Introduction to Natural Infrastructure in Coastal Wetlands

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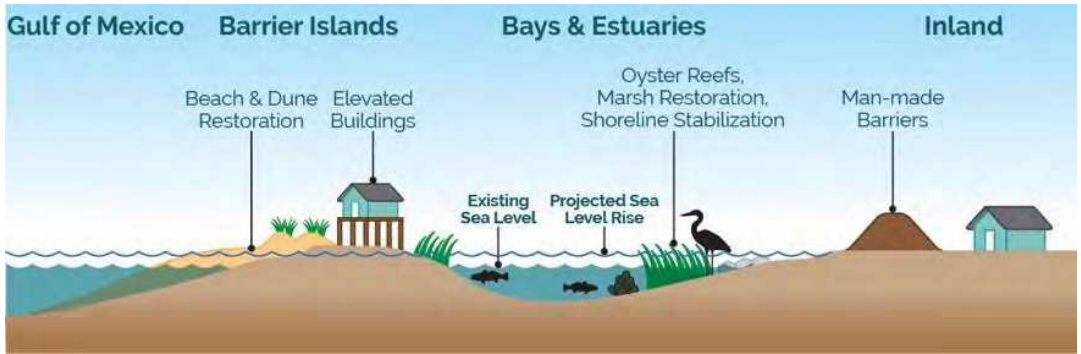
EWN® and NNBF

Natural and Nature-based Features (NNBF)

- **Natural features**: created & evolved over time through physical, biological, geologic and chemical processes operating in nature over time
- **Nature-based features**: mimic characteristics of natural features but created by human design, engineering and construction to provide coastal risk reduction
- **Natural infrastructure**: naturally occurring landscape features and/or nature-based solutions that promote, use, restore or emulate natural ecological processes (EDF)
- **Built components**: include nature-based features as well as "gray" infrastructure (i.e., levees, floodwalls, etc.)
- **Non-structural measures**: policies, building codes, land use zoning



Scaling Natural Infrastructure
https://ewn.erdc.dren.mil/?p=7967

Range of Coastal Wetland NI Techniques

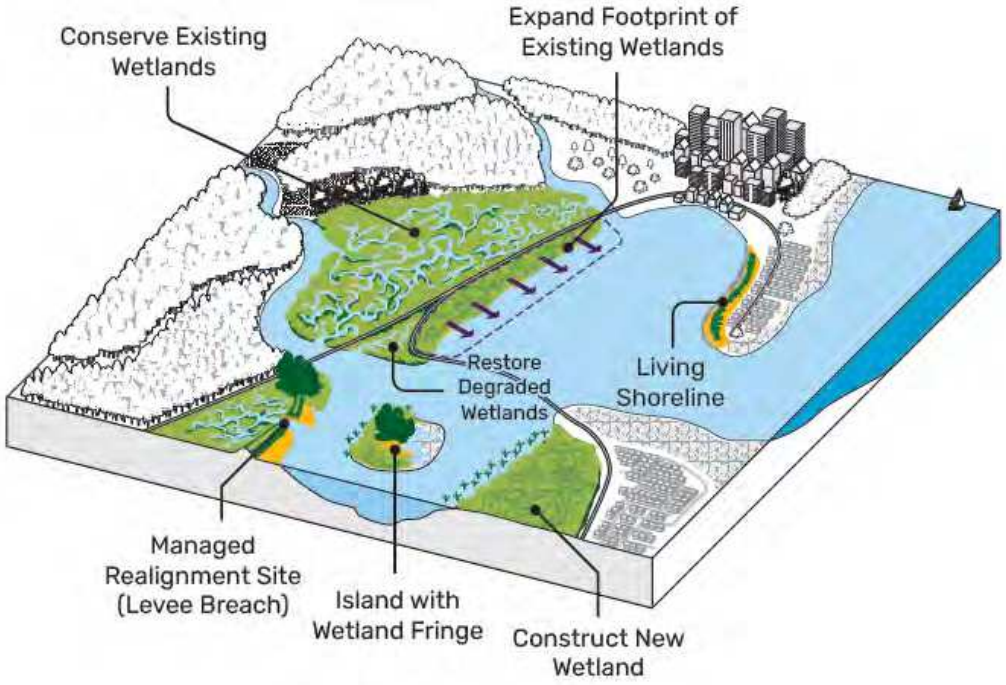
- Species control (e.g., invasive species removal; diversity planting
- Vegetation seeding or planting
- Living shoreline with or without sill
- Enhanced tidal exchange (e.g., culvert enlargement)
- Retention structures (e.g., berms for wave reduction)
- Thin-layer placement
- Direct and strategic sediment placement
- Sediment diversions
- Wetland creation
- Regrading
- Terracing
- Managed realignment, tidal flow restoration
- Flood storage areas

Horizontal levee rendering along the upper Texas coast (Holmes et al. 2021).

Wetland NI Implementation at Estuary Scale

Wetland NI approaches include:

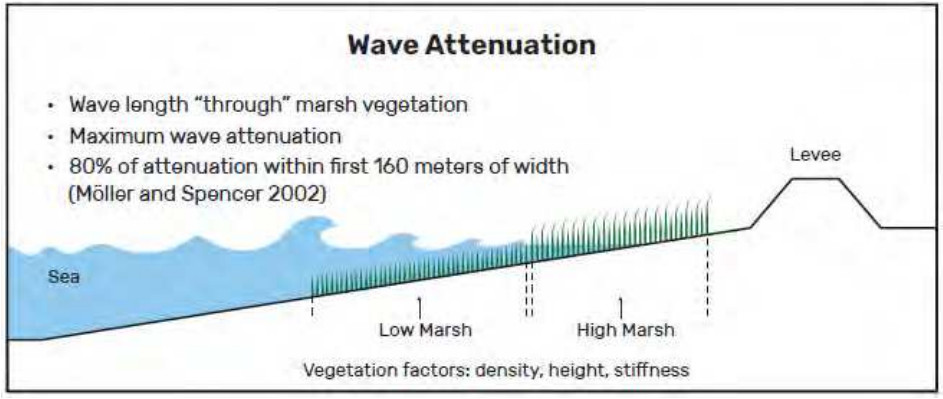
- Conserving existing wetlands
- Creating narrow fringes of wetland along shorelines to mitigate erosion (a.k.a. living shorelines)
- Improving condition (e.g., height, density, area) of existing wetlands through restoration
- Restoring previously reclaimed estuarine wetlands for flood control (i.e., managed realignment)
- Constructing new wetlands where none previously existed

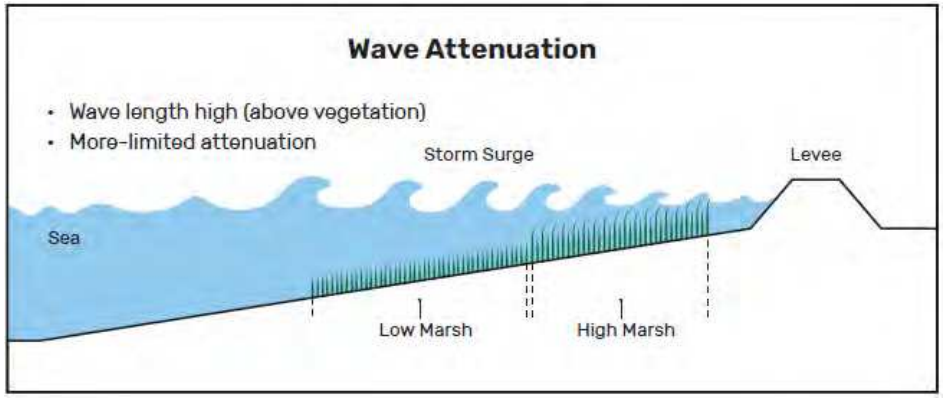


Piercy, C. D., et al. 2021."Chapter 10: Coastal Wetlands and Tidal Flats." In International Guidelines on Natural and Nature-Based Features for Flood Risk Management. Edited by T. S. Bridges, et al. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Wetland Vegetation and Wave Attenuation

Interaction between Wetland Vegetation and Water Levels on Wave-Attenuation Function





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Research Informs NI Value: Mangroves

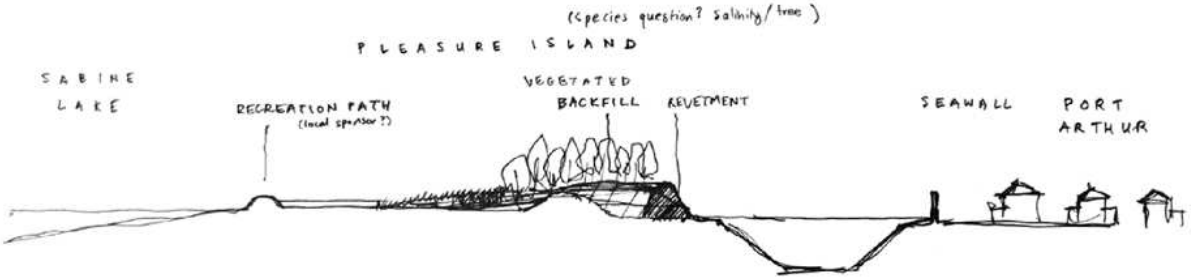
Evaluating Engineering Benefits of Mangrove Forests

- Collaboration between USACE SAJ, ERDC, & US Naval Academy
- Florida mangrove focus
- 1:2 scale model built at ERDC to help reduce uncertainty at smaller scales
- Testing on waves and transport
- Working towards describing, measuring and providing predictive capabilities for use of NNBF in practice to reduce flood and storm risk

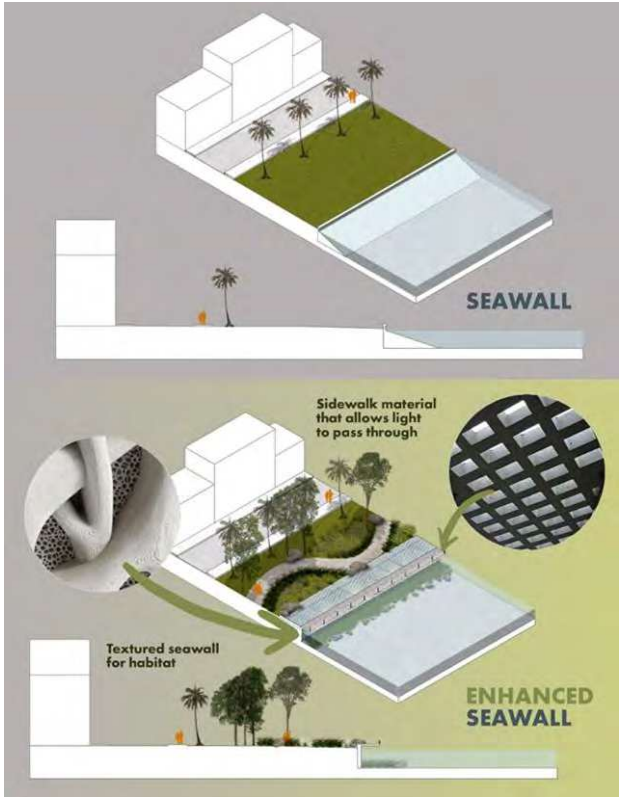
https://www.youtube.com/watch?v=GN4ZgReug48

Leveraging EWN + Landscape Architecture to Promote NI

- Collaborations amongst science, engineering, and landscape architects jointly contribute to EWN implementation through best management practices and scientific research
- CSRM projects are being implemented that incorporate EWN+LA practices to achieve additional environmental and social benefits maintaining intended engineering project functions



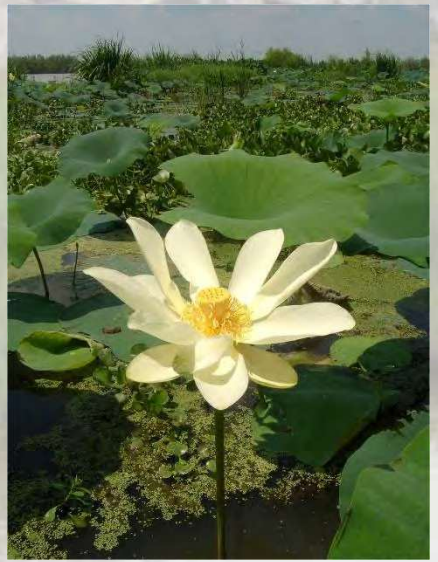
Drawing showing a potential augmentation to an existing coastal flood protection system (King et al. 2021)

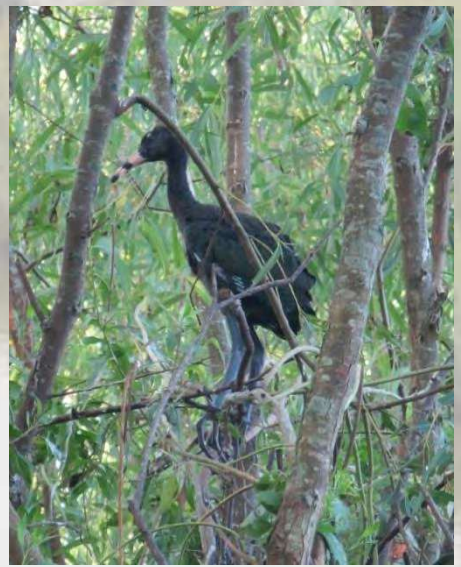


Suedel et al. (In press; JEMA)

EWN website designs page: https://ewn.el.erdc.dren.mil/designs.html

Examples of NI in Coastal Wetlands that Engineer with Nature





Mobile Bay Thin Layer Placement

- 25 years ago, in-bay disposal of dredged material was banned
- Shoreline erosion and loss of habitat followed
- Thin-layer placement was demonstrated on full-scale to restore sediment processes
- Many opportunities for in-water beneficial use
- Ecosystem benefits being documented

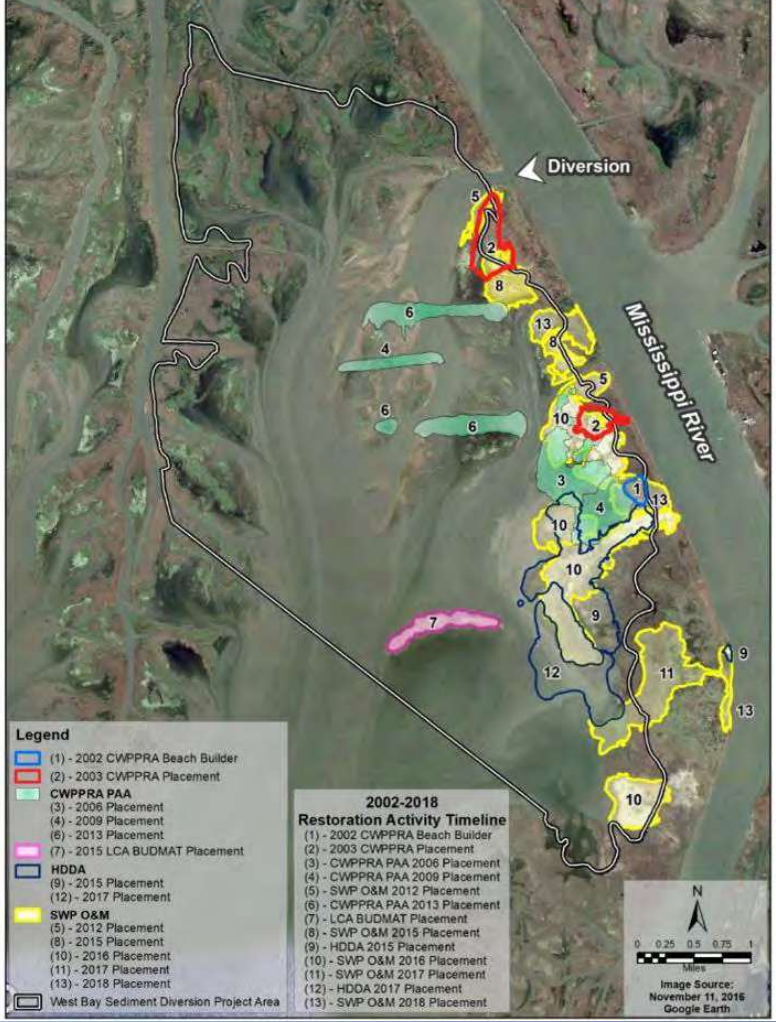
Deer Island, Biloxi, MS

- Biloxi Harbor Navigation Project - 12-ft deep navigation channel
- BU of dredged material to restore marsh, create terrestrial and aquatic habitat, provide a more resilient shoreline for future storm events, create long term disposal capacity
- Hurricanes over time destroyed forests, significantly eroded shoreline, and left elevations too low to support marsh vegetation
- Filled breach in west end of the island
- 1.95 mcy DM to restore southern shoreline using 2.5-mile long wave barrier
- Strategic vegetation plantings (625,000+ plants)
- Construction of a 1 mcy lagoon for BU dredged material from navigation channels
- Providing significant environmental, coastal storm, and recreational benefits

West Bay, Louisiana Direct Placement

- 12,000 acre sub-delta on Miss. River
- Lost >70% of land since the 1940's
- Stability of Federal navigation bankline threatened
- Bank notched in 2003 to mimic natural crevasse
- First 5 years evidence of land building minimal
- Dynamic berms built to increase sediment deposition
- Multiple placement events
- Restored 2,300 acres of land since 2005

Year	SRED	Cubic Yards of Dredged Sediment	Land Created (Acres)
2009	1	386,233	35
2013	2	1,325,614	97
	3	1,308,435	86
	4	328,567	13
2015	5	2,299,295	80



Horseshoe Bend, LA Strategic Placement

Last dredged:
2014
915,000 cy Apr-May 2019
Photo: June 2019

500,000 cy 10-21 Jan 2020
Photo: 30 Jan 2020

- Island formation reduced dredging requirements
- Natural channel formed east of the island due to self-scouring
- US Coast Guard realigned channel
  - channel length reduced
  - sharp bends eliminated
  - improved navigation safety
- Reduction in long-term dredging requirements
- Resultant carbon savings and reduced air pollution

Middle Harbour Port of Oakland, USA

2018 PIANC *Working with Nature* Award Winner

Wetland Infrastructure (CA)

Sears Point Wetland Restoration

- San Pablo Bay, CA
- 6 ft subsidence of tidal marsh due to anthropogenic and other stressors
- Sonoma Land Trust et al. breached levee to restore marsh tidal flow
- Designed and constructed in place round marsh mounds (500) to attenuate wind-wave energy and to accrete sediments
- Restored 400 acres seasonal wetlands; 1,000 acres of upland grasslands and riparian corridors
- Opened Bay Trail to create recreational opportunity

In: EWN Atlas Volume 1 (2018)

MacDill AFB Oyster Reef Shoreline Stabilization

Increased shoreline erosion prompted innovative placement of nature-based features in intertidal environment creating a self-maintaining oyster reef system

- Oyster reefs reduced wave energy & promoted sediment accumulation & restoration of coastal vegetation
- EWN approach to shoreline resilience self-maintaining and regrows quickly when impacted by storm events
- NI strategies achieve resilience goals while also increasing marine habitat while providing refuge, food, and structure for marine organisms
- Collaboration achieves the best and most desirable outcomes in the shortest time
- People want to volunteer and contribute to these EWN projects, creating outreach opportunities

In: EWN Atlas Volume 1 (2018)

Before construction (Peter Clark; Tampa Bay Watch)

Post-construction (Jason Kirkpatrick; MacDill AFB Environmental Office)

Mangroves & Recreation Infrastructure

Nature-based Solutions

- Ecological Functions
- Amenities / recreational values
- Cost reduction (e.g., vs. seawall)
- Adaptability to sea level rise

Potential Environmental Design Features

- Living shorelines
- Mangrove islands
- Boardwalks & kayak trails

Mangrove Shoreline
(Harborside, Jupiter, FL)

Mangrove Shoreline
(Admiral's Cove, Jupiter, FL)

Mangrove Marina Edge
(Jupiter Yacht Club, FL)

Courtesy: Esteban Biondi (ATM)

Take Home Points

- Environmental and developmental pressures increasingly threaten coastal communities, yet hardened shorelines are leading to environmental degradation and biodiversity loss.
- Such pressures necessitate the development of NI to provide more sustainable and resilient solutions in ways that balance economic, environmental, and social benefits through collaboration.
- Coastal engineering practice can be advanced through structured decision-making that integrates multiple disciplines for enhancing coastal resilience.
- Challenges >>> Opportunities

Questions?

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