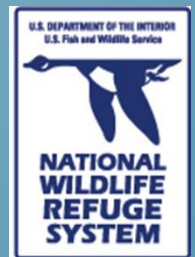


# HURRICANE SANDY RESILIENCE PROJECTS IN NEW JERSEY

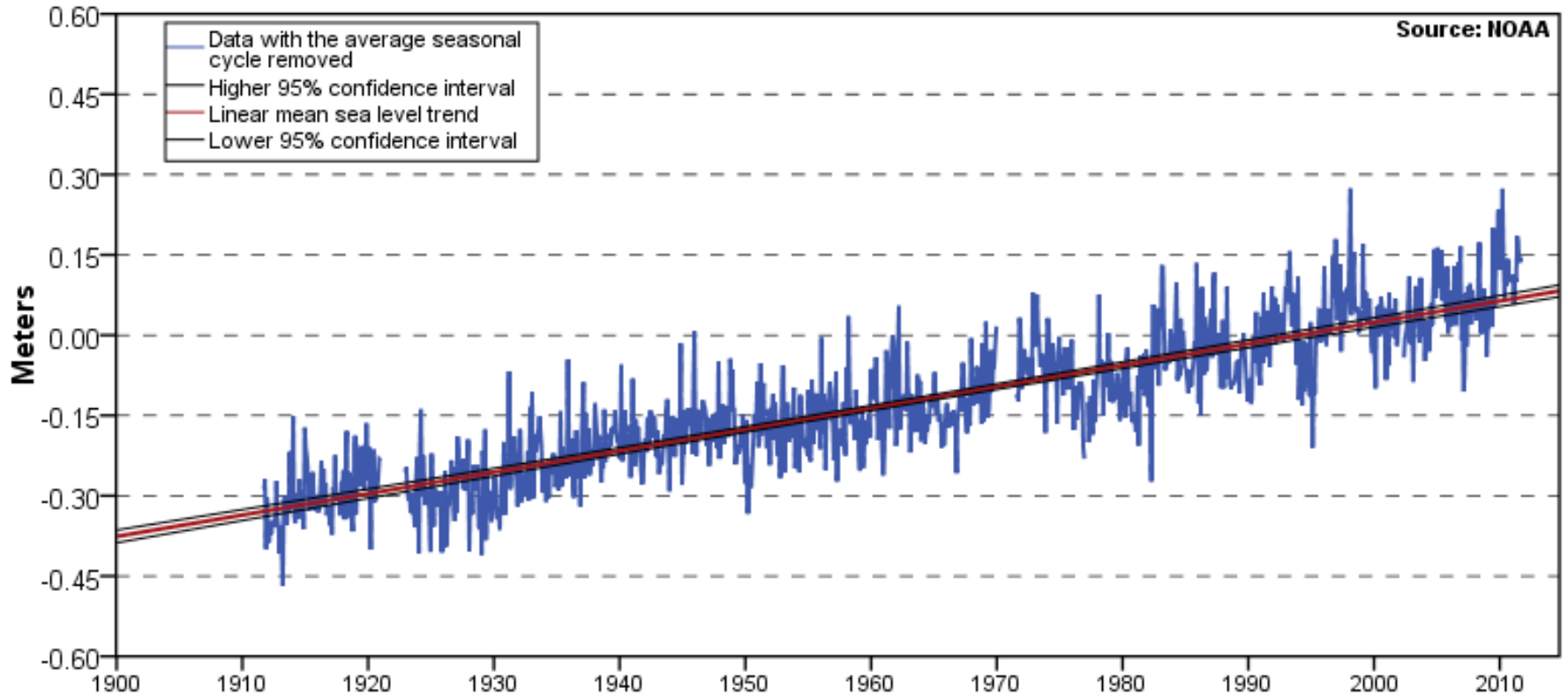
EDWIN B. FORSYTHE  
CAPE MAY AND SUPAWNA  
NATIONAL WILDLIFE REFUGES

Paul M Castelli



# ACCELERATED RATE OF SEA LEVEL RISE EXPECTED

Atlantic City, NJ 3.99 +/- 0.18 mm/yr



# TIDAL MARSH RESILIENCE (PERSISTENCE)

ELEVATION –

*Relative to sea level*

NATURAL TIDAL FLOW –

*Natural sinuous channels*

MARSH MIGRATION –

*Marine transgression*



# EDWIN B. FORSYTHE NWR SANDY RESILIENCE PROJECTS

## CONSTRUCTION PROJECTS

*3 Contracts*

*1 Inter Agency agreements*

*Monitoring – Refuge staff &*

*2 Cooperative agreement's*

*youth & public outreach*

## SCIENCE PROJECTS

*1 Inter-Agency agreement*

*4 Cooperative agreement's*

*Monitoring*

*Associated projects*

*Youth & public outreach*

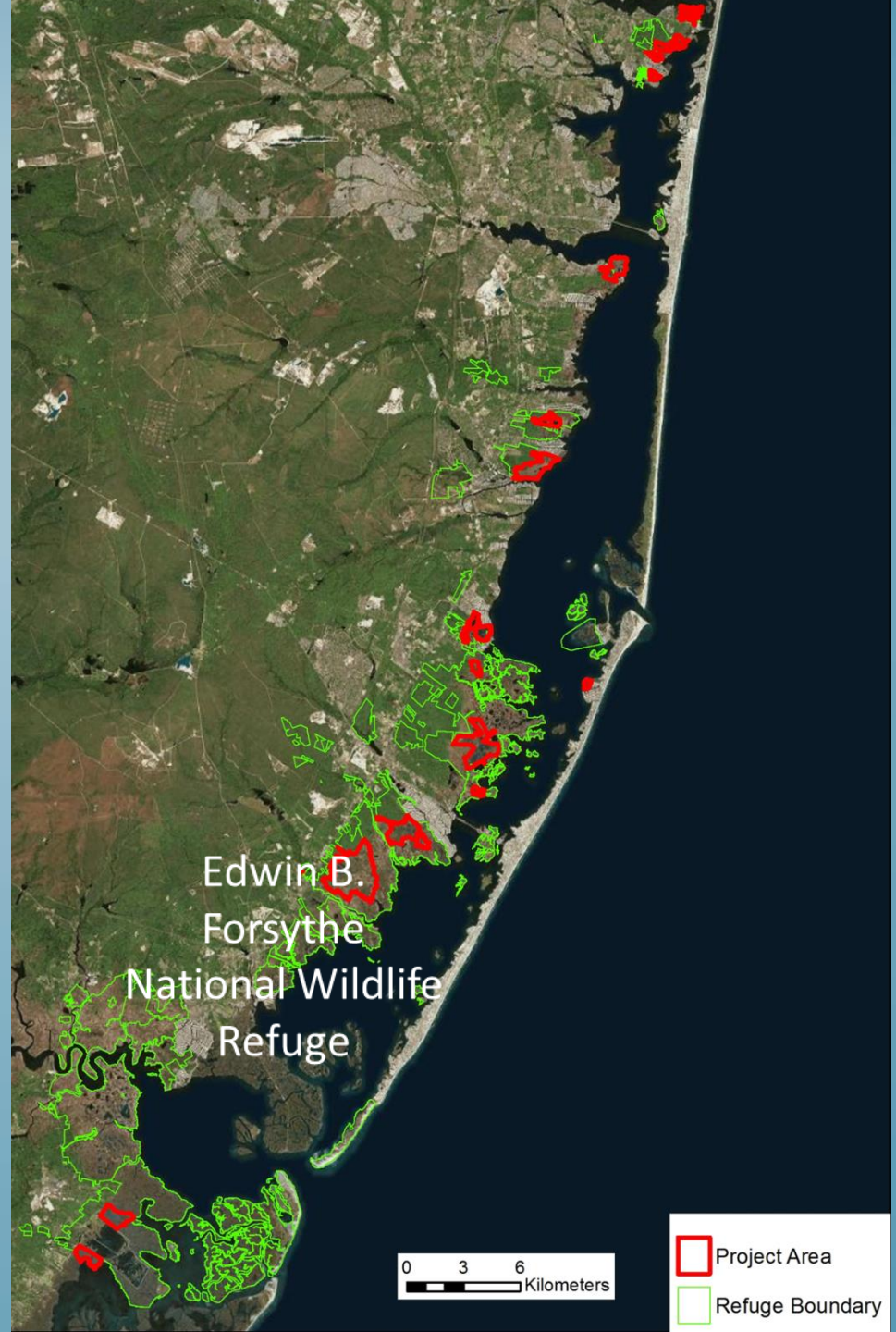
# TIDAL MARSH RESTORATION CONTRACT

SEDIMENT  
ENRICHMENT

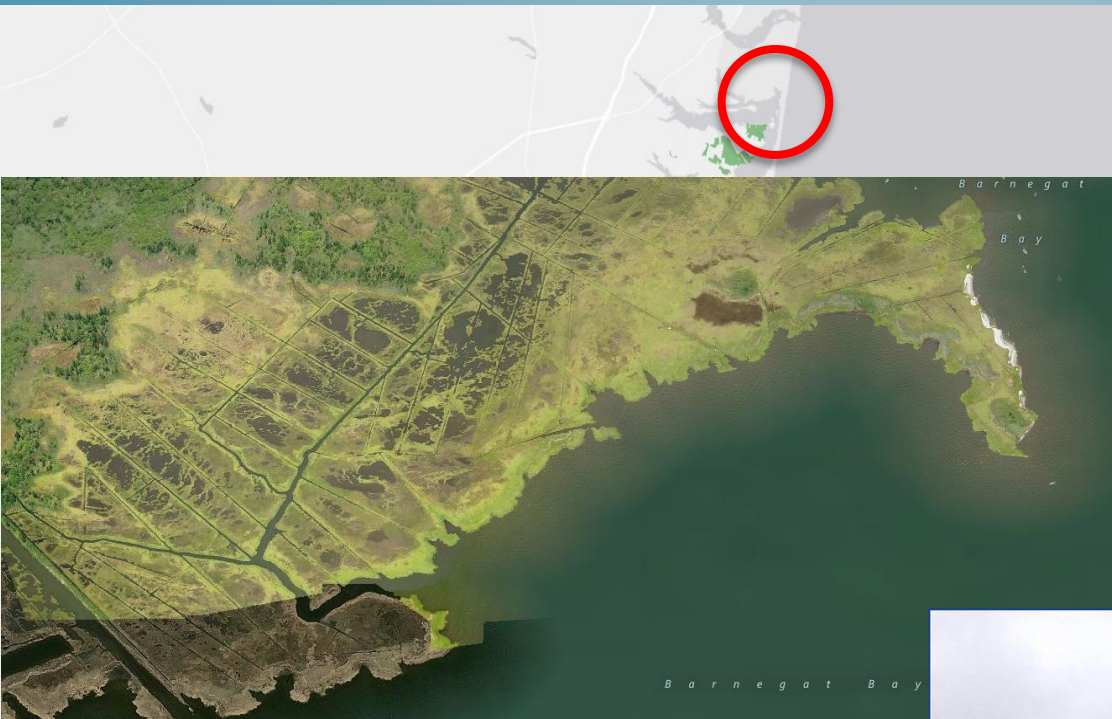
TIDAL FLOW  
RESTORATION

POLE REMOVAL

ACOE IAA



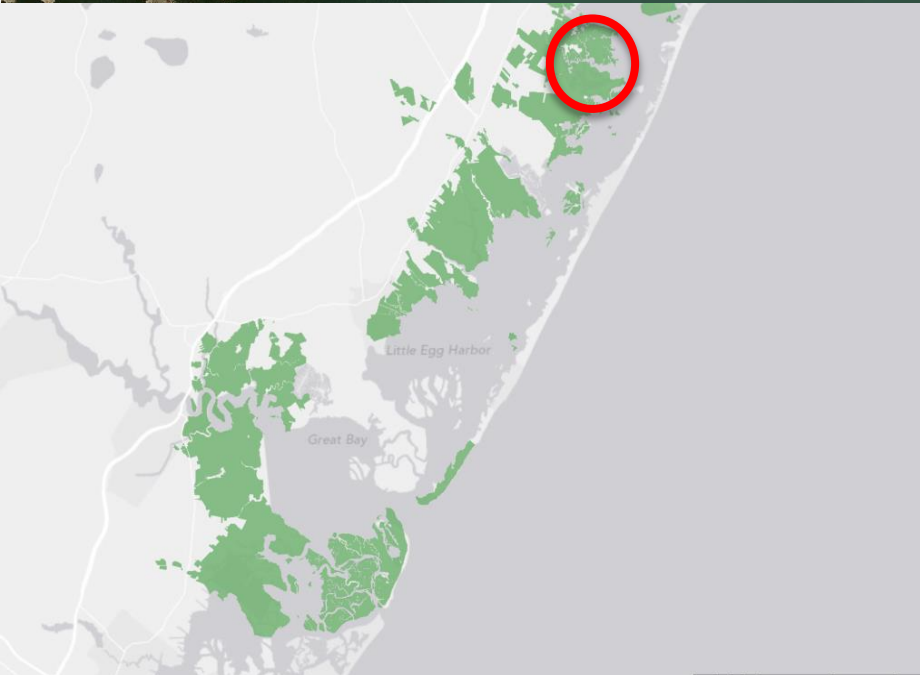




## E.B. Forsythe NWR

3,814 acres of former salt hay farms and ditched areas identified for potential restoration

Thin layer deposition using clean dredged material to suitable depth



# E.B. Forsythe NWR

Restore tidal flow to marshes where hydrology has been restricted by roads, dikes or filling

~225 acres identified for hydrologic restoration



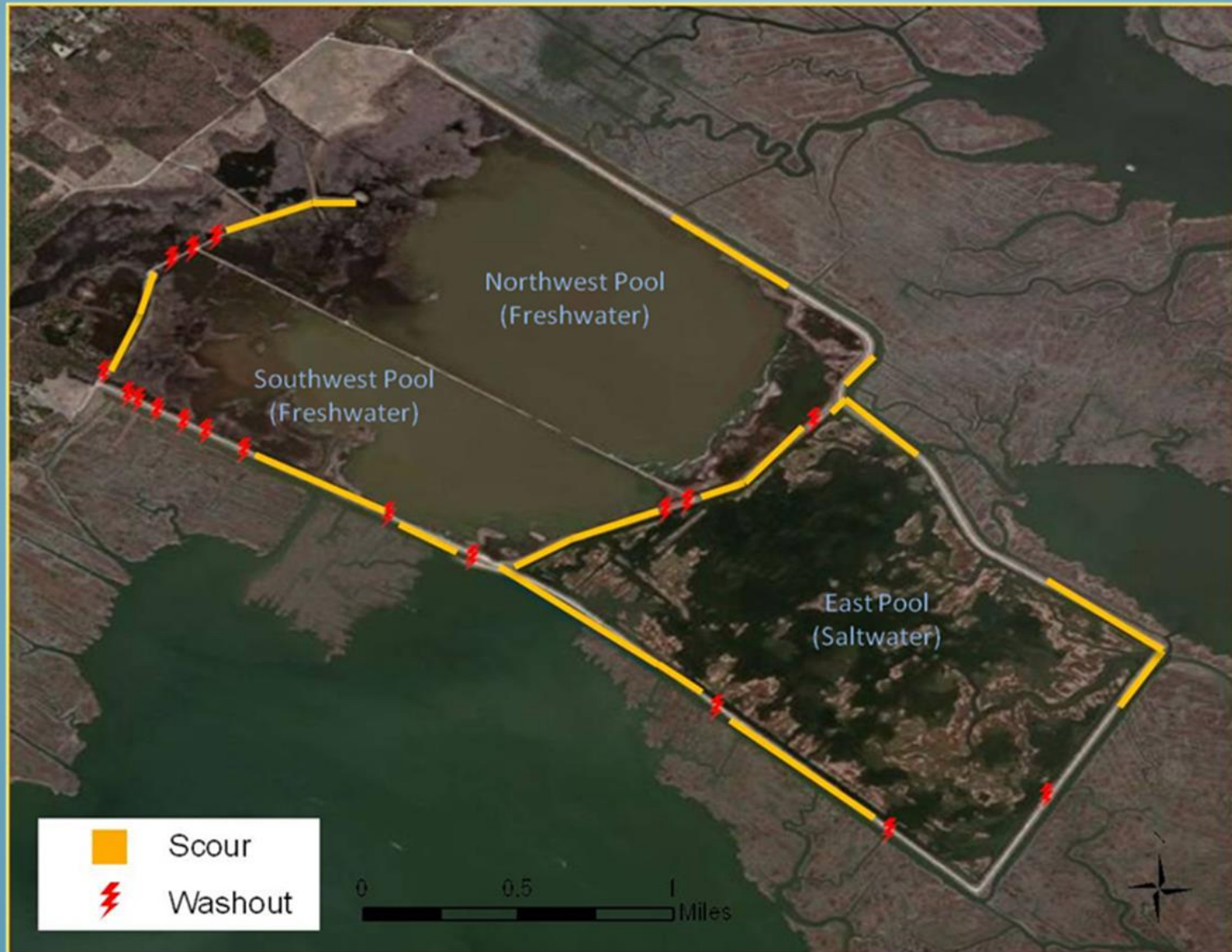


# E. B. FORSYTHE NWR IMPOUNDMENT ASSESSMENT AND MANAGEMENT



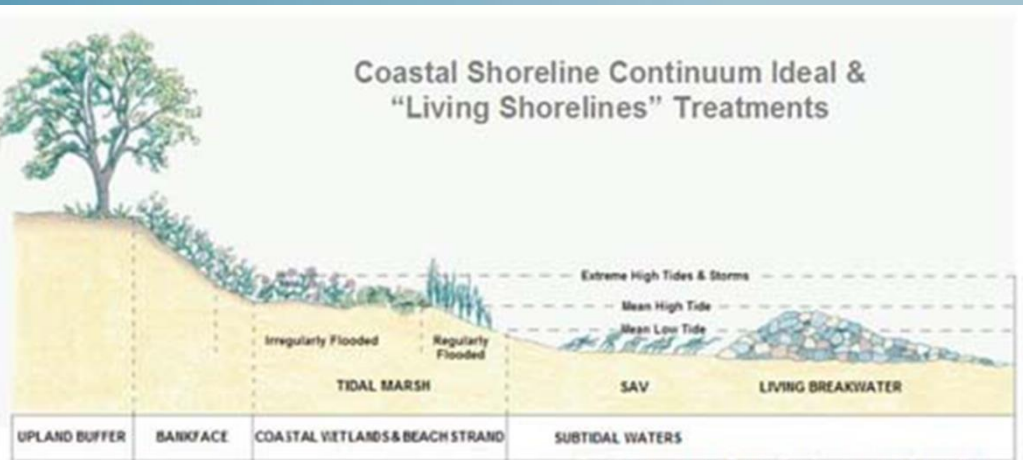


# HQ IMPOUNDMENTS CONTRACT (RECOVERY + RESILIENCE) LONG DIKE LIVING SHORELINE



# E. B. FORSYTHE NWR

## FRESH & SALINE LIVING SHORELINES



Graphic courtesy Burke Environmental Associates

### Tidal Marsh Enhancement

Riparian Vegetation Management  
Bank Grading  
Fiber Logs

Tidal Marsh Creation  
Beach Nourishment & Dune Restoration  
Marsh Toe Revetment  
Marsh Sill  
Marsh with Groins

### Living Breakwater

Offshore Breakwater System  
Oyster Reefs





# WESTECUNK CREEK DAM REMOVAL CONTRACT





# - MONITORING WITH BACI DESIGN

## - ESTABLISH ADAPTIVE MGMT SCENARIO

*SHARP and SMI*

- Bird Popn's
- Vegetation
- Nekton
- SET's

*Expanded water  
logger use*

*Physical attributes*

- Elevation
- Sediment Supply
- Soil characteristics



# COOPERATIVE AGREEMENT

*(University of Delaware Black duck food energy)*

*Compare food energy on paired  
treatment and control sites before  
& after restoration/enhancement*

*Also inform BDJV and ACJV  
modeling efforts*



# EDWIN B. FORSYTHE NWR SANDY RESILIENCE PROJECTS

## CONSTRUCTION PROJECTS

*3 Contracts*

*1 Inter Agency agreements*

*Monitoring - 2 Cooperative  
agreement's*

*youth & public outreach*

## SCIENCE PROJECTS

*1 Inter Agency agreement*

*4 Cooperative agreement's*

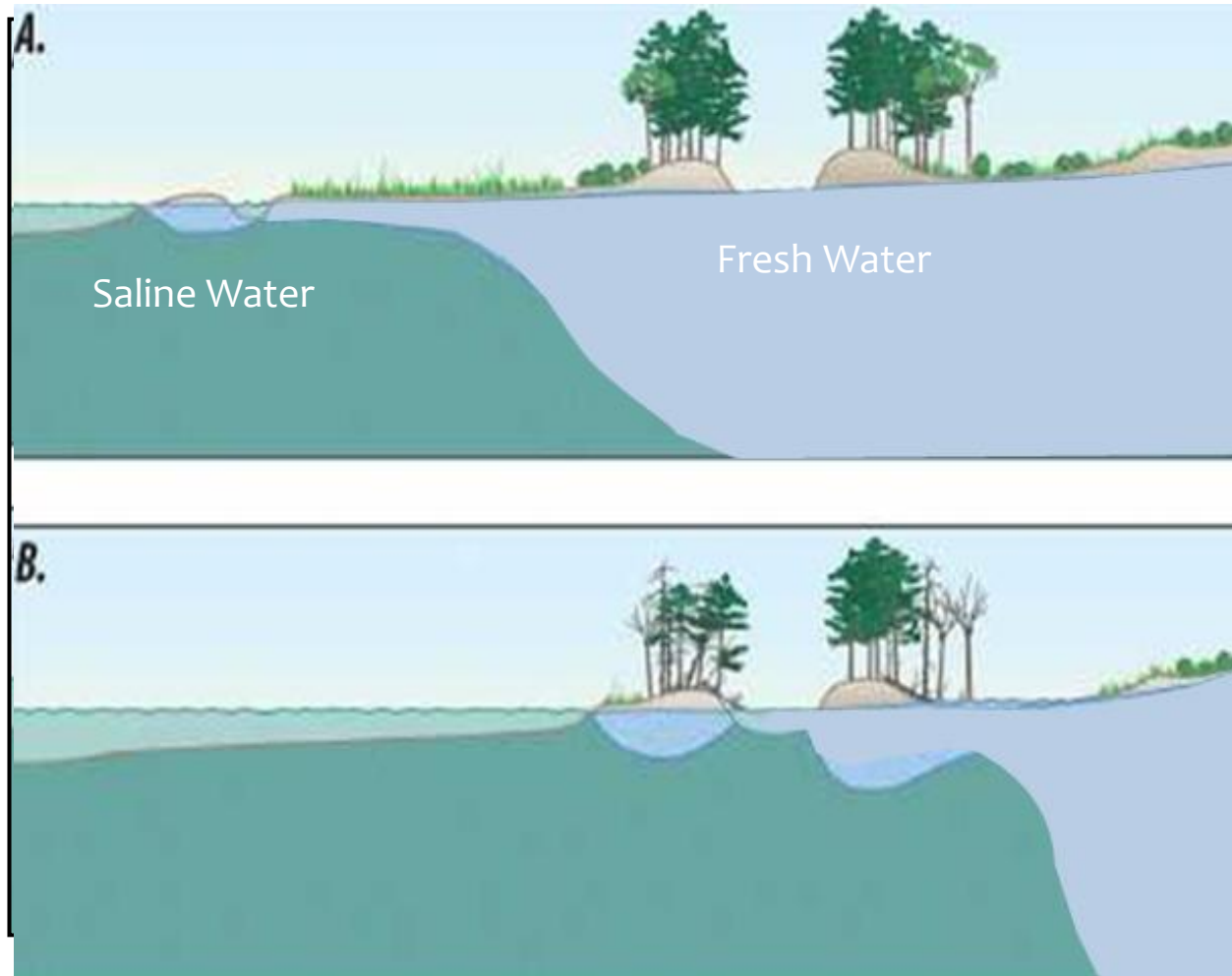
*Monitoring*

*Youth & public outreach*

*Associated projects*



# Effect of Sea-Level Rise on Coastal Groundwater Regime



From Masterson, et al (2013)

# USGS HYDROLOGY INTER-AGENCY AGREEMENT

CHARACTERIZE REFUGE SURFACE  
AND SHALLOW GROUNDWATER





# COOPERATIVE AGREEMENTS (4 BEACH / PIPL PROJECTS)

*Stockton College beach sediment  
and profile monitoring*

*NJ CWF PIPL Recruitment Monitoring*

*USGS PIPL Recruitment Model*

*SUNY College of Environmental Science  
and Forestry PIPL Model and Decision  
Support Tool*





# ASSOCIATED PROJECTS

PARTICIPATING *in* iPLOVER “DEEP DIVE”

UNIV OF DELAWARE - ATLANTIC BRANT FOOD ENERGY STUDY (DOI ROUND 3)

BDJV + USGS - DEVELOPING FIELD PROTOCOLS FOR ESTIMATING BLACK DUCK ABUNDANCE AND WETLAND CHARACTERISTICS USING AN UNMANNED AERIAL SYSTEM.

USGS - COASTAL FOREST WORK

TNC - MEASURING & MONITORING WORKGROUP

NOAA - ECOSYSTEM SERVICES VALUATION WORK

FWS/RALPH TINER - MARSH TRANSGRESSION MONITORING

# PROPOSED PROJECTS

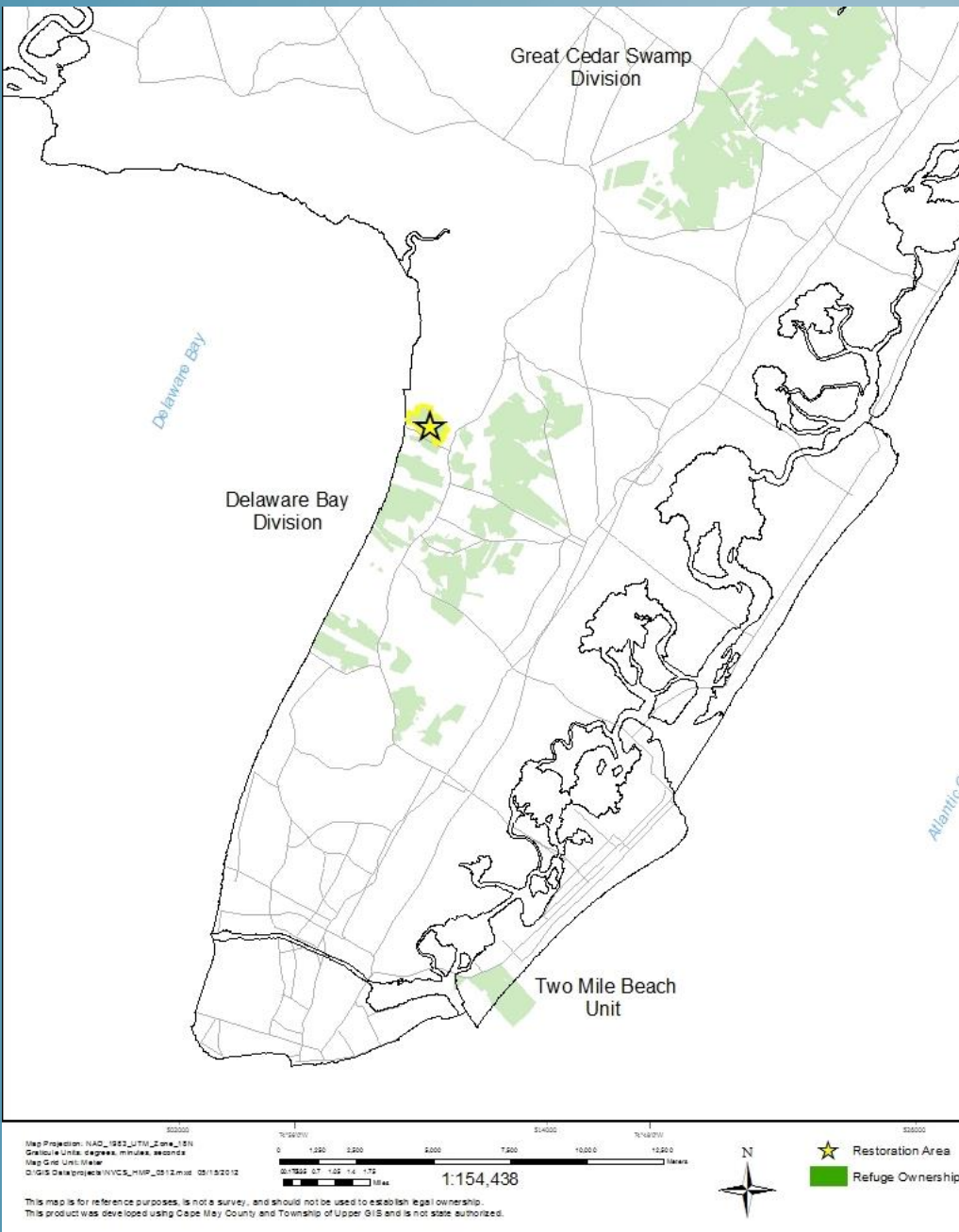
CONTAMINANTS WORK WITH USGS AND UNIV OF DELAWARE

MARSH TRANSGRESSION RUTGERS / NJ AUDUBON / UNIV OF DELAWARE – LEWES

BLUE CARBON MEASUREMENTS / CARBON SEQUESTRATION

# Cape May NWR

Approximately 20 ac.  
formerly salt hayed and  
ditched wetlands  
identified for thin layer  
deposition  
Wetland elevation to be  
raised up to 8 in.





# Supawna Meadows NWR

Evaluate effect of 3.3 mile  
Rock revetment along the  
Delaware shoreline  
Approximately 48 acres identified  
for possible wetland restoration





# YOUTH & PUBLIC OUTREACH



# Post-Hurricane Sandy Tidal Marsh Restoration at Edwin B. Forsythe and Cape May National Wildlife Refuges



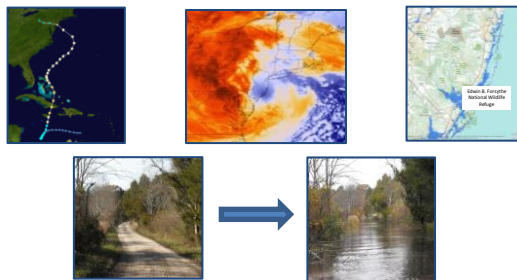
Paul Castelli<sup>1</sup>, Virginia Rettig<sup>1</sup>, Brian Braudis<sup>2</sup>, Heidi Hanlon<sup>2</sup>

<sup>1</sup>U.S. Fish and Wildlife Service, Edwin B. Forsythe National Wildlife Refuge

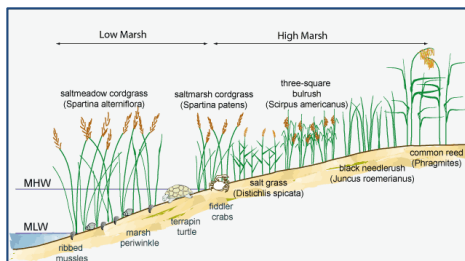
<sup>2</sup>U.S. Fish and Wildlife Service, Cape May National Wildlife Refuge



Hurricane Sandy began as a low pressure system in the Caribbean and grew to a Category 1 hurricane as it tracked northward. The slow approach of the storm produced prolonged east winds and extra high tides that flooded Edwin B. Forsythe National Wildlife Refuge (Forsythe) salt marshes for five days prior to Sandy's eventual landfall on October 29, 2012. Hurricane Sandy and the extremely low barometric pressure associated with the storm eye passed directly over the southern part of Forsythe during the peak of a full moon high tide, which facilitated a large storm surge. Water depths were estimated to be 3 meters above mean high water during the height of the storm. In addition, 20 centimeters of rain also contributed to major flooding at Forsythe. The high water appears to have protected Forsythe's salt marshes from damaging high winds and waves. Preliminary surveys indicate that the majority of marshes are intact and functional, while anthropogenic infrastructure sustained extensive damage.



The frequency of strong storms like Hurricane Sandy is predicted to increase<sup>1</sup>. The greater potential for the occurrence of catastrophic weather events, combined with accelerated sea level rise is a concern for refuge managers. Rising sea level may result in tidal marsh submergence<sup>2</sup> and habitat migration as salt marshes transgress landward and replace tidal freshwater and irregularly flooded marsh<sup>3</sup>. However, salt marsh migration may not happen at the same rate as marsh loss. Our management actions will extend the time that existing marshes persist while marsh migration occurs.



A suite of projects designed to mitigate the impacts of Hurricane Sandy and address threats to the integrity and persistence of 14,500+ hectares of salt marsh and other coastal habitats at Edwin B. Forsythe NWR and the Cape May NWR are underway. Our goals are to maintain and improve green infrastructure in coastal New Jersey using a combination of natural and engineered features, and to safeguard a variety of ecosystem services.

Hurricane Sandy made landfall    Restoration planning    Contracting begins    Short and long-term monitoring of ecological data

Storm damage assessment    Baseline ecological data collection    Restoration efforts begin



**Monitoring:** We will employ a Before, After, Control, Impact (BACI) design to evaluate to efficacy of these enhancement and restoration projects. Metrics include marsh elevation, breeding bird indices, wintering black duck carrying capacity, vegetation characteristics, nekton (fish and crustaceans) density, and soil-water level changes. These data are collected by Student Conservation Association interns, Refuge interns, and Biological Science Technicians under the direction of Refuge Biologists.

**Sediment Enrichment Projects:** We will spray a thin layer of soil using clean dredged material. A range of 5-15 cm of sediment applied to salt marsh areas results in the existing *Spartina alterniflora* and associated biota re-establishing through the soil deposition within 1-3 years<sup>4</sup>.



**Tidal Flow Restoration Projects:** We will restore tidal flow to marshes where hydrology has been restricted by roads, dikes or filling. We will replace undersized culverts and restore natural creek channels. Many studies have determined that increasing tidal flow to tide-restricted salt marshes often restores ecological functions. Roman et al.<sup>5</sup> found that nekton (fish and crustaceans) density and species richness were similar between marshes that had tidal flow restored and marshes that had unrestricted tidal flow. At Supawna Meadows NWR, we will study impacts to the marsh from a rock dike and potentially remove portions of the dike to restore functions of the marsh.



**Pole Removal Projects:** We will remove ~1,000 telephone poles along with associated cables and antennas from sites. The poles contain contaminants that may leach into the marsh. The poles and wires are a source of bird collisions, and they can negatively impact salt marsh birds by providing avian predators with elevated perches<sup>6</sup>. Poles also detract greatly from the refuge visitor experience.



**Living Shoreline Projects:** Several sites in fresh and salt water areas will be considered for Living Shoreline construction, where plants, sand, and limited use of rock provide shoreline protection and maintain valuable habitat.

**Status and Accomplishments:** As of November 1, 2014, Refuge staff and partners have identified 9 project areas where salt marshes appear to be deficient in elevation or tidal flow. Two areas have been slated for pole removal. A request for proposals for contractors has been released and potential contractors have met with refuge staff and visited the sites. We have engaged Federal, State, University and NGO partners to conduct associated assessments and monitoring. The projects will be successful if the preponderance of the marsh areas enhanced are stable and support high quality, functioning habitat that supports healthy densities of representative species.

**Acknowledgements:** Mason Sieges, William Crouch, Vinny Turner, Rebecca Reeves Eugene McColligan, and Nicole Kirkos assisted with poster design and editing. Funding: Hurricane Sandy Disaster Relief Supplemental Appropriation Act of 2013.

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3. Park, R. A., J. K. Lee, P. W. Maudslai, and R. C. Howe. 1991. Using remote sensing for modeling the impacts of sea level rise. *World Resources Review* 3:184-220.
4. Slocum, M. G., Mendenhall, I. A., & Kuhn, N. L. 2005. Effects of sediment slurry enrichment on salt marsh rehabilitation: plant and soil responses over seven years. *Estuaries*, 28(4), 519-528.
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# COOPERATIVE AGREEMENT (Barnegat Bay Partnership )

Fish monitoring at  
Westecunk Creek before  
and after dam removal

