



# Evaluation of Hurricane Sandy Coastal Resilience Program

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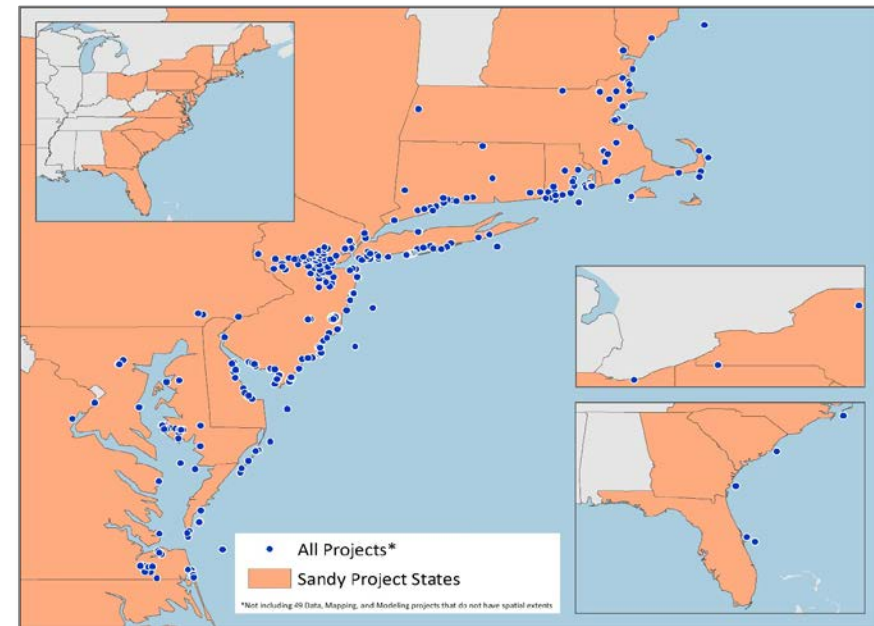


National Conference on Ecosystem Restoration 2018, New Orleans, LA

# DOI & NFWF Sandy Resilience Program



- Build community and ecological resilience through projects
- Fill knowledge gaps and science needs
- Measure project performance and benefits (metrics & evaluation)
- Identify best practices
- Apply lessons learned to future projects and conservation frameworks
- Communicate results



# Sandy Program Components



- Project Implementation: 2013-2018
- Core Metrics Established: 2015
- Complete Evaluation: April 2018
- Long-term Monitoring: 2017-2023

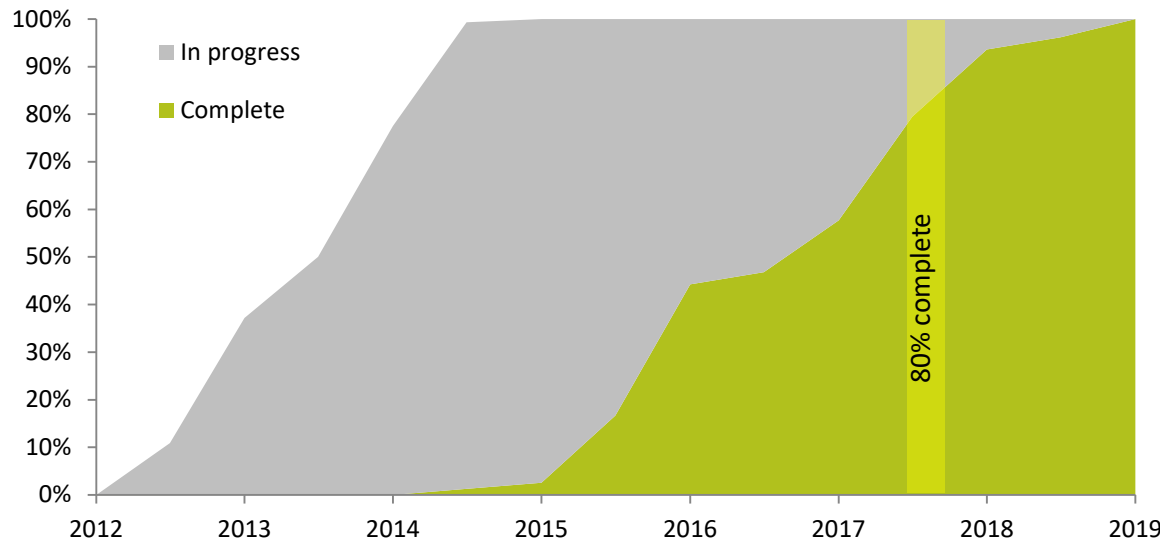


**Implementation**  
Projects underway,  
followed by data  
collection strategy

**Core Measures**  
Core measures with  
some existing record  
and allow for project  
comparison

**Detection**  
Early detection of  
resilience change

**Linkage**  
Between social  
and ecosystem  
resilience



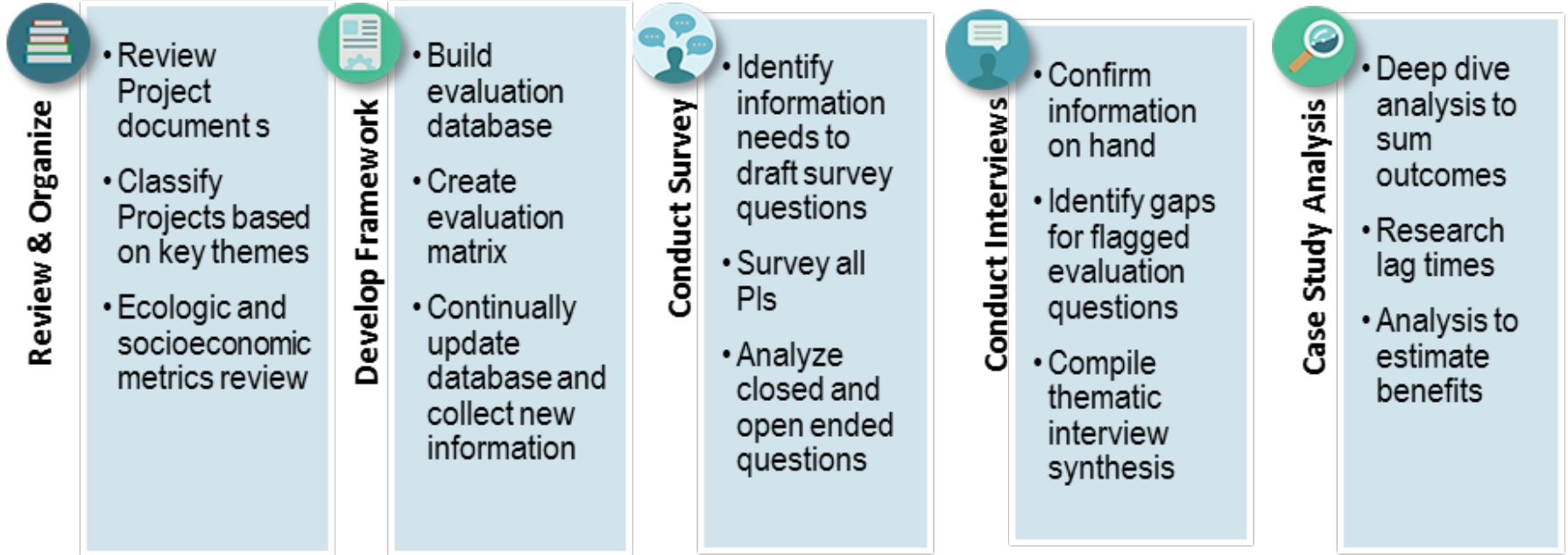
# Presentation Outline



- Describe evaluation methods and Sandy portfolio
- Discuss key findings
  - Project outcomes (projects implemented as intended and quality)
  - Resilience impacts (Ecological and Socioeconomic)
  - Cost effectiveness
  - Improved understanding
- Preliminary recommendations

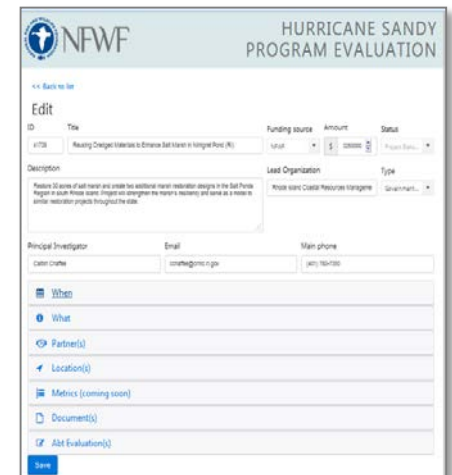


# Evaluation Methods

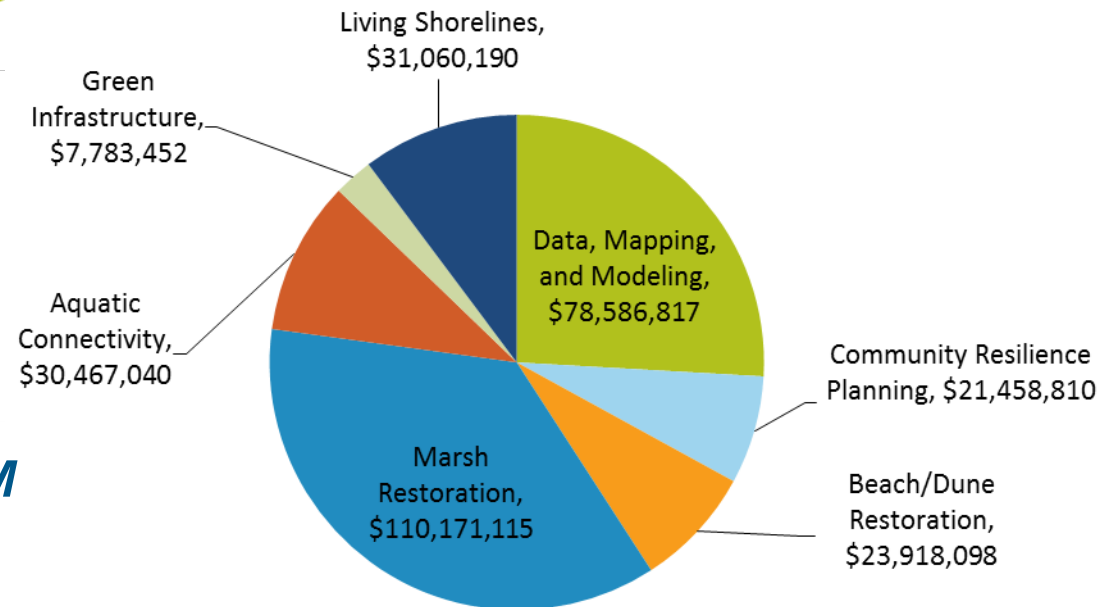
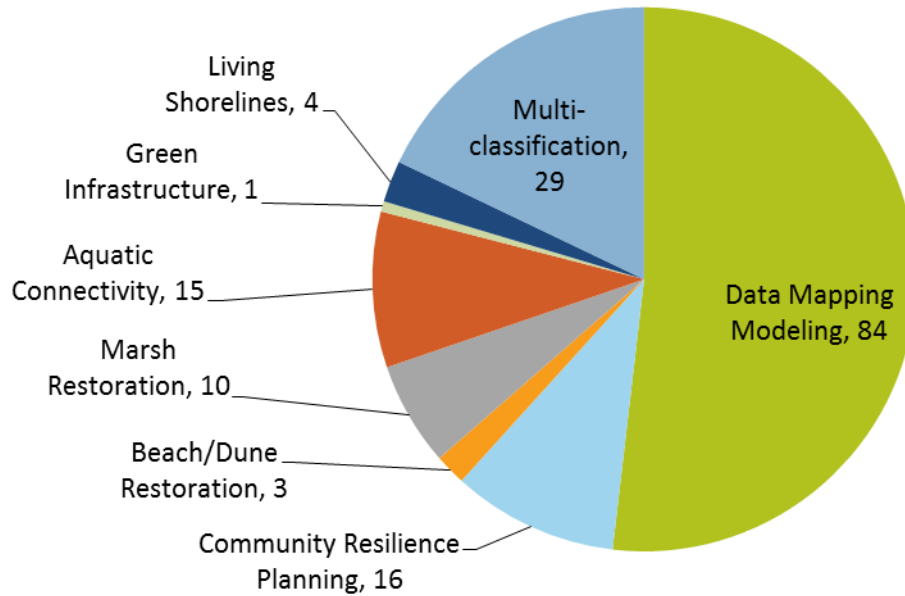


Ecological Indicators  
*(measured)*

Biophysical indicators directly relevant to socio-economic resilience *(estimated)*



# Portfolio Overview

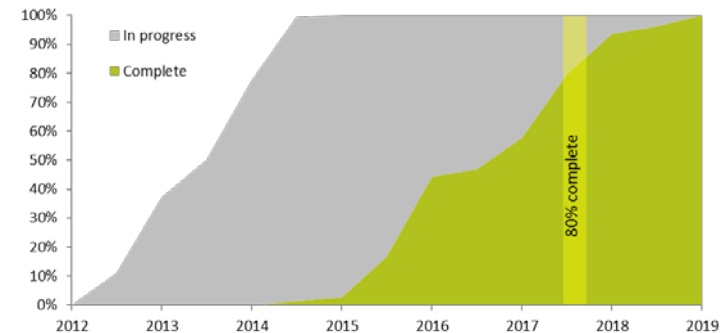
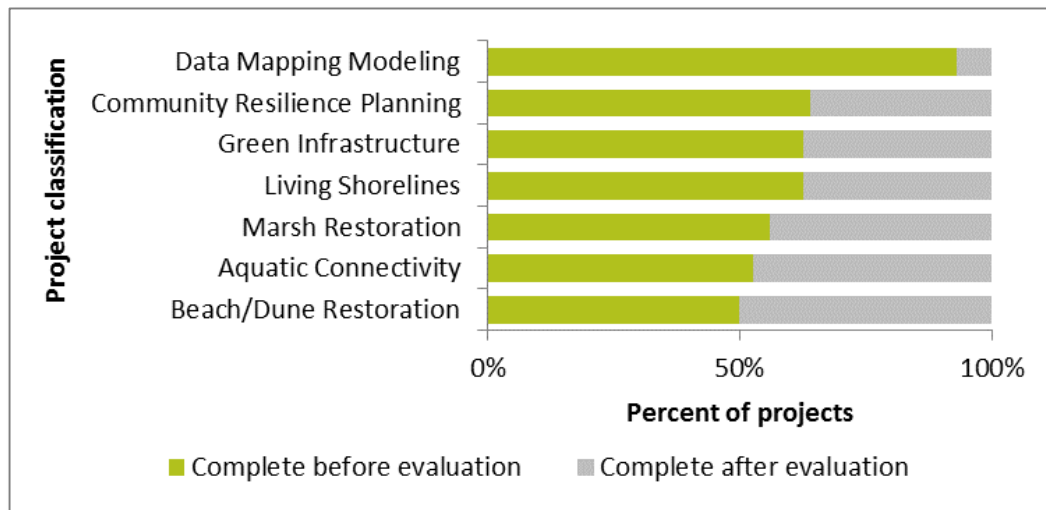


- **Average project cost ~ \$1.8M**
- **Science & Planning lowest average cost ~ \$800K**

# Findings: Implementation Lessons



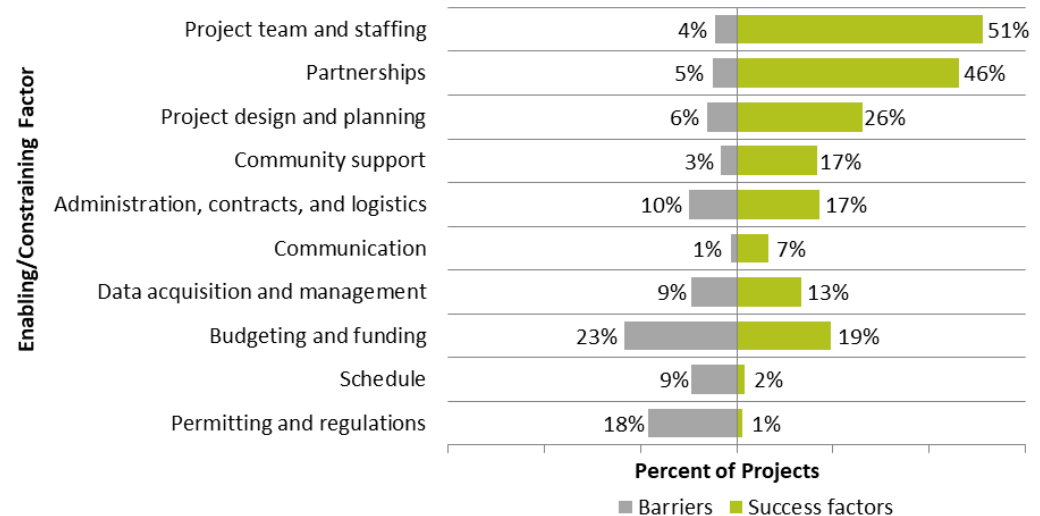
- 80% of projects complete as of June 2018
- Staggered start dates (2013-2015)
- 54% of projects implemented as proposed



# Findings: Implementation Lessons



- 46% of projects submitted formal amendments (majority – 75% – no cost schedule extensions)
- Major factors influencing *not implementing as proposed*: data or knowledge gaps, funding shortfalls, and permitting issues
- Permitting timeline top limiting factor for almost all project classifications





# Findings: Outcome Achievement



## Objectives

## Activities

## Outcomes

### Marsh Restoration

- Providing short and mid-term resilience to sea level rise
- Addressing coastal habitat loss from flooding, storm damage, and erosion



- Increase marsh elevation
- Restore habitat
- Restore marsh hydrology



- 195,000+ marsh acres restored

### Living Shorelines

- Reducing erosion to prevent habitat loss
- Protecting shore and infrastructure from storm impacts, sea level rise
- Trapping sediment, filtering nutrients from runoff



- Install hybrid protection including vegetation, stone structures, reefs
- Increase marsh elevation



- 56,000+ feet of living shorelines created

### Beach/Dune Restoration

- Creating dune area that provides additional habitat, storm protection
- Restoring beach to improve habitat resilience, halt erosion, and encourage accretion



- Repair or create dunes
- Nourish beaches



- 19+ shore miles restored using 1,700,000+ cubic yards of sand
- Return of migratory species

### Aquatic Connectivity

- Providing upstream habitat access for aquatic species
- Improving tidal flushing and water quality
- Creating free flowing rivers to remove risk of dam failure, flooding



- Remove dams or culverts that are barriers to flow
- Replace old or hazardous structures



- 10 culverts right-sized, 23 dams removed
- 250+ river miles opened
- Return of fish

# Findings: Outcome Achievement



## Objectives

### Green Infrastructure

- Restoring lost habitat, improving water quality, and providing shelter for marine organisms
- Reducing nutrient loads through stormwater management

## Activities



- Install green infrastructure: rain gardens, basins, permeable paving

## Outcomes



- 124 structures installed
- 26,000,000+ gal SW storage
- 1,000+ acres improved SWM

### Data Mapping Modeling

- Support long-term restoration and planning
- Improve hazard response
- Addressing data gaps and increasing data diversity



- Identify sand resources
- Quantify marsh capacity
- Document real-time storm impacts



- 500+ products completed and tracked

### Community Resilience Planning

- Addressing development through recreational enhancement
- Supporting local floodplain management and planning
- Creating plans for communities to implement



- Develop shovel-ready plans
- Develop tools, trainings
- Create conceptual designs



- 28 plans complete, with 60%+ of completed projects secured additional funds

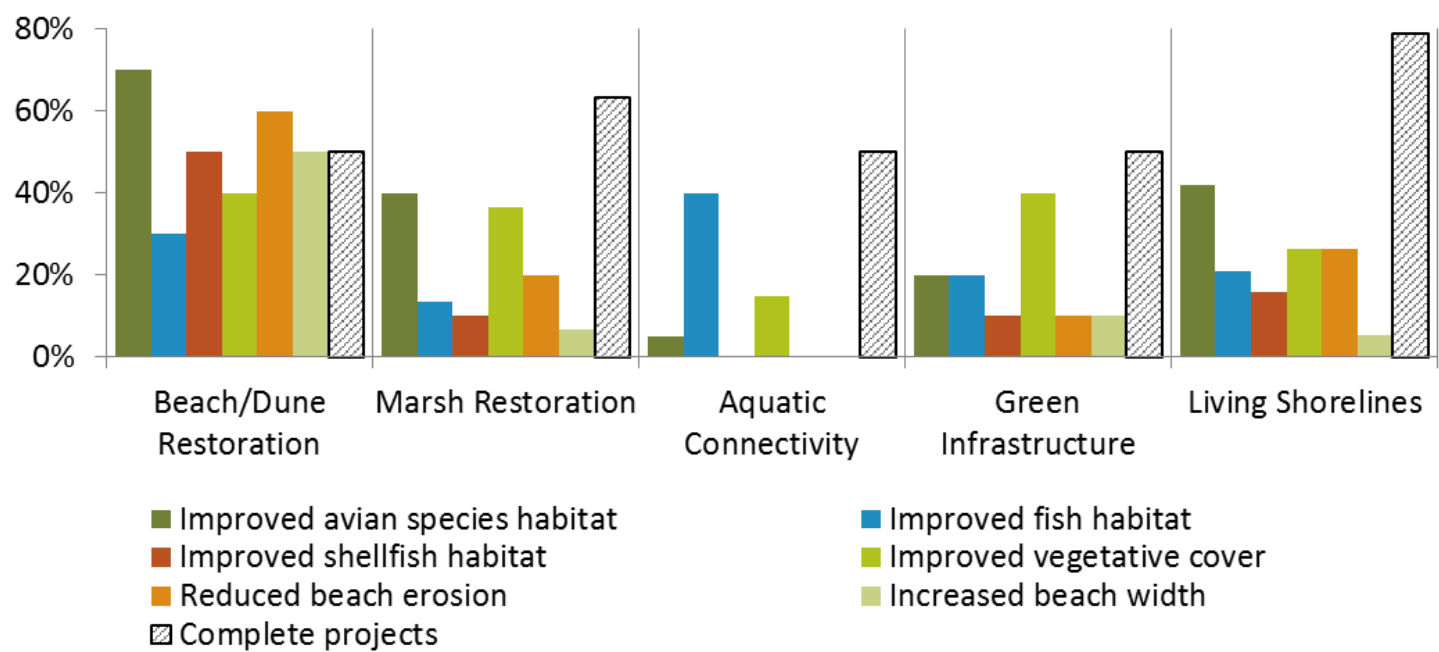
# Findings: Resilience Benefits



- Ecological and socioeconomic benefits
- Assessed by leading indicators (*e.g., ecological: improved fish habitat, improved vegetative cover, and improved avian species habitat*)
- Detailed case studies to assess lag time
- Key focus of long-term monitoring

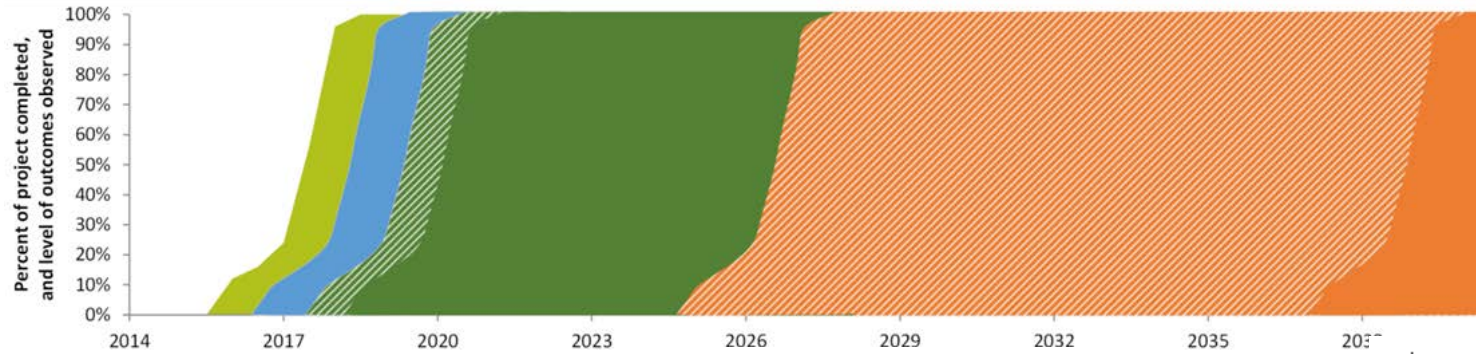


# Findings: Ecological Outcomes



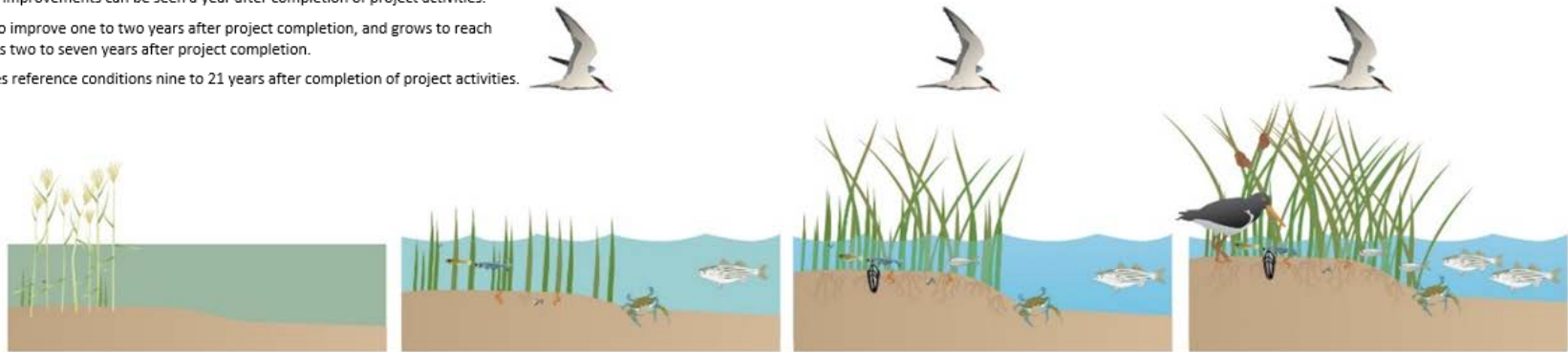
- **Beach & Dune:** quick biotic response for horseshoe crab spawning and migratory birds
- **Marsh:** removal of reeds (Phragmites) and perennial Pepperweed, reduced ponding/ increased flushing, water quality/salinity and nekton abundance (species richness)
- **Aquatic Connectivity:** immediate flushing of trapped sediment and return of crucial fish species, faster than expected.

# Findings: Ecological Lag Time



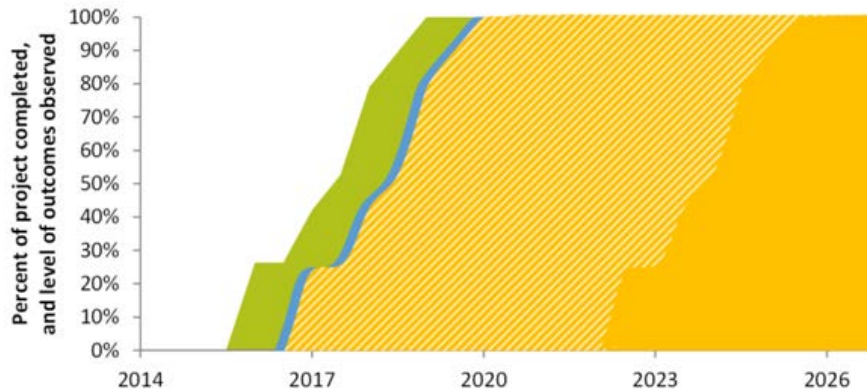
- Marsh projects begin to be complete beginning in 2016.
- Initial water quality improvements can be seen a year after completion of project activities.
- Vegetation begins to improve one to two years after project completion, and grows to reach reference conditions two to seven years after project completion.
- Marsh fauna reaches reference conditions nine to 21 years after completion of project activities.

## MARSH RESTORATION



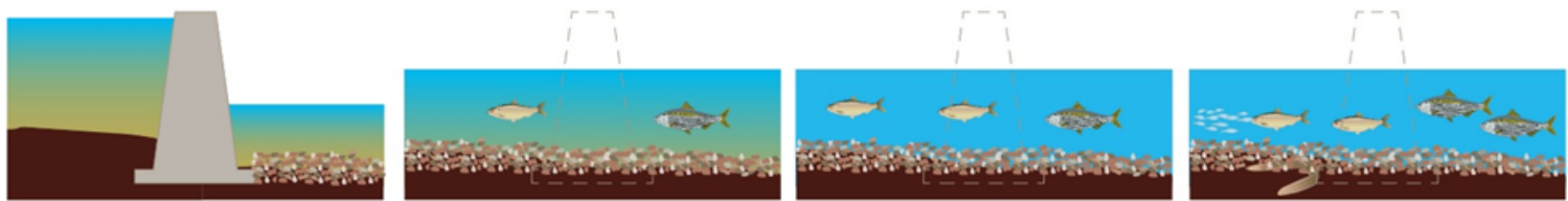
	Year 0	Year 1	Year 3	Year 7
<b>WATER QUALITY</b>	Water is stagnant and often contaminated	Water quality begins to improve with initial nutrient uptake	Water quality continues to improve with nutrient removal and sediment trapping	Water quality continues to improve with nutrient removal and sediment trapping
<b>VEGETATION</b>	Native vegetation is sparse or nonexistent, invasive species (Phragmites) often dominate	Initial plantings begin to stabilize marsh	Planted vegetation grows to be comparable to natural marshes	Planted vegetation is comparable to natural marshes
<b>STORM PROTECTION</b>	Provides little to no storm protection	Storm protection begins to improve with increasing marsh elevation	Marsh elevation continues to increase with sediment supply	Increased bulk density of soil with buried biomass and increased elevation protects from storms
<b>HABITAT</b>	Not suitable for key species	Initial small return numbers for key aquatic species (e.g. blue crab, striped bass) and some avian foragers (e.g. blue heron, egret)	Key avian species return (e.g. oystercatcher, marsh sparrow, tern), ribbed mussels attach to grasses	Key species continue to approach reference conditions
<b>HYDROLOGY</b>	System is fragmented and often contaminated	Immediate improvements depending on degree of tidal restoration	Flooding duration decreases as marsh elevation increases, vegetation grows	Hydrology normalizes comparable to natural marsh conditions

# Findings: Ecological Lag Time



- Aquatic Connectivity projects begin to be complete beginning in 2015.
- Initial water quality improvements can be seen a year after completion of project activities.
- Fish passage (and therefore fish return) improves in the year following completion of project activities, and fish establish spawning populations seven years following.

## DAM REMOVAL

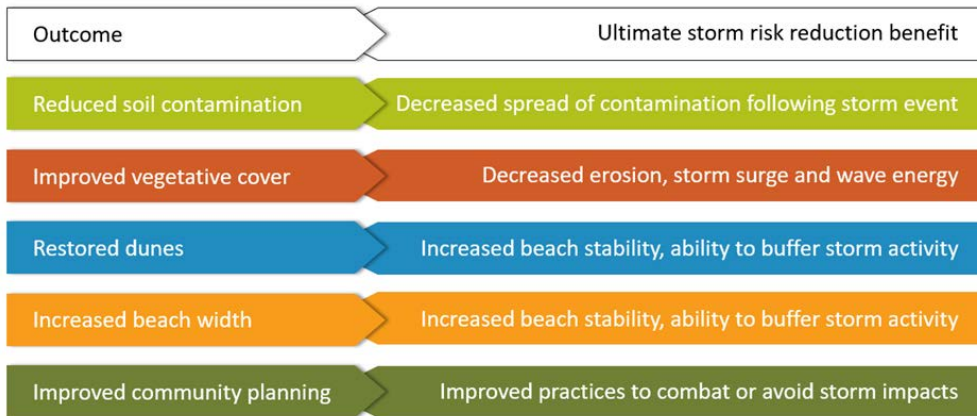


	Year 0	Year 1	Year 3	Year 7
<b>CONNECTIVITY</b>	Barrier prevents flow, traps sediment	Immediate sediment flushing and transport downstream, natural rocky streambed habitat exposed upstream	Bathymetry of stream and tributaries begins to restore, water temperature cools	Flow continues to improve
<b>FISH</b>	Habitat not suitable for fish, cannot progress upstream past barrier	Initial small return numbers on the first upstream run of key aquatic species (e.g. river herring, American shad, American eel)	Fish passage continues, change from warm to cool water fish species, more anadromous fish	Upstream spawning fish include recruits from the first upstream returns
<b>FLOODING</b>	Barrier or risk of failure can cause flooding	Immediate reduction in downstream inundation risk	Water levels continue to normalize, additional decrease in floodplain upstream	Water levels continue to normalize, additional decrease in floodplain upstream

# Findings: Socioeconomic Outcomes

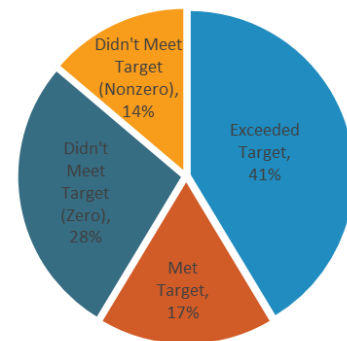
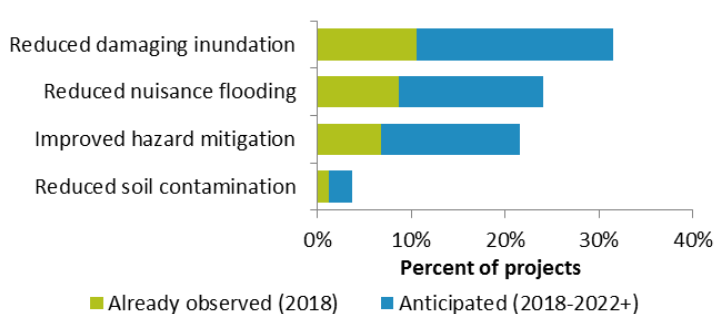


- Leading indicators and metrics monitored: *increased data analysis, acquisition, & delivery*
- Socioeconomic outcomes not explicitly measured, but interest from PI's to measure socioeconomic impacts
- Over half of the planning projects secured funding to implement next step

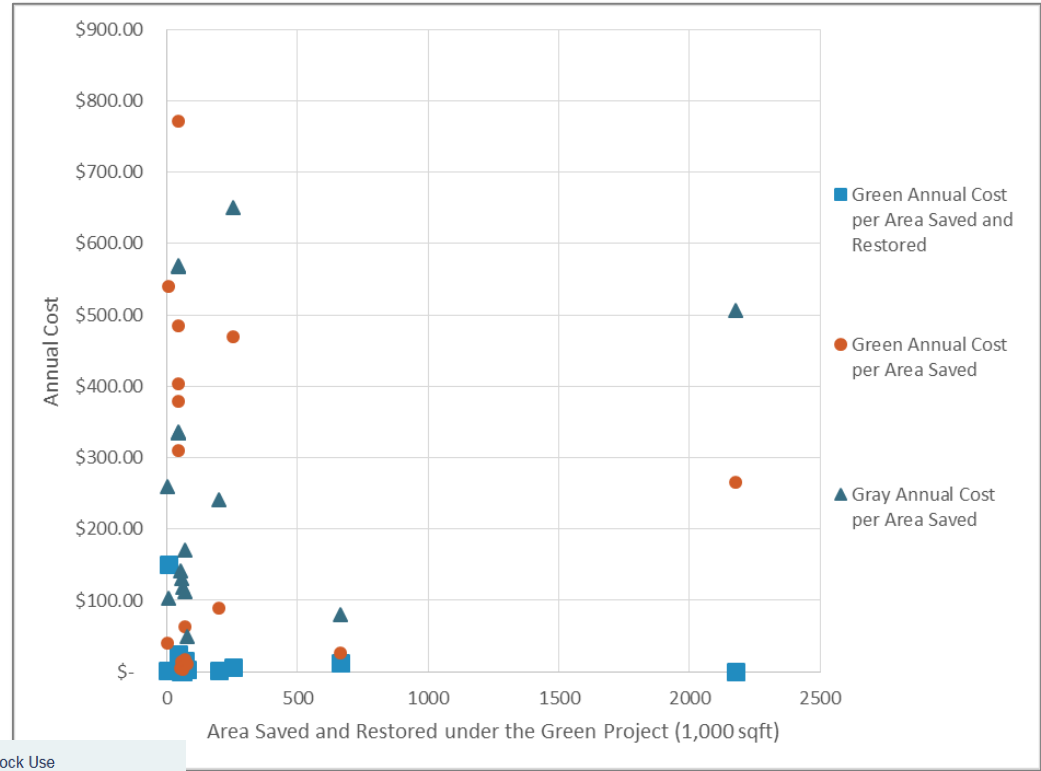
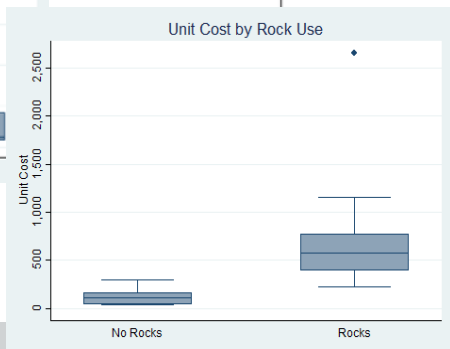
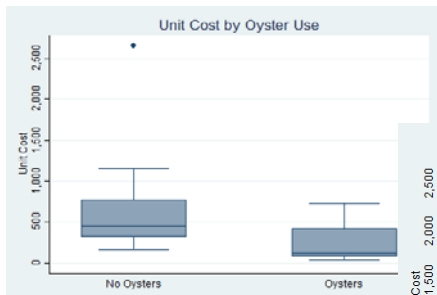
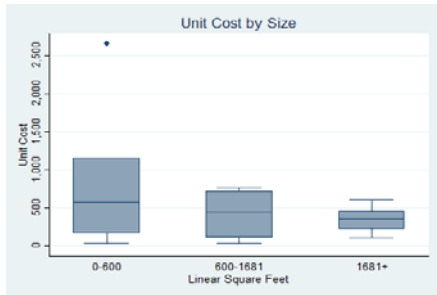
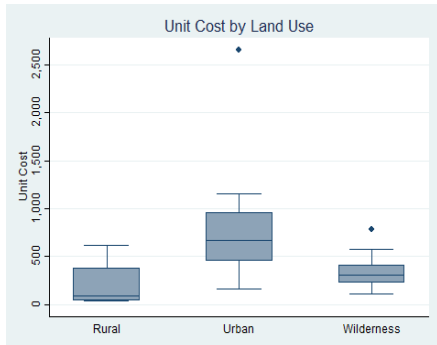


**Assessed:**  
*Economic & Job Protection*  
*Recreation*  
*Education & Outreach*  
*Storm Risk Reduction*

Timeline to observe storm risk reduction

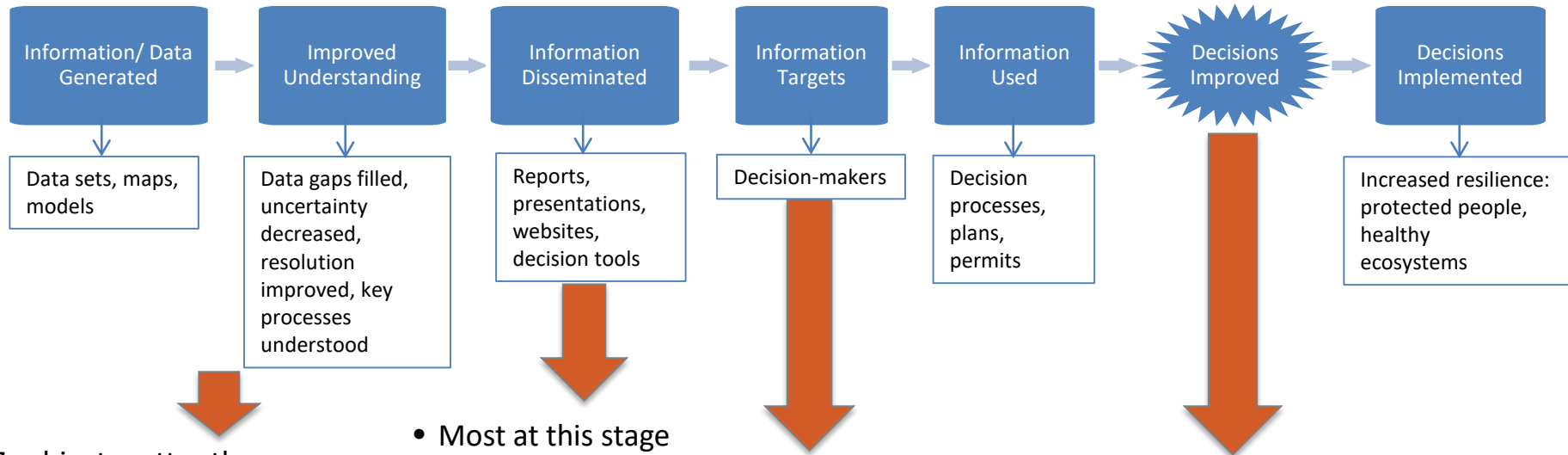


# Findings: Cost Effectiveness





# Findings: Improved Understanding

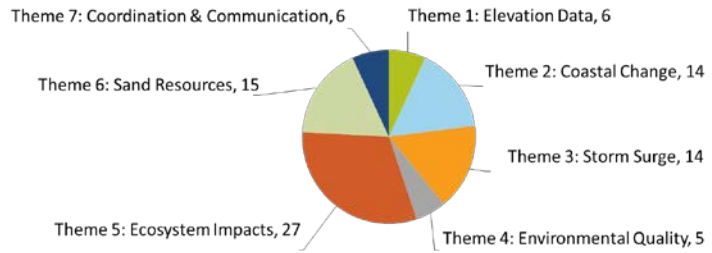


- 7 subject matter themes
- 500+ products and deliverables tracked in a living database

- Most at this stage
- Many went beyond publication

- Governments and NGOs
- Private businesses/ citizens for some project types/themes

- Several early examples of informing decision-making
- Recommendations for future DMM projects:
  - Collect more data
  - Collaborate and communicate
  - Plan in advance
  - Plan and execute long-term



# Summary / Lessons



- Achieving success requires synergies
  - Coordinating projects increases overall effectiveness
  - Coordination at portfolio scale supports targeted and strategic investments and evaluation (*includes: metrics, cost outlines, & reporting*)
- Communicating impacts
  - Measure the ecological and the “so-what”
  - Train staff/require PI’s to measure socioeconomic benefits
- Implementation
  - Phased funding for innovative and new approaches
  - Early permitting/compliance, plan for adaptive management
  - Require and fund monitoring

Thank you!

- Questions: [Susan\\_Taylor@abtassoc.com](mailto:Susan_Taylor@abtassoc.com)
- DOI Sandy Program:  
<https://www.doi.gov/hurricanesandy>
- NFWF Sandy Program:  
<http://www.nfwf.org/hurricanesandy/Pages/home.aspx>



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