Natural and Nature-based Solutions for the Texas Coast

Developing a Decision Support System to Quantify a Full Array of Benefits

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US Army Corps of Engineers
BUILDING STRONG®

The problem in a nutshell

- Coastal projects are not isolated, but rather exist at the ***interface*** of population centers and their supporting waterways

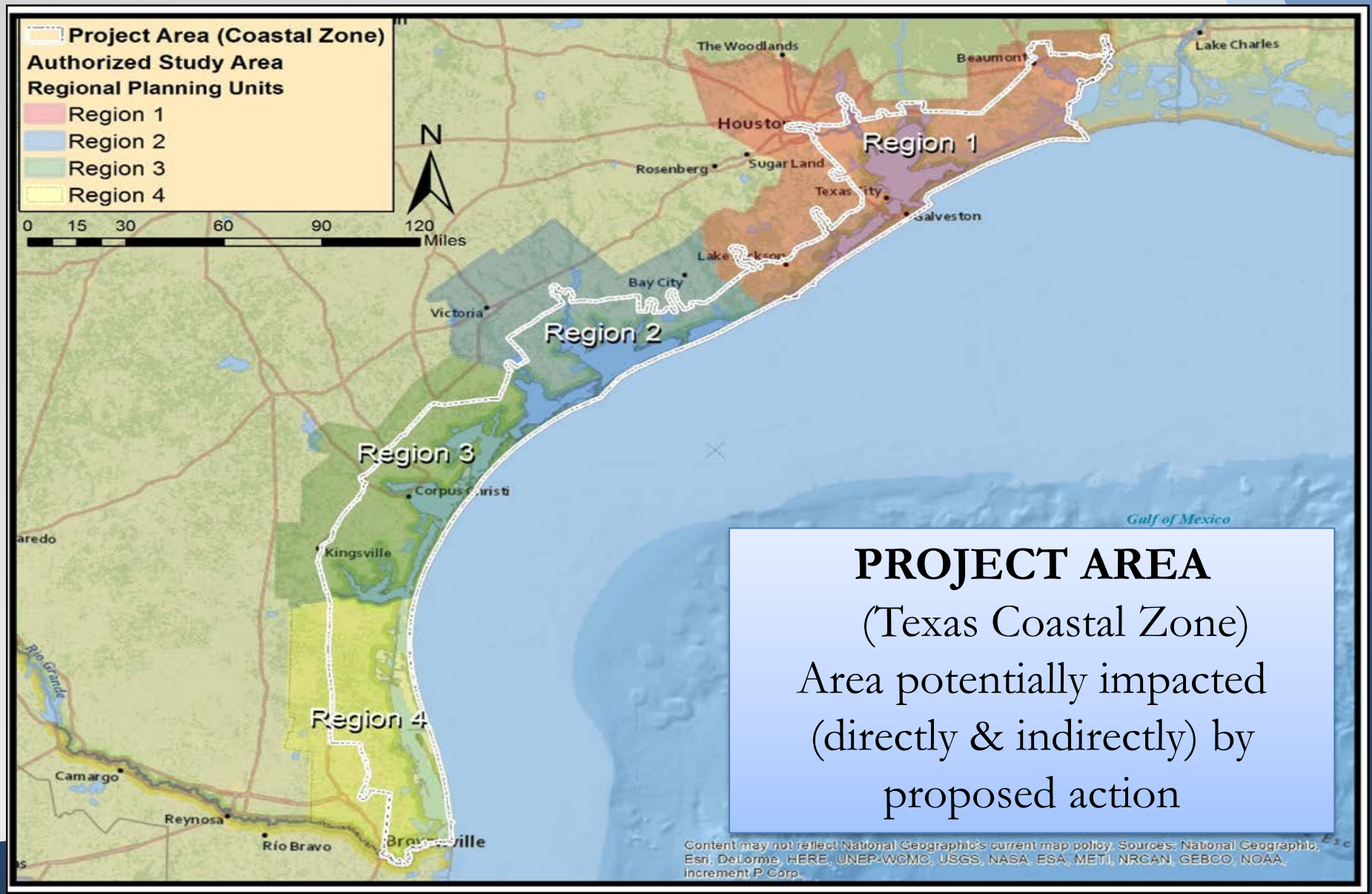
- We need a rapid assessment approach that can operate in the ***3x3x3*** SMART planning paradigm

- Plans will contain a ***full array of measures***: natural, nature-based, non-structural and structural.

- So we need to capture the ***full range*** of benefits: Environmental + Social + Economic

- We need a ***desk-top application*** that is fast AND science-driven

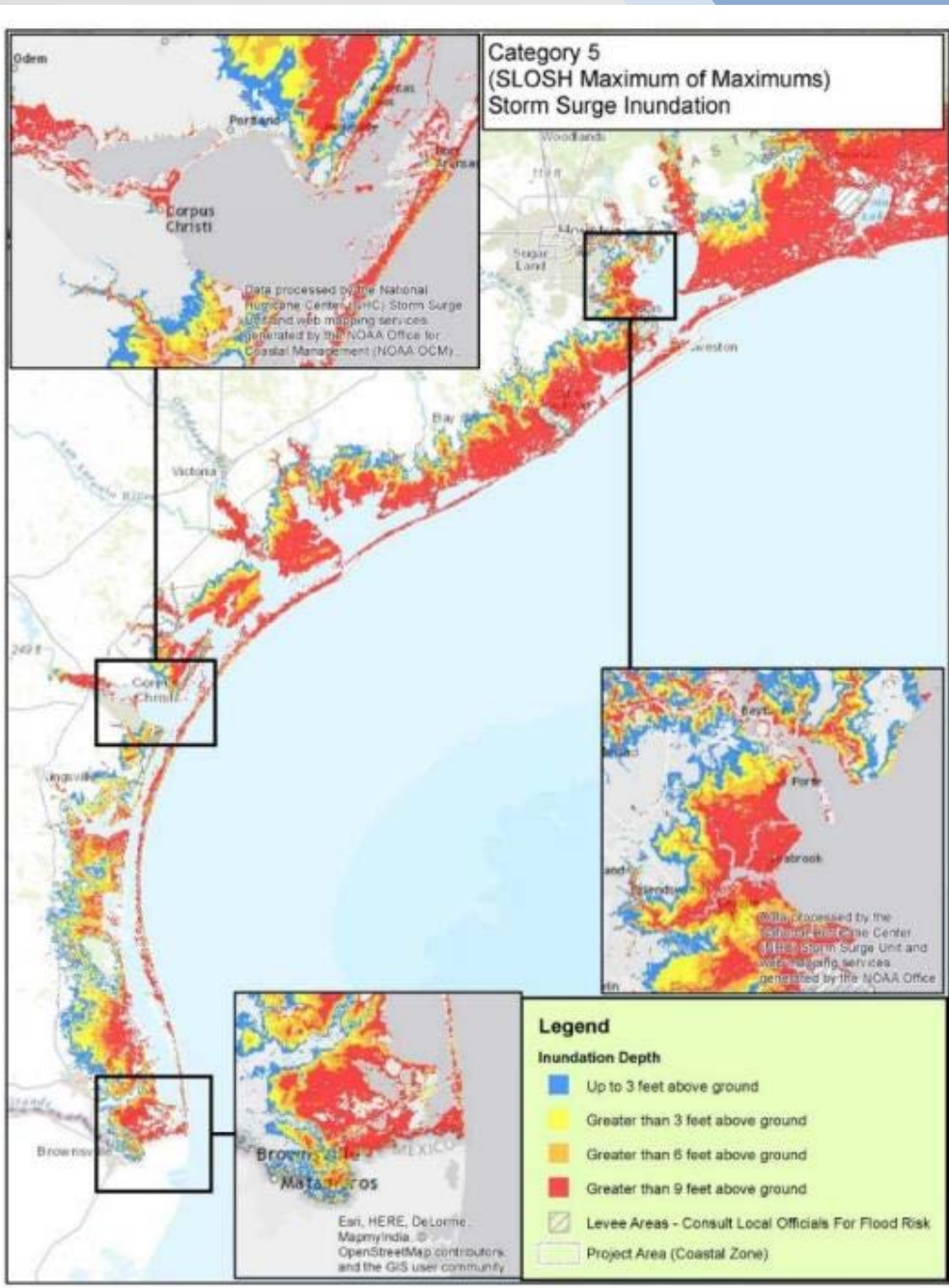
Let's Set the Stage:
USACE TX Coastal Study



PROJECT AREA
(Texas Coastal Zone)
Area potentially impacted (directly & indirectly) by proposed action

Climate Change:
What happens if. . .

Trend Continues: Limited Flooding of other Developed Area of the Coastal Texas



Coastal TX Study Authority

(Section 4091, Water Resources Development Act (WRDA) of 2007 Public Law (P.L.) 110-114)

Sec. 4091. Coastal Texas Ecosystem Protection and Restoration, Texas.

(a) In General.—The Secretary shall develop a ***comprehensive plan*** *to determine the feasibility of carrying out projects for flood damage reduction,* ***hurricane and storm damage reduction****, and* ***ecosystem restoration*** *in the* ***coastal areas*** *of the State of Texas.*

(b) Scope.—The comprehensive plan shall provide for the ***protection, conservation, and restoration of wetlands, barrier islands, shorelines****, and related lands and features that* ***protect critical resources, habitat, and infrastructure*** *from the impacts of* ***coastal storms, hurricanes, erosion, and subsidence****.*

(c) Definition.—For purposes of this section, the term "coastal areas in the State of Texas" means the coastal areas of the State of Texas from the ***Sabine River on the east to the Rio Grande River on the west*** *and includes* ***tidal waters, barrier islands, marshes, coastal wetlands, rivers and streams, and adjacent areas****."*

Chasing the Big Blue Rabbit

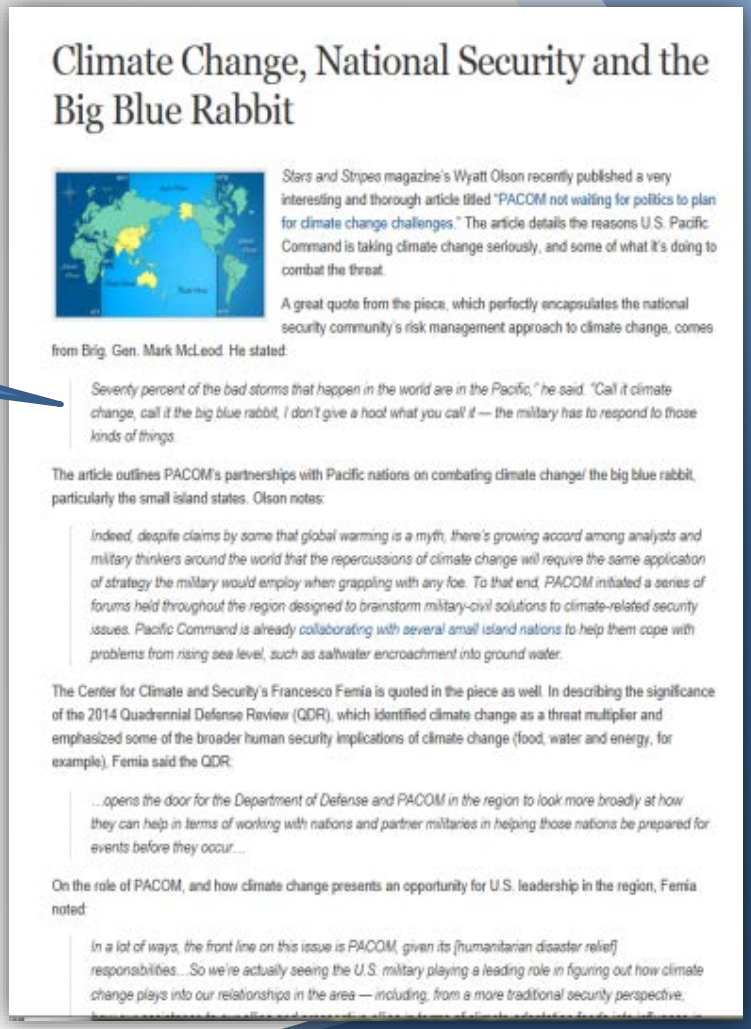
"Call it climate change, call it the big blue rabbit. I don't give a hoot what you call it – the military has to respond to those kinds of things."

Brig. Gen. Mark McCleod
Commander, Defense Logistics Agency,
Energy, Defense Logistics Agency, Fort Belvoir, VA

Resilience is the ability of a system to **prepare for**, **resist**, **recover**, and **adapt** to achieve functional performance under the stress of natural hazards and human-related disturbances through time.

Vulnerability is the opposite side of the coin . . . . . i.e., the degree to which a system is susceptible to, and unable to cope with, the adverse effects of natural hazards or human-induced disturbances over a period of time or temporal reference

(exposure + sensitivity + adaptive capacity)



Climate Change, National Security and the Big Blue Rabbit

Stars and Stripes magazine's Wyatt Olson recently published a very interesting and thorough article titled "PACOM not waiting for politics to plan for climate change challenges." The article details the reasons U.S. Pacific Command is taking climate change seriously, and some of what it's doing to combat the threat.

A great quote from the piece, which perfectly encapsulates the national security community's risk management approach to climate change, comes from Brig. Gen. Mark McLeod. He stated:

> *Seventy percent of the bad storms that happen in the world are in the Pacific," he said. "Call it climate change, call it the big blue rabbit, I don't give a hoot what you call it — the military has to respond to those kinds of things.*

The article outlines PACOM's partnerships with Pacific nations on combating climate change/ the big blue rabbit, particularly the small island states. Olson notes:

> *Indeed, despite claims by some that global warming is a myth, there's growing accord among analysts and military thinkers around the world that the repercussions of climate change will require the same application of strategy the military would employ when grappling with any foe. To that end, PACOM initiated a series of forums held throughout the region designed to brainstorm military-civil solutions to climate-related security issues. Pacific Command is already collaborating with several small island nations to help them cope with problems from rising sea level, such as saltwater encroachment into ground water.*

The Center for Climate and Security's Francesco Femia is quoted in the piece as well. In describing the significance of the 2014 Quadrennial Defense Review (QDR), which identified climate change as a threat multiplier and emphasized some of the broader human security implications of climate change (food, water and energy, for example), Femia said the QDR:

> *...opens the door for the Department of Defense and PACOM in the region to look more broadly at how they can help in terms of working with nations and partner militaries in helping those nations be prepared for events before they occur...*

On the role of PACOM, and how climate change presents an opportunity for U.S. leadership in the region, Femia noted:

> *In a lot of ways, the front line on this issue is PACOM, given its [humanitarian disaster relief] responsibilities...So we're actually seeing the U.S. military playing a leading role in figuring out how climate change plays into our relationships in the area — including, from a more traditional security perspective,*

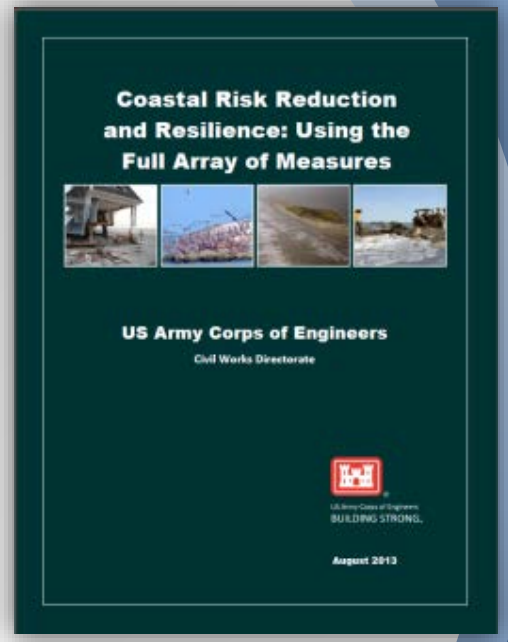
http://climateandsecurity.org/2014/08/13/climate-change-national-security-and-the-big-blue-rabbit/

Multiple Lines of Defense

Natural features are created and evolve over time through the actions of physical, biological, geologic, and chemical processes operating in nature. 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.

Nature-based features are those that **may mimic** characteristics of natural features but are **created by human** design, engineering, and construction to provide specific services such as coastal risk reduction.

The **built components** of the system include nature-based and other structures that support a range of objectives, including erosion control and storm risk reduction (e.g., seawalls, levees), as well as infrastructure providing economic and social functions (e.g., navigation channels, ports, harbors, residential housing).



http://www.corpsclimate.us/ccacrrr.cfm

Improved coastal storm risk management measures are needed

Employing three primary strategies—**protect, accommodate, and retreat**—coastal communities should consider a system of **comprehensive, resilient, and sustainable** coastal storm risk management measures. The system should include a **combination of measures** (structural, NNBF, and nonstructural measures) to form **resilient, redundant, robust, and adaptable strategies** and measures that are tailored to enhance life safety, local site conditions, and societal values.

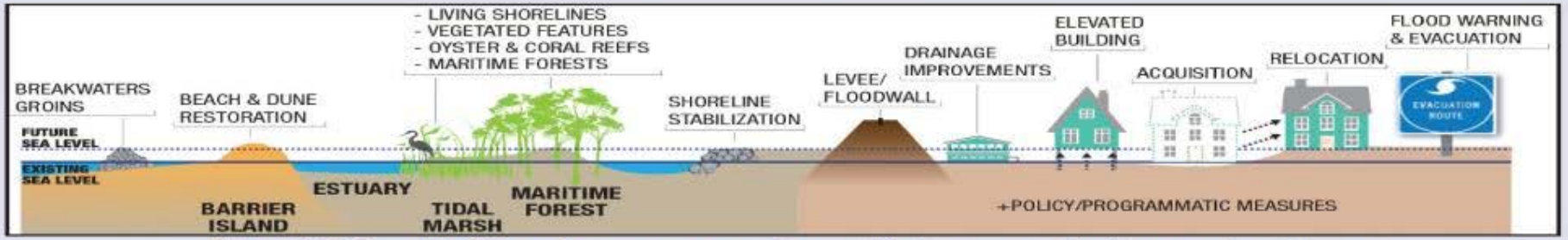


Figure II-1. Combinations of measures may be used to improve redundancy and resilience associated with coastal flood risk management.

Natural and Nature-Based Infrastructure at a Glance

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED; SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY

Dunes and Beaches	Vegetated Features	Oyster and Coral Reefs	Barrier Islands	Maritime Forests/Shrub Communities
Benefits/Processes Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer Increased infiltration	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Wave attenuation and/or dissipation Sediment stabilization	**Benefits/Processes** Wave attenuation and/or dissipation Shoreline erosion stabilization Soil retention
Performance Factors Berm height and width Beach slope Sediment grain size and supply Dune height, crest, and width Presence of vegetation	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density

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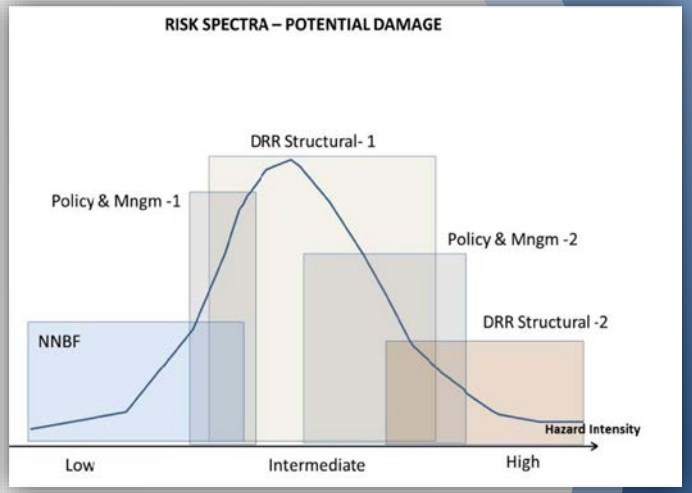
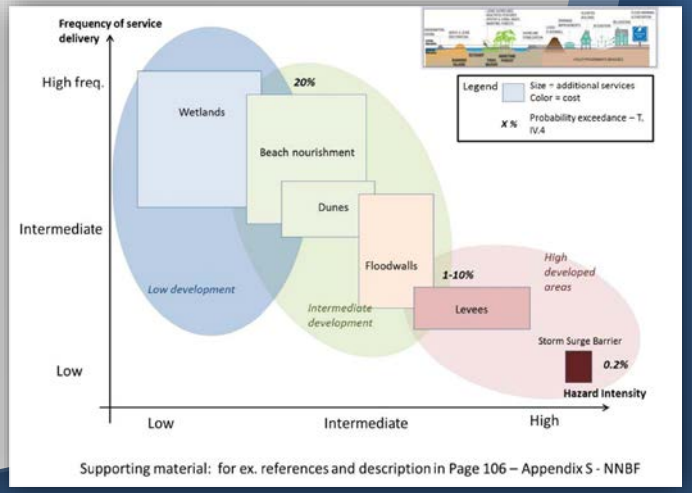




Reguero et al. 2014 (in press)

Lines of Defense Under Consideration

- Low surge protection
  - Offshore breakwaters
  - Reduce waves and coastal erosion

Lines of Defense Under Consideration

- Low/medium surge protection
  - Marsh, beach and dune restoration

Lines of Defense Under Consideration

- High surge protection
  - Levees/flood walls
  - Block storm surge from moving inland

Freeport Hurricane Protection System

Texas City Levee
Hurricane Ike Aftermath

BUILDING STRONG®

Lines of Defense Under Consideration

- High surge protection
  - Seawalls/flood gates
  - Protect developed areas from storm surges
  - Prevent storm surge from entering coastal inlets and bays

Galveston Seawall

Dutch Floodgate

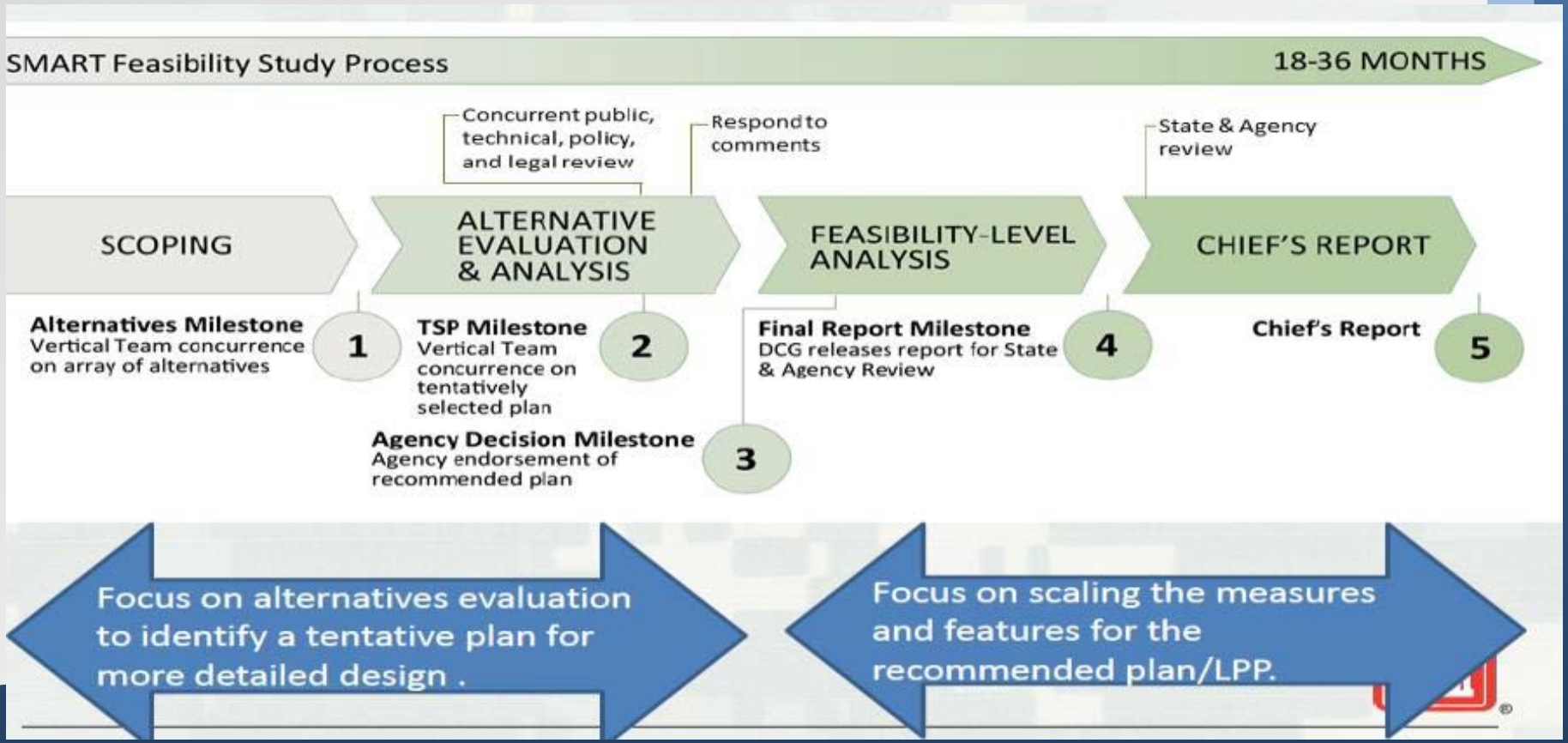
Ecosystem Restoration Ideas

The Constraint: SMART PLANNING

New USACE Planning Paradigm:

Specific
Measureable
Attainable
Risk Informed
Timely

- 3 x 3 x 3 SMART Planning
  - Completed in 3 yrs
  - For no more than $3M
  - 3 levels of vertical alignment
- Balance uncertainty & level of detail



What is needed. . . .

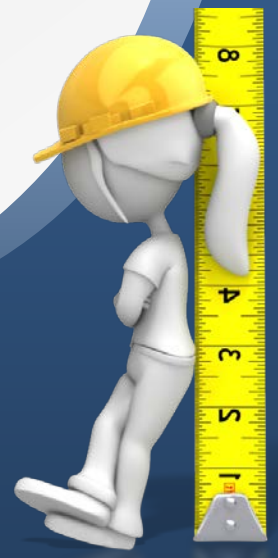
Performance Metrics that provide **specific** measures of production or indicators of system response that can be used to **consistently** estimate and report the anticipated **consequences** of an alternative plan with respect to a particular planning and engineering objectives.

They must 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



State of the Science: State of the Practice

- Site selection exercise – purely qualitative exercise
- All benefits/impacts MUST be quantified
- Currently limited to the “Certified Model” Rule
- Also limited by the “HEP” Rule

  (Quantity x Quality)
- And we don’t have much time (May 2018)

State of the Science: State of the Practice

Which means. . . .

- We have to use what's available – species-based tools

Barrier Islands/dunes
WVA Model

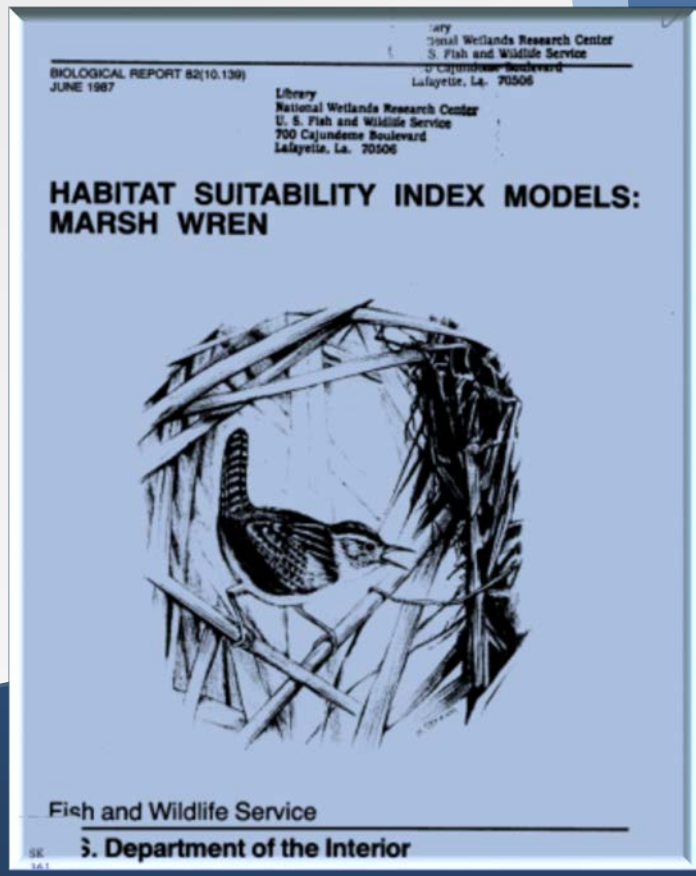
Oyster Reefs
Oyster Community Model

Tidal Flats
Mottled duck
Least tern
Red drum

Islands
Brown pelican
Roseate spoonbill
Forster's tern

Submerged Aquatic Vegetation
Red drum
Brown/white shrimp
Spotted seatrout
Atlantic croaker
Redhead

Marsh (Salt & Brackish)
Atlantic croaker
Red drum
Spotted seatrout
Brown/white shrimp
Northern pintail
Marsh wren



State of the Science: State of the Practice

But. . . . What we really want is a Decision Support System . . .

- A suite of community-based models like the WVA & Oyster
- Based on a data-driven process – using readily available data and developing a plan to fill the gaps
- An internet-based system would be ideal – Dial-a-Plan
- Using a spatially explicit – GIS-driven dataset

- And then we need to train the work force

Food for Thought . . . .

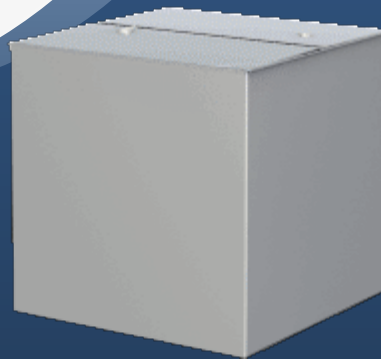
How can we account for NNBF Benefits?

Ecosystem Goods and Services

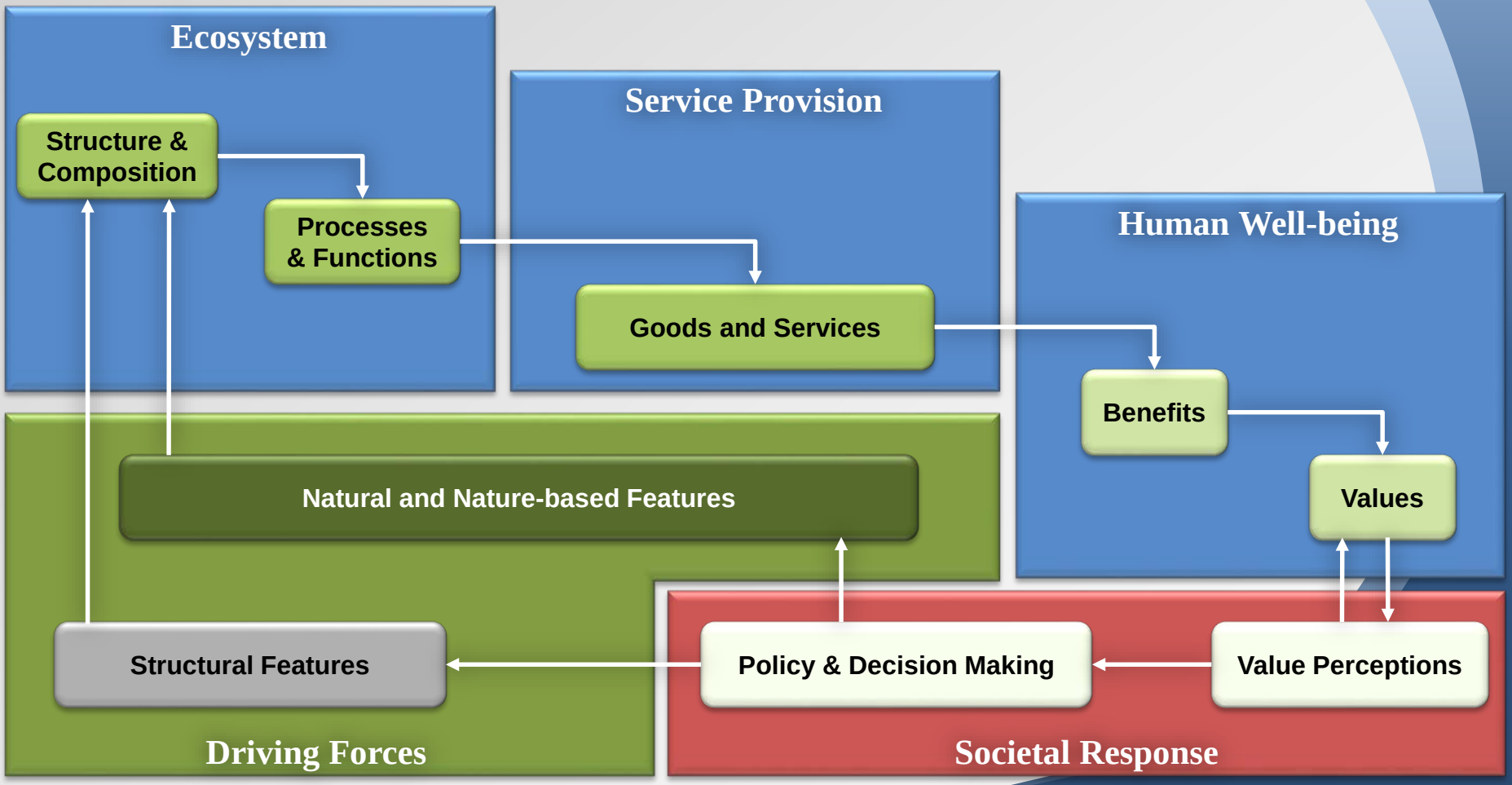
Tangible items or intangible commodities generated by self-regulating or managed ecosystems whose composition, structure, and function are comprised of natural, nature-based and/or structural features that produce socially-valued benefits that can be utilized either directly or indirectly to promote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



EGS production by NNBF & Traditional Solutions

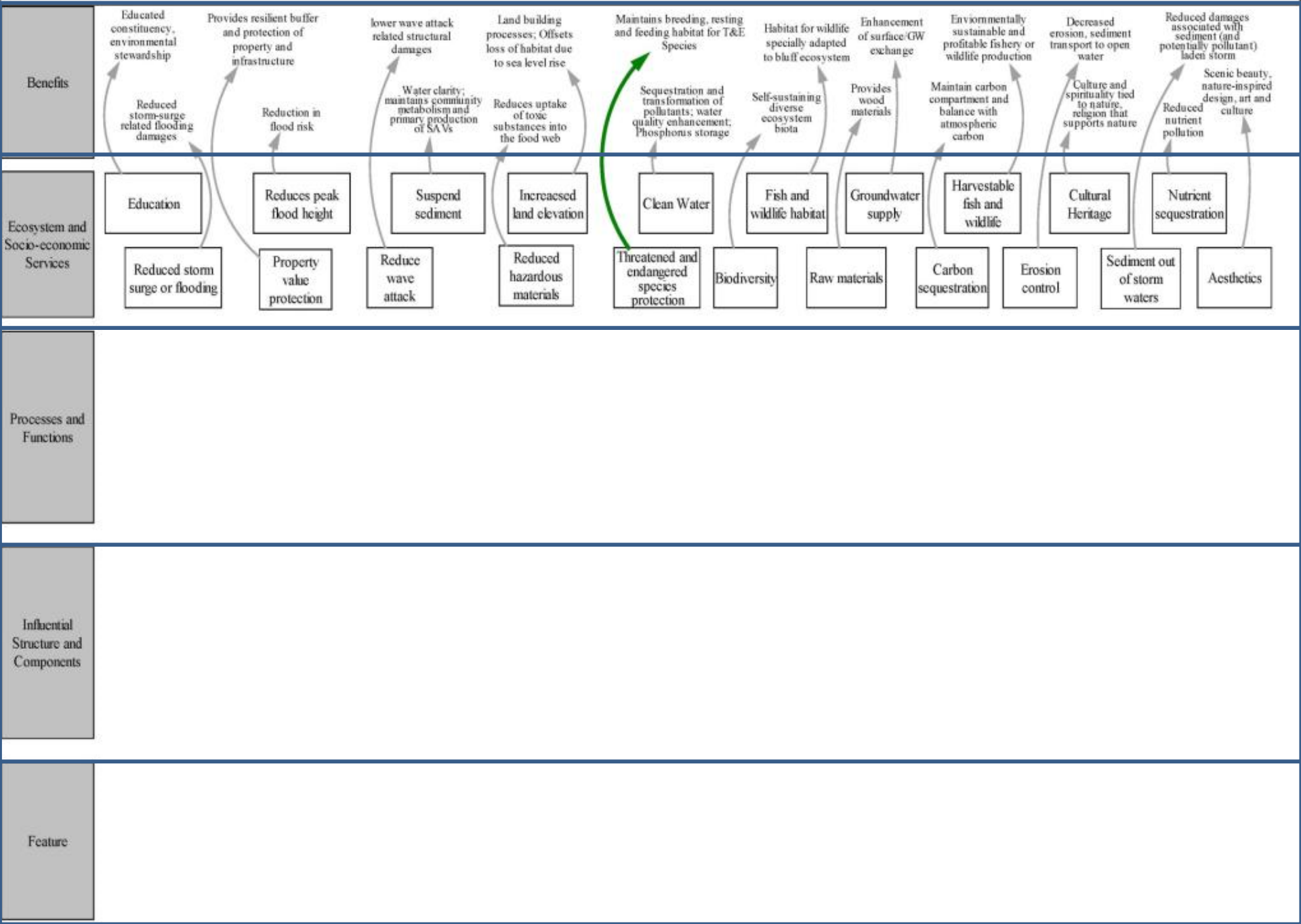


Goods and Services Generated by NNBF

- Aesthetics
- Biological diversity
- Carbon sequestration
- Clean water provisioning
- Harvestable fish and wildlife production
- Cultural heritage and identity
- Education
- Erosion protection and control
- Habitat provisioning
- Increase/maintain land elevation
- Maintain background suspended sediment
- Nutrient sequestration
- Property value protection
- Groundwater provisioning and storage
- Raw materials production
- Recreation
- Reduce hazardous or toxic materials
- Reduce storm surge
- Reduce the peak floods
- Reduce wave attack
- Threatened and Endangered species protection

Multiple lines of defense in the face of coastal storms and sea level rise

Natural and Nature-Based Features



Food for Thought . . . .

How can we account for Benefits?

- What about using Ecosystem Production Functions?
- Can we extract key performance metrics from LiDAR?
- How will we handle trade-offs between monetizable and non-monetizable benefits?

How can we capture EGS from a systems perspective?

- How should we define service area?
- How can we account for competing EGS?
- How will we distinguish between Intermediate vs. Final EGS?

How can we address blended solutions?

- If we agree that structural features can produce EGS, then how do we tackle solutions that have EGS generated by a blended solution?

Overarching R&D questions

O&M activities and the R&D activities surrounding the use of hybrid solutions and their associated EGS operate at the frontiers of science and engineering experience.

Several questions still remain:

- How do we **establish goals and objectives** using NNBF & EGS within a given setting, site, and application where O&M is concerned?
- **When and where** can or should NNBF be deployed?
- Must we **monetize EGS**, or can we consider using **non-monetized** strategies such as ecosystem production functions?
- Will NNBF performance **metrics adequately capture resilience**?
- Are there identifiable **dependencies or associations** amongst NNBF features (both built and natural) that affect their performance **from a systems perspective**, and can EGS capture these sufficiently?
- Are O&M activities (particularly those that include NNBF) truly **adaptive** and can EGS be used to prove **cost effectiveness**?
- **At what scale** do we prove NNBF's **demonstrable**, **measureable**, and **meaningful contribution** to the ecosystem's function, integrity and resilience?

Stakeholder perceptions and values of NNBF wi
play a significant role in USACE activitie
and the accounting of their benefits to th
society at large remains a HUGE challenge

Ongoing Efforts:

Natural Infrastructure Metrics Working Group (NIMs)

- **Co-led by USFWS & NWF**
- **NGGI WG Goals:**
  - Develop core metrics that cut across agency missions, supporting efficiencies and knowledge base that prove that NGGI are:
    - Effective
    - Resilient
    - Cost Effective
- **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 and test on demo sites
  6) Develop a web-based database

Ongoing Efforts:
LiDAR-based LULC Trends on the TX Coast
(USACE-SWG, ERDC, JABLTCX, RPEC)

Objectives:

- Conduct an extensive cataloguing of existing electronic & hard copy data - includes all historic geo-rectified imagery covering the TX Coast – 1990 & 2016
- Scan, catalog, georeference, and establish a GIS-ready database of unique data sets
- Digitize shorelines of scanned historic aerials & establish feature classes of these aerials and shoreline locations
- Perform an analysis of the shorelines, categorizing areas of significant change

	Variables
Geomorphic	dune peak
	barrier island width
	dune toe
	beach width
	slope of beach
	barrier island cross-section volume
Environmental	impervious area
	dune vegetation coverage
	height of veg. above ground

The CSEC is ideally positioned to tackle the big blue rabbit . . . .

We have **enough science & technology** to inform adaptation policy and guidance now

We already serve as **aggregators and translators** of technical information, applying new and changing information from science across the spectrum of engineering practice.

Engineering With Nature (EWN) solutions will be required in the next 10-20 years to enhance human and ecosystem health and resilience to climate and other changes

EWN is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

EWN solutions will involve **novel application of existing technologies** and materials, or combinations of existing and new technologies and materials

Performance and cost will be the major drivers

www.EngineeringWithNature.org
http://el.erdc.usace.army.mil/ewn

Parking Lot Slides & Notes

ESG Collaborative

- USFWS $10K available to co-host a workshop

Other Efforts Along the Way

- TNC & Lloyds Report last week – would there be a way to apply this to TX – Mike Beck/SNAPP
- Yoskowitz efforts – Hart Research Institute @ TAMU
- NOAA EESLR project
- OMB Guidance coming out any day
- Proactively consider the Executive Order on EGS and determine how they could inform the TX Coastal Study – pilot (engage Sue Hughes, HQ/ Maria Wegner, HQ, Mindy Simmons) - Experimental Stations like South Padre