Developing Ecosystem Goods and Service Performance Metrics for Natural and Nature-based Infrastructure to Support the NACCS

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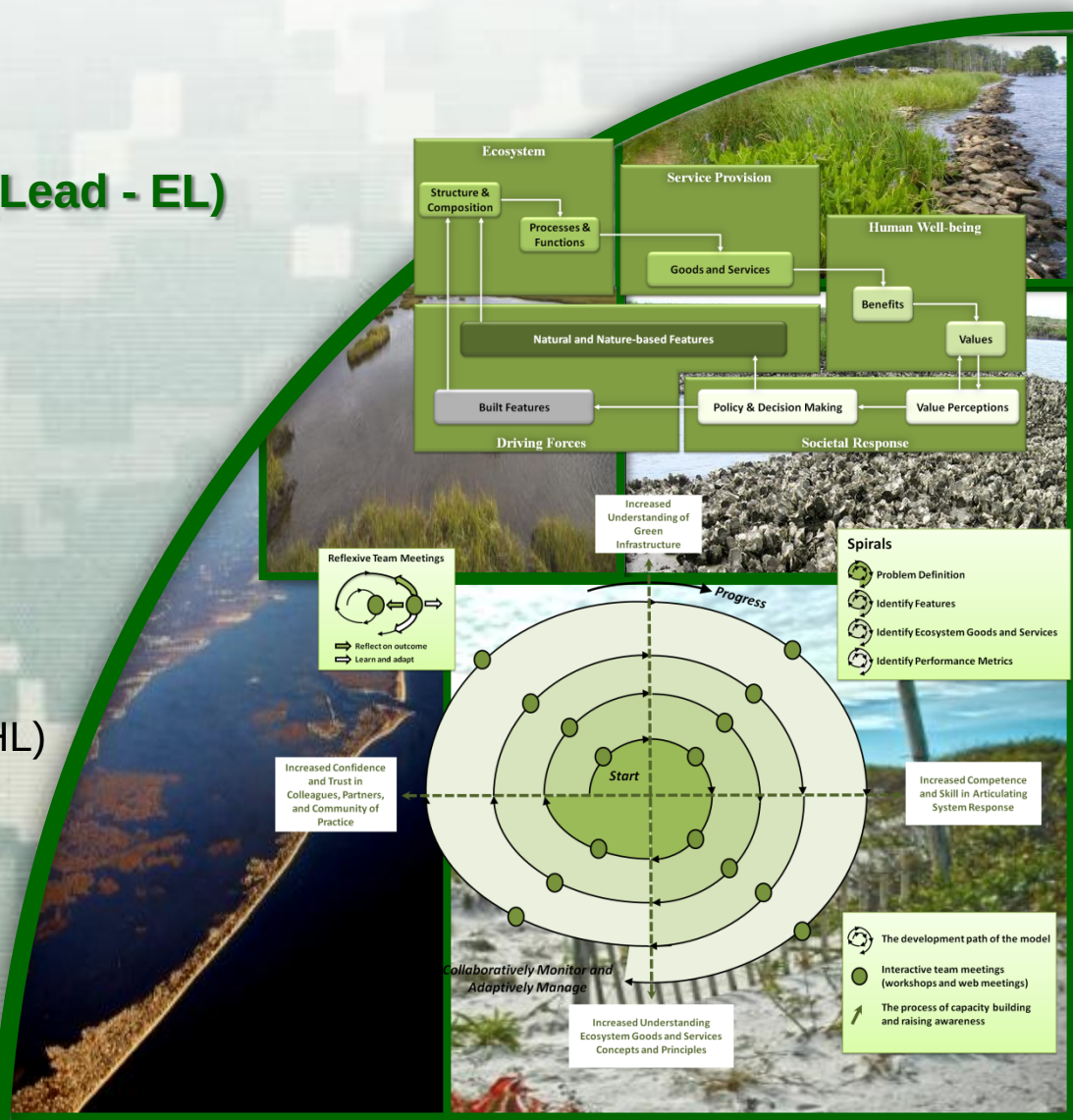

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Scope of Effort

Task 1: Characterize Nature-Based Infrastructure (NBI) Contribution to Resilience and Risk Reduction

- **Task 1A: Define** resilience with respect to NBI features
- **Task 1B: Identify** characteristics of natural systems
- **Task 1C: Identify** categories of NBI that contribute to resilience

Task 2: Data Integration and Metrics for NBI Features

- **Task 2A: Data** integration
- **Task 2B: Develop** performance metrics for NBI
- **Task 2C: Develop** vulnerability metrics

Task 3: Evaluation Framework for NBI

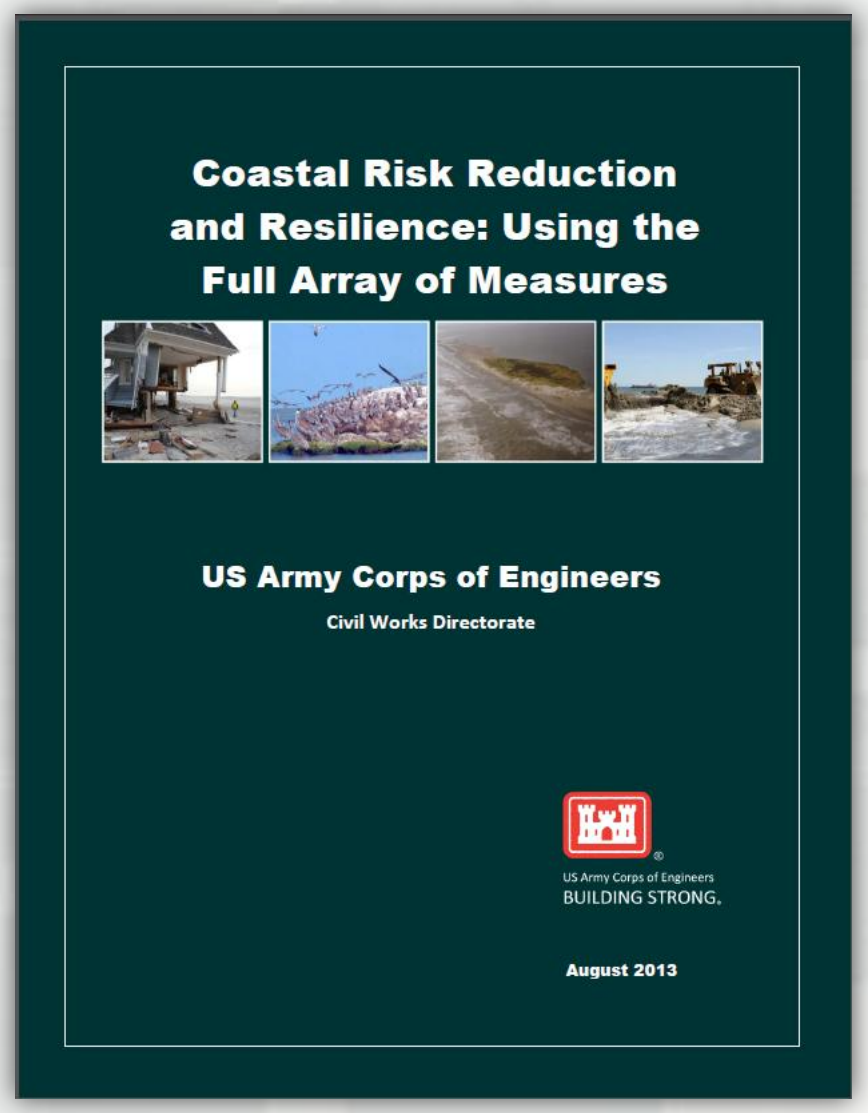
- **Task 3A: Develop** evaluation framework
- **Task 3B: Apply** the NBI evaluation framework
- **Task 3C: Demonstrate** of ecosystem goods & services assessment

Goal: *Assist the USACE Baltimore District in obtaining* ***scientifically defensible justification*** *to incorporate* ***Nature-Based*** *(NB) features into the District's current management portfolio and acquire the necessary knowledge and methodologies to integrate NB into* ***tactical*** *and* ***strategic*** *planning initiatives in a post-Sandy planning environment.*

Green Paper (August 2013)

The USACE planning approach supports an ***integrated approach*** *to reducing coastal risks and increasing human and ecosystem community resilience through a combination of the full array of measures:* ***natural, nature-based, non-structural and structural****.*

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.*



Key Definitions – Refined based on HQUSACE "Green" Paper

Nature-Based Infrastructure (NBI) refers to the intentioned use of natural and engineered features to produce engineering functions in combination with ecosystem services and social benefits.

- Natural and nature-based features include a **spectrum of features**, ranging from those that exist due exclusively to the work of natural process to those that are the result of human engineering and construction.
- The built components of the system include nature-based and engineered structures that support a range of objectives, including storm risk reduction (e.g., seawalls, levees), as well as infrastructure providing economic and social functions (e.g., navigation channels, ports, harbors, residential housing).
- Natural coastal features take a **variety of forms**, including reefs (e.g., coral and oyster), barrier islands, dunes, beaches, wetlands, and maritime forests. The relationships and interactions among the natural and built features comprising the coastal system are important variables determining coastal vulnerability, reliability, risk and resilience.

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

Key Definitions

Performance Metrics are **specific** measures of production or indicators of system response that can be used to **consistently** estimate and report the anticipated **consequences** of an alternative plan with respect to a particular planning and engineering objectives.

They articulate the exact information that will be collected, modeled, elicited from experts, or otherwise developed and presented to decision makers to characterize plan performance and engineering designs.

They must provide the ability to **distinguish** the relative degree of ecosystem response (conveyed in terms of impacts or benefits) **across alternatives and designs**, either qualitatively or quantitatively, in ways that make sense and will help decision makers consistently and transparently compare alternatives and designs.

Good performance metrics are:

- Complete and concise
- Transparent and unambiguous
- Accurate
- Direct
- Understandable
- Operational

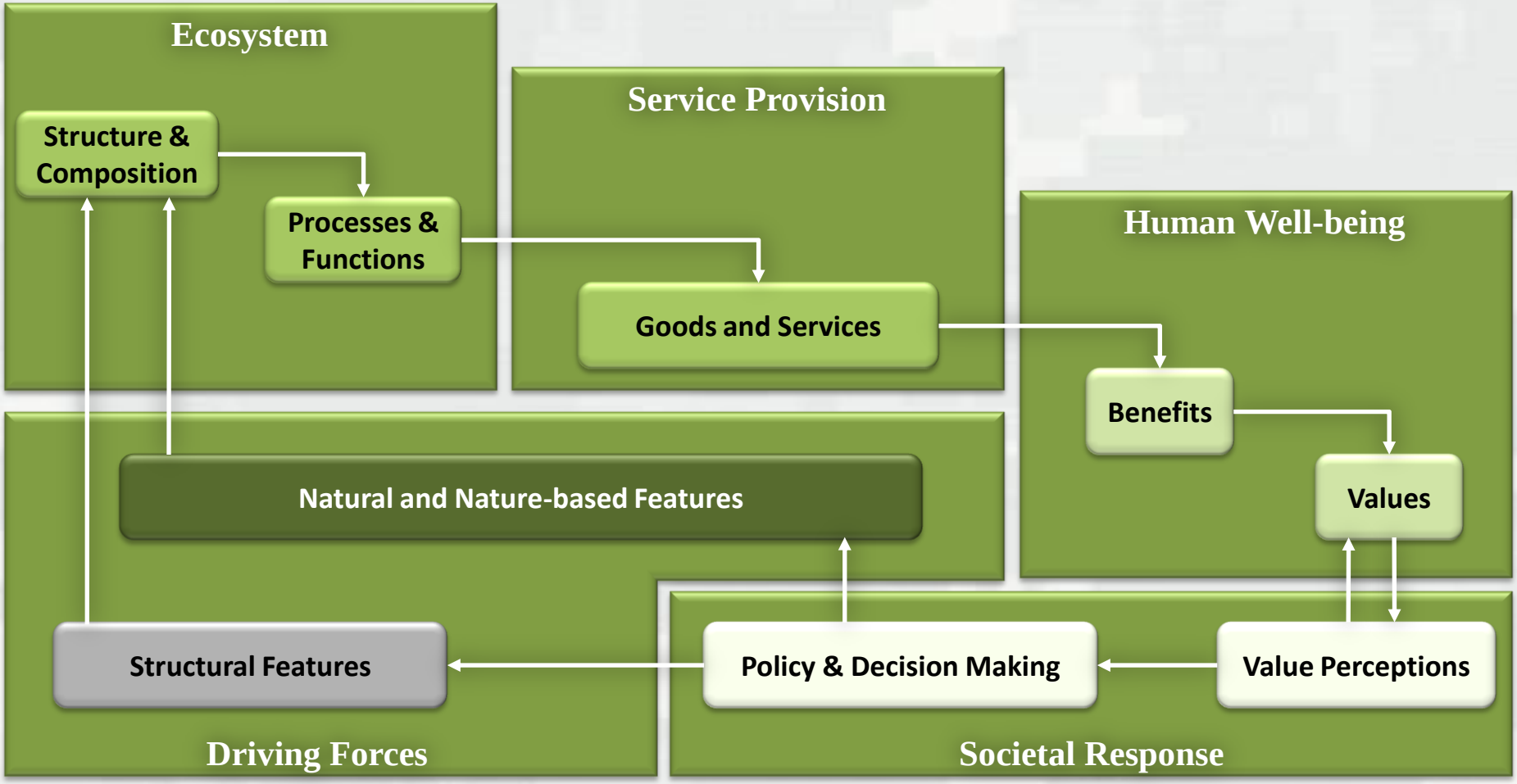
Key Definitions

Ecosystem Goods and Services are tangible items or intangible commodities generated by self-regulating or managed ecosystems whose composition, structure, and function are comprised of natural, nature-based and/or structural features that produce socially-valued benefits that can be utilized either directly or indirectly to promote human well-being.

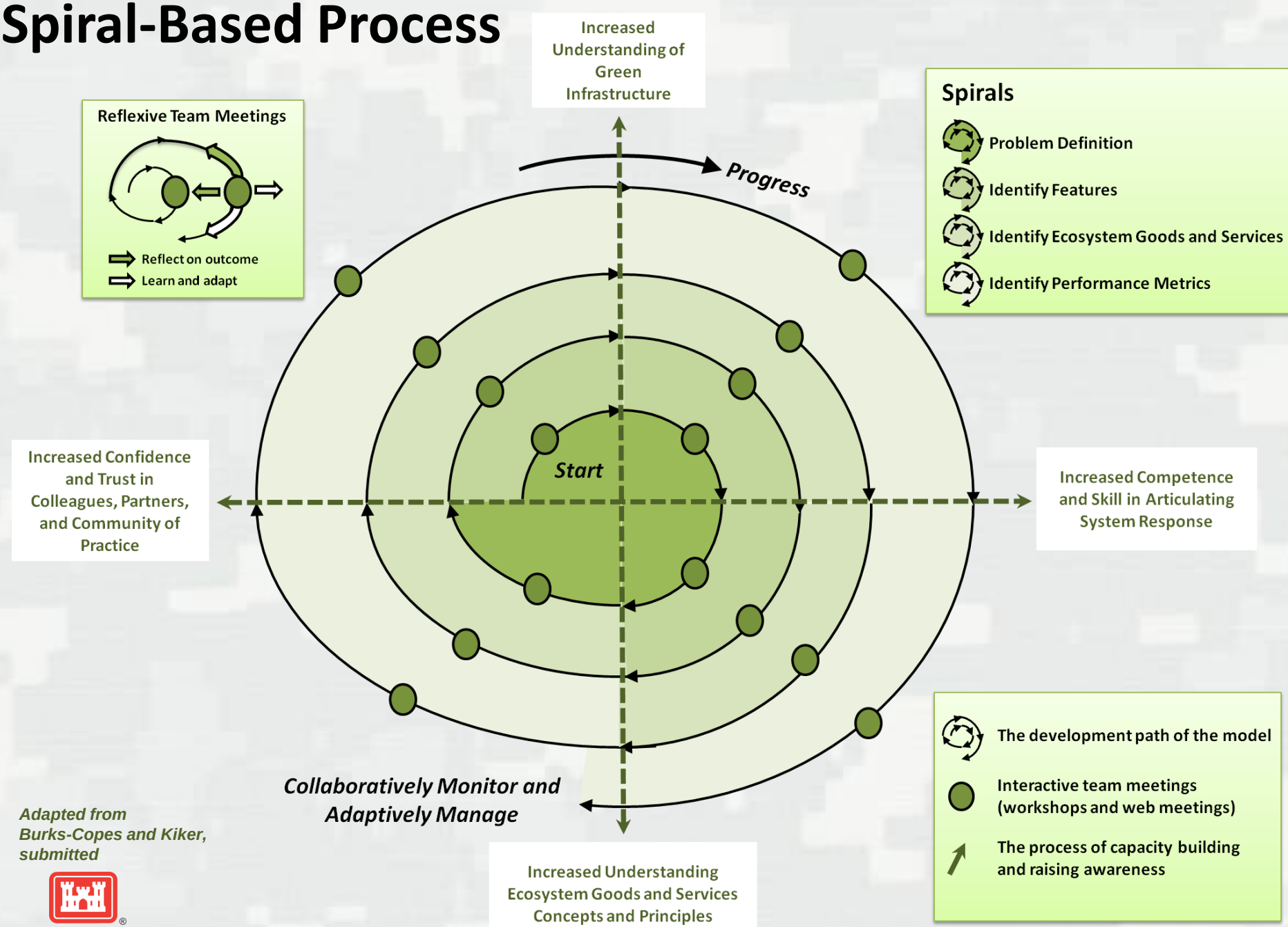
Key Take-home points:

1. EGS can be derived from either built or natural capital (or a combination of the two)
2. Their value is simply a way to depict their importance or desirability to the consumers.
3. The ability of ecosystems to provide goods and services is dependent on critical ecosystem processes tied to structure and function either alone or in concert.

Performance can be characterized by the production of ecosystem goods and services . . . .



Spiral-Based Process



Adapted from Burks-Copes and Kiker, submitted

Feature List (30 Total)

Natural and Nature-based Features

1. Beach (sand, gravel, cobble)
2. Mudflat / sandflat
3. Bluff (any material, if sand assume eroding dune)
4. Dune / swale complex
5. Salt marsh (emergent herbaceous)
6. Shrub-scrub wetlands (brackish)
7. Flooded swamp forest (brackish)
8. Maritime grassland
9. Maritime shrubland
10. Maritime forest
11. Submerged aquatic vegetation (seagrass, other - fresh or saline)
12. Riparian buffer
13. Emergent herbaceous marsh / wetland (fresh)
14. Shrub-scrub wetlands (fresh)
15. Flooded swamp forest (fresh)
16. Pond
17. Terrestrial grassland
18. Terrestrial shrubland
19. Terrestrial forest

Natural and Nature-based Complexes

20. Reef, intertidal or submerged (also see breakwater)
21. Breakwater, subaerial or emergent (nearshore berm, sill, reef, can contain oysters, rock, shells, mussels, SAV, emergent or herbaceous vegetation)
22. Breakwater, submerged (nearshore berm, sill, artificial reef - if containing living organisms or plants, see reef)
23. Island (can include one or more of beach, dune, breakwater, bluff, marsh, maritime forest, other veg
24. Barrier island (can include one or more of beach, dune, breakwater, bluff, marsh, maritime forest, other veg)
25. Living shoreline (vegetation w/ sills, benches, breakwaters, etc.)

Built Features

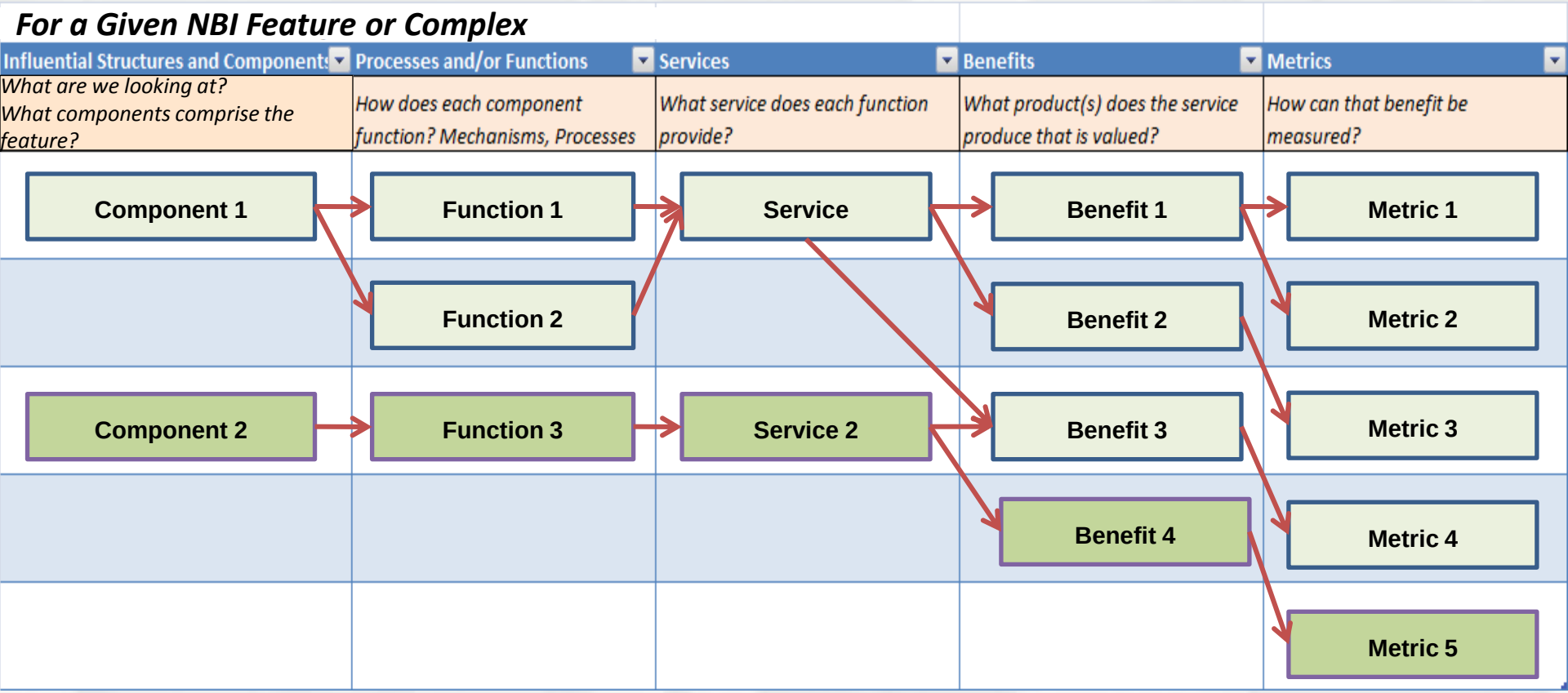
26. Levee
27. Storm surge barrier
28. Seawall / revetment / bulkhead
29. Groin
30. Breakwater

Service List (21 Total – Presented Alphabetically)

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. Maintain background suspended sediment in surface 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

Services Table Approach

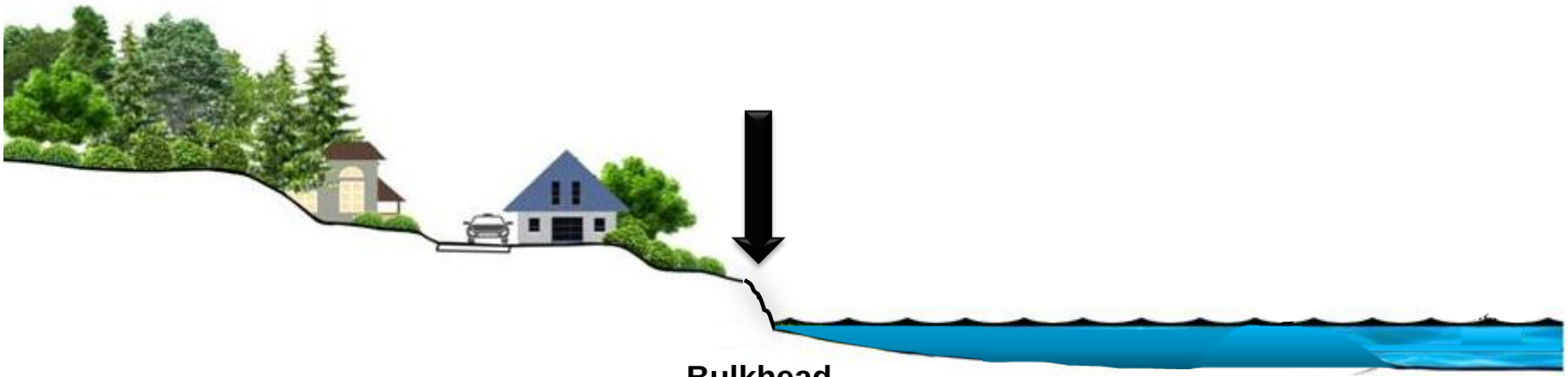
For a Given NBI Feature or Complex



NBI FEATURE: Beach (sand, gravel, cobble)					
Influential structure and components	**Processes, functions**	**Ecosystem and Socioeconomic Services**	**Benefits**	**Performance Metric**	**Data sources**
Characteristic Intertidal Substrate	Geomorphologic diversity and natural ecosystem components	Aesthetics - appreciation of natural scenery (other than through deliberate recreational activities), Inspiration for culture, art and design	Scenic beauty, nature-inspired design, art and culture	log(Feature Size) x population density in Plan Reach	C-CAP, Census
Substrate Type and Cross-Sectional and Longitudinal Distribution	series of ecosystem elements that that support a variety of native biota	Biological diversity (biodiversity)	self-sustaining diverse ecosystem biota	log(Feature Size) * Landfire veg cover * ((25 - % imp cover in 100-m radius)/15 [max = 1, min = 0])	C-CAP, Landfire, NLCD
Characteristic Intertidal Substrate	persistent native ecosystem structure, function and dynamic processes	Cultural heritage and identity - sense of place and belonging, spiritual and religious inspiration	culture and spirituality tied to nature, religion that supports nature	log(Feature Size) x population density in Plan Reach	C-CAP, Census
Substrate Type and Cross-Sectional and Longitudinal Distribution	variety of ecosystem types with balanced processes	Education and scientific opportunities (for training and education)	educated constituency, environmental stewardship	log(Feature Size) x (population density in Plan Reach + # schools in 10 km radius)/2	C-CAP, Census, Schools layer
Substrate Type and Cross-Sectional and Longitudinal Distribution	attenuation of erosive processes	Erosion protection and control (water and wind, any source)	decreased erosion, sediment transport to open water	Feature size x Landfire veg cover x Prop Native x veg height/perc slope	USGS Landfire, 10-m NED

Services to NBI Matrix

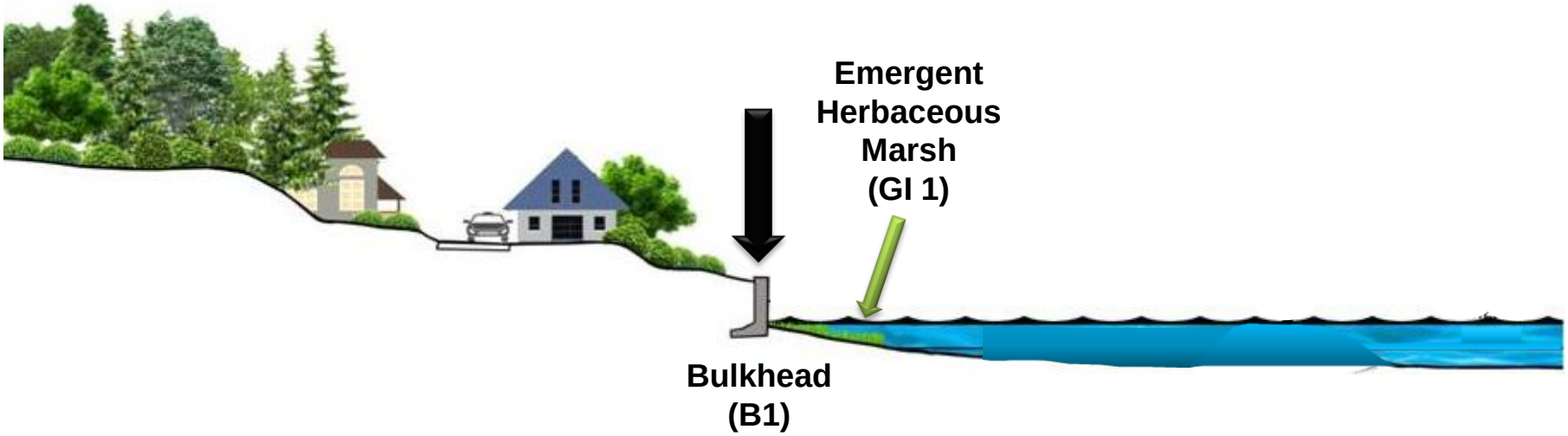
	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✔				
S2	✔				
S3					
S4					
S5					
S6					



Bulkhead (B1)

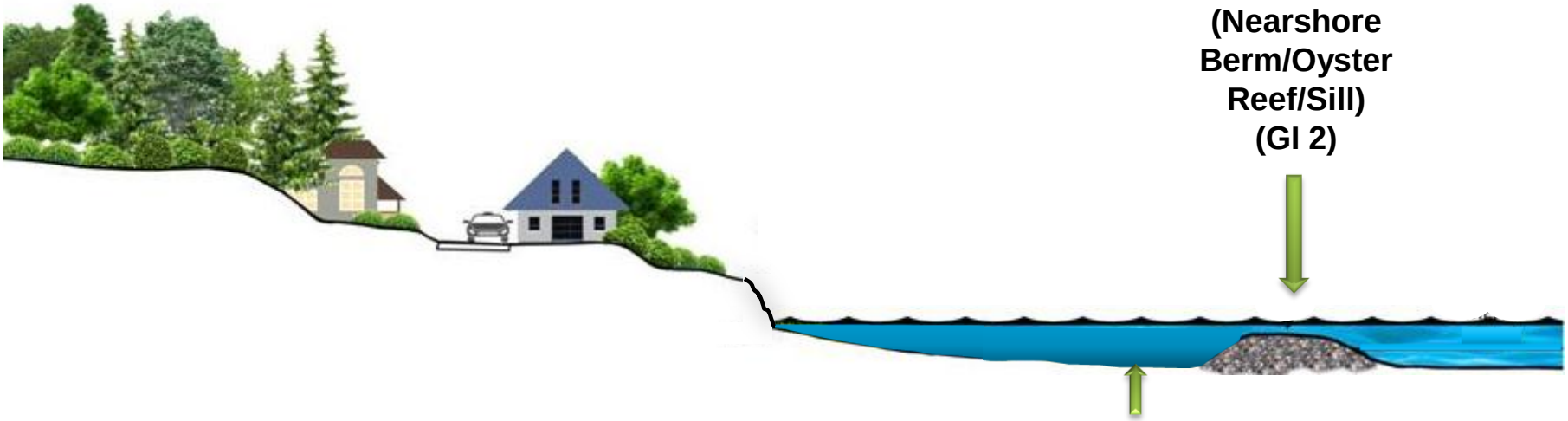
Services to NBI Matrix

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✔				
S2	✔				
S3					
S4					
S5		✔			
S6		✔			



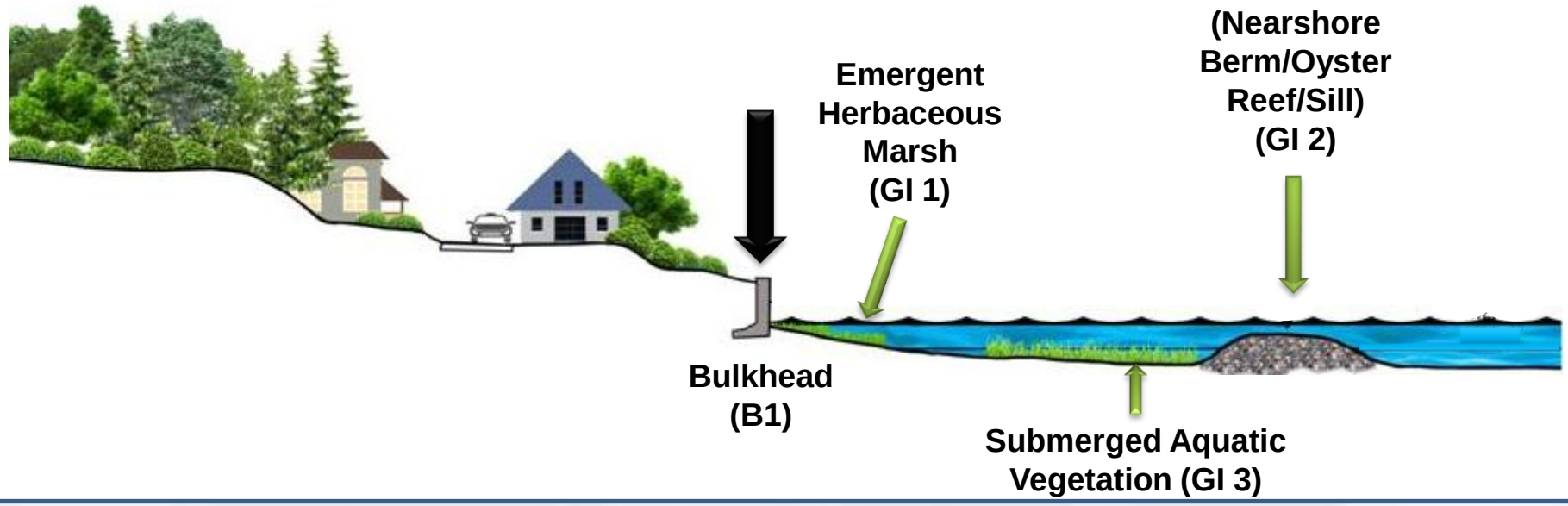
Services to NBI Matrix

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✓		✓		
S2	✓		✓	✓	
S3			✓		
S4				✓	
S5		✓	✓		
S6		✓		✓	



Services to NBI Matrix

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✓		✓		✓
S2	✓		✓	✓	✓
S3			✓		✓
S4				✓	✓
S5		✓	✓		✓
S6		✓		✓	✓



Define Requirements for Applications

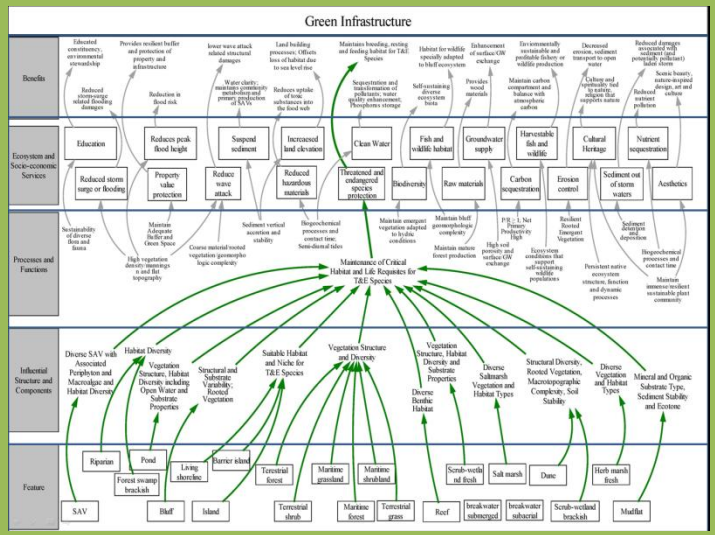
- Sync with Task 3A & 3B
  – Tiered Approach
  - **Level 1** – Qualitative characterization of performance

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
Plan D	6	10	10	8	5	7.8	115
Plan E	5	5	5	10	10	7	115
Plan F	7	7	3	4	7	5.6	80

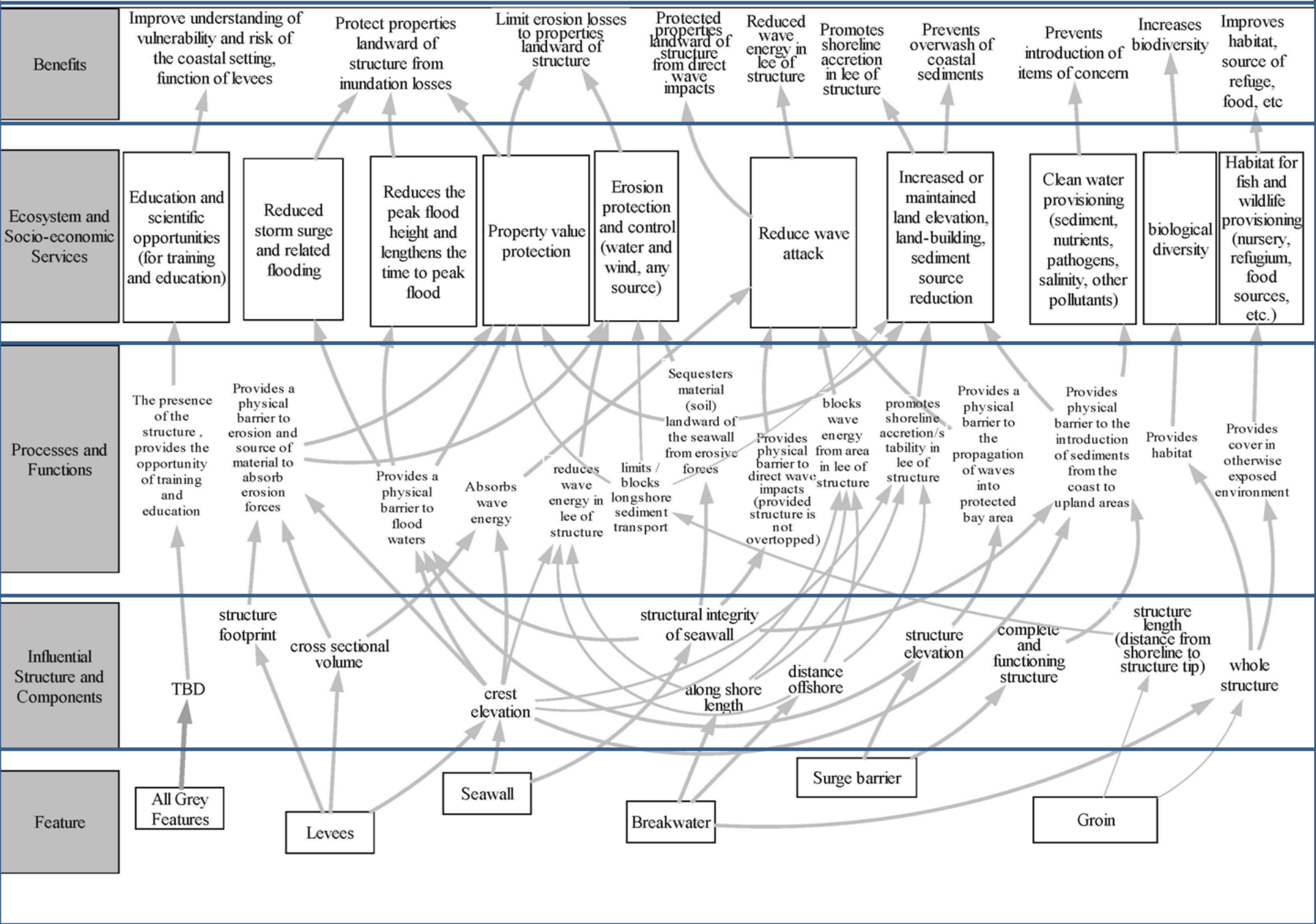
Define Requirements for Applications

- Sync with Task 3A & 3B – Tiered Approach
  - **Level 1** – Qualitative characterization of performance
  - **Level 2** – Semi-quantitative characterization of performance

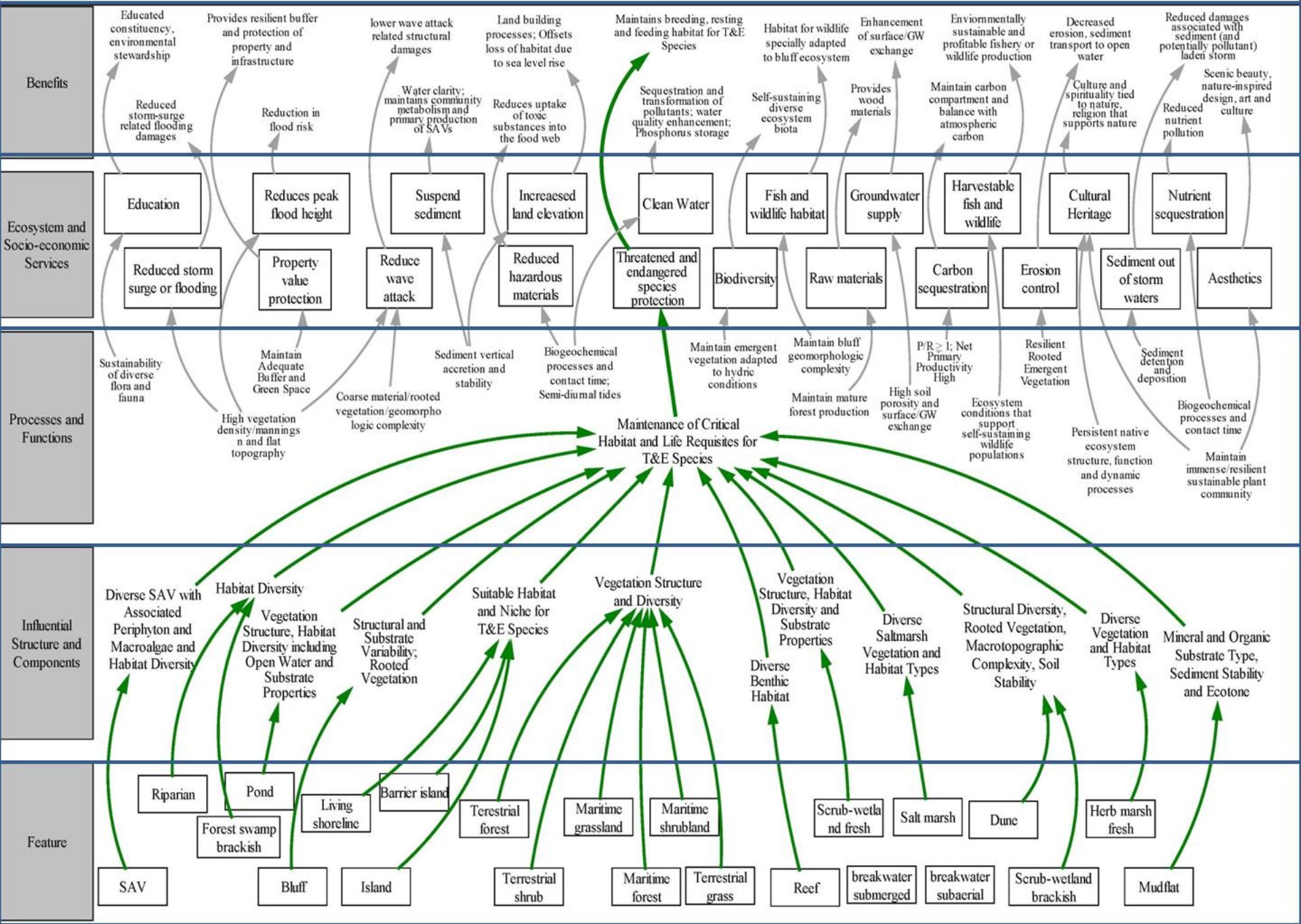
Wt	1	2	4	3	5		
	B1	B2	B3	B4	B5	Mean	Wtd
Plan A	10	8	5	1	0	4.8	49
Plan B	10	10	0	0	0	4	30
Plan C	10	5	5	9	7	7.2	102
Plan D	6	10	10	8	5	7.8	115
Plan E	5	5	5	10	10	7	115
Plan F	7	7	3	4	7	5.6	80



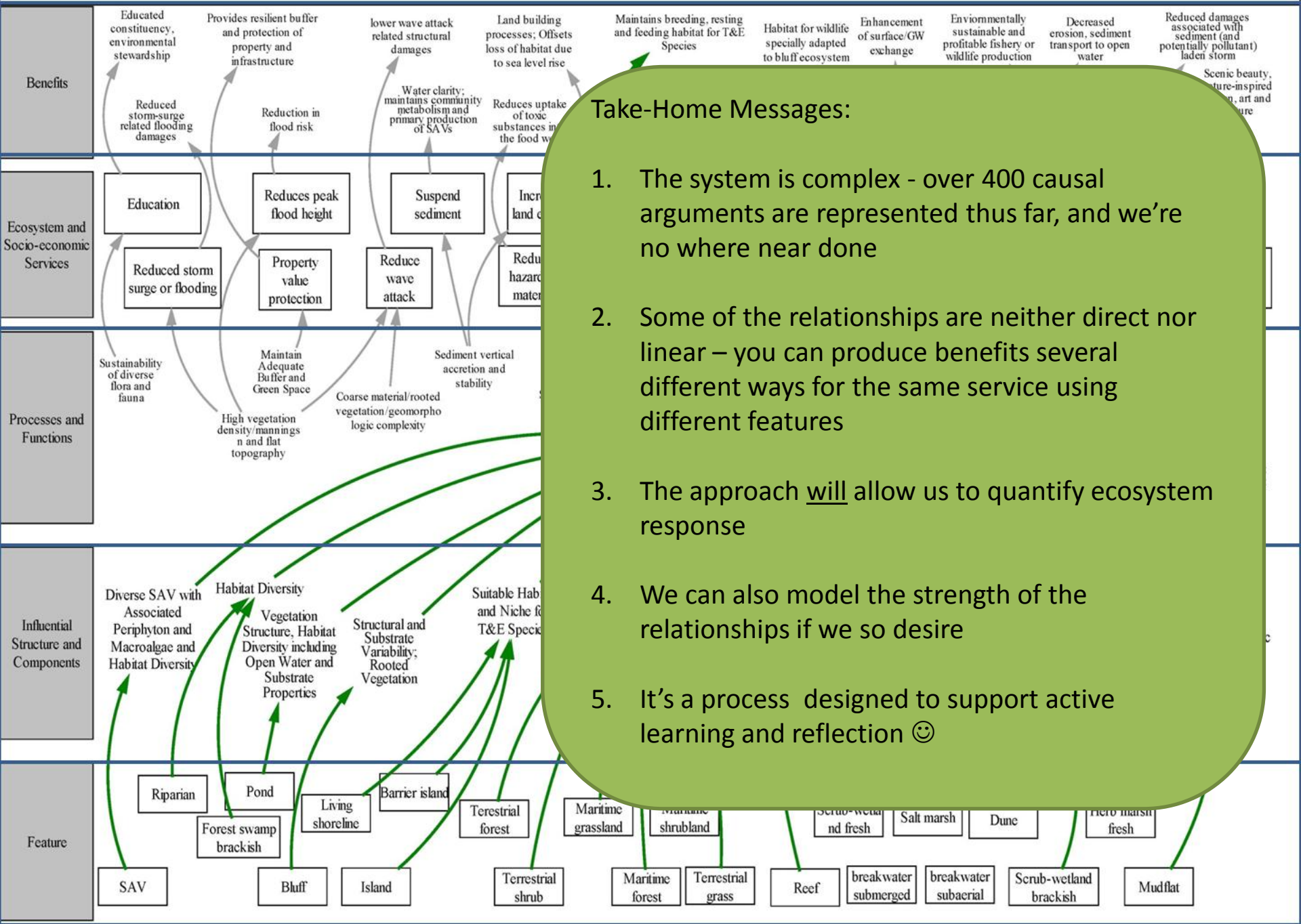
Structural Features



Natural and Nature-Based Features



Natural and Nature-Based Features

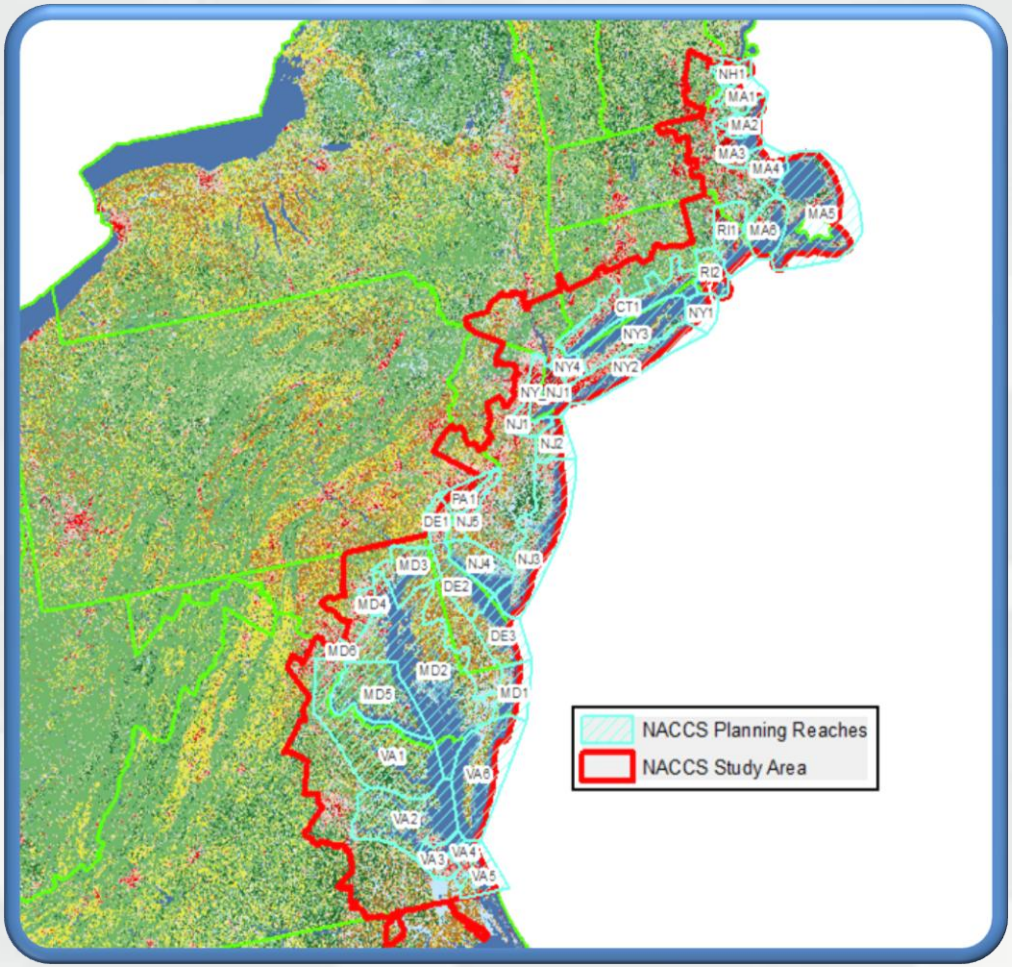


Take-Home Messages:

1. The system is complex - over 400 causal arguments are represented thus far, and we're no where near done
2. Some of the relationships are neither direct nor linear – you can produce benefits several different ways for the same service using different features
3. The approach <u>will</u> allow us to quantify ecosystem response
4. We can also model the strength of the relationships if we so desire
5. It's a process designed to support active learning and reflection ☺

Define Requirements for Applications

- Sync with Task 3A & 3B – Tiered Approach
  - **Level 1** – Qualitative characterization of performance
  - **Level 2** – Semi-quantitative characterization of performance
  - **Level 3** – Quantitative characterization of performance



Define Requirements for Applications

- Sync with Task 3A & 3B
  - Tiered Approach
    - **Level 1** – Qualitative characterization of performance
    - **Level 2** – Semi-quantitative characterization of performance
    - **Level 3** – Quantitative characterization of performance

Option 1: Value Transfer ($ Value per acre)

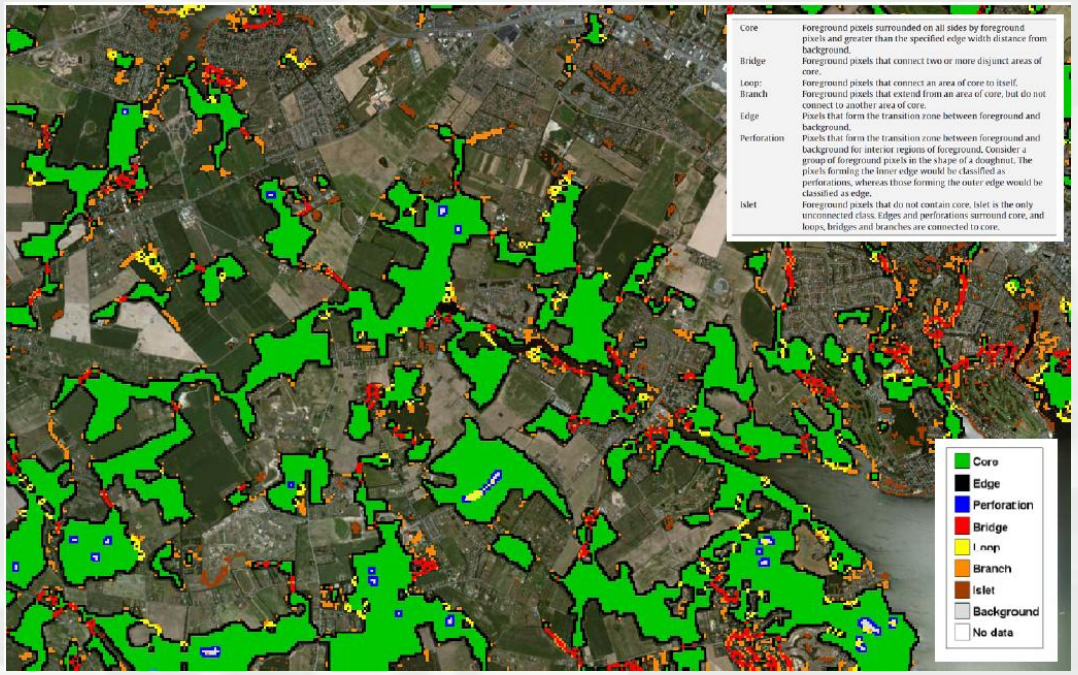
Ecosystem Service Values Based on Peer-Reviewed Original Research in Temperate North America/Europe (2012 $/(ac*yr))												
	Coastal Shelf	Beach	Estuary	Saltwater Wetland	Forest	Grass/ Rangelands	Cropland	Freshwater Wetland	Open Fresh Water	Riparian Buffer	Urban Greenspace	Urban/ Barren
Gas/Climate Regulation		n/a			72	6					404	
Disturbance Regulation		32794		1						106		
Water Regulation								7162			7	
Water Supply	745		59		11			1396	492	2310		
Soil Formation	n/a	n/a				7			n/a			
Nutrient Cycling		n/a										
Waste Treatment		n/a		7322								
Pollination	n/a	n/a			195		10		n/a			
Biological Control		n/a										
Habitat/Refugia			438	277	1110			6				
Aesthetic/Recreation		17851	364	31	156	1	18	1889	428	1647	2562	
Cultural/Spiritual		29		216						5		

Ecosystem Service Values Based on Peer-Reviewed Original Research, Grey Literature, and Meta-analysis Studies in Temperate North America/Europe (2012 $/(ac*yr))												
	Coastal Shelf	Beach	Estuary	Saltwater Wetland	Forest	Grass/ Rangelands	Cropland	Freshwater Wetland	Open Fresh Water	Riparian Buffer	Urban Greenspace	Urban/ Barren
Gas/Climate Regulation		n/a			65	4		161			404	
Disturbance Regulation		32794	344	373				4397		106		
Water Regulation						2		3590			7	
Water Supply	626		59		196			1856	492	2310		
Soil Formation	n/a	n/a			6	4			n/a			
Nutrient Cycling	869	n/a	12814									
Waste Treatment		n/a		6508	53	53		1008				
Pollination	n/a	n/a			195	16	10		n/a			
Biological Control	24	n/a	47		2	14	14					
Habitat/Refugia			378	242	1110		999	136				
Aesthetic/Recreation		17851	351	31	147	1	18	1690	428	1647	2562	
Cultural/Spiritual	42	29	18	216	1			1070		5		

Define Requirements for Applications

- Sync with Task 3A & 3B
  - Tiered Approach
    - **Level 1** – Qualitative characterization of performance
    - **Level 2** – Semi-quantitative characterization of performance
    - **Level 3** – Quantitative characterization of performance

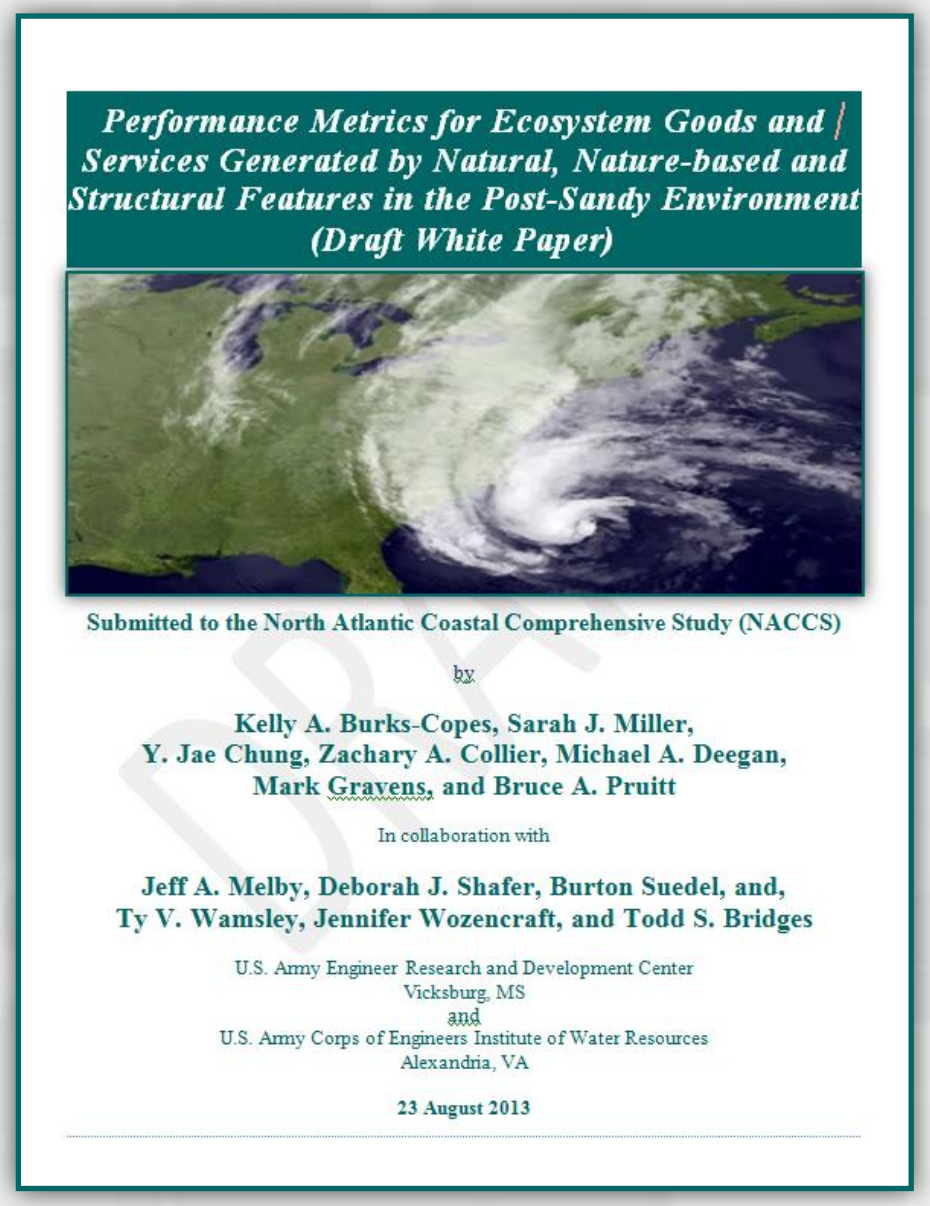
Option 2: Ecosystem Production Functions



72 individual performance metrics have been developed and are ready for deployment!

Status

- Scoped Tasks
  - Lexicon complete
  - Service & feature list complete
  - Metric development complete
- White paper submitted to NACCS (**23 Aug 2013)**
  - 68 pages + 5 appendices
- Final due to NACCS (**6 Sep 2013)**



Performance Metrics for Ecosystem Goods and Services Generated by Natural, Nature-based and Structural Features in the Post-Sandy Environment (Draft White Paper)

Submitted to the North Atlantic Coastal Comprehensive Study (NACCS)

by

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U.S. Army Engineer Research and Development Center
Vicksburg, MS
and
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Alexandria, VA

23 August 2013

Issues still unresolved . . .

What's important to remember:

- This is a reconnaissance level investigation that was done very quickly
- What can the USACE & the NACCS stakeholders consider to address flood damage reductions (structural vs. nature-based vs. composite)?
- How effective will these solutions be?
- Are they cost effective?

What's important to recognize:

- Nature-based solutions and the goods and services they could provide are at the frontiers of science and engineering, and the answers to these questions are uncertain.
- Stakeholder perceptions and values will play a significant role in the use of both nature-based solutions and the accounting of their benefits to the society at large.

Questions & Comments?

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