Evaluation of Hurricane Sandy Coastal Resilience Program
Susan Taylor & Claire Goydan, Abt Associates
Amanda Bassow & Christina Kakoyannis, NFWF
Lisa Wainger & Virginia Institute of Marine Science
Rick Bennett FWS & Pete Murdoch USGS

National Conference on Ecosystem Restoration 2018, New Orleans, LA
- 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
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

**Review & Organize**
- Review project documents
- Classify projects based on key themes
- Ecologic and socioeconomic metrics review

**Develop Framework**
- Build evaluation database
- Create evaluation matrix
- Continuously update database and collect new information

**Conduct Survey**
- Identify information needs to draft survey questions
- Survey all PIs
- Analyze closed and open ended questions

**Conduct Interviews**
- Confirm information on hand
- Identify gaps for flagged evaluation questions
- Compile thematic interview synthesis

**Case Study Analysis**
- Deep dive analysis to sum outcomes
- Research lag times
- Analysis to estimate benefits

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**Ecological Indicators (measured)**
- Acres of coastal wetland restored
- Increase in average elevation within floodplain

**Biophysical Indicators directly relevant to socio-economic resilience (estimated)**
- Reduction in storm surge height
- Reduced exposure to storm surge (e.g. # ppl affected)
- Decrease in # of injuries or casualties

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[Diagram showing project actions, outcomes, and resilience goals]
- **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

![Hyde Pond, CT](image)
**Findings: Outcome Achievement**

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

**Activities:**
- Increase marsh elevation
- Restore habitat
- Restore marsh hydrology

**Outcomes:**
- 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

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

**Outcomes:**
- 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

**Activities:**
- Repair or create dunes
- Nourish beaches

**Outcomes:**
- 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

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

**Outcomes:**
- 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

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**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

**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 11 years after completion of project activities.

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

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

<table>
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<tr>
<th>Outcome</th>
<th>Ultimate storm risk reduction benefit</th>
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<tr>
<td>Reduced soil contamination</td>
<td>Decreased spread of contamination following storm event</td>
</tr>
<tr>
<td>Improved vegetative cover</td>
<td>Decreased erosion, storm surge and wave energy</td>
</tr>
<tr>
<td>Restored dunes</td>
<td>Increased beach stability, ability to buffer storm activity</td>
</tr>
<tr>
<td>Increased beach width</td>
<td>Increased beach stability, ability to buffer storm activity</td>
</tr>
<tr>
<td>Improved community planning</td>
<td>Improved practices to combat or avoid storm impacts</td>
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**Assessed:**
- Economic & Job Protection
- Recreation
- Education & Outreach
- Storm Risk Reduction

**Timeline to observe storm risk reduction**

- Reduced damaging inundation
- Reduced nuisance flooding
- Improved hazard mitigation
- Reduced soil contamination

**Percent of projects**

- Already observed (2018)  
- Anticipated (2018-2022+)

**Exceeded Target, 41%**

**Exceeded Target (Nonzero), 14%**

**Did Not Meet Target (Zero), 28%**

**Did Not Meet Target, 17%**
Findings: Cost Effectiveness

- **Unit Cost by Land Use**
- **Unit Cost by Size**
- **Unit Cost by Oyster Use**
- **Unit Cost by Rock Use**

**Graph:**
- Green Annual Cost per Area Saved and Restored
- Green Annual Cost per Area Saved
- Gray Annual Cost per Area Saved

**Area Saved and Restored under the Green Project (1,000 sqft)**

- **Y-axis:** Annual Cost
- **X-axis:** Area Saved and Restored (1,000 sqft)
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
- DOI Sandy Program: https://www.doi.gov/hurricanesandy
- NFWF Sandy Program: http://www.nfwf.org/hurricanesandy/Pages/home.aspx