Hurricane Sandy

Storm Impacts and Damages:

▶ Human
- 286 people killed (159 in the US)
- 500,000 people affected by mandatory evacuations
- 20,000 people required temporary shelter
- Extensive community dislocations – continuing today in some areas

▶ Economic
- $65B in damages in the U.S.
- 26 states affected (10 states and D.C are in the NACCS study area)
- 650,000 houses damaged or destroyed
Resilience: the ability of a system to Prepare for, Resist, Recover, and Adapt to achieve functional performance under the stress of disturbances through time.

<table>
<thead>
<tr>
<th>Study</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>NAS (2012)</td>
<td>“Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.”</td>
</tr>
<tr>
<td>E.O. 13653 (2013)</td>
<td>&quot;resilience means the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.”</td>
</tr>
</tbody>
</table>

Disturbance

Prepare Anticipate

Adapt Evolve

Resist Withstand

Recover Bounce Back

Functionality

Time

Engineering

Environmental

Community
In the Context of Coastal Resilience…

- What opportunities are there for achieving better alignment of natural and engineered systems?
  - Can improved alignment reduce risks to life and property?
  - What additional services can be produced?
  - What are the science and engineering needs in order to achieve better alignment?

Sustainable Solutions Vision: “Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation’s water resources challenges.”
Systems: 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.”
NACCS Natural and Nature-Based Features: Multi-Disciplinary Team

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- Michelle Haynes (IWR)
- Lauren Leuck (IWR)
- David Raff (IWR)
- Lisa Wainger (U. Maryland)
- Sam Sifleet (U. Maryland)
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>Dunes and Beaches</th>
<th>Vegetated Features: Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)</th>
<th>Oyster and Coral Reefs</th>
<th>Barrier Islands</th>
<th>Maritime Forests/Shrub Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits/Processes</td>
<td>Break offshore waves</td>
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<td>Wave attenuation and/or dissipation</td>
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<td>Sediment stabilization</td>
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</tr>
<tr>
<td>Slow inland water transfer</td>
<td>Increase infiltration</td>
<td>Slow inland water transfer</td>
<td>Performance Factors</td>
<td>Shoreline erosion stabilization</td>
</tr>
<tr>
<td>Performance Factors</td>
<td>Berm height and width</td>
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<td>Island elevation, length, and width</td>
<td>Soil retention</td>
</tr>
<tr>
<td>Berm height and width</td>
<td>Beach slope</td>
<td>Reef width, elevation and roughness</td>
<td>Land cover</td>
<td>Performance Factors</td>
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<tr>
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<td>Sediment grain size and supply</td>
<td></td>
<td>Breach susceptibility</td>
<td>Vegetation height and density</td>
</tr>
<tr>
<td>Sediment grain size and supply</td>
<td>Dune height, crest, width</td>
<td></td>
<td>Proximity to mainland shore</td>
<td>Forest dimension</td>
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<tr>
<td>Dune height, crest, width</td>
<td>Presence of vegetation</td>
<td></td>
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<td>Sediment composition</td>
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<tr>
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<td>Performance Factors</td>
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</tbody>
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Natural and Nature-Based Features Evaluation and Implementation Framework

- Identify and Organize Stakeholders, Partners and Authorities
- 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
  - Advance through Tiers as Appropriate
- Select NNBF Alternatives
- Design Implementation Plan: Elaborate Operational and Engineering Practices
- Implement NNBF Alternative
- Monitor for Performance and Assess Ecosystem Goods and Services

EVALUATION

ITERATE AS NEEDED

ORGANIZATIONAL ALIGNMENT

IMPLEMENTATION

Feedback
1 A 1-1. Drowned River Valley
Examples: Chesapeake and Delaware Bays

11 B 1. Marine Depositional Barrier Coast
Examples: Virginia coast

NOT TO SCALE
Assessing vulnerability and resilience over the long term: performance metrics

Inundated under 1 ft of RSLR

Drum Bay, Follets Island
Identifying Opportunities

Manasquan Inlet, NJ
System Performance Evaluation

- **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
Example: Wave Dampening by Wetlands

- What are the engineering benefits of wetlands with respect to waves?
- Flume studies being performed in the 10 ft flume
  - Complemented by examination of sediment processes and field studies
- Wave attenuation was found to:
  - increase with stem density
  - increase with submergence ratio
  - slight increase with incident wave height
- Results used to update STWAVE
D2M2: Dredged Material Management Decisions
Moving Forward. . .

- Organize and expand science and engineering related to natural processes and features
  - Reduce uncertainties regarding design and performance of NNBF
  - Understand dynamic performance of NNBF
  - How to effectively integrate NNBF with other measures

- Integrating expertise across disciplines and organizations
  - Planning, designing, constructing, operating, monitoring, and maintaining integrated systems