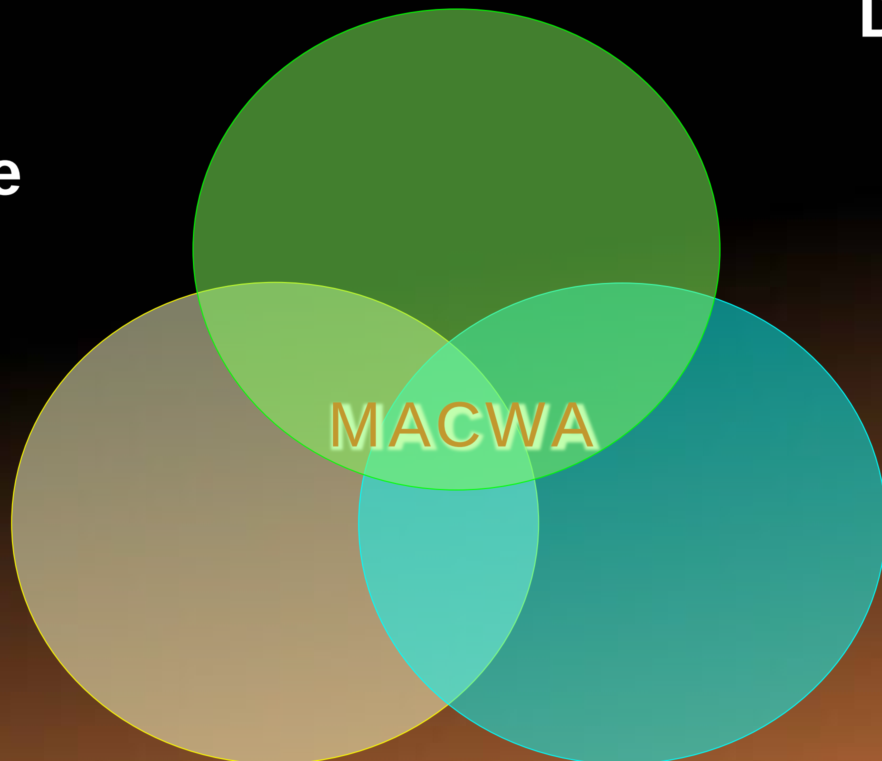
State of Estuary Reporting

On-the-Ground Projects

Regulatory Decision-Making

Fish and Wildlife Management

Water Quality Management

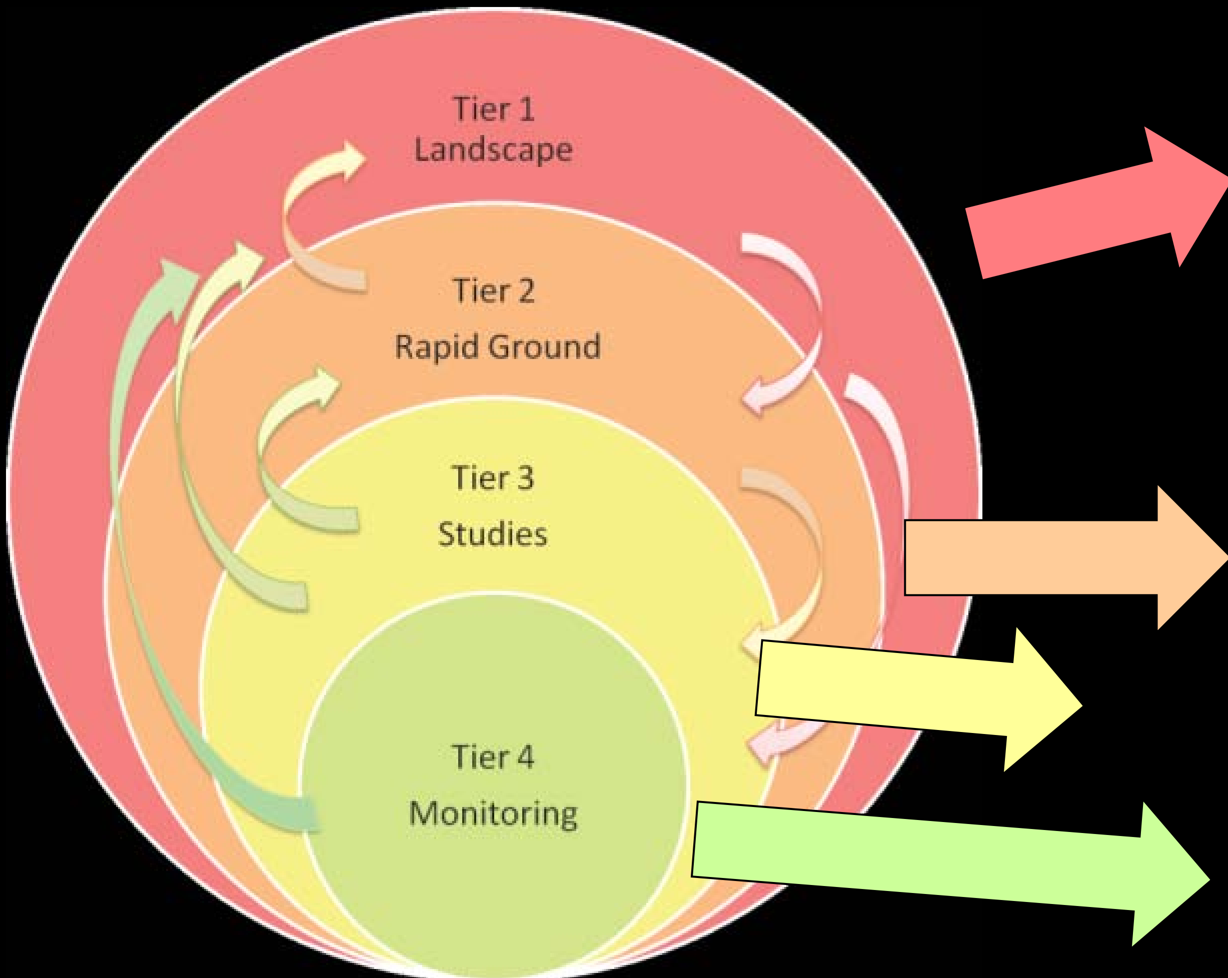


Restoration Planning

Climate Adaptation

Response: The Mid-Atlantic Coastal Wetland Assessment:

Integrated Monitoring of Tidal Wetlands for Water Quality/Habitat Management and Climate/Restoration Planning



MACWA Design:

Tier 1

Remotely sensed data on acreage, some condition

Tier 2

On-the-ground data on condition, stressors

Tiers 3 and 4

Intensive studies and monitoring data on condition, function

Design Component	Example Indicators	Example Metrics
Tier 1	Wetland Extent	wetland acreage (hectares) per subpopulation and NWI attribute type
	Wetland Buffer Condition	adjacent land use (e.g., % natural vs. developed in 100m band)
	Wetland Contiguousness	connectivity (inter/intra); patch sizes and fragmentation
	Historic Change	loss or gain in acreage for different subpopulations & attributes
	Wetland Morphology	percent open water; edge to area ratios
	Plant Community Integrity	vegetation community/type (e.g., *Phragmites* vs. *Spartina*, high marsh vs. low marsh, bare soil, open water)
	Shoreline Condition	edge status (e.g., hardening, erosion)
	Anthropogenic Alterations	channel straightening, ditching, tide gates, groundwater withdrawals
Tier 2	Plant Community Integrity	vegetation community type (description of species assemblage)
		invasive species (percent cover of *Phragmites*)
		species list (floristic quality assessment index)
		vegetation structure board
	Primary Production	below and above ground biomass
	Wetland Morphology	percent open water; edge to area ratios
	Invertebrate Community Integrity (sessile species)	presence and relative abundance of functional dominant and bioindicator species
	Wildlife Habitat Integrity (mobile species)	evidence of fish and mobile shellfish; avian IBI
	Hydrological and Shoreline Integrity	evidence of hydrological alterations or impairment (e.g. depressions, dikes, rip rap)
	Substrate Integrity	percent organic matter and sediment description
	Elevation and Sediment Budget	relative elevation, evidence of accretion or subsidence, wrack accumulation
Tier 3	Water Quality	fixed monitoring stations in second order tidal creek (temperature, specific conductivity, pH, turbidity, DO, water level)
		grab samples in tidal creek for dissolved nutrients and seston quantity & quality, ebb & flood tides (TSS, chlorophyll, proximate biochemistry and stoichiometry)
	Biogeochemical Cycling	sediment porewater nutrient concentrations, forms, stoichiometric ratios; denitrification rates
	Carbon Storage	carbon sequestration in belowground biomass; litter accumulation
	Elevation and Sediment Budget	Sediment Elevation Table (SET), elevation relative to sea level (in addition to Tier 2 metrics)
	Plant Community Integrity	vegetation robustness (percent cover and stem counts per species) (in addition to Tier 2 metrics)
	Functional Dominant Fauna Integrity	invertebrate and vertebrate species lists along intertidal edge and high marsh, biofiltration capacity of bivalves

Tier 2

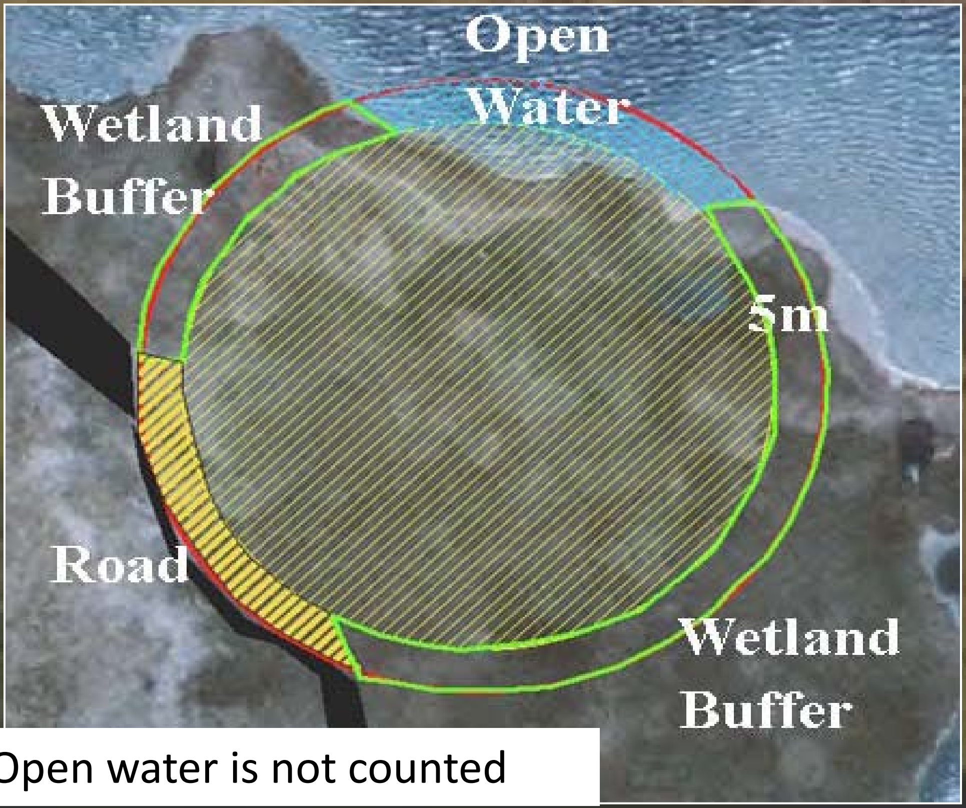
Mid-Atlantic Tidal Rapid Assessment Method (Mid-TRAM v.3)

- Buffer Integrity
- Hydrologic Integrity
- Habitat/Bio Integrity
- Shoreline Integrity

Attribute	Metric	Description
Buffer/Landscape	Percent of AA Perimeter with 5m-Buffer	Percent of AA perimeter that has at least 5m of natural or semi-natural condition land cover
Buffer/Landscape	Average Buffer Width	The average buffer width surrounding the AA that is in natural or semi-natural condition
Buffer/Landscape	Surrounding Development	Percent of developed land within 250m from the edge of the AA
Buffer/Landscape	250m Landscape Condition	Landscape condition within 250m surrounding the AA based on the nativeness of vegetation, disturbance to substrate and extent of human visitation
Buffer/Landscape	Barriers to Landward Migration	Percent of landward perimeter of wetland within 250m that has physical barriers preventing wetland migration inland
Hydrology	Ditching & Draining	The presence of ditches in the AA
Hydrology	Fill & Fragmentation	The presence of fill or wetland fragmentation from anthropogenic sources in the AA
Hydrology	Wetland Diking / Tidal Restriction	The presence of dikes or other tidal flow restrictions
Hydrology	Point Sources	The presence of localized sources of pollution
Habitat	Bearing Capacity	Soil resistance using a slide hammer
Habitat	Vegetative Obstruction	Visual obstruction by vegetation <1m measured with a cover board.
Habitat	Number of Plant Layers	Number of plant layers in the AA based on plant height
Habitat	Percent Co-dominant Invasive Species	Percent of co-dominant invasive species in the AA
Habitat	Percent Invasive	Percent cover of invasive species in the AA

Step 1. GIS Analysis

e.g. Barriers to Landward Migration,
Development



Open water is not counted

~30% is road or development

Step 2. Field Assessment

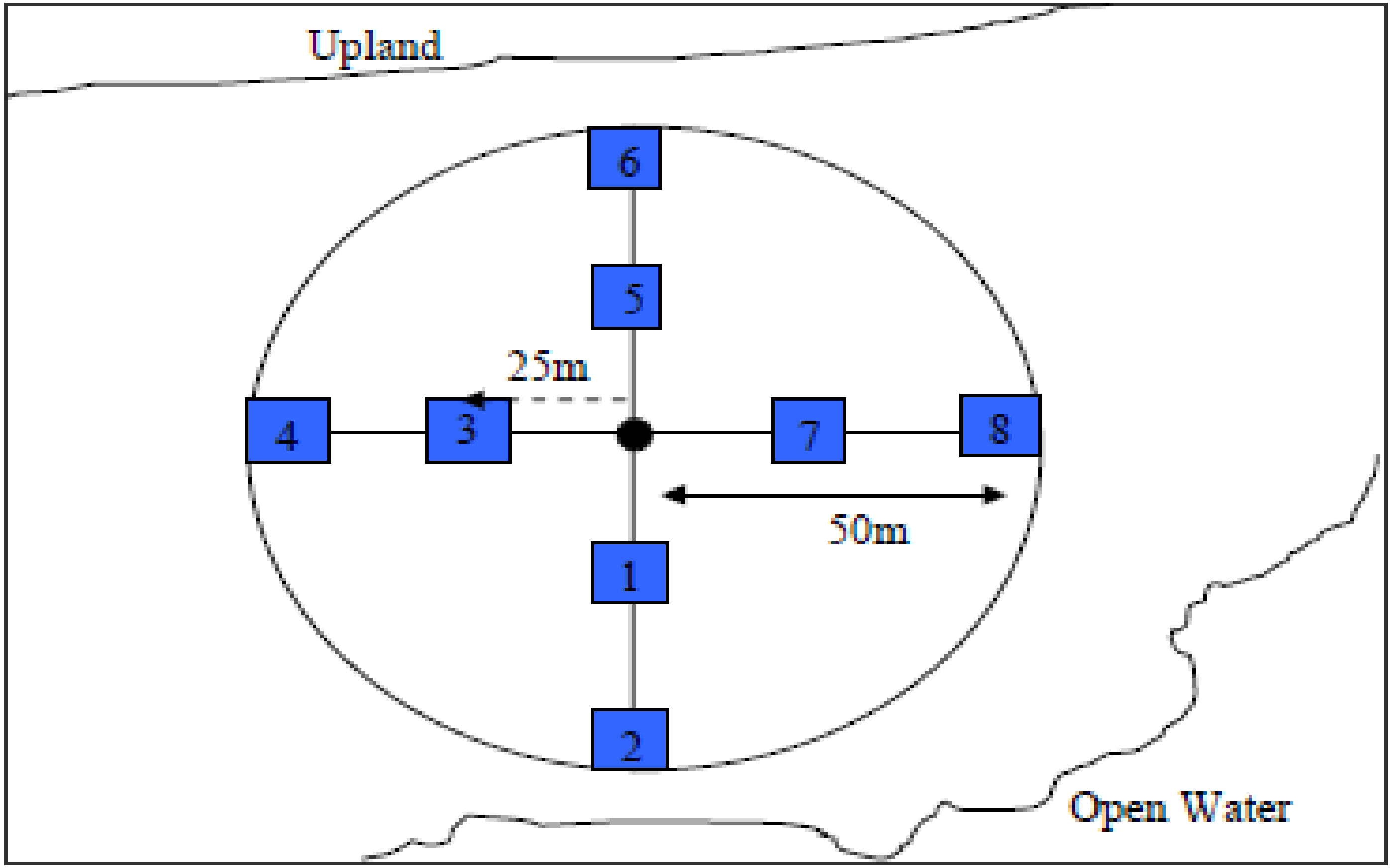


Figure 3: Location of Subplots in a circular assessment area.

Bearing Capacity

Percent Invasive

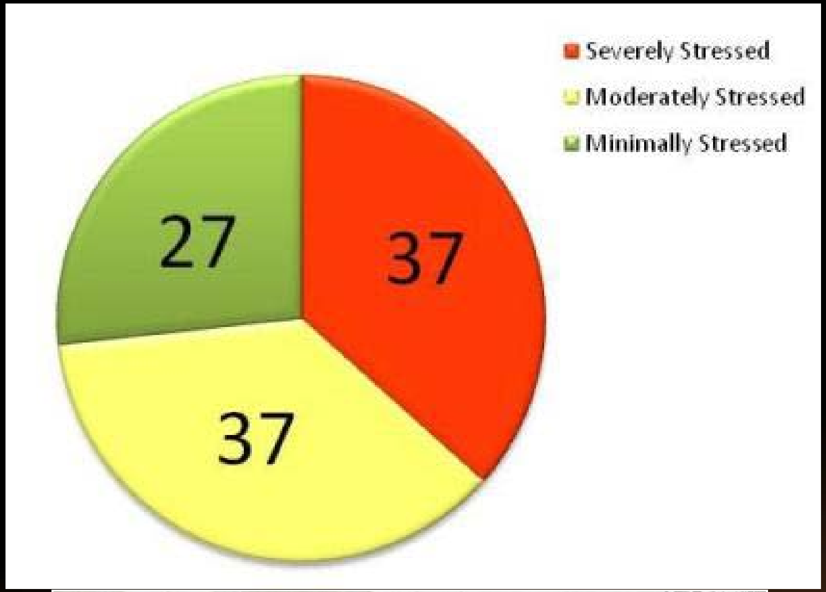
Shoreline Integrity

Shoreline Alterations

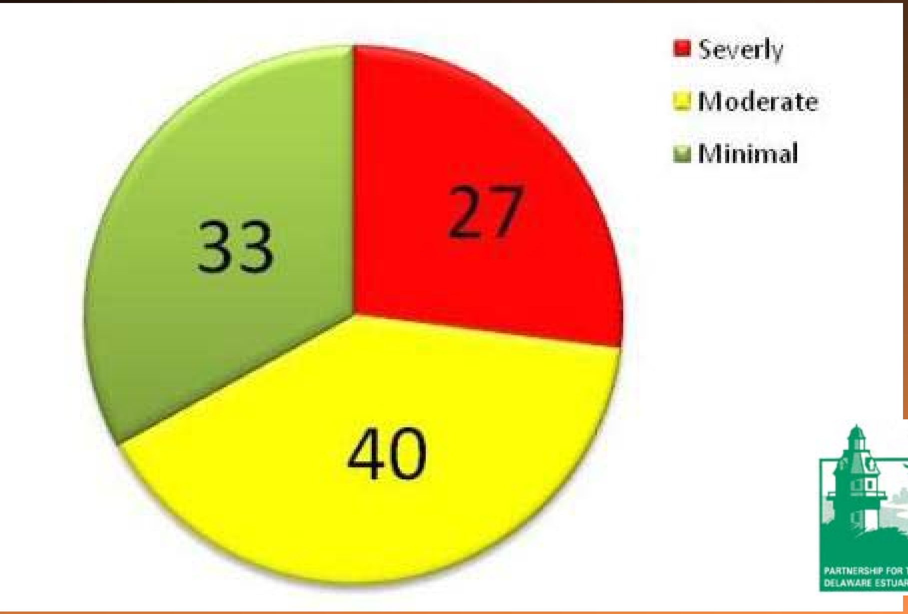
Shoreline Erosion

Configuration of the assessment area (red circle) buffer area (yellow circle,) and shoreline transects (green lines) for each random wetland sample point

PA Tidal Wetlands – Condition Summary



Maurice Tidal Wetlands – Condition Summary



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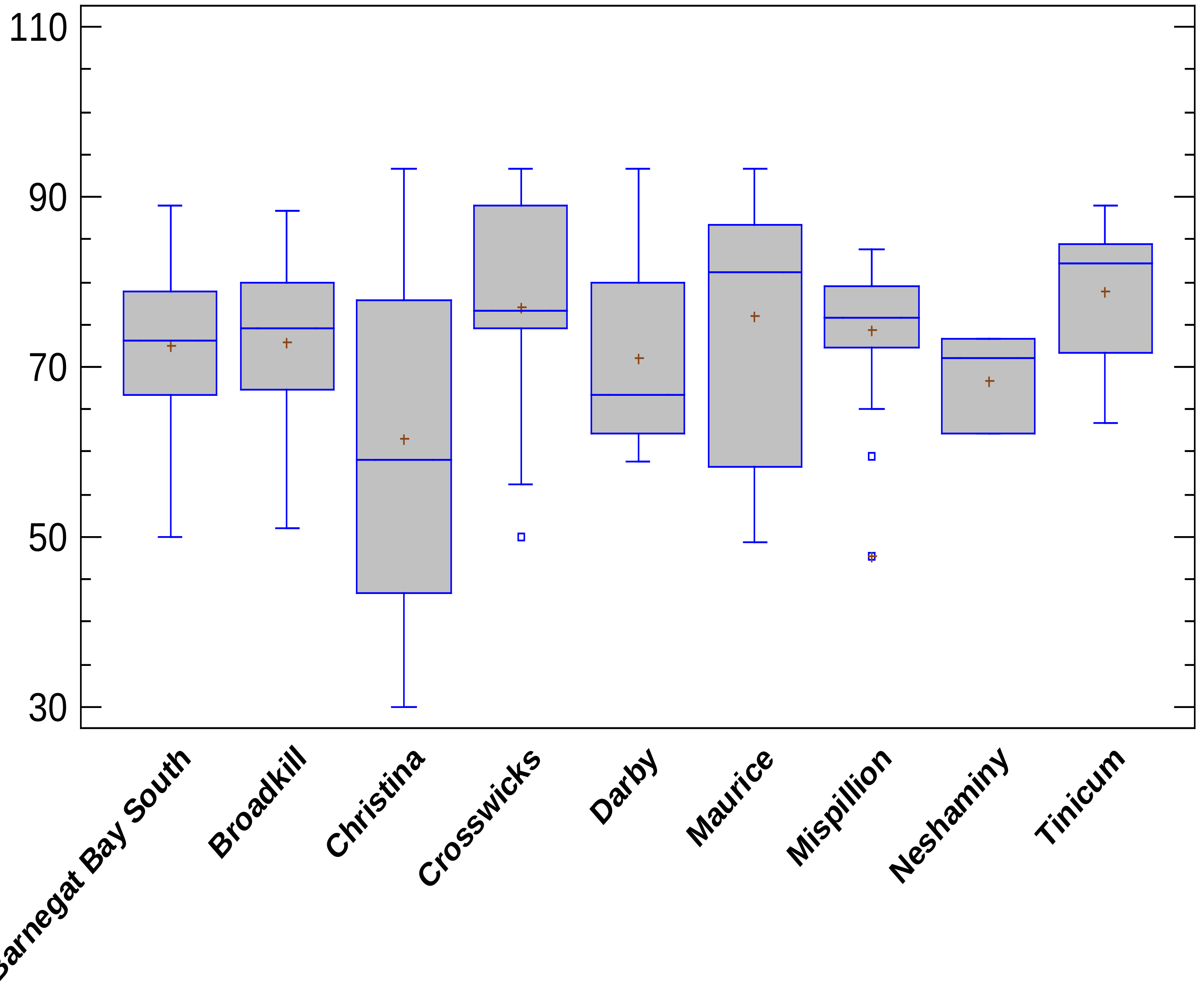
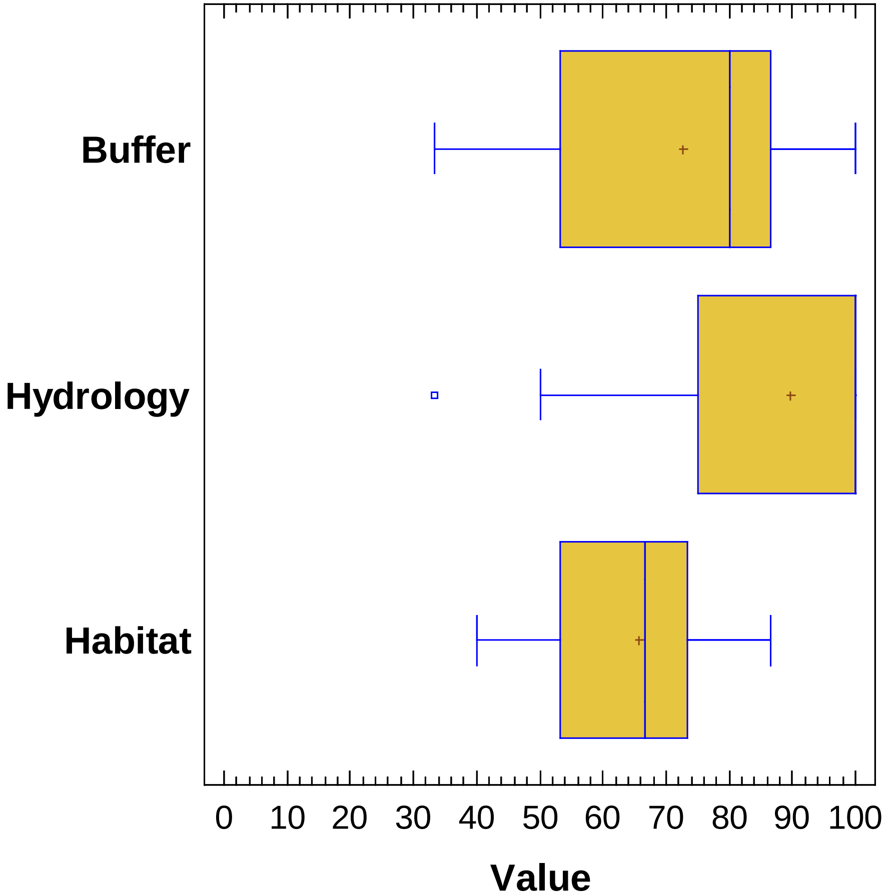
Overall RAM Scores Across Watersheds

206 Sites



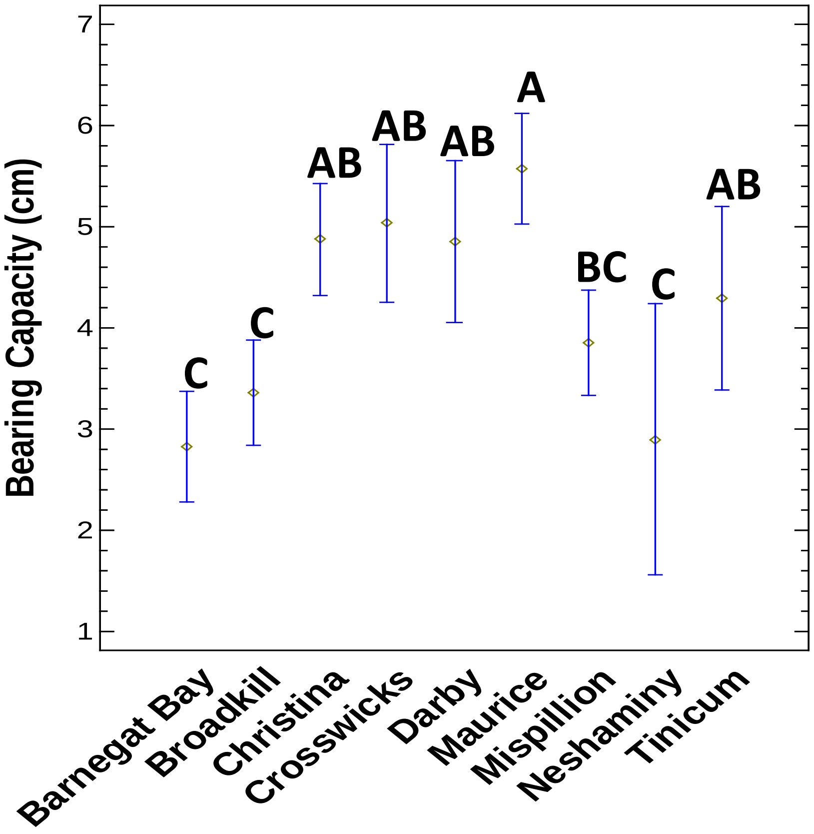
Most interesting RAM results are in the weeds

Watershed data shows the main local issues



Main attribute means in Maurice

Comparative analyses among watersheds highlight variations



Lower bearing capacity = firmer substrate

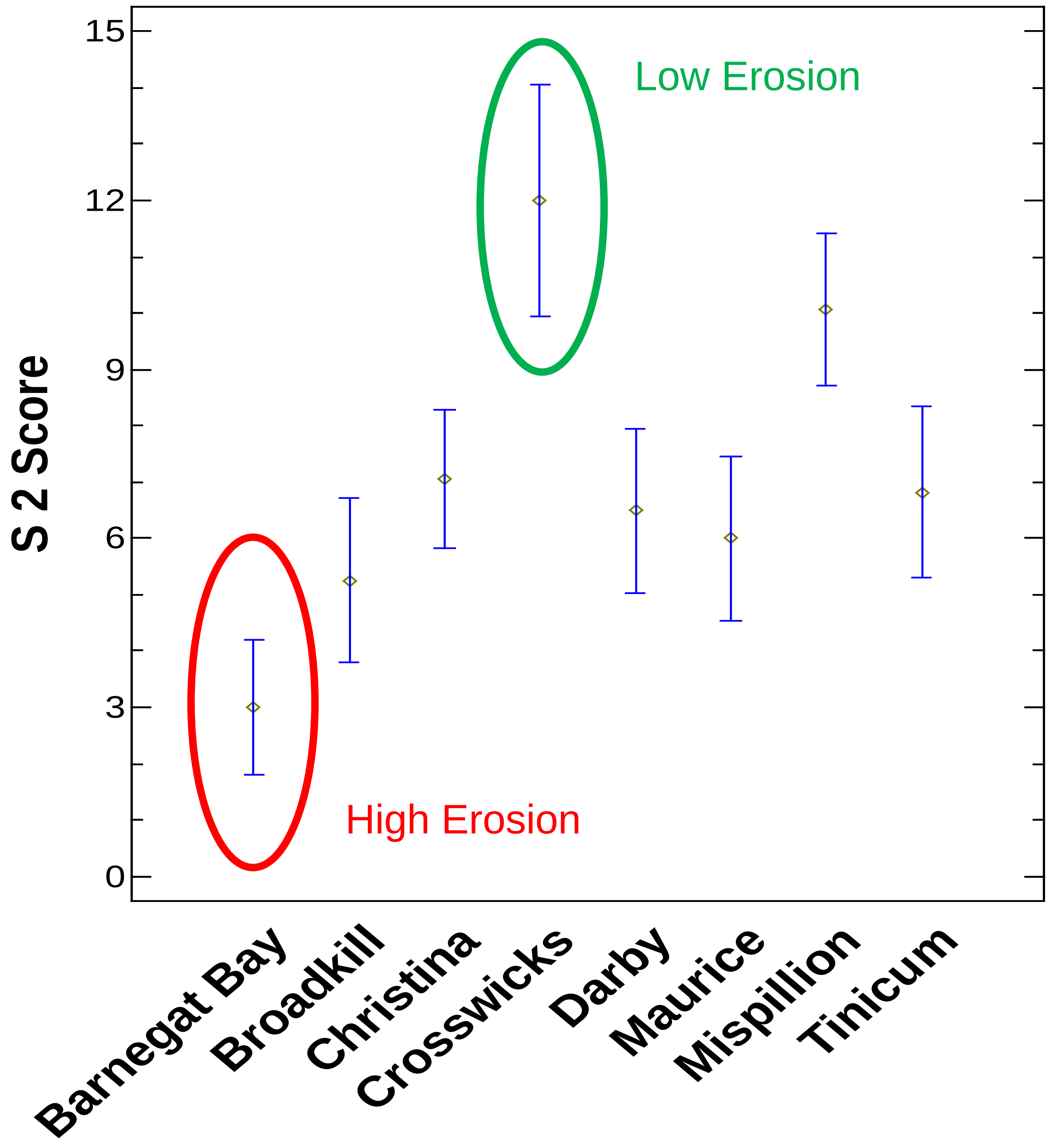
Shoreline Condition

Compared among representative watersheds

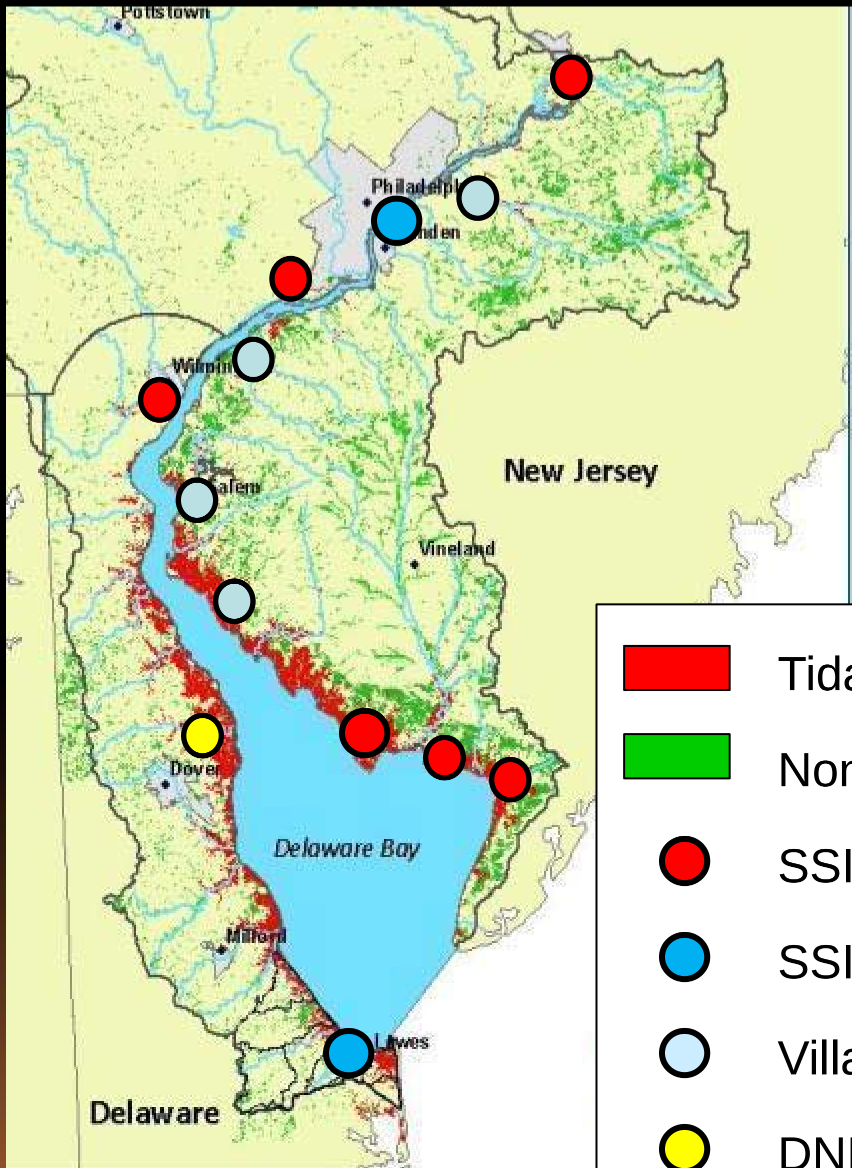
>100 Sites

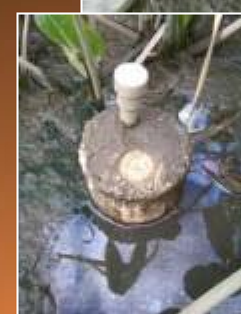
Lower scores mainly due to higher erosion

Dozens of other metrics



Tier 4 - Site-Specific Intensive Monitoring (SSIM)





Metrics

Water Quality	Elevation and Sediment Budget
Biogeochemical Cycling	Plant Community Integrity
Carbon Storage	Dominant Fauna Integrity

Stations

Station	Location	State	Estuary	Description
1	Tinicum NWR	PA	Delaware	Oligohaline, freshwater tidal marsh
2	Christina River	DE	Delaware	Mesohaline, brackish tidal marsh
3	Crosswicks Cr	NJ	Delaware	Oligohaline, freshwater tidal marsh
4	Dennis Creek	NJ	Delaware	Euryhaline, *Spartina* salt marsh
5	Maurice River	NJ	Delaware	Euryhaline, *Spartina* salt marsh
6	Dividing Creek	NJ	Delaware	Mesohaline, brackish tidal marsh
7	Reedy	NJ	Barnegat	Euryhaline, *Spartina* salt marsh
8	Island Beach	NJ	Barnegat	Euryhaline, *Spartina* salt marsh
9	West Creek	NJ	Barnegat	Euryhaline, *Spartina* salt marsh
Proposed	Broadkill River	DE	Delaware	Euryhaline, *Spartina* salt marsh

Methods

Elevation and Accretion





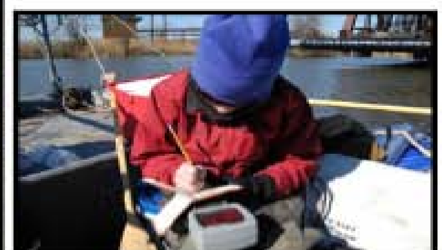


Plant Biomass


Algal Biomass

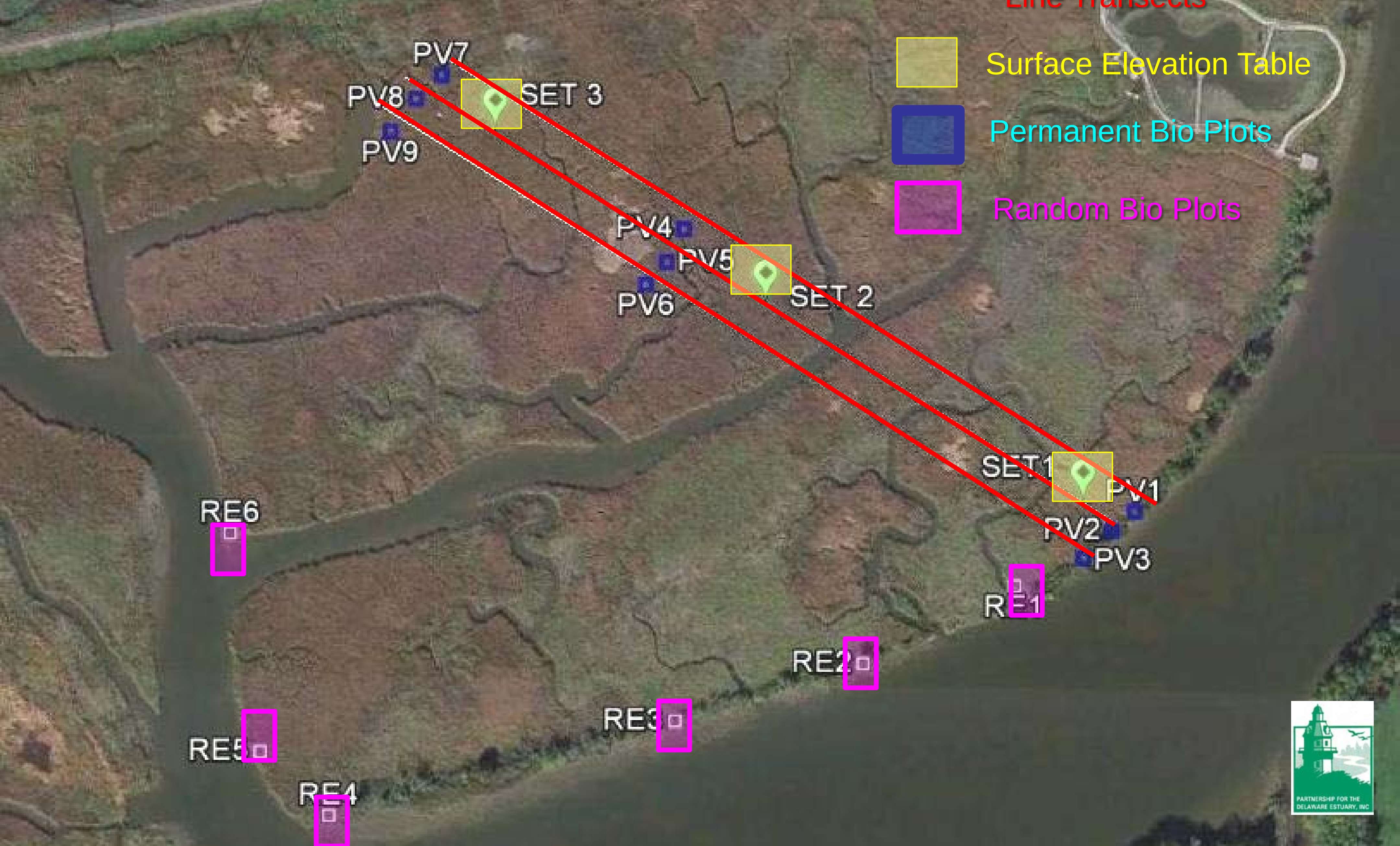
Plant community

Soil and Water Chemistry

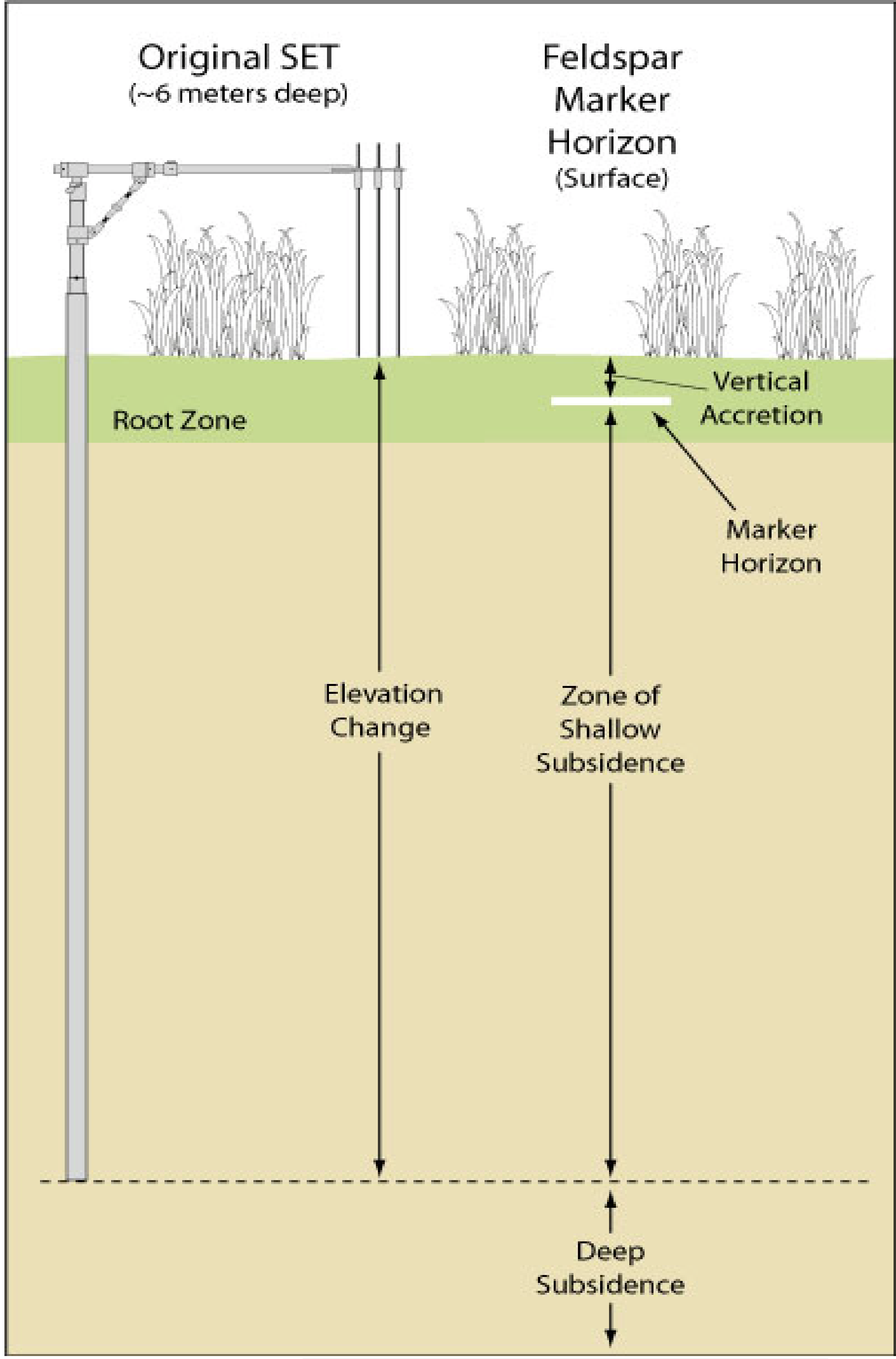




Slide credit: Dr. Tracy Quirk

Christina Marsh SSIM Station

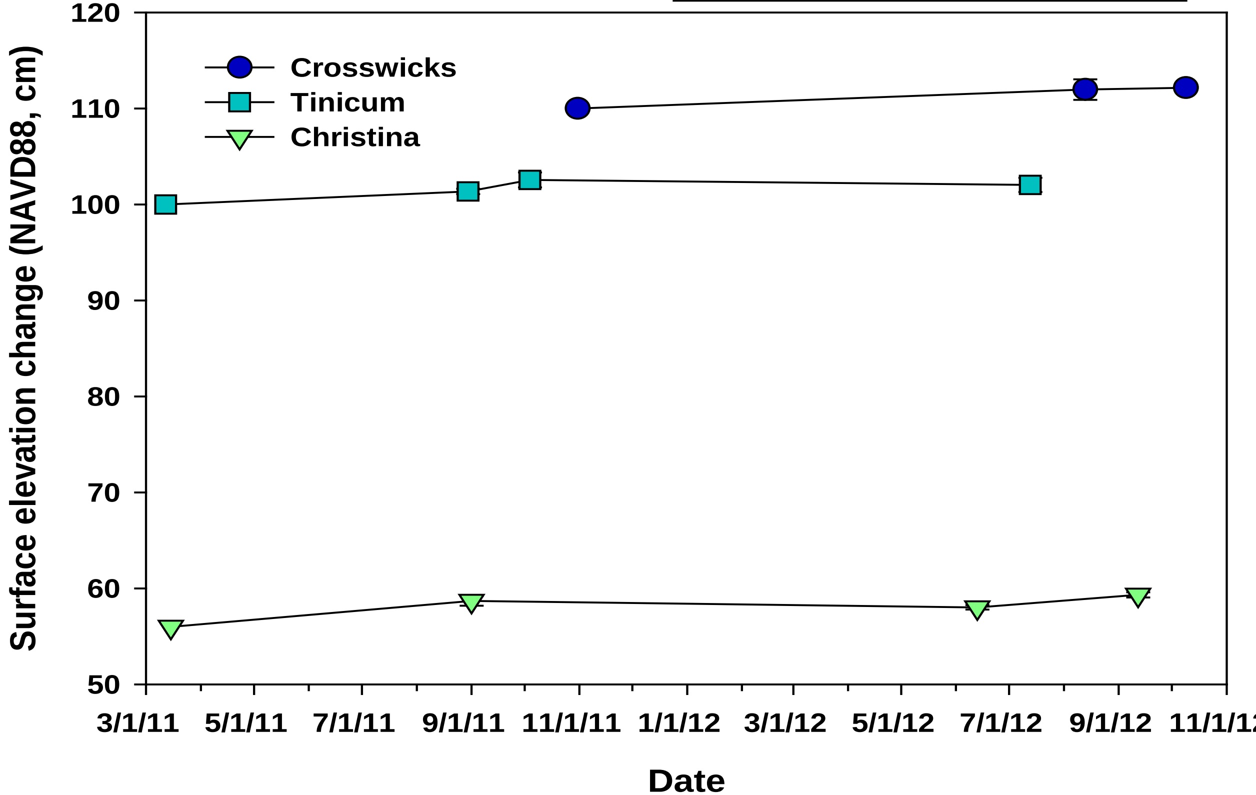


Measures of Elevation, accretion and subsidence



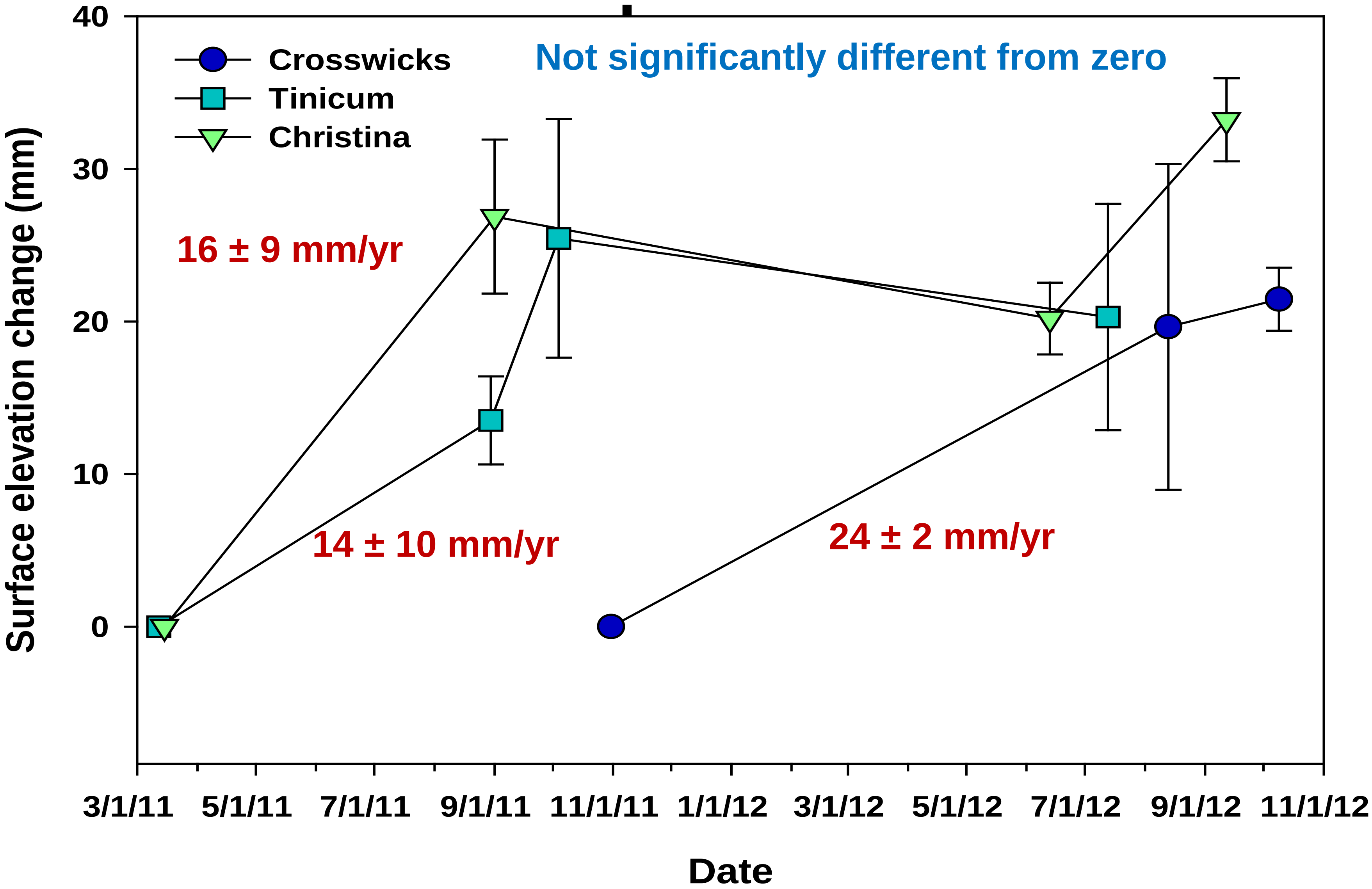
Slide credit: Dr. Bob Christian

Elevation



Slide credit: Dr. Tracy Quirk

Surface elevation



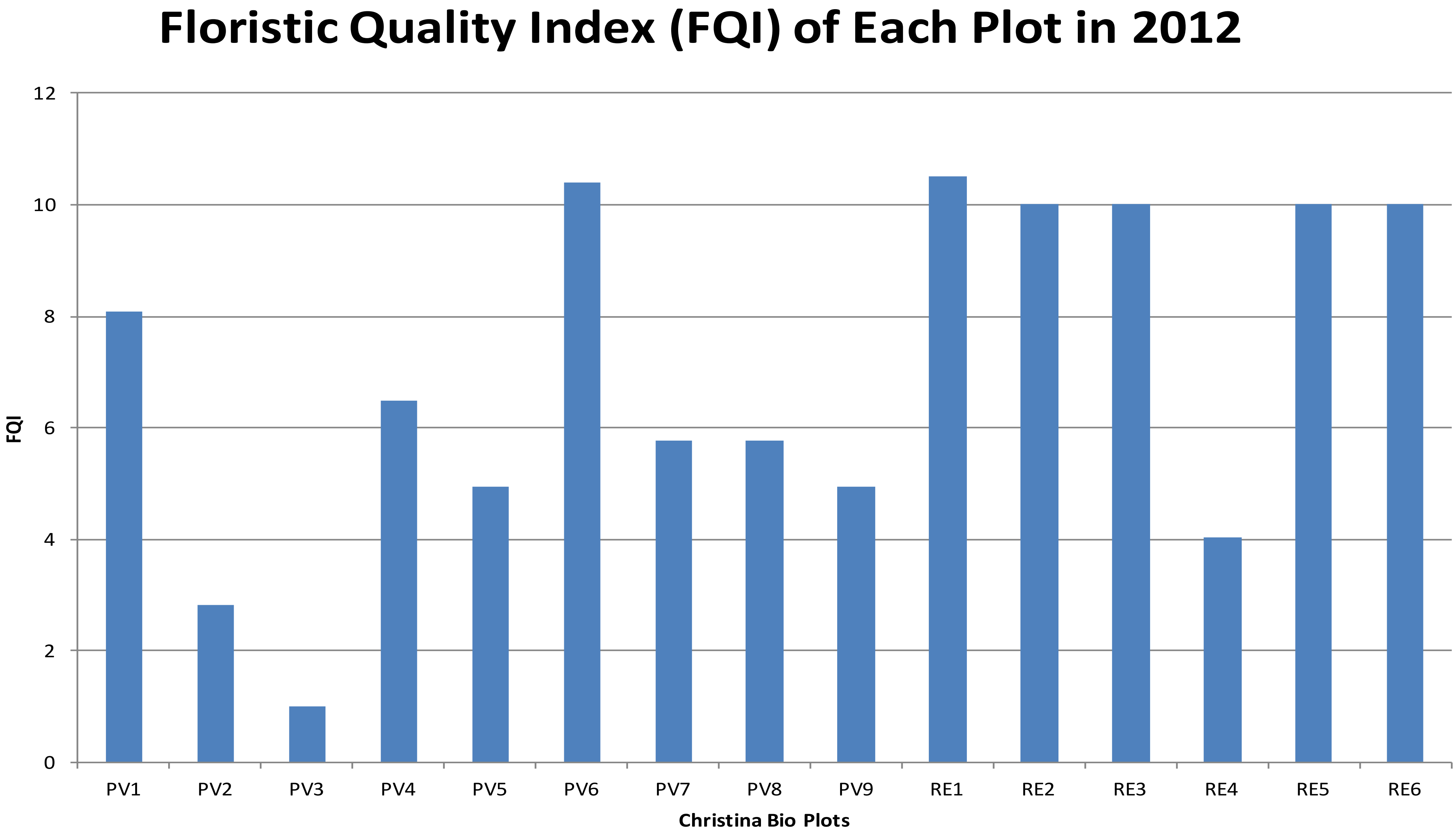
Slide credit: Dr. Tracy Quirk

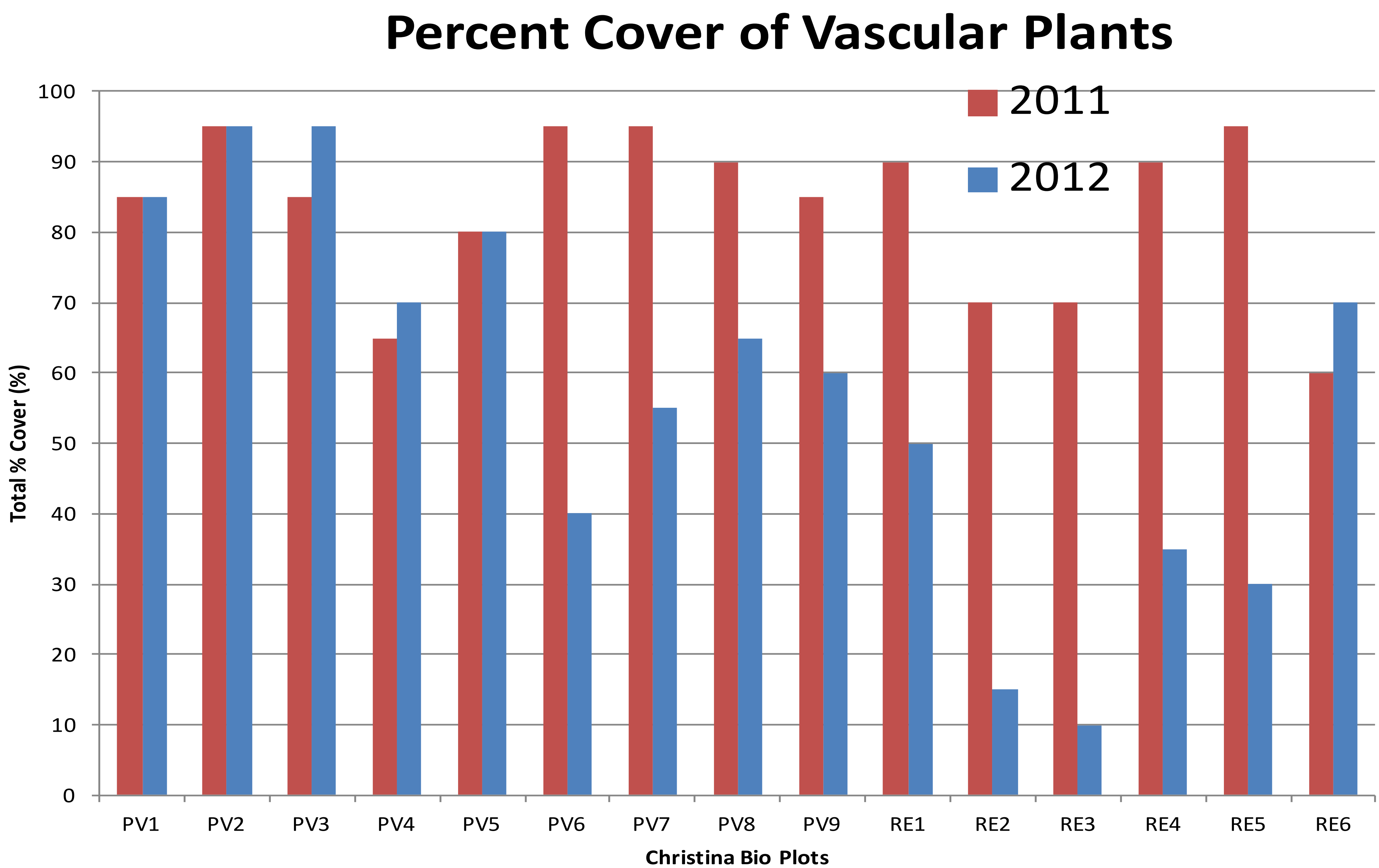
Biological Communities

Species Inventories

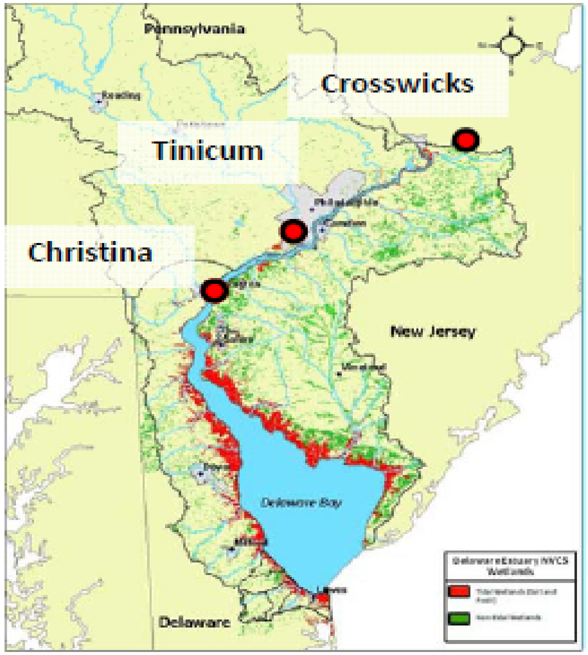
Table 11. Time, location, elevation and dominant plant species along line transects in Christina River, Delaware Estuary, DE.

Date/Time	Transect	Date/Time	Latitude	Longitude	Ortho Ht (m)	Dom Spp	Subdom Spp
7/13/2011 12:08	1	7/13/2011 12:08	39° 43' 18.81131" N	75° 33' 55.31529" W	0.6896	*Peltandra virginica*	*Typha angustifolia*
7/13/2011 12:11	1	7/13/2011 12:11	39° 43' 19.20260" N	75° 33' 56.08420" W	0.6912	*Typha angustifolia*	*Peltandra virginica*
7/13/2011 12:13	1	7/13/2011 12:13	39° 43' 19.27854" N	75° 33' 56.61466" W	0.571	*Typha angustifolia*	mix *P. virginica/A. cannabinus*
7/13/2011 12:22	1	7/13/2011 12:22	39° 43' 18.48583" N	75° 33' 54.12005" W	0.6224	*Peltandra virginica*	*Typha angustifolia*
7/13/2011 12:26	1	7/13/2011 12:26	39° 43' 18.45173" N	75° 33' 54.02064" W	0.5419	*Nuphar lutea*	*Peltandra virginica*
7/13/2011 12:28	1	7/13/2011 12:28	39° 43' 18.37777" N	75° 33' 53.93586" W	0.5369	*Typha angustifolia*	*Pontederia chordata*
7/13/2011 12:31	1	7/13/2011 12:3					*Peltandra virginica*
7/13/2011 12:45	1	7/13/2011 12:4					*Typha angustifolia*
7/13/2011 12:46	1	7/13/2011 12:4					*Sagittaria latifolia*
7/13/2011 12:49	1	7/13/2011 12:4					*Peltandra virginica*
7/13/2011 12:53	1	7/13/2011 12:5					*Impatiens capensis*
7/13/2011 14:10	1	7/13/2011 14:1					*Peltandra virginica*
7/13/2011 14:13	1	7/13/2011 14:1					*Peltandra virginica*
7/13/2011 14:13	1	7/13/2011 14:1					*Peltandra virginica*
7/13/2011 9:58	2	7/13/2011 9:58					*Peltandra virginica*
7/13/2011 10:03	2	7/13/2011 10:0					*Peltandra virginica*
7/13/2011 10:05	2	7/13/2011 10:0					*Peltandra virginica*
7/13/2011 10:30	2	7/13/2011 10:3					*Peltandra virginica*
7/13/2011 10:41	2	7/13/2011 10:4					*Peltandra virginica*
7/13/2011 11:55	2	7/13/2011 11:5					*Sagittaria latifolia*
7/13/2011 11:58	2	7/13/2011 11:5					*Peltandra virginica*
7/13/2011 12:03	2	7/13/2011 12:0					*Peltandra virginica*
7/13/2011 12:58	2	7/13/2011 12:5					*Peltandra virginica*
7/13/2011 13:01	2	7/13/2011 13:0					*Peltandra virginica*
7/13/2011 13:08	2	7/13/2011 13:0					
7/13/2011 13:10	2	7/13/2011 13:1					*Sagittaria latifolia*
7/13/2011 13:11	2	7/13/2011 13:1					*Sagittaria latifolia*
7/13/2011 13:12	2	7/13/2011 13:1					*Peltandra virginica*
7/13/2011 13:57	2	7/13/2011 13:5					*Peltandra virginica*
7/13/2011 14:01	2	7/13/2011 14:0					*Peltandra virginica*
7/13/2011 14:05	2	7/13/2011 14:05	39° 43' 12.67657" N	75° 33' 42.92313" W	1.0101	*Scirpus fluviatilis*	*Typha angustifolia*
7/13/2011 9:33	3	7/13/2011 9:33	39° 43' 19.65615" N	75° 34' 00.52903" W	0.6778	*Typha angustifolia*	*Peltandra virginica*
7/13/2011 9:35	3	7/13/2011 9:35	39° 43' 19.20277" N	75° 33' 59.42181" W	0.7322	*Typha angustifolia*	*Peltandra virginica*
7/13/2011 9:39	3	7/13/2011 9:39	39° 43' 18.53628" N	75° 33' 58.67170" W	0.5856	*Peltandra virginica*	*Typha angustifolia*

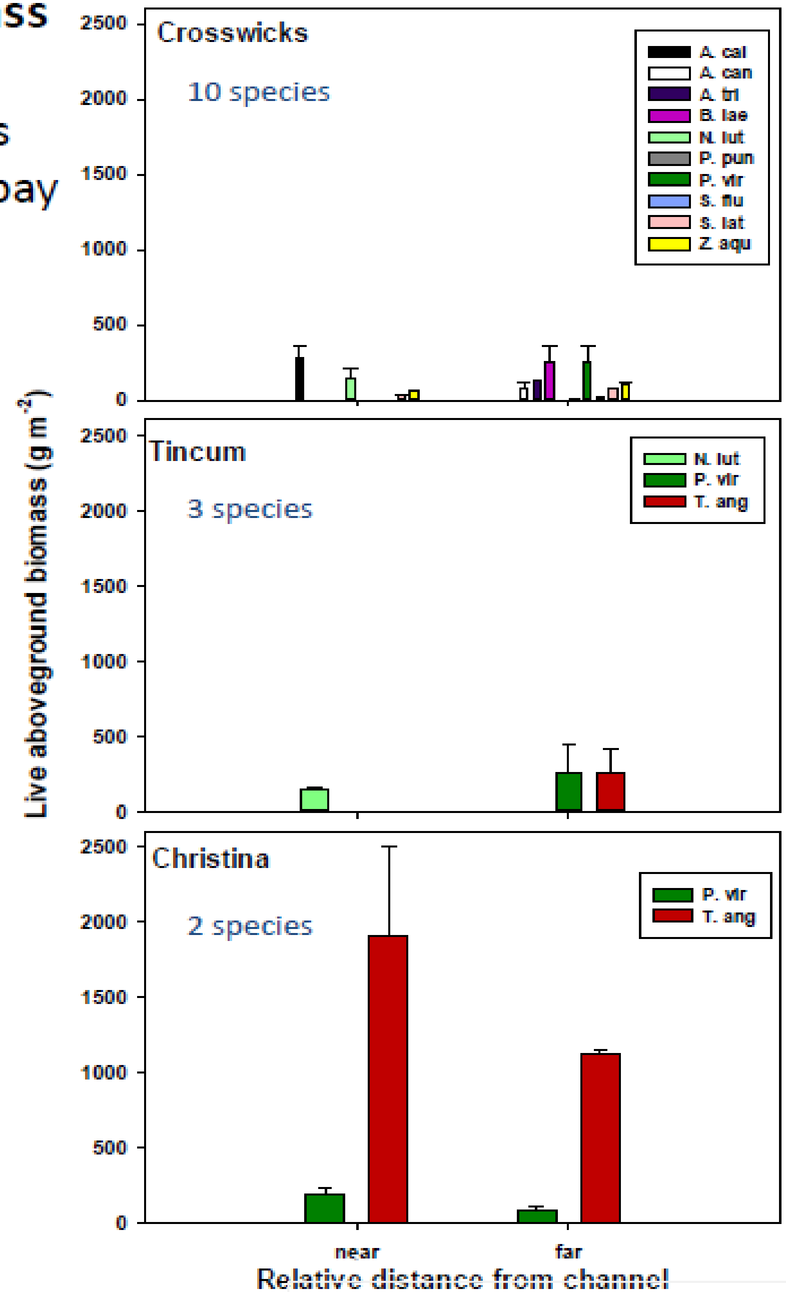

Floristic Quality Index (FQI) of Each Plot in 2012
FQI
0
2
4
6
8
10
12
PV1
PV2
PV3
PV4
PV5
PV6
PV7
PV8
PV9
RE1
RE2
RE3
RE4
RE5
RE6
Christina Bio Plots


Percent Cover of Vascular Plants
2011
2012
Total % Cover (%)
100
90
80
70
60
50
40
30
20
10
0
PV1
PV2
PV3
PV4
PV5
PV6
PV7
PV8
PV9
RE1
RE2
RE3
RE4
RE5
RE6
Christina Bio Plots

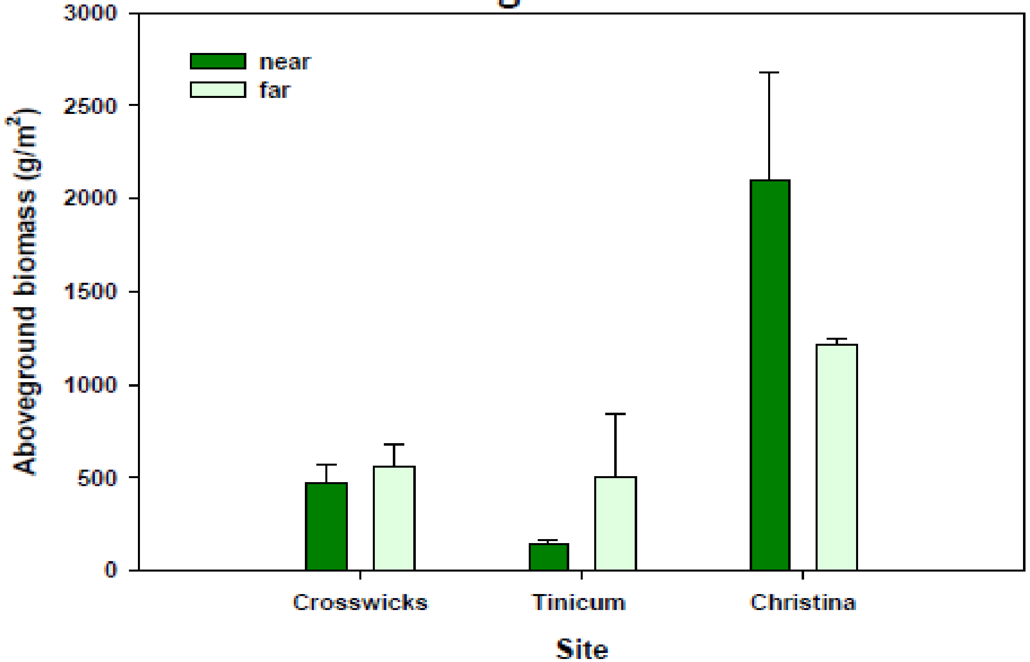
Aboveground Biomass



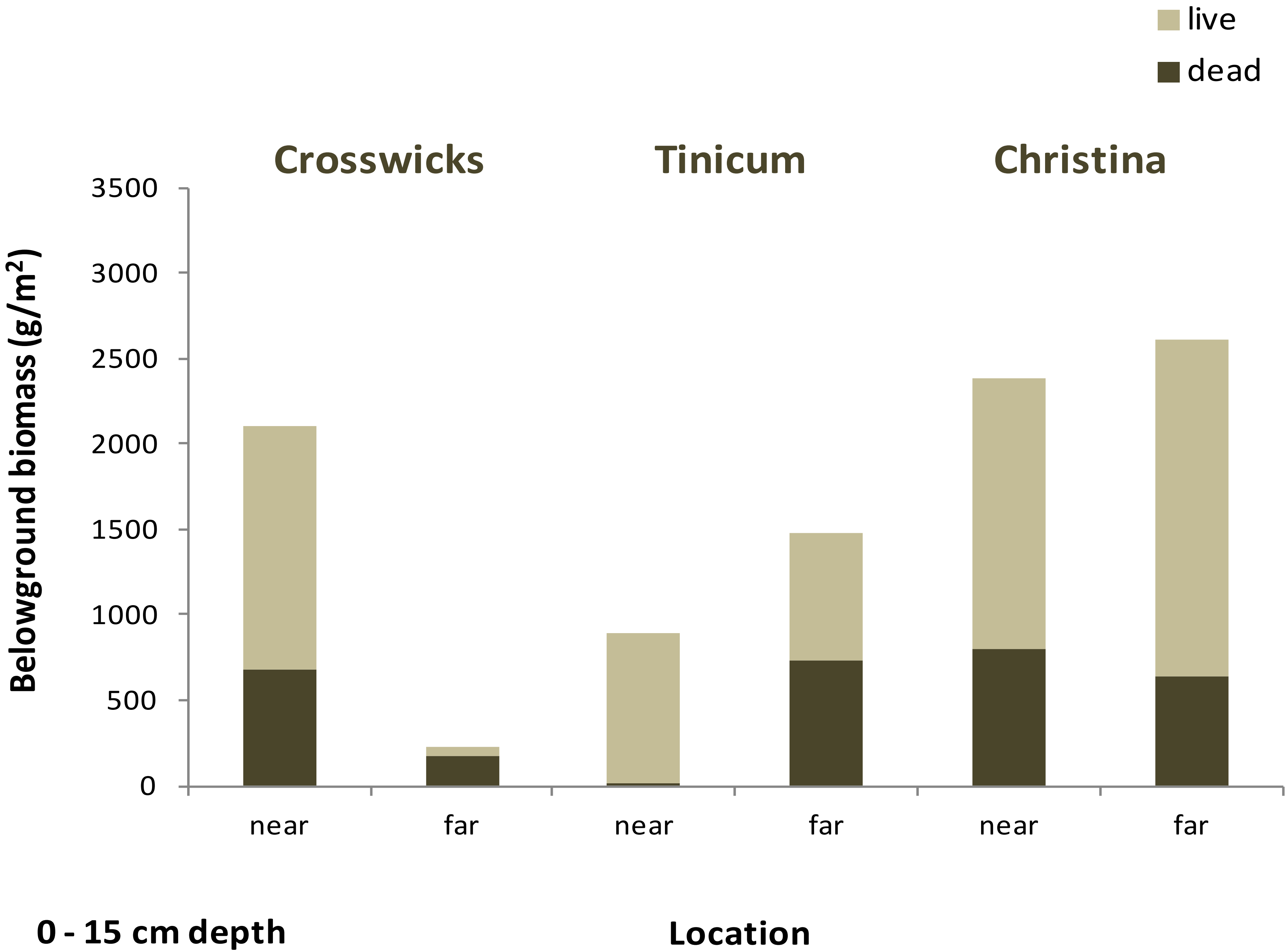
Species richness declines down bay



Biomass highest at Christina



Slide credit: Dr. Tracy Quirk



Slide credit: Dr. Tracy Quirk

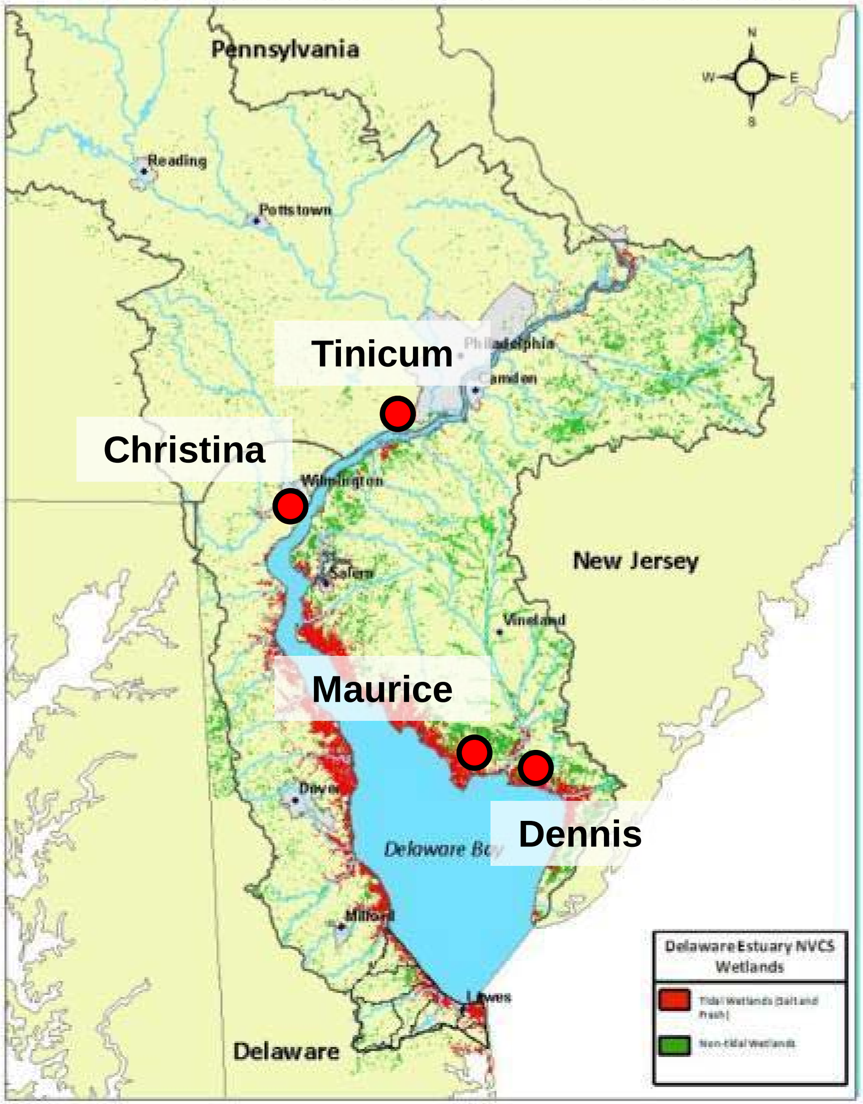
Faunal Communities

Water and soil

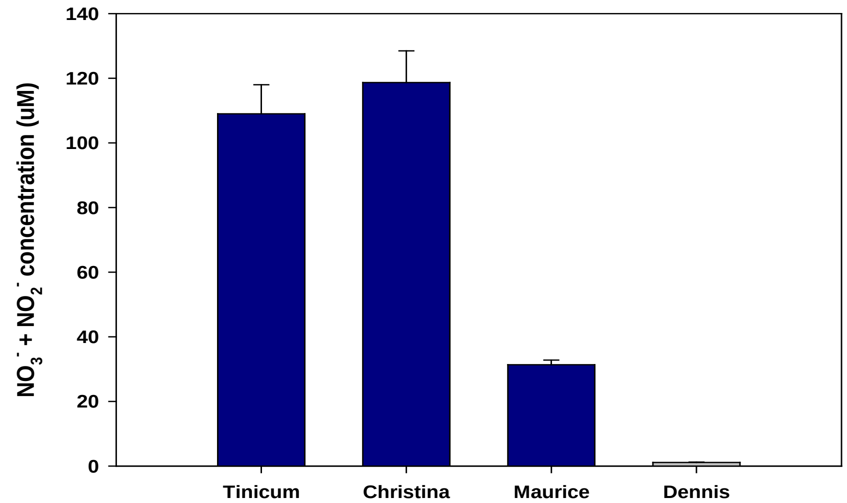
Slide credit: Dr. Tracy Quirk

Tidal Creek Nutrients

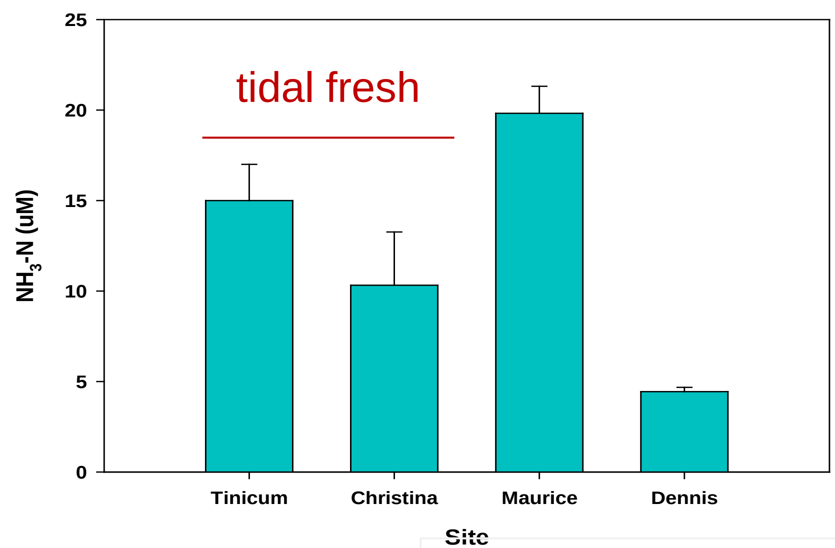
NVCS - Tidal and Non-tidal systems of the lower Delaware Estuary



Nitrate + Nitrite



Ammonium



Slide credit: Dr. Tracy Quirk

How are we funding MACWA?

Any way we can!

- National Estuary Programs
- EPA Wetland Program Development Grants
  - design and implement RAM and SSIM
  - helping to build state capacity
- Coastal Zone Management Grants (NJ and PA)
  - MACWA-affiliated Intensive studies
- Private Sector Support (DuPont)
- Non-Profits (Christina Conservancy)
- In-Kind Match (Rutgers, Academy of Natural Sciences)

Challenges?

- **Funding**

  - state budgets and capacity extremely limited (NJ and PA)
  - no federal grants/programs to sustain wetland monitoring
  - remote sensing data out of date or low resolution

- **Access**

  - coastal wetlands vary greatly in ease of access
  - landowner permission

Summary

- Coastal wetlands are a hallmark feature of the Delaware and Barnegat Estuaries
- They provide diverse benefits that sustain lives and livelihoods
- They are vulnerable to combined watershed and climate stressors, especially post-Sandy
- Monitoring of wetland status and trends will assist in managing and sustaining them
- Regional coordination strengthens scientific outcomes, improves management and leverages more diverse funding

Martha Maxwell Doyle

We Thank the Many People Who Have Assisted in Workshops, Workgroups and in the Field

And We Are Grateful to Our Primary Funders:

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DE Dept. of Natural Resources Environ. Control
NJ Coastal Management Program
PA Coastal Management Program