Natural and Nature-Based Features to Enhance the Resilience of Coastal Systems: Post-Sandy Recovery Efforts

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Background

• Hurricane/Post-Tropical Cyclone Sandy moved to the U.S. Atlantic Ocean coastline 22-29 October 2012

• Affected entire U.S. east coast: 24 States from Florida to Maine; New Jersey to Michigan and Wisconsin

• Areas of extensive damage from coastal flooding: New Jersey, New York, Connecticut

• Public Law 113-2 enacted 29 January 2013
The Disaster Relief Appropriations Act of 2013

1. Near-Term Coastal Restoration ($656 M; 25/13)
2. Operations and Maintenance ($621 M; 85/37)
3. Authorized But Not Yet Constructed ($2.76 M; 18/0)
4. Storm Damage Risk Reduction Studies ($28 M; 18/0)
5. Continuing Authorities Program ($48 M; 9/0)
Collaborative development of a Risk Reduction Framework for the 31,000 miles of coastline affected by Hurricane Sandy.

Support Resilient Coastal Communities and robust, Sustainable Coastal Landscape Systems, considering future sea level rise and climate change scenarios, to reduce risk to vulnerable population, property, ecosystems, and infrastructure.

$19M study submitted to Congress in January 2015.
Green Infrastructure (e.g. Living Shorelines)

- Tidal wetlands plants
- SAV grass
- Breakwater or Artificial Oyster Reef

Image adapted from Burke Environmental Associates
# Coastal Risk Reduction & Resilience Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Definition</th>
<th>Effect</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Natural</td>
<td>Created through the action of biochemical and physical processes operating in nature</td>
<td>Shoreline erosion control, wave and surge attenuation, especially in low-energy environments; additional resilience benefits; performance difficult to quantify</td>
<td>Barrier islands, dunes, reefs, wetlands, and riparian corridors</td>
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<tr>
<td>Nature-Based</td>
<td>Products of planning, engineering design, and construction incorporating natural processes that contribute to coastal risk reduction and resilience</td>
<td>Shoreline erosion control, wave and surge attenuation, especially in low-energy environments; performance difficult to quantify</td>
<td></td>
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<tr>
<td>Non-Structural</td>
<td>Products of public policy, management and regulatory practices; may include pricing schemes, planning, engineering design, and construction</td>
<td>Modify or avoid the impacts of the hazard (vs. modifying the hazard); quantifiable performance</td>
<td>Structure acquisitions or relocations, flood proofing of structures, implementing flood warning systems, flood preparedness planning, land use regulations, development restrictions within the greatest flood hazard areas, elevated development, managed retreat, evacuation, buyout and leaseback</td>
</tr>
<tr>
<td>Structural</td>
<td>Products of planning, engineering design, and construction</td>
<td>Shoreline erosion control, wave and surge attenuation, reduced flooding; quantifiable performance</td>
<td>Levees, storm surge barrier gates, seawalls, groins, revetments, and near-shore breakwaters</td>
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## Natural and Nature-Based Infrastructure at a Glance

### General Coastal Risk Reduction Performance Factors:
Storm Intensity, Track, and Forward Speed, and Surrounding Local Bathymetry and Topography

<table>
<thead>
<tr>
<th>Infrastructure Type</th>
<th>Benefits/Processes</th>
<th>Performance Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dunes and Beaches</strong></td>
<td>Break offshore waves, Attenuate wave energy, Slow inland water transfer</td>
<td>Berm height and width, Beach slope, Sediment grain size and supply, Presence of vegetation</td>
</tr>
<tr>
<td><strong>Vegetated Features:</strong> Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)</td>
<td>Break offshore waves, Attenuate wave energy, Slow inland water transfer, Increase infiltration</td>
<td>Marsh, wetland, or SAV elevation and continuity, Vegetation type and density</td>
</tr>
<tr>
<td><strong>Oyster and Coral Reefs</strong></td>
<td>Break offshore waves, Attenuate wave energy, Slow inland water transfer</td>
<td>Reef width, elevation and roughness</td>
</tr>
<tr>
<td><strong>Barrier Islands</strong></td>
<td>Wave attenuation and/or dissipation, Sediment stabilization</td>
<td>Island elevation, length, and width, Land cover, Breach susceptibility, Proximity to mainland shore</td>
</tr>
<tr>
<td><strong>Maritime Forests/Shrub Communities</strong></td>
<td>Wave attenuation and/or dissipation</td>
<td>Shoreline erosion stabilization, Soil retention, Vegetation height and density, Forest dimension, Sediment composition, Platform elevation</td>
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</table>
Coastal Risk Reduction and Resilience

The USACE planning approach supports an integrated approach to reducing coastal risks and increasing human and ecosystem community resilience through a combination of natural, nature-based, non-structural and structural measures. This approach considers the engineering attributes of the component features and the dependencies and interactions among these features over both the short- and long-term. It also considers the full range of environmental and social benefits produced by the component features.
Natural and Nature-Based Features Evaluation and Implementation Framework

**ORGANIZATIONAL ALIGNMENT**
- Identify and Organize Stakeholders, Partners and Authorities

**EVALUATION**
- Define Physical and Geomorphic Setting
- Assess Vulnerability and Resilience
- Identify NNBF Opportunities
  - Formalize NNBF Objectives
  - Identify NNBF Alternatives
  - Define NNBF Performance Metrics
- Evaluate NNBF Alternatives
  - Tier 1
  - Tier 2
  - Tier 3

Iterate as Needed

**IMPLEMENTATION**
- Select NNBF Alternatives
- Design Implementation Plan: Elaborate Operational and Engineering Practices
- Implement NNBF Alternative
- Monitor for Performance and Assess Ecosystem Goods and Services

Feedback
Classification System

1 A 1-1. Drowned River Valley

Examples: Chesapeake and Delaware Bays

Terace
Cool Temperate Forest
T15

Temperate Grassland Meadow Shrubland

Armor, Bulkhead or Seawall may or may not be present

M1
Submerged Breakwater (Nearshore Berm/Sill Mollusk Reef)

Submerged Aquatic Vegetation

E2
Emergent Herbaceous Marsh

NOT TO SCALE

“Living Shorelines”

Substrate: Silt, some sand, peat

EXTREME HIGH TIDE
MLW
MLW
**Vulnerability**

 Metrics must consider **EXPOSURE**, **SENSITIVITY**, and **ADAPTIVE CAPACITY** of a system.

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**Vulnerability**: Degree to which a system is susceptible to, and unable to cope with, adverse effects from a hazard; vulnerability is a function of the character and magnitude of a hazard to which a system is exposed, its sensitivity, and its adaptive capacity.

**Vulnerability factors:**
- **Internal**
- **External**
- **Socioeconomic**
- **Biophysical**

Metrics must consider **EXPOSURE**, **SENSITIVITY**, and **ADAPTIVE CAPACITY** of a system.
21 Ecosystem Goods and Services Associated with NNBF

1. Aesthetics - appreciation of natural scenery (other than through deliberate recreational activities), Inspiration for culture, art and design
2. Biological diversity (biodiversity)
3. Carbon sequestration
4. Clean water provisioning (sediment, nutrients, pathogens, salinity, other pollutants)
5. Commercial harvestable fish and wildlife production
6. Cultural heritage and identity - sense of place and belonging, spiritual and religious inspiration
7. Education and scientific opportunities (for training and education)
8. Erosion protection and control (water and wind, any source)
9. Habitat for fish and wildlife provisioning (nursery, refugium, food sources, etc.)
10. Increase or maintain land elevation, land-building, sediment source reduction
11. Keeping unwanted sediments out of storm waters
12. Nutrient sequestration or conversion
13. Property value protection
14. Provision and storage of groundwater supply
15. Raw materials production (timber, fiber and fuel, etc.)
16. Recreation - opportunities for tourism and recreational activities
17. Reduce hazardous or toxic materials in water or landscape
18. Reduce storm surge and related flooding
19. Reduce the peak flood height and lengthen the time to peak flood
20. Reduce wave attack
21. Threatened and Endangered species protection
3 Levels of Performance Metrics

- **Level 1** – Qualitative characterization of performance
- **Level 2** – Semi-quantitative characterization of performance
- **Level 3** – Quantitative characterization of performance

72 individual performance metrics identified for NNBF
## Decision Framework

<table>
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<tr>
<th>Objective</th>
<th>Performance Metric</th>
<th>Measure</th>
<th>Alternative Performance</th>
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<tbody>
<tr>
<td>Developed by Stakeholders</td>
<td>Developed From Performance &amp; Vulnerability Metrics (Section 2)</td>
<td>Selected for Tier (Section 3) &amp; Informed by NNBF Performance (Sections 1&amp;2)</td>
<td>Formulated Using NNBF Descriptions (Section 1)</td>
</tr>
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<td>Sustain Ecosystem Services Generated by Coastal Systems</td>
<td>Average annual damages avoided</td>
<td>% of workforce unemployed</td>
<td></td>
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<tr>
<td>Fish &amp; wildlife habitat provision</td>
<td>Habitat Quality Index</td>
<td></td>
<td></td>
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<tr>
<td>Maintain water quality</td>
<td>WQ Index</td>
<td></td>
<td></td>
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<tr>
<td>Promote Resilient Coastal Communities</td>
<td>Population</td>
<td>No. residents</td>
<td></td>
</tr>
<tr>
<td>Vulnerability to coastal storms</td>
<td>Exposure + Sensitivity</td>
<td></td>
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Performance Evaluation Case Studies

1. **Proof of concept analysis**
   - Quantify benefits of environmental restoration projects using an ecosystem goods and services (EGS) analysis framework

2. **Hurricane Sandy case study**
   - Use extreme event to improve understanding of restoration effectiveness & benefits

3. **Focused on two general types of services:**
   - Flood damage Reduction
   - Wildlife Habitat (emphasis on T&E species)

4. **3 Study Sites**
   - Jamaica Bay
   - Cape May Meadows
   - Cape Charles South
Moving Forward. . .

• Organize and expand science and engineering understanding regarding NNBF
  – Reduce uncertainties regarding design and performance
  – Differences among types of NNBF
  – Dynamic performance of NNBF

• Integrating expertise both within and across organizations
  – Planning, designing, constructing, monitoring, and maintaining NNBF