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

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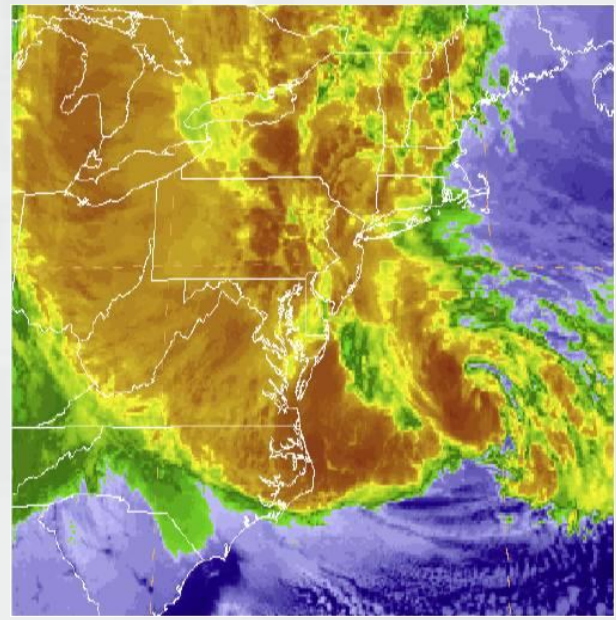**US Army Corps of Engineers**
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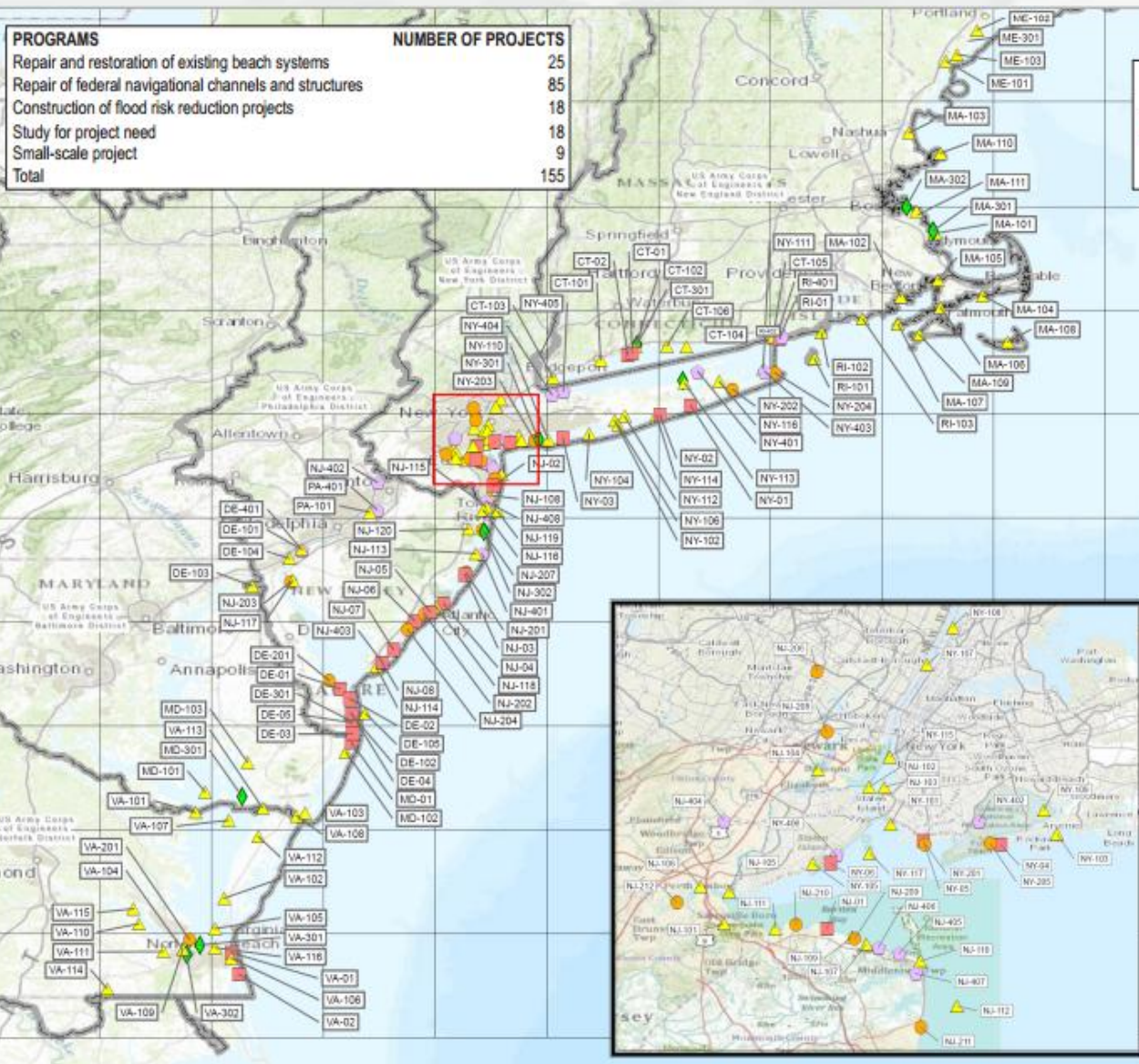- Sam Sifleet (U. Maryland)

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

North Atlantic Coast Comprehensive Study

- 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

NACCS

Study Area with County Impact Level
- Green - Low
- Yellow - Moderate
- Red - High
- Purple - Very High
- NAD Districts
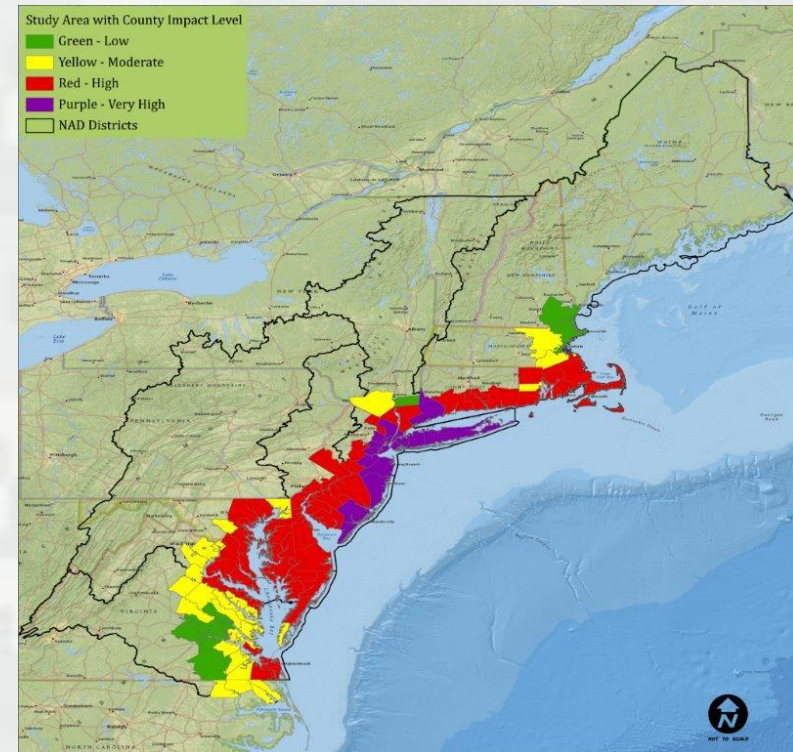
Green Infrastructure (e.g. Living Shorelines)
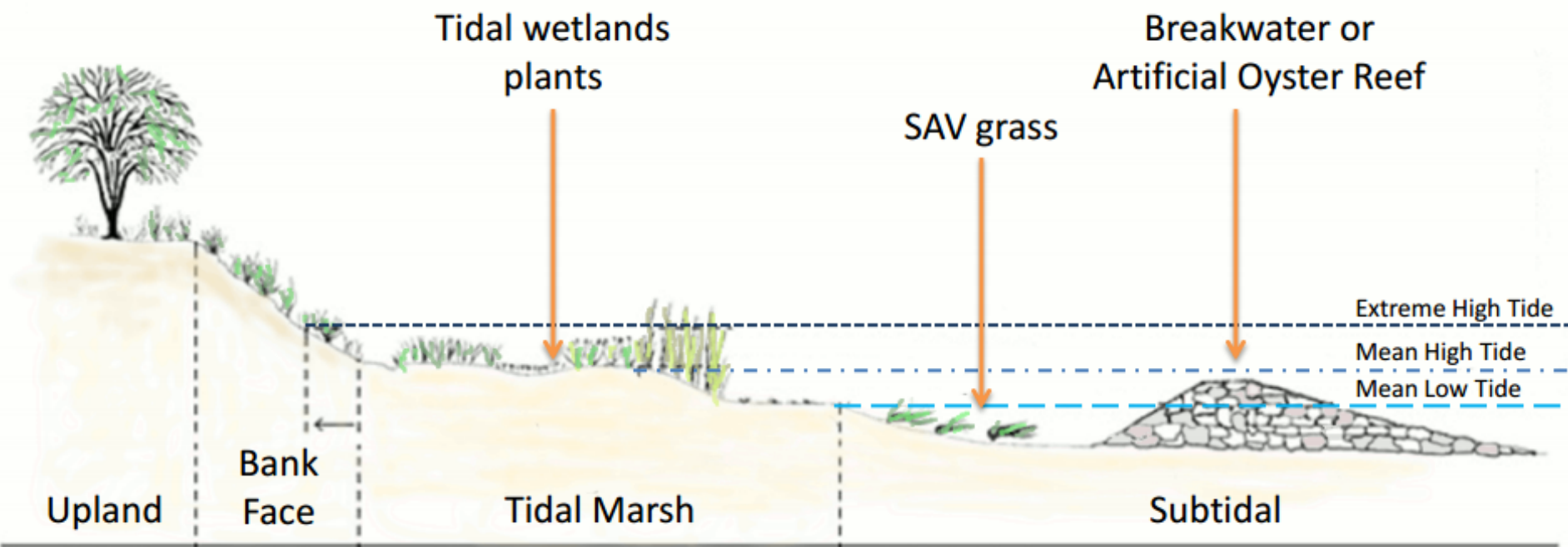
Image adapted from Burke Environmental Associates

Coastal Risk Reduction & Resilience Measures

Measure	Definition	Effect	Examples
Natural	Created through the action of biochemical and physical processes operating in nature	Shoreline erosion control, wave and surge attenuation, especially in low-energy environments; additional resilience benefits; performance difficult to quantify	Barrier islands, dunes, reefs, wetlands, and riparian corridors
Nature-Based	Products of planning, engineering design, and construction incorporating natural processes that contribute to coastal risk reduction and resilience	Shoreline erosion control, wave and surge attenuation, especially in low-energy environments; performance difficult to quantify	
Non-Structural	Products of public policy, management and regulatory practices; may include pricing schemes, planning, engineering design, and construction	Modify or avoid the impacts of the hazard (vs. modifying the hazard); quantifiable performance	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
Structural	Products of planning, engineering design, and construction	Shoreline erosion control, wave and surge attenuation, reduced flooding; quantifiable performance	Levees, storm surge barrier gates, seawalls, groins, revetments, and near-shore breakwaters

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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

Dunes and Beaches

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Berm height and width

Beach Slope

Sediment grain size and supply

Dune height, crest, width

Presence of vegetation

Vegetated Features:
Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Increase infiltration

Performance Factors

Marsh, wetland, or SAV elevation and continuity

Vegetation type and density

Oyster and Coral Reefs

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Reef width, elevation and roughness

Barrier Islands

Benefits/Processes

Wave attenuation and/or dissipation

Sediment stabilization

Performance Factors

Island elevation, length, and width

Land cover

Breach susceptibility

Proximity to mainland shore

Maritime Forests/Shrub Communities

Benefits/Processes

Wave attenuation and/or dissipation

Shoreline erosion stabilization

Soil retention
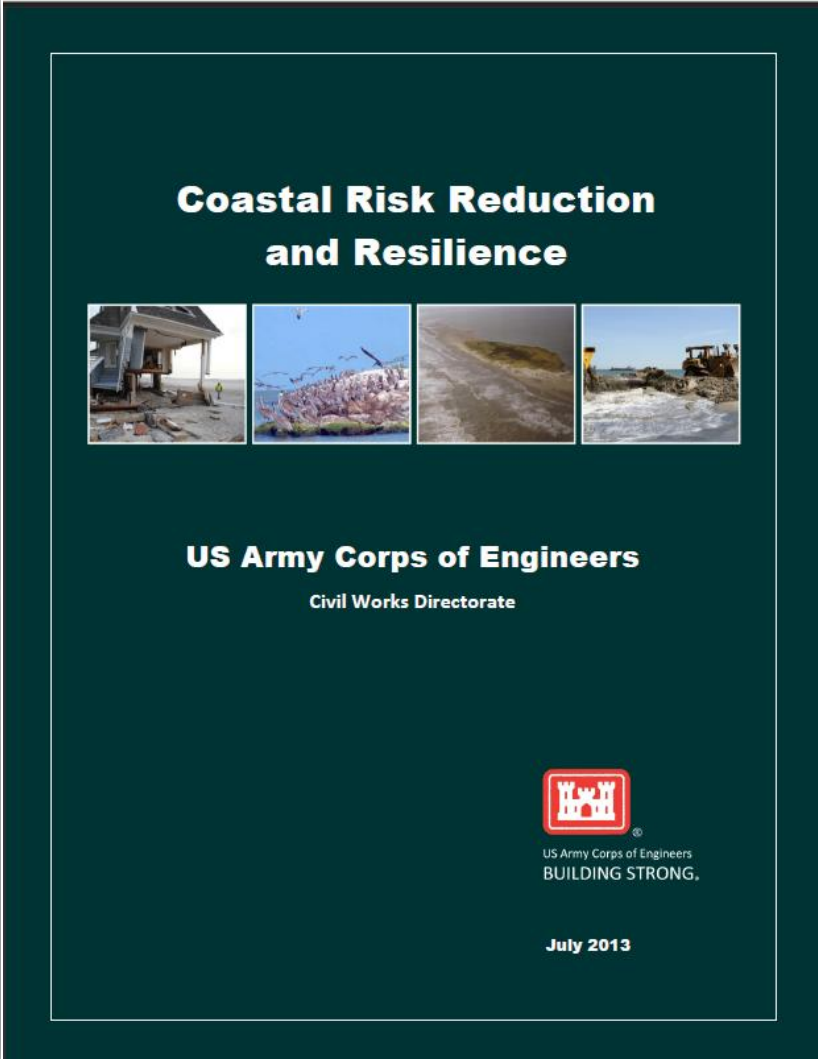
Performance Factors

Vegetation height and density

Forest dimension

Sediment composition

Platform elevation

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.*

Coastal Risk Reduction and Resilience

US Army Corps of Engineers
Civil Works Directorate

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July 2013

Natural and Nature-Based Features Evaluation and Implementation Framework
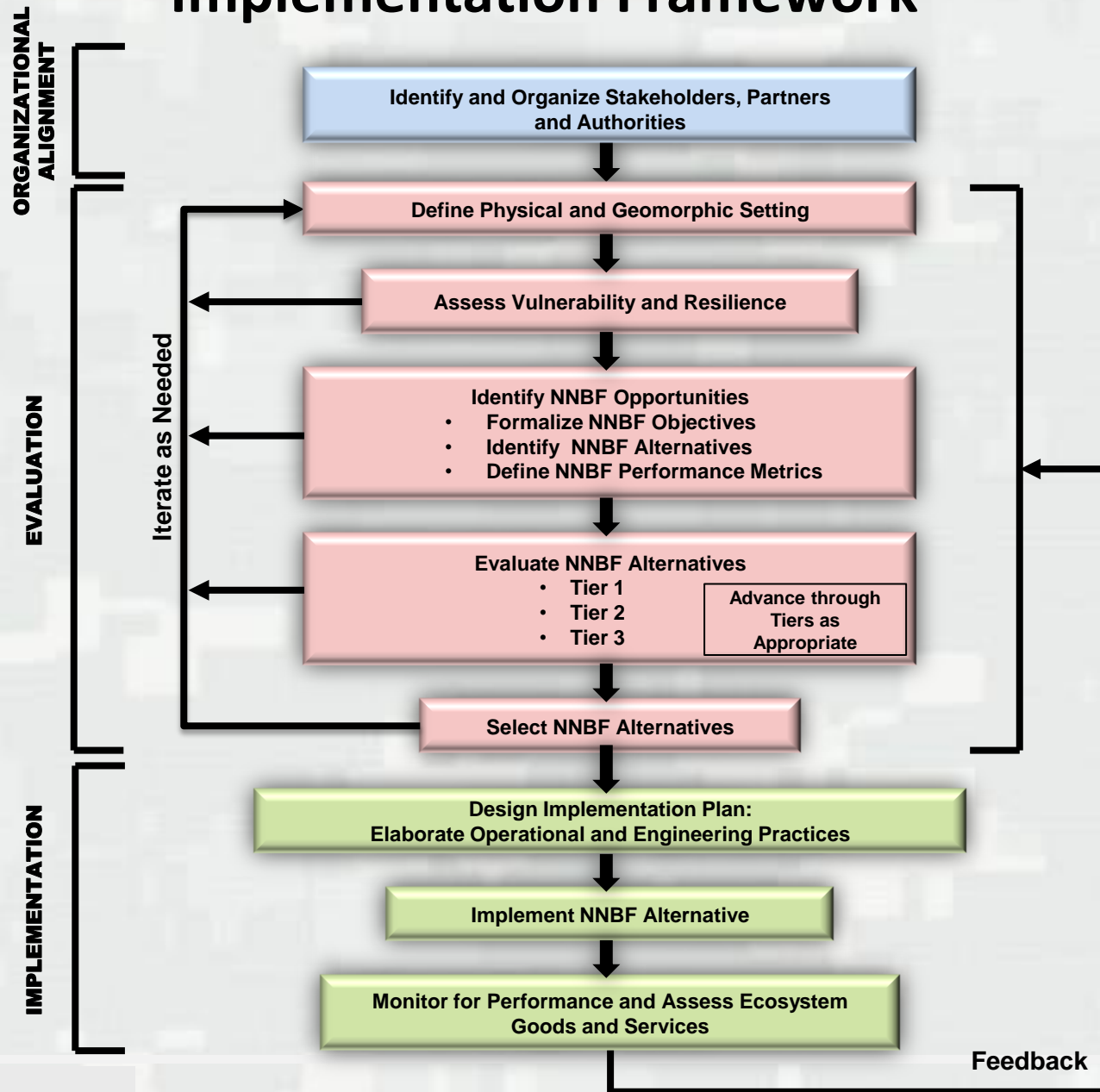
Classification System

1 A 1-1. Drowned River Valley

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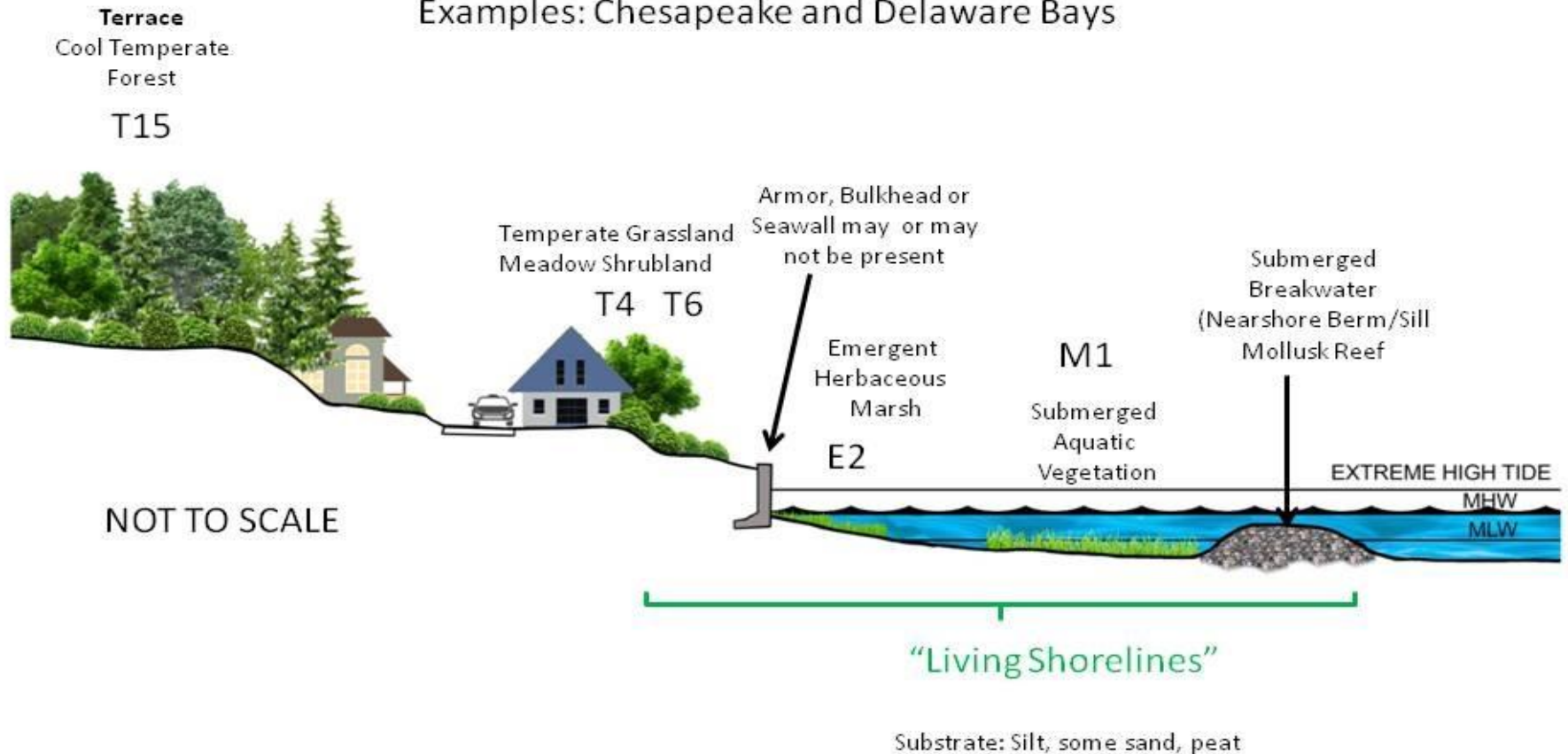
Vulnerability
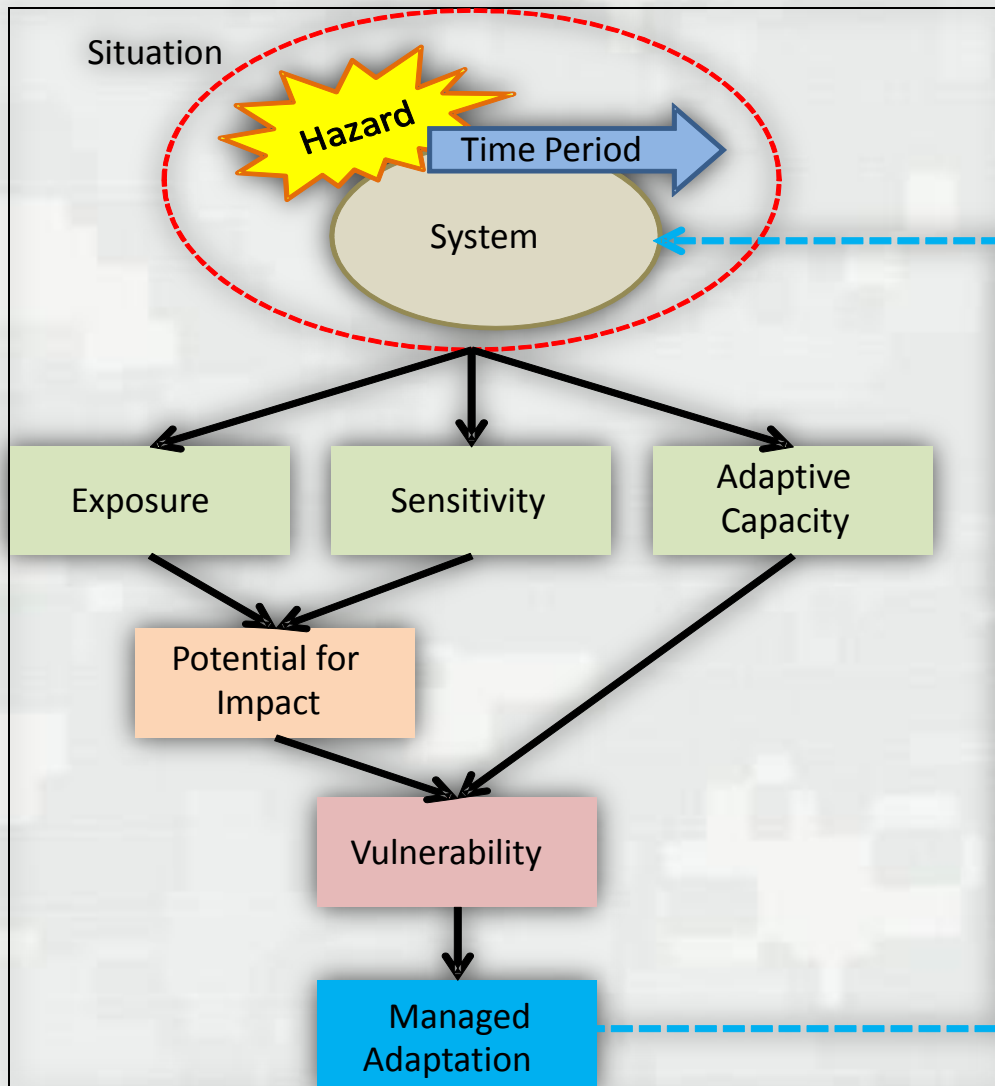
Vulnerability: Degree to which a system is susceptible to, and unable to cope with, adverse effects from a hazard; vulnerability is a function of the character and magnitude of a hazard to which a system is exposed, its sensitivity, and its adaptive capacity.

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)
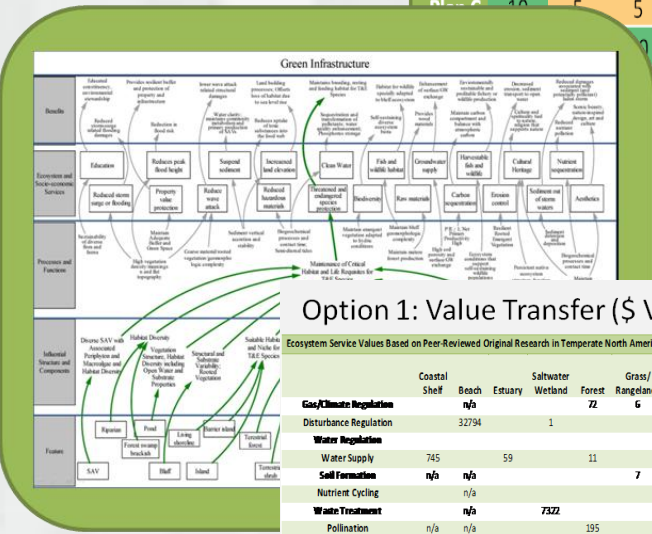3. Carbon sequestration
4. Clean water provisioning (sediment, nutrients, pathogens, salinity, other pollutants)
5. Commercial harvestable fish and wildlife production
6. Cultural heritage and identity - sense of place and belonging, spiritual and religious inspiration
7. Education and scientific opportunities (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

Wt	1	2	4	3	5		
	B1	B2	B3	B4	B5	Mean	Wtd
Plan A	10	8	5	1	0	4.8	49
Plan B	10	10	0	0	0	4	30
Plan C	10	5	5	9	7	7.2	102
				8	5	7.8	115
				10	10	7	115
				4	7	5.6	80

Green Infrastructure

Option 1: Value Transfer ($ Value per acre)

Option 2: Ecosystem Production Functions

Decision Framework

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