The Department of the Interior Metrics Expert Group Report

Chesapeake Bay Program
Climate Resilience Workgroup

Rick Bennett, USFWS
Pete Murdoch, USGS
Susan Taylor, Abt Assoc.

March 2, 2016

Recommendations for assessing the effects of the DOI Hurricane Sandy Mitigation and Resilience Program on ecological system and infrastructure resilience in the Northeast coastal region

https://www.doi.gov/hurricanesandy/news/hurricane-sandy-project-metrics-report

The DOI Hurricane Sandy Program

- DOI funded over 140 projects, about $342 million for projects aimed at improving resilience
- Need for a resilience assessment, to see how effective projects were
- July 2014, DOI convened a team of scientists and socio-economists charged by DOI to identify measurements to assess changes in coastal resilience resulting from DOI-sponsored projects.

Key Definitions

Resilience:

- ***The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions (Executive Order 13653).***

Performance Metric:

- ***A qualitative or quantitative measurement or suite of measurements (index) that can be used to detect and assess a change in DOI coastal resilience objectives.***

Core Performance Metrics:

- ***A subset of performance metrics that are applied to multiple projects and at the full range of temporal and spatial scales to detect a change in resilience in one or more coastal features.***

Process:

Organized metrics around coastal features

Identify core metrics (Abiotic, Biotic, Structural)

Peer review

Benefits: project comparisons and regional resilience assessments

Metrics Organized by Natural and Artificial Coastal Features

- *Beach System: Beach, Barrier Island, and Dunes*
- *Nearshore Shallow and Nearshore Deep*
- *Riverine and Riparian Zone*
- *Marshes and Wetlands*
- *Uplands and Watersheds*
- *Maritime Forests and Shrublands*
- *Estuaries and Ponds*
- *Built Environment: Grey infrastructure*
- *Green Infrastructure: Living shorelines*
- *Green Infrastructure: Other methods*

Ecological Performance Metrics

- *Organized by Natural and Artificial Coastal Features*
- *Provides Objectives and Ecosystem Services*
- *Identifies Performance Metrics, and*
- *Recommends Core Performance Metrics*

Table 1. Recommended ecological core performance metrics by coastal feature for Department of the Interior Resilience projects funded through the Disaster Relief Recovery Act of 2013.

Natural and Artificial Coastal Features	Primary Objectives and Ecosystem Services	Recommended Core Performance Metrics
Beach System: Beach, Barrier Island, and Dunes (for back bay areas, see Estuaries and Ponds)	Beaches and Dunes: 1) Restore or improve beach habitat to enhance resilience of fish, wildlife, and plants, and their habitats (e.g., spawning, migration stopovers, critical habitats) 2) Restore/improve dune habitat to enhance resilience of coastal infrastructure by reducing flooding extent and attenuating wave energy 3) Improve/sustain beach/barrier island ecological system and community resilience to storm surge events 4) Enhance understanding of natural system dynamics including immediate storm responses, natural recovery from disturbance events, and natural adaptation capacities and tendencies. 5) Improve recreation/aesthetics Breaches: 1) Manage breach occurrences to maximize ecosystem function and reduce risks to built infrastructure, human health, and human safety.	Beaches and Dunes: Biotic • Vegetation cover of dunes pre and post event • Fish and wildlife population/ recruitment/ overwintering/stopover weight/health relative to other mitigating factors (e.g. other threats throughout range: site and species specific) Abiotic • Post-storm volume of sand in the active shoreface • Recovery rates of beach and dunes Structural/Engineering • Beach width, elevation, volume, shoreline position (post-event) • Dune characterization (height, width, length, texture, substrate) Breaches: Biotic • Fish and wildlife population/ recruitment/ overwintering/ stopover weight/health changes relative to other mitigating factors (e.g. other threats throughout its range: site and species specific) Abiotic • Volumes of material in flood and ebb shoals • Water flow and current dynamics • Water quality: temperature, salinity, pH, dissolved oxygen, turbidity, nutrients, contaminants • Water level changes, especially in back bays Structural/Engineering • monitoring of breach morphologic changes

Core Performance Metrics:

A set of performance metrics that are applied to multiple projects and at the full range of temporal and spatial scales to represent a change in resilience in one or more coastal features.

Protocols for measuring potential performance metrics

Provides protocol name, associated performance metrics, and citation/source

Organized by:

Biotic
- Fish and Wildlife Species
- Habitat
- Landscape Context Metrics

Abiotic
- Hydrology/Wave Energy
- Water/Air Quality
- Soils/Sediment

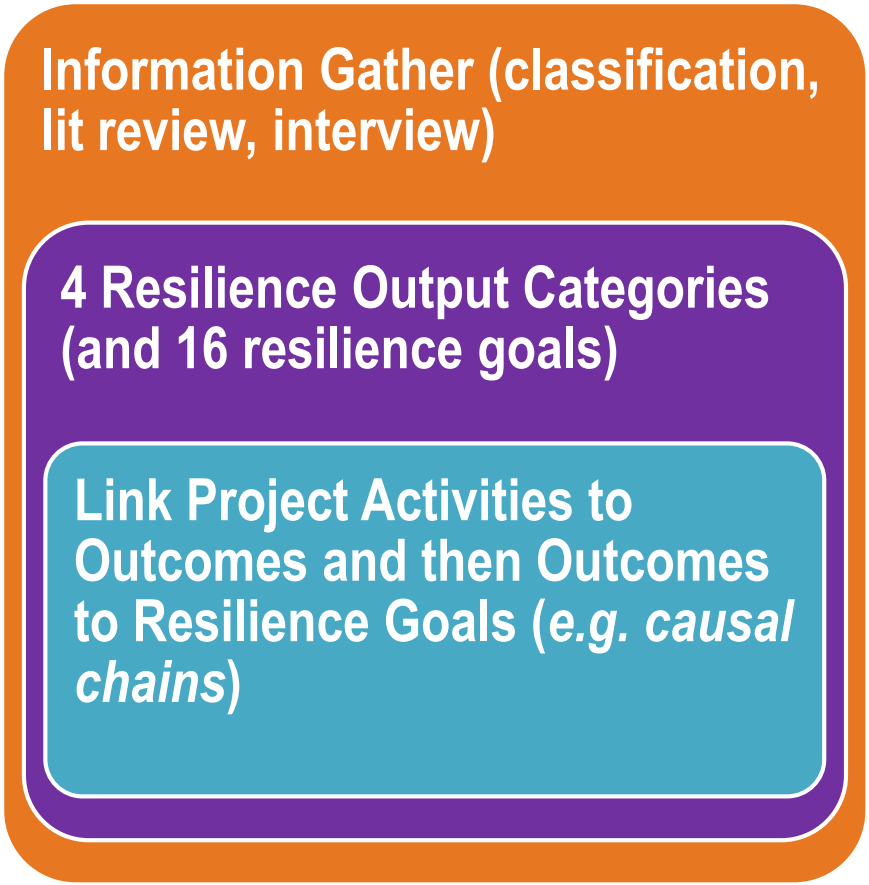
Structural/Engineering
- Shoreline Position
- Coastal Topography/Elevation


SET Installation


Subbottom profiles in nearshore

Socio-Economic Metrics

Initial Tasks:



- Develop measures of community well-being and resilience
- Communicate value of projects with social relevance
- Objectives: Develop socio-economic metrics and assign to each project

Classification

Information Gather (classification, lit review, interview)

4 Resilience Output Categories (and 16 resilience goals)

Link Project Activities to Outcomes and then Outcomes to Resilience Goals (*e.g. causal chains*)

Project Activity Category	# Projects Assigned with one activity	# Projects in multi-activity projects
Community Resilience Planning	2	19
Contaminant Assessment or Remediation	3	4
Critical Infrastructure Assessment or Protection	N/A	3
Data, Mapping, and Modeling	40	60
Ecological Resilience Planning	1	13
Green Infrastructure Planning and Implementation (living shorelines, etc.)	6	33
Grey Infrastructure (dams, culverts, berms)	12	26
Habitat Restoration	11	49
Impact or Vulnerability Assessments	11	24
Public Access	N/A	5
Sand Resource Identification or Assessment	13	13

Resilience Categories

Information Gather (classification, lit review, interview)

4 Resilience Output Categories (and 16 resilience goals)

Link Project Activities to Outcomes and then Outcomes to Resilience Goals (*e.g. causal chains*)

Organize into categories to ensure metrics link to socio-economic benefit and resilience definition

Resilience Categories

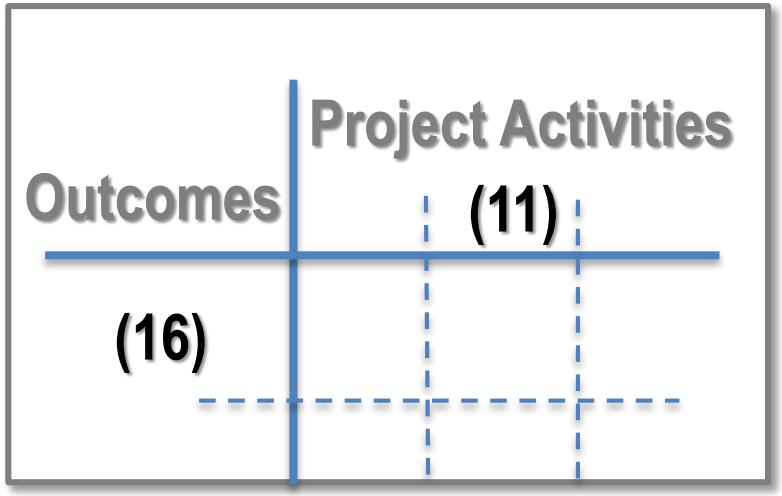
1. Human Health and Safety
2. Physical Infrastructures
3. Economic Resilience
4. Community Competence and Empowerment

Map Activities to Resilience Goals

Information Gather (classification, lit review, interview)

4 Resilience Output Categories (and 16 resilience goals)

Link Project Activities to Outcomes and then Outcomes to Resilience Goals (*e.g. causal chains*)



16 goals identified, unique to each of the four resilience categories

Ecological Indicators

Biophysical indicators directly relevant to socio-economic resilience

Example: Human Health and Safety

Ecological Outcomes	Socio-economic Metrics
• Changes in floodplain area • Changes in the maximum height of water from a particular flood	**Reduction in # of households exposed to flood hazard**
• Improved water quality • Reduced soil contamination • Increase in % native vegetation • Improved water management and fire control	**Reduction in # people exposed to contaminated water, soil, mosquito-borne disease, and wildfire**

Metrics: Property and Infrastructure Protection

Metrics for Property and Infrastructure Protection		Resilience Goals		
		Reduction in number of residential, commercial, cultural, and heritage properties at risk to potentially damaging inundation	Reduction in miles of roads, highways, and rail lines at risk to potentially damaging inundation	Reduction in number of critical service facilities at risk to potentially damaging inundation
		Metrics[a]		
Biophysical and Ecological Outcomes	Reduced extent of damaging inundation from major storm and flood events[b]	1. Reduction in number of properties exposed to flood event with the project as compared to without 2. Reduction in percentage of total residential and commercial property value expected to be damaged in floods with the project as compared to without 3. Property value of residential and commercial properties exposed to a flood event with and without project 4. Tax base attributed to residential and commercial properties exposed to a flood event with and without project 5. Reduction in expected damages to properties from floods with the project as compared to without	1. Reduction in miles of transportation infrastructure exposed to a flood event with the project as compared to without 2. Reduction in number of users potentially affected due to exposed transportation infrastructure 3. Avoided repair/replacement cost to transportation infrastructure exposed to a flood event 4. Avoided days of closure of transportation infrastructure	1. Reduction in number of critical service and utility facilities exposed to a flood event with the project as compared to without 2. Reduction in number of users or customers potentially affected due to disruption of critical services or utilities 3. Avoided days of closure or disruption of critical services or utilities
	Reduced hazard of nuisance flooding[c]			

. Metrics are numbered in order of increasing level of detail and potential difficulty in measuring
. Major storm and flood events are defined as FEMA's 0.2%, 1%, 2%, or 5% flood events.
. Nuisance flooding is defined as flood events that occur at least every year or more.

Next Steps

- **Implement Ecological and Socio-economic Metrics**
- **Conduct Independent Resilience Assessment of DOI Projects**

Final Thought

"If resilience is built through a project, and no perfect resilience metric is around to measure it, does it have an impact?"

Anonymous, National Adaptation Forum, St. Louis, MO 2015

Natural Infrastructure Metrics Workgroup

A Systems Approach to Geomorphic Engineering (SAGE) Workgroup

U.S. Fish and Wildlife Service and National Wildlife Federation, co-chairs

NIMs Goals:

Develop core metrics that cut across agency missions, supporting efficiencies and knowledge base that demonstrate that natural infrastructure is:

- **Effective**
- **Resilient**
- **Cost Effective**

NIMW Objectives:

- **Identify and develop metrics to measure the success of existing and planned ecosystem and community resilience projects**
- **Demonstrate proof of concept: partners are expected to measure something that they normally do not**
- **Focus on coastal resilience**
- **Highlight gaps and steps to fill these gaps in the future**

NIMW Approach:

1) **Convene** multi-agency/organization team

2) **Compile** a list of intermediate and final services per organization

3) **Compile** list of metrics per organization

4) **Identify and fill** knowledge gaps

5) **Select** a common core set of metrics

6) **Implement** with pilots

Evolution of Thinking

1. Develop a set of metrics to measure the success of projects that use Natural infrastructure (by Agency mission)

   Metrics would ideally be tested in cost-benefit analyses

2. Identify the ecosystem services you (your organization) wants from Natural infrastructure that addresses your agency mission. Then provide the metric

3. Organize metrics by ecosystem services and by landscape feature

NIMs Services

Ecological	Provide Habitat; Maintain Biodiversity; Protect TES; Buffer Ocean Acidification
Sociological	Provide Recreation; Provide & Support Navigation; Produce-Provide Food, Feed, etc.; Provide & Improve Aesthetics; Promote Environmental Justice; Protect Property Value; Protect Cultural Heritage; Provide & Support Education; Provide-Support Scientific Research
Hydrological	Reduce Storm Surge & Flooding; Provide Flood Storage; Attenuate Waves; Provide and Store Groundwater; Reduce Overtopping; Reduce Current - Wave Velocity; Restore Functional Hydrology
Geological	Reduce & Control Erosion; Protect & Enhance Healthy Soils
Biogeochemical	Improve Water Quality; Sequester & Convert Nutrients; Reduce Hazardous-Toxic Materials
Climatological	Regulate Microclimate; Sequester Carbon
Other	Reduce Wildfire Potential; Protect Against Wind Shear; Attenuate Drought

31 total [draft] services (intermediate and final)
12 Features

Features:

- Nearshore Shallow and Nearshore Deep
- Bluff or Scarp
- Marshes/Wetlands
- Beach System: Beach/Barrier Island/Dune
- Mudflat/Sandflat or Tidal Flat
- Estuaries/Ponds
- Upland/Watersheds
- Maritime Forests, Shrublands, and Grasslands
- Riverine/Riparian Zone
- Hybrid Infrastructure
- Hybrid Infrastructure - Living Shorelines
- Green Infrastructure

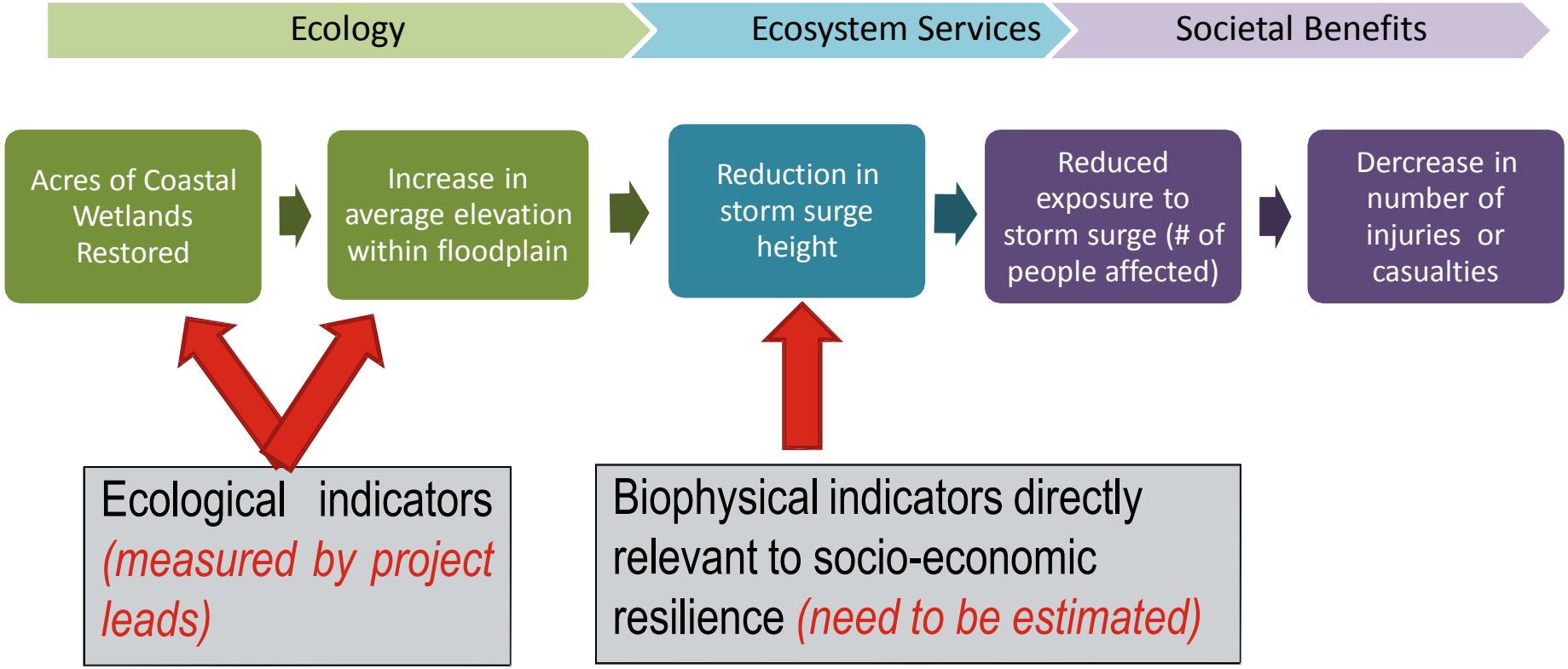
NIMs Table

	ECOLOGICAL	SOCIOLOGICAL			HYDROLOGICAL	
Good or Service:	**Maintain Biodiversity**	**Provide Recreation**	**Protect Property Value**	**Protect Cultural Heritage**	**Reduce Storm Surge & Flooding**	**Provide Flood Storage**
Features					Metrics	
Nearshore Shallow and Nearshore Deep (includes submerged aquatic vegetation and/or aquatic vegetation bed both fresh and saline)	density of each species of species group (individuals/unit area of measurement)	number of visitors to the site	number of homes within walking distance that would benefit from open space, which could be assessed using GIS software	social;/cultural value that individuals place on the resource, which can be valued using a stated preference method such as contingent valuation or a choice experiment	SEAGRASS BEDS: Area of Seagrass	
	CONNECTIVITY: 1)is connectivty needed and type of connectivity required; 2) importance of the connectivity (area/zone/system) for habitat persistence; 3) importance of the connectivity (area/zone/system) for ecosystem service provision; 4) protection of connectivity, including if it can be protected	value that visitors place on the recreational experience	change in property values due to an increase in natural space, analyzed through a hedonic valuation study	cultural indicators can be developed based upon feedback from residents through focus groups, interviews or surveys. These indicators may fall into a variety of categories, such as quality of life, shoreline activities, sense of place, or sommunity well-being and will vary depending upon habitat type, project, and relevance to the community	SEAGRASS BEDS: species composition	
			change in property values due to a perceived decrease in flood risk, analyzed through a hedonic valuation study		SEAGRASS BEDS: mean shoot density	
			change in property values due to an improvement in water clarity, analyzed through a hedonic valuation study		SEAGRASS BEDS: mean shoot height	

Intermediate and Final Services are incorporated in the spreadsheet

Generate Causal Chain

- **For example, Causal Chain for Wetland Restoration**



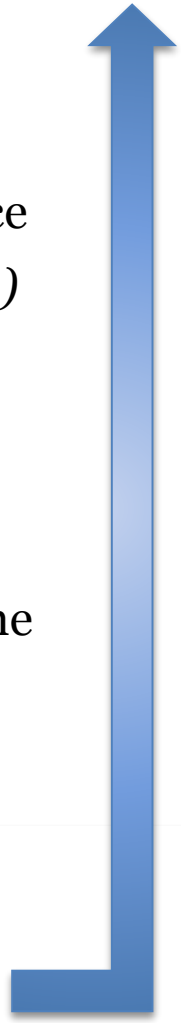
NIMs Next Steps and Time Line

In Progress:

- ✓ Comprehensive compilation (& cleaning) of all responses by service and feature (*removing affiliations)*
- ✓ Create sample causal chain for report
- ✓ Organize and determine prioritization/ process to determine core metrics

March 2016:

- Draft metrics out for peer review
- Release metrics and report



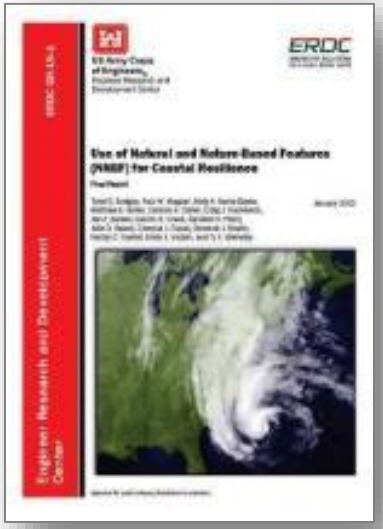
Next Steps (2016):

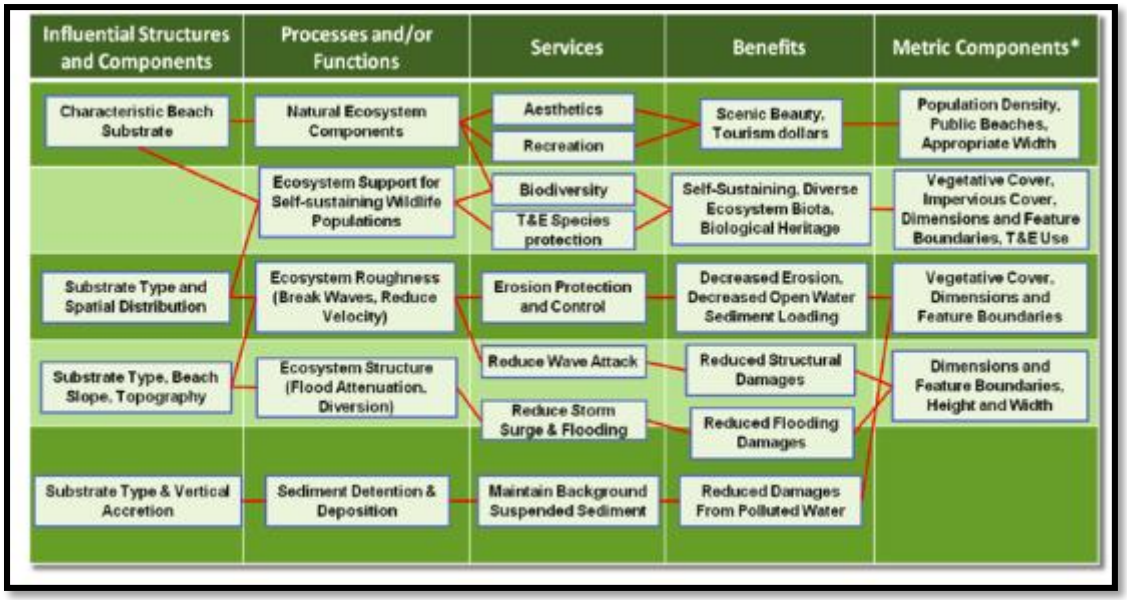
- **Test metrics on pilot sites**
- **Integrate with other efforts (e.g. Ecosystem Resilience Index)**
- **Revise based on additional agency and expertise feedback to report**

http://sagecoast.org/

Other Relevant metric work

USACE NACCS





- Objective is resilience (re-establish or enhance)
- 30 features related to recovery efforts (NNBF, Feature Complexes, Structural)
- 21 ecosystem-based goods and services, 72 “quantitative” performance metrics

http://www.nad.usace.army.mil/CompStudy.aspx

Final Thought

"If resilience is built through a project, and no perfect resilience metric is around to measure it, does it have an impact?"

Anonymous, National Adaptation Forum, St. Louis, MO 2015