U.S.ARMY

A MULTI-DECADAL ASSESSMENT OF DREDGED SEDIMENT BENEFICIAL USE PROJECTS

Western Dredging Association Webinar
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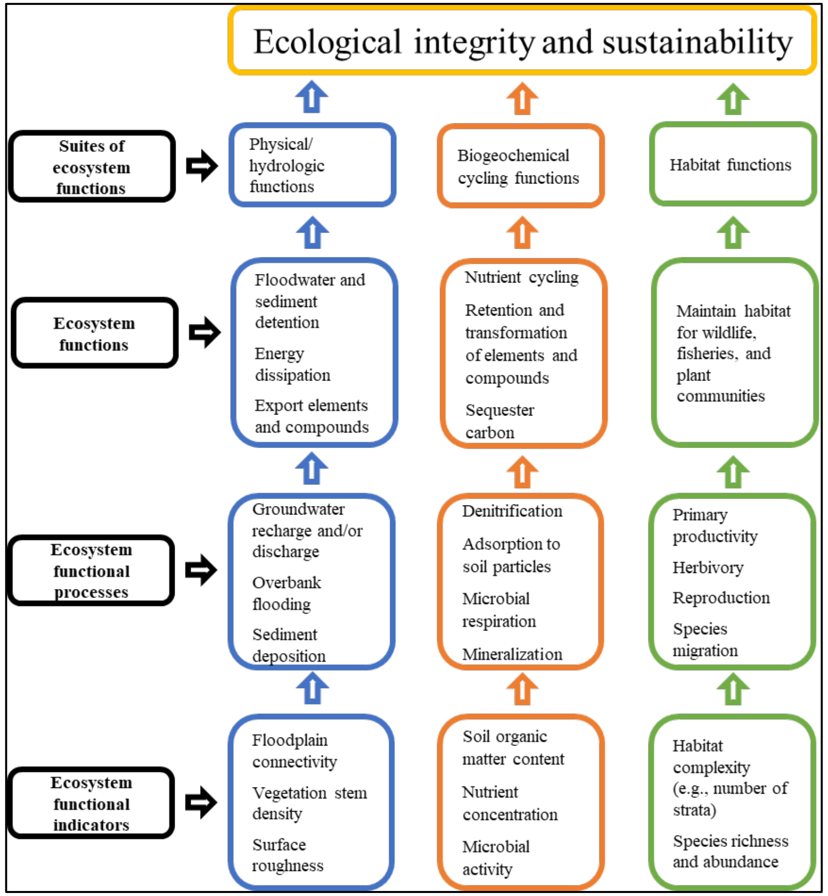
Thanks to our funders, collaborators, & wetlands team members!

Engineering With Nature

DOER

DOTS

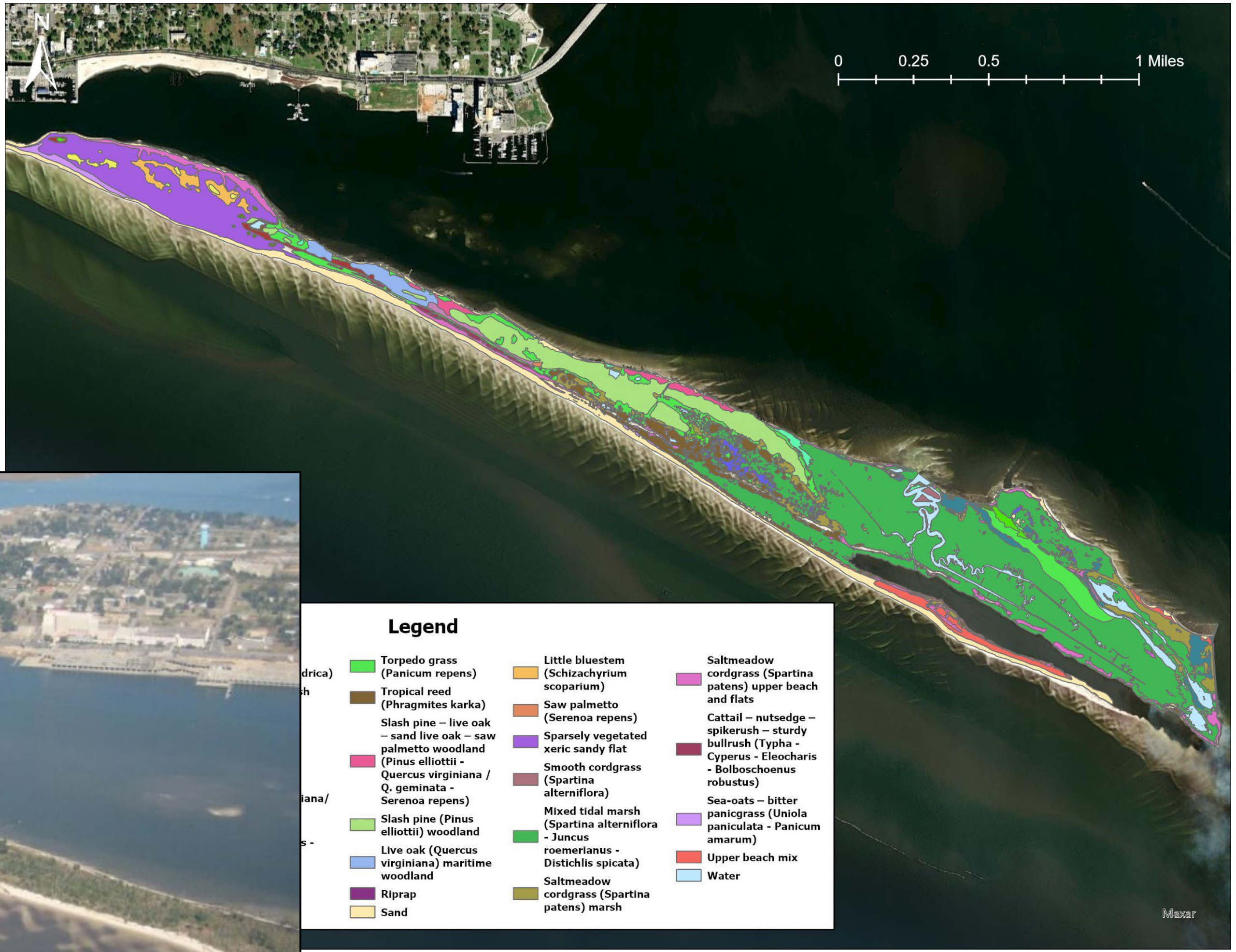
Recent publications – Multidecadal BU outcomes

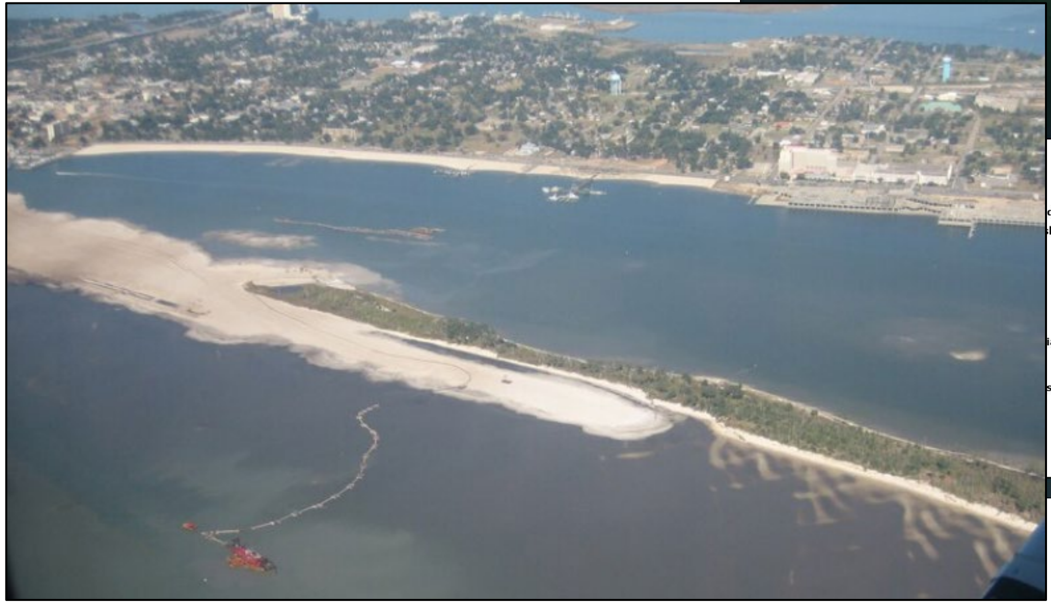


https://apps.dtic.mil/sti/citations/AD1144436

1) Ecological outcomes 2) Ecosystem functions, goods, and services

The effect of scale on BU restoration outcomes

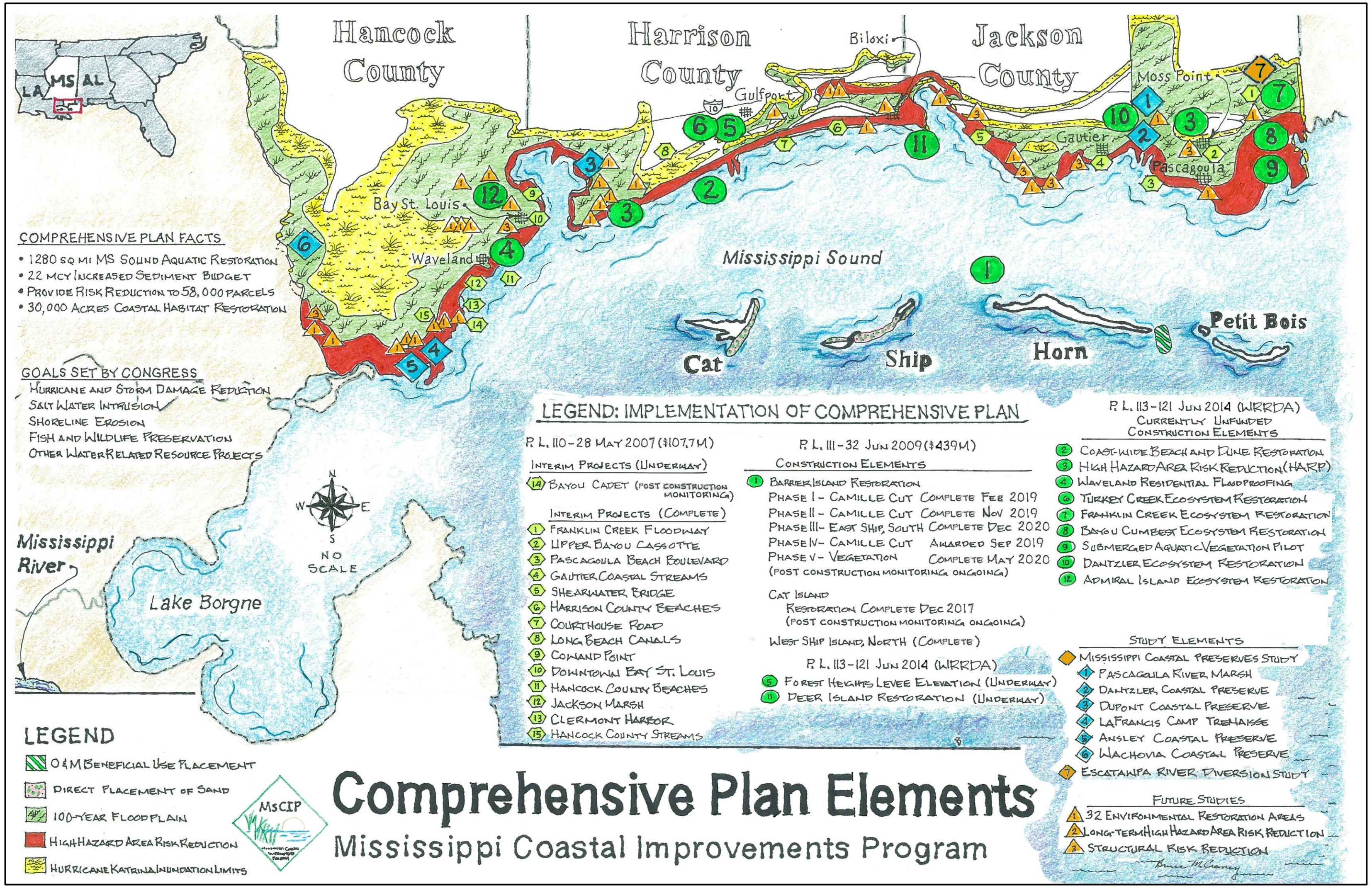




'Scaled up' regional efforts needed to address current/future environmental challenges

10 Tricks to Appear Smart During Meetings (Cooper)

The effect of scale on restoration outcomes

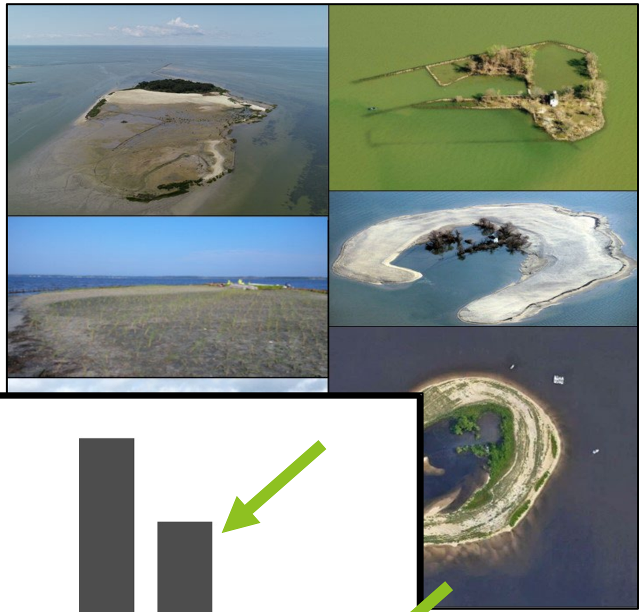


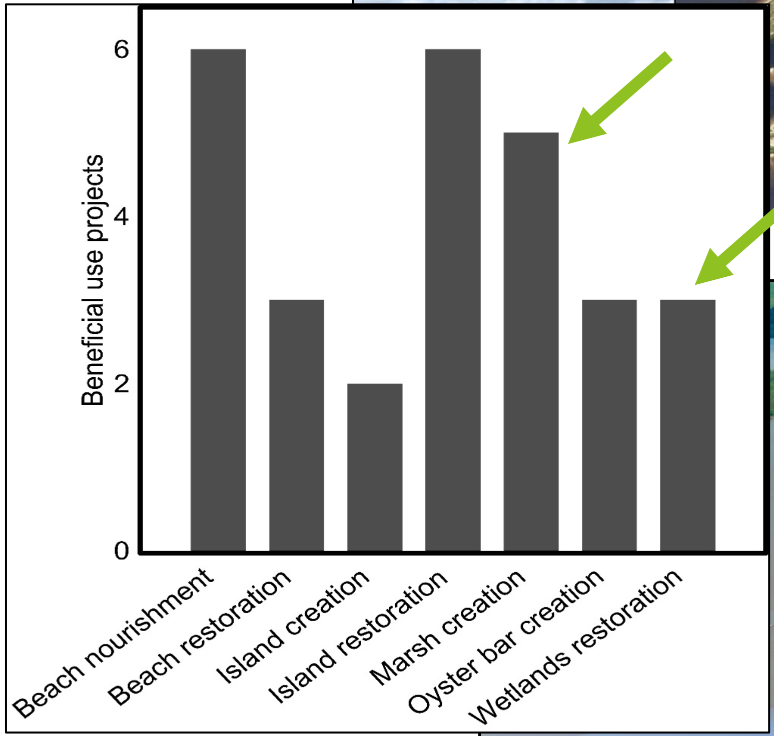
Beneficial use of dredged material

Over 1,300 beneficial use projects documented to date in the US

Range of project objectives/benefits (Berkowitz and Szimanski 2020)

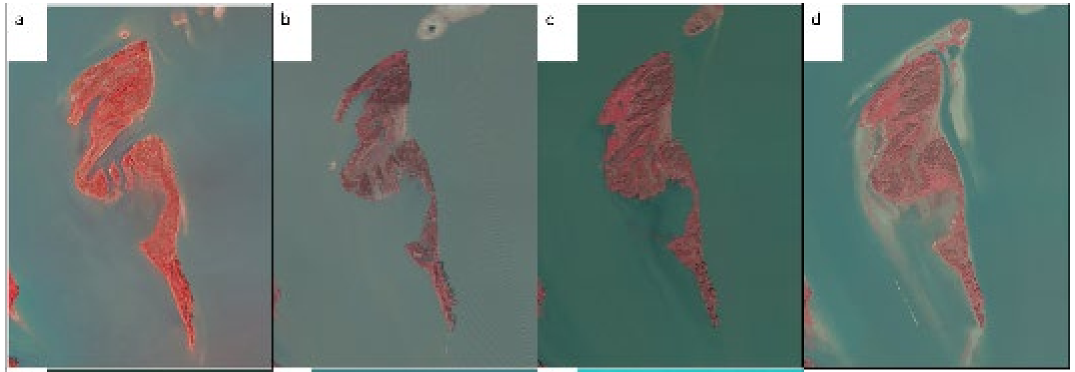
EWN® initiative to deliver navigation and cost-effective dredged material management while improving environmental outcomes (Bridges et al 2014)

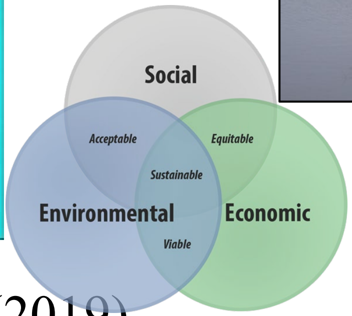




Engineering With Nature® is the *intentional* alignment of natural and engineering *processes* to efficiently and sustainably deliver economic, environmental, and social *benefits* through *collaboration*.

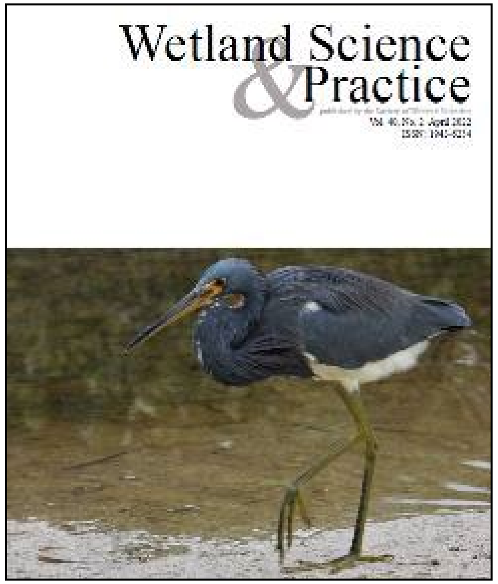
https://ewn.erdc.dren.mil/





Berkowitz et al. (2016); Foran et al (2019)

Vanzomeren et al. (2018) Eco Eng



IMPROVING WETLAND RESTORATION

New Initiatives Improve Wetland Restoration Outcomes: Engineering with Nature and the Use of Natural and Nature-Based Features

Berkowitz and Hurst (2022) WSP

International efforts –Natural and Nature-Based Features

https://ewn.erdc.dren.mil/?page_id=4351

Natural and Nature-Based Features key elements:

Uses a systems approach to leverage existing components and projects through interconnectivity

Engages communities, stakeholders, partners, and multidisciplinary team members to develop innovative solutions.

Identifies sustainable and resilient solutions to produce multiple benefits.

Anticipates, evaluates, and manages risks to project or system performance.

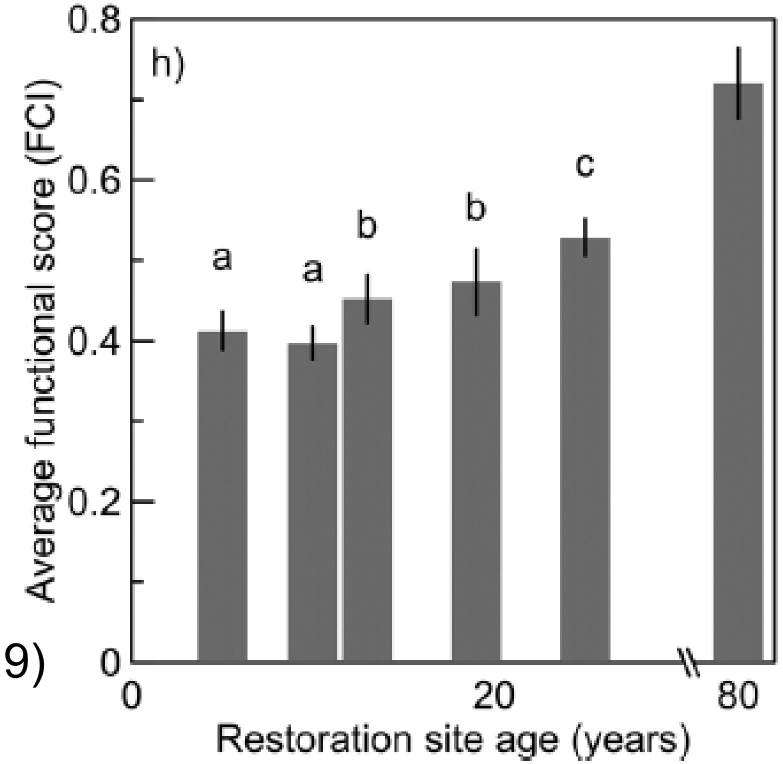
Expects change and manages change adaptively

“The NNBF Guidelines are the next step toward revolutionary infrastructure” MG Scott Spellmon, USACE Commanding General (2022)

U.K. Environment Agency’s Flood and Coast Excellence Award

Wetland creation/restoration outcomes using EWN

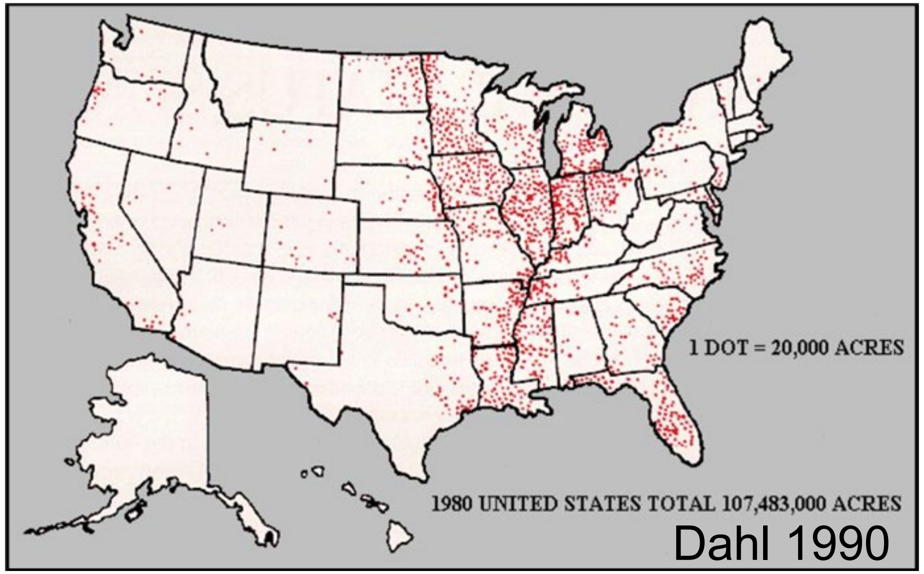
- We can enhance wetland ecosystem functions via restoration!
- We studied >11,000 ha of wetlands restored by USACE over 25 years
- Restored wetlands provide many wetland functions that increase with age
- Need better guidance on how specific engineering practices/features maximize BENEFITS, minimize COSTS in highly altered wetlands

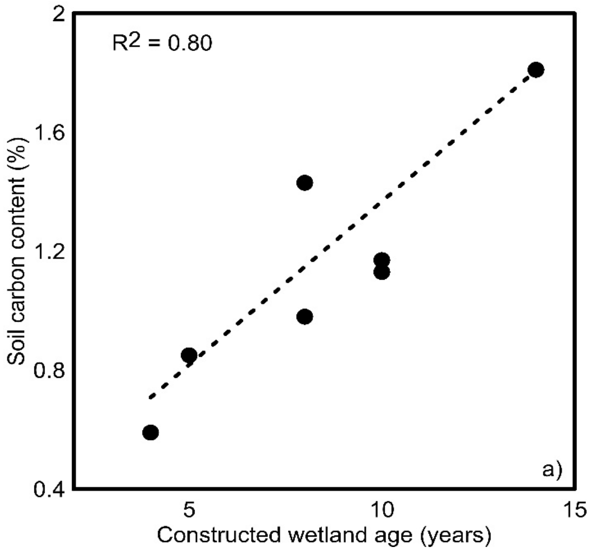


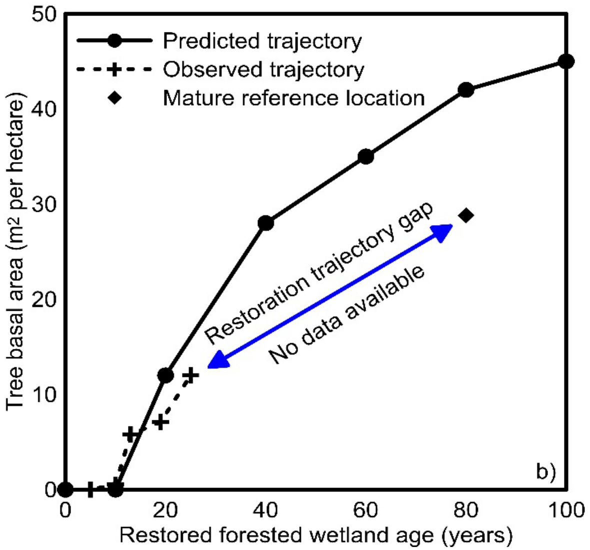
Berkowitz (2019) Wetlands

We live in an altered landscape

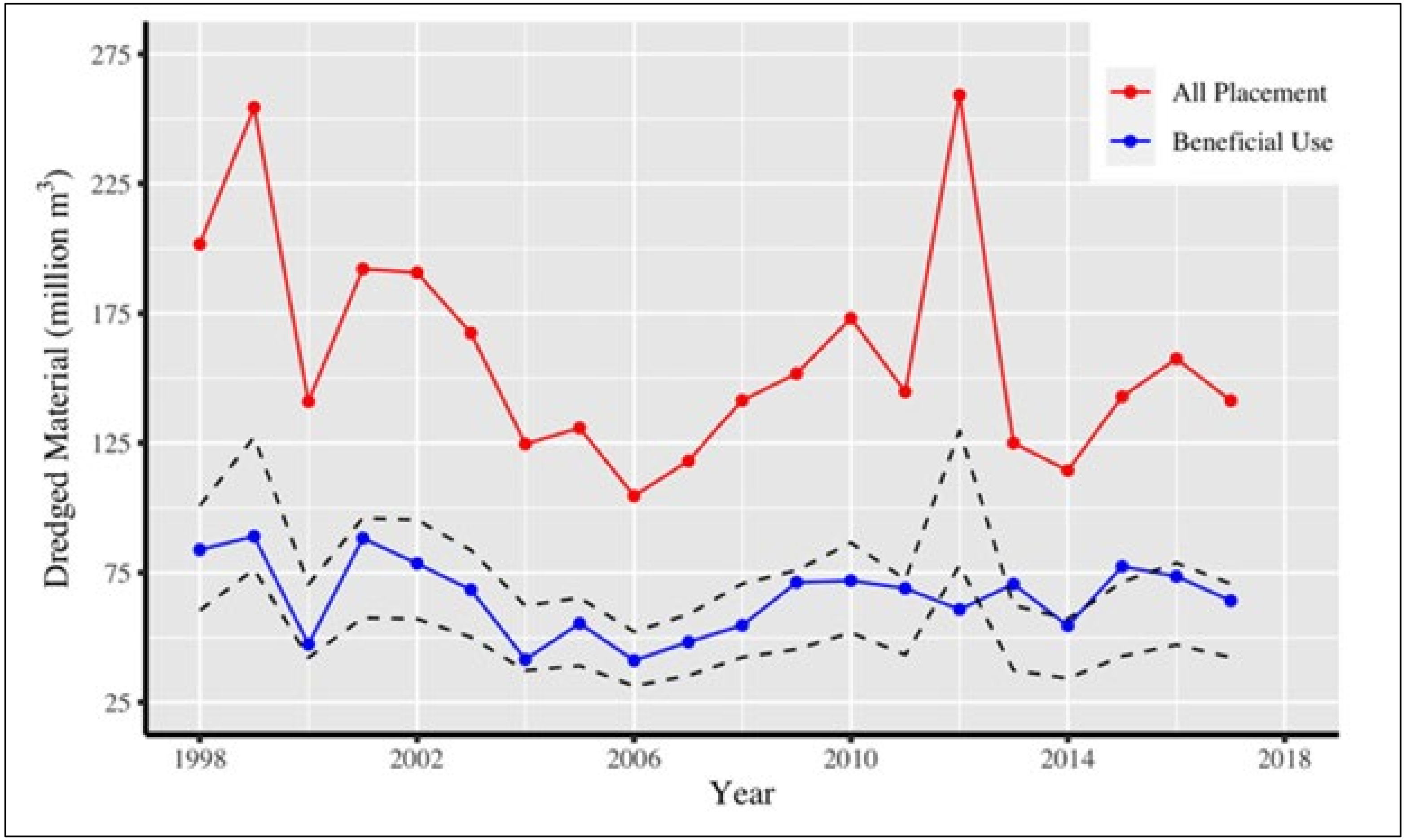
- Altered conditions dominate wetlands in the US and internationally
  - Unaltered reference conditions often unknown (Otte et al 2021)
- Alteration changes wetland functional magnitude compared to undisturbed areas (Novitski et al 1996)
- Long-term functional trajectory of altered wetlands remains unknown (Berkowitz et al. 2017; Berkowitz 2018)
- Alteration creates opportunities for BU

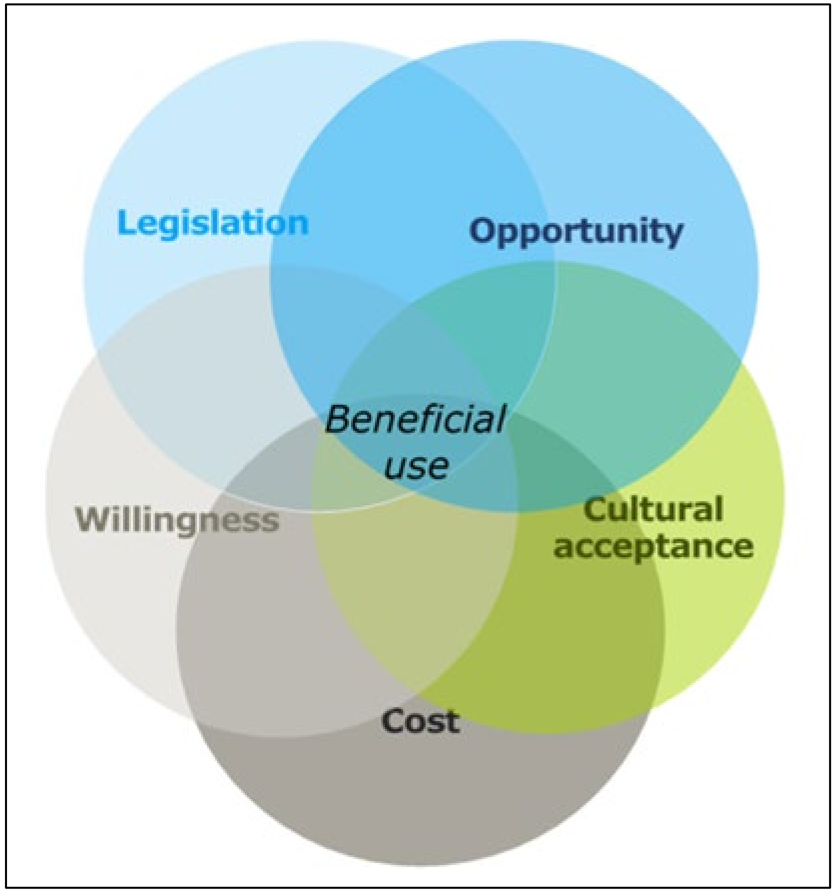






Alteration extent means that BU oportunities abound!



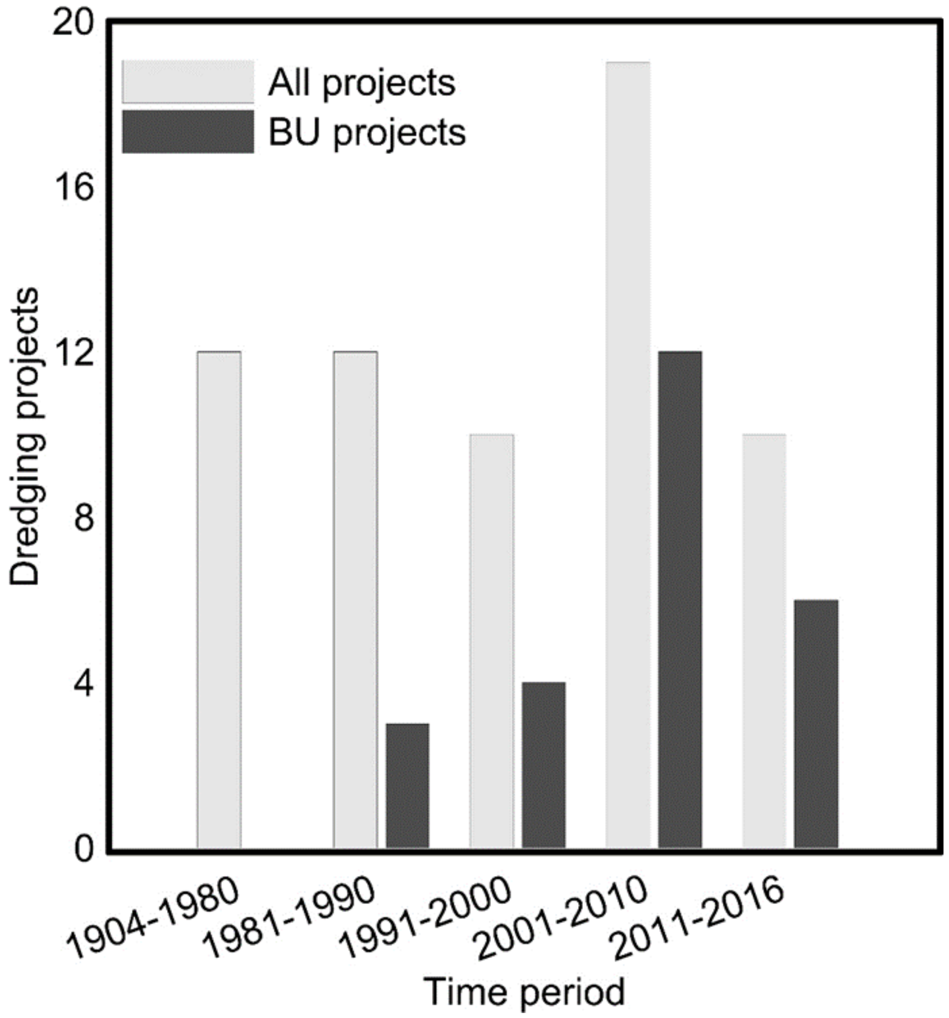


Bell et al (2021) JoD

Less than 40% of dredged material in the US is used beneficially

Evolution of beneficial use activities

- Historic attitude → dredged "spoil"; placement in wetlands
- Expanding beneficial use of dredged materials over time
- Early assessments of habitat improvement using dredged materials (1970s)
- Long term trajectory of restored features remains unknown
- Revisited six historic wetland restoration sites after >40 yrs to evaluate project outcomes



Berkowitz and Szimanski (2020)

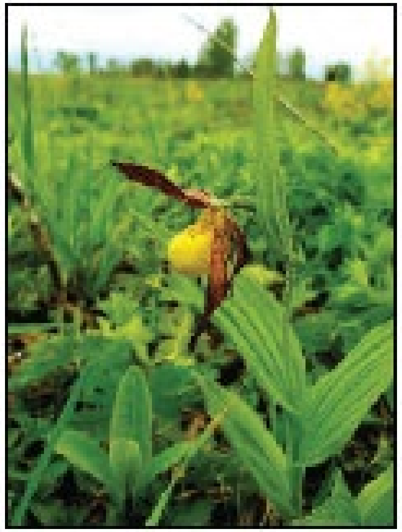
Objectives and approach

Assess long-term benefits of wetlands restored or created using dredged material

Six wetland sites across the US

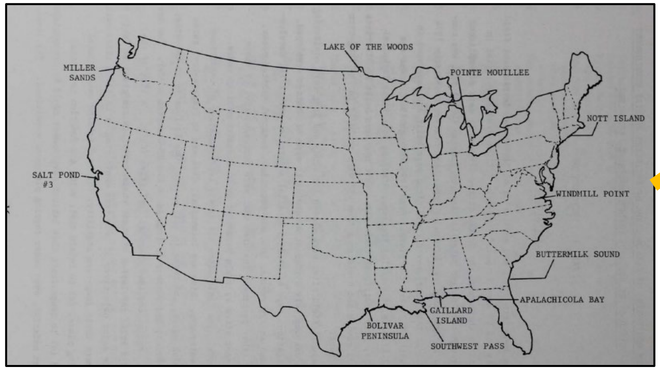
Wide range of geographic and geomorphic diversity in study sites

Focus on ecological functions → related ecosystem goods and services



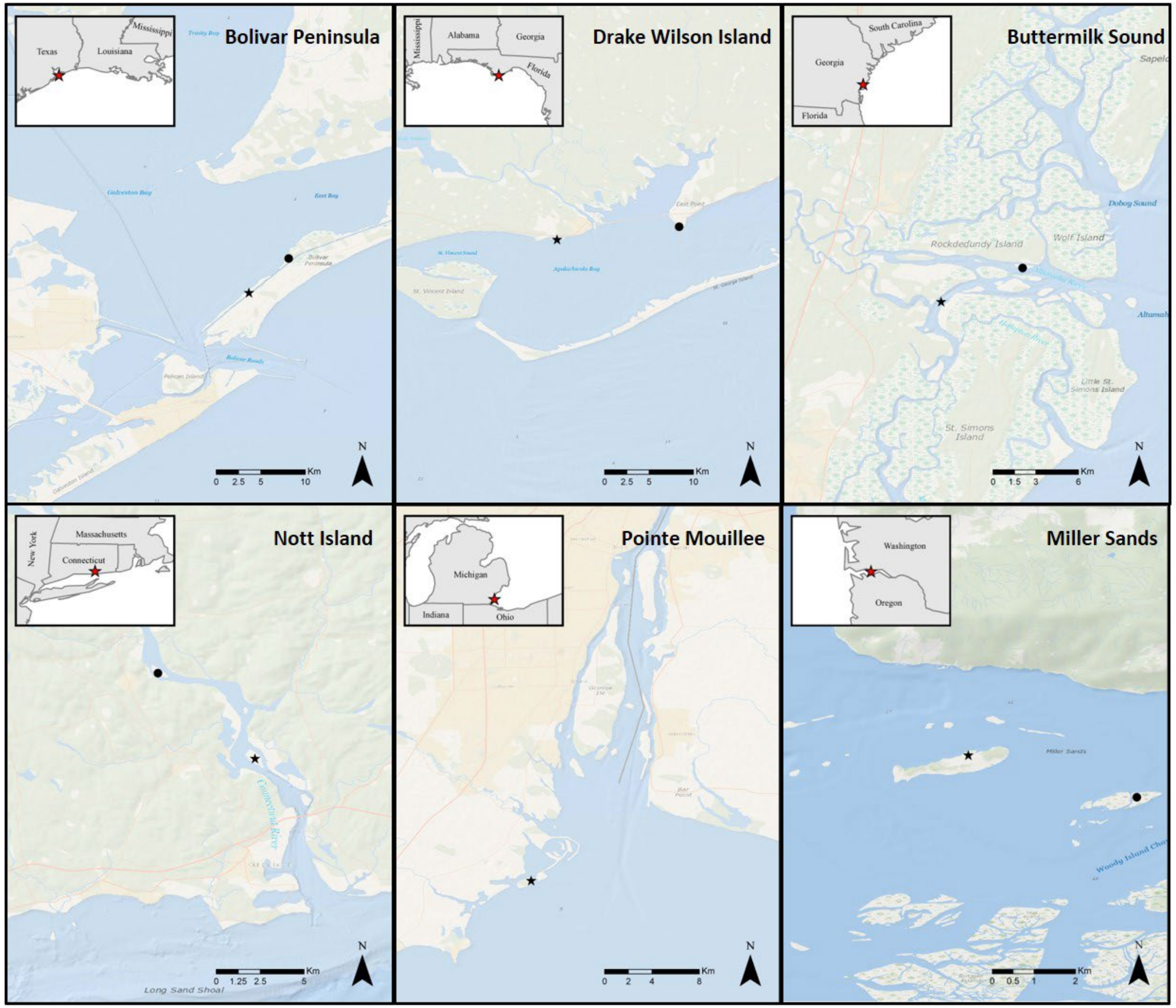
Objectives and approach

- Projects constructed using dredged materials (1974-1978)
- These represent some of the oldest wetland restoration sites in the US for which monitoring data is available
- Re-created the previous study to evaluate conditions at each location after >40 years
- Geomorphology, vegetation, avian habitat, and soils



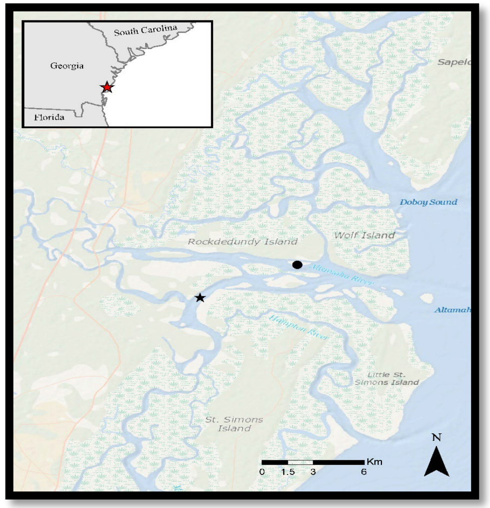
There was no Google Earth in 1978!

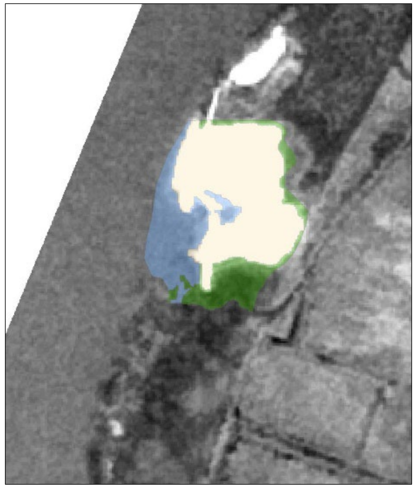
Study locations



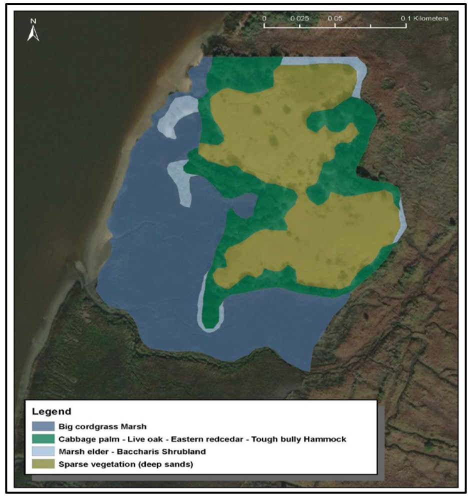
Example: Buttermilk Sound, GA

- 3 ha sandy dredge island built in 1974, adjacent to the ICWW
- Originally a high, unvegetated sand mound
- Site was graded to intertidal elevation, planted, and fertilized
- Monitored through the early 1980s, then in 2019
- Currently displays a diverse array of habitats, ecological functions, and ecological goods & services





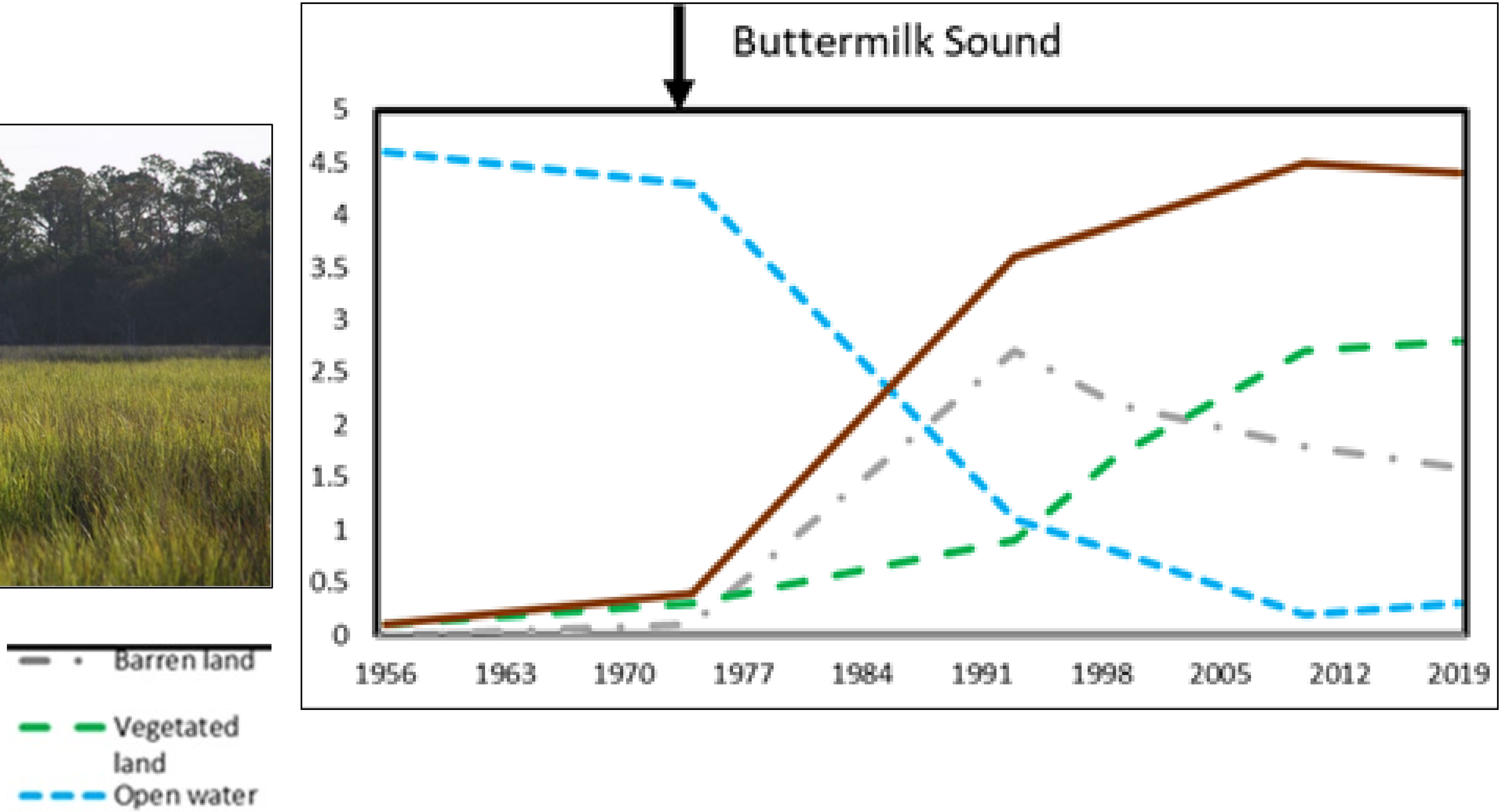
1993



2010

2019

Example: Buttermilk Sound, GA



40 years of ecosystem functional outcomes

General findings:
- Project sites persisted without hard structures or intervention
- Continue to provide a range of wetland functions & EGS after more than four decades

Avian communities:
- Habitat for a diversity of avian communities
- Numerous Species of Conservation Concern utilize these locations

(Berkowitz et al, 2022)

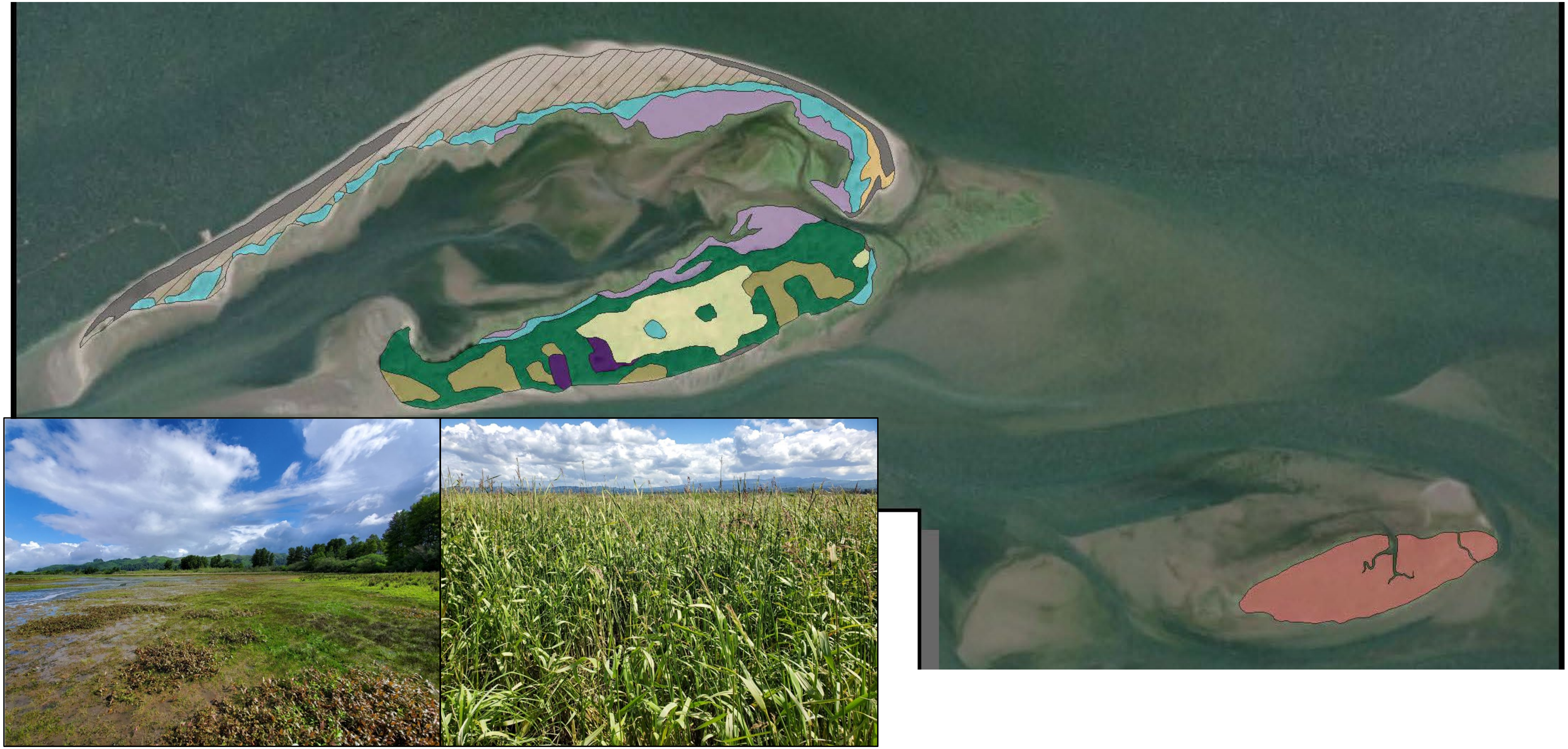
Soils:
- Bulk density decreased
- Salinity decreased
- Organic matter increased
- Nutrient availability increased
- Hydric soil indicators now present in all sites

Vegetation communities:
- Species richness increased over time
- Planting helped vegetation establishment and soil stabilization
- Planting had limited effect on current species composition
- Elevation/salinity determined ecological endpoints

40 years of ecosystem functional outcomes

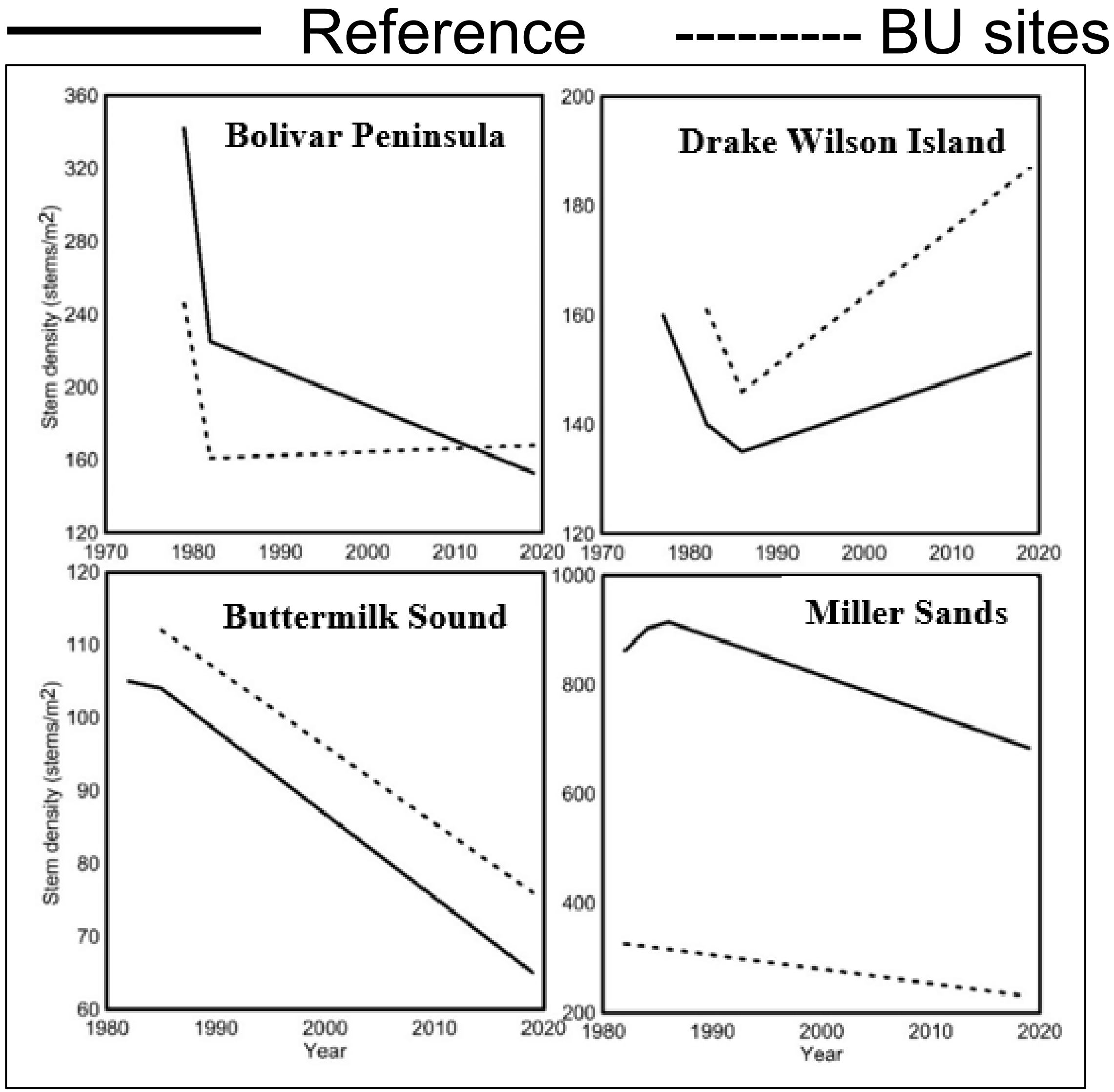
- Restored sites became more similar to the reference areas over time
- Remain on unique trajectories compared with unaltered natural wetlands
- More diverse vegetation and avian communities than reference areas due to elevation gradients and a wider range of substrate characteristics

	Vegetation community assemblages (count)		Dominant species richness in target community types (count)			
Location	Beneficial use (BU) site	Reference location	Habitat type	BU (2019)	Historic	Reference (2019)
Bolivar Peninsula, TX	10	1	Low marsh	4	2	2
Drake Wilson Island, FL	6	8	Low marsh	2	2	2
Buttermilk Sound, GA	4	2	Marsh	3	4	3
Nott Island, CT	10	4	Meadow	16	5	NA
Pointe Mouillee, MI	7	NA	Marsh	7	4	NA
Miller Sands, OR	7	1	Marsh	18	17	15



40 years of ecosystem functional outcomes

- **Similar response to ecological perturbation as unaltered wetlands, despite differences in magnitude**



What we know about long-term ecological BU outcomes:

Projects differ from natural wetlands initially

Provide habitat for a variety of species

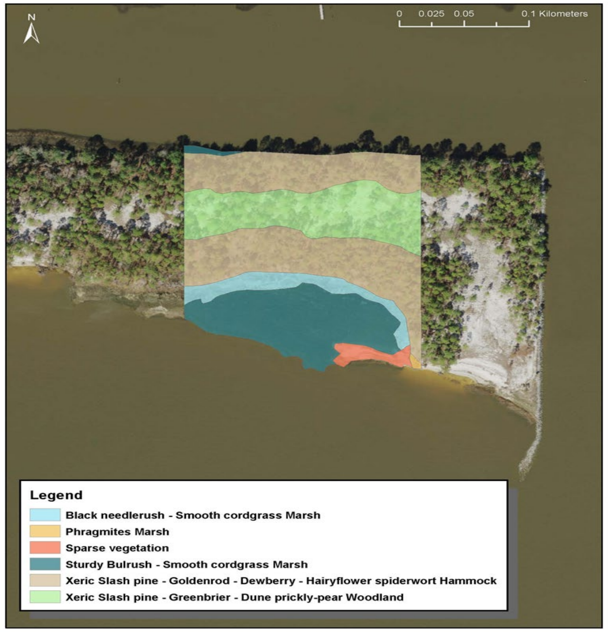
Provide better habitat for some avian species prior to the establishment of robust vegetation

Show increasing similarity with natural areas over time when natural designs are mimicked

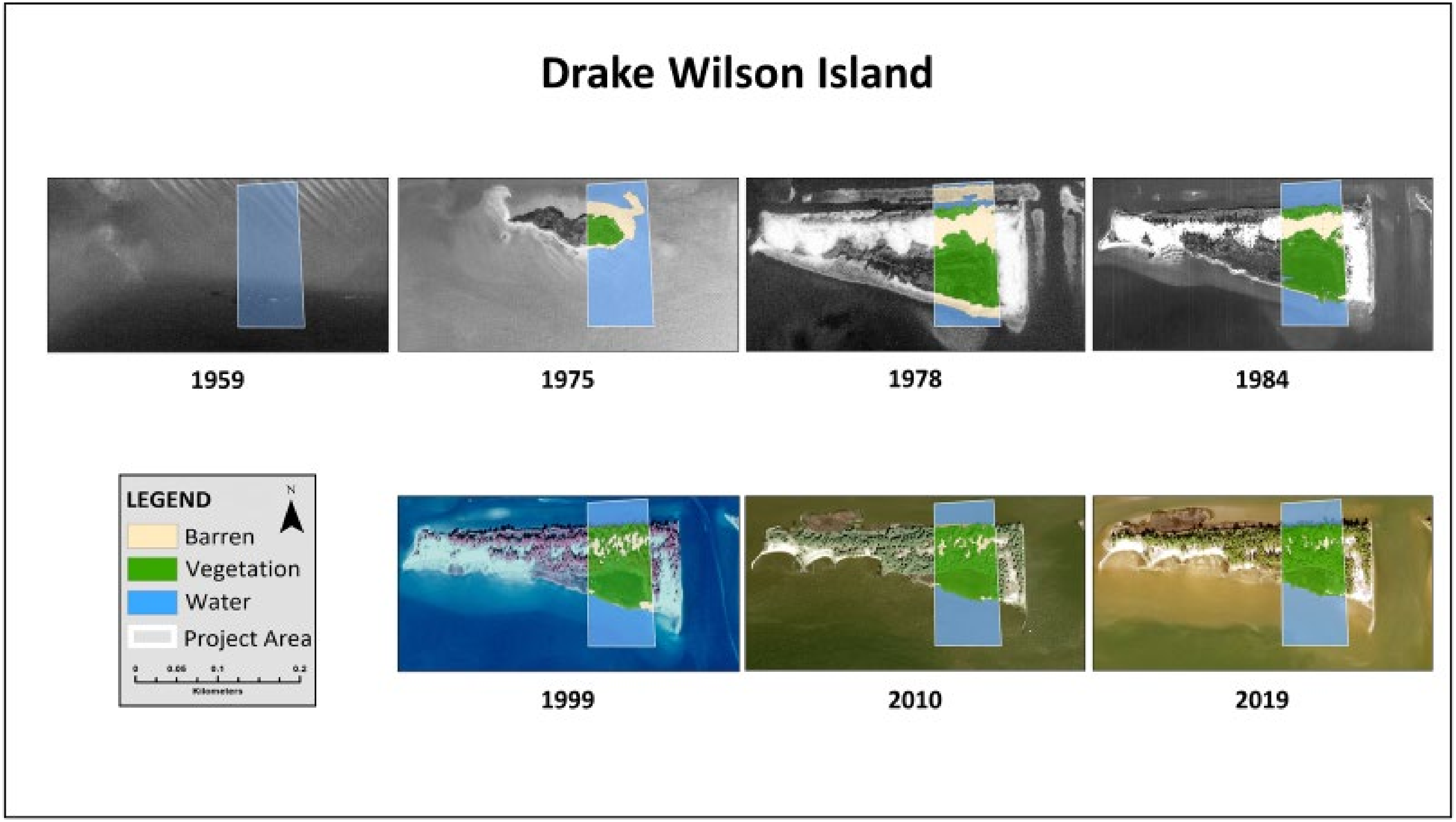
Fail to develop soil characteristics (e.g., C accumulation) equivalent to natural wetlands*

Opportunities to improve site conditions through management

- Selective species removal; sediment deposition



What we know about long-term ecological BU outcomes:



Remaining questions about long-term ecological BU outcomes:

Long-term trajectories require additional research → geomorphology, vegetation, fauna, soils

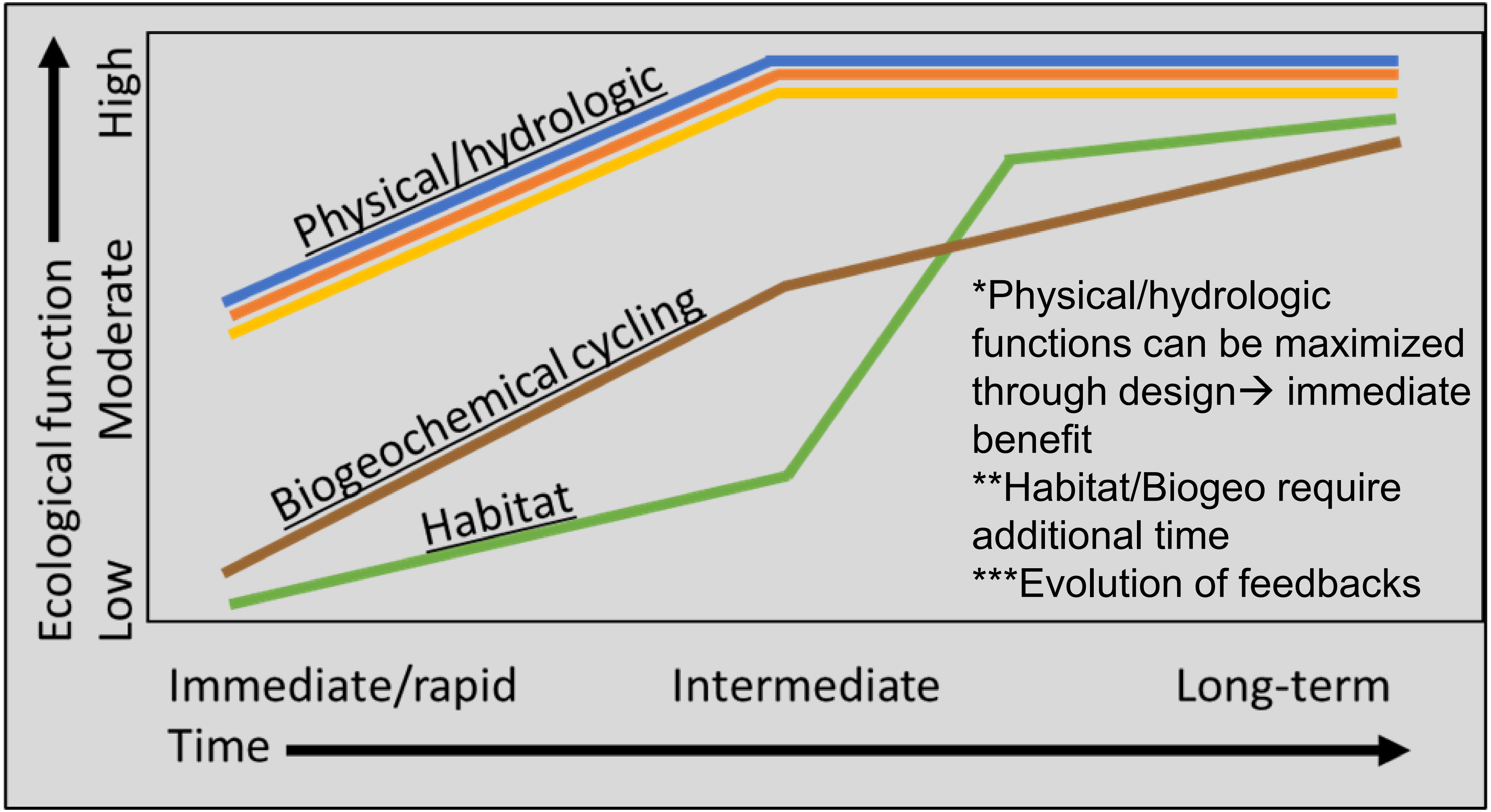
Project life-cycle analysis and associated cost-benefit analysis

Need better linkages between ecological functions and ecosystem gods and service benefits*

These unknowns limit our capacity to promote additional beneficial use projects that increase wetland functions at landscape scales

Linking long-term BU outcomes with EGS:

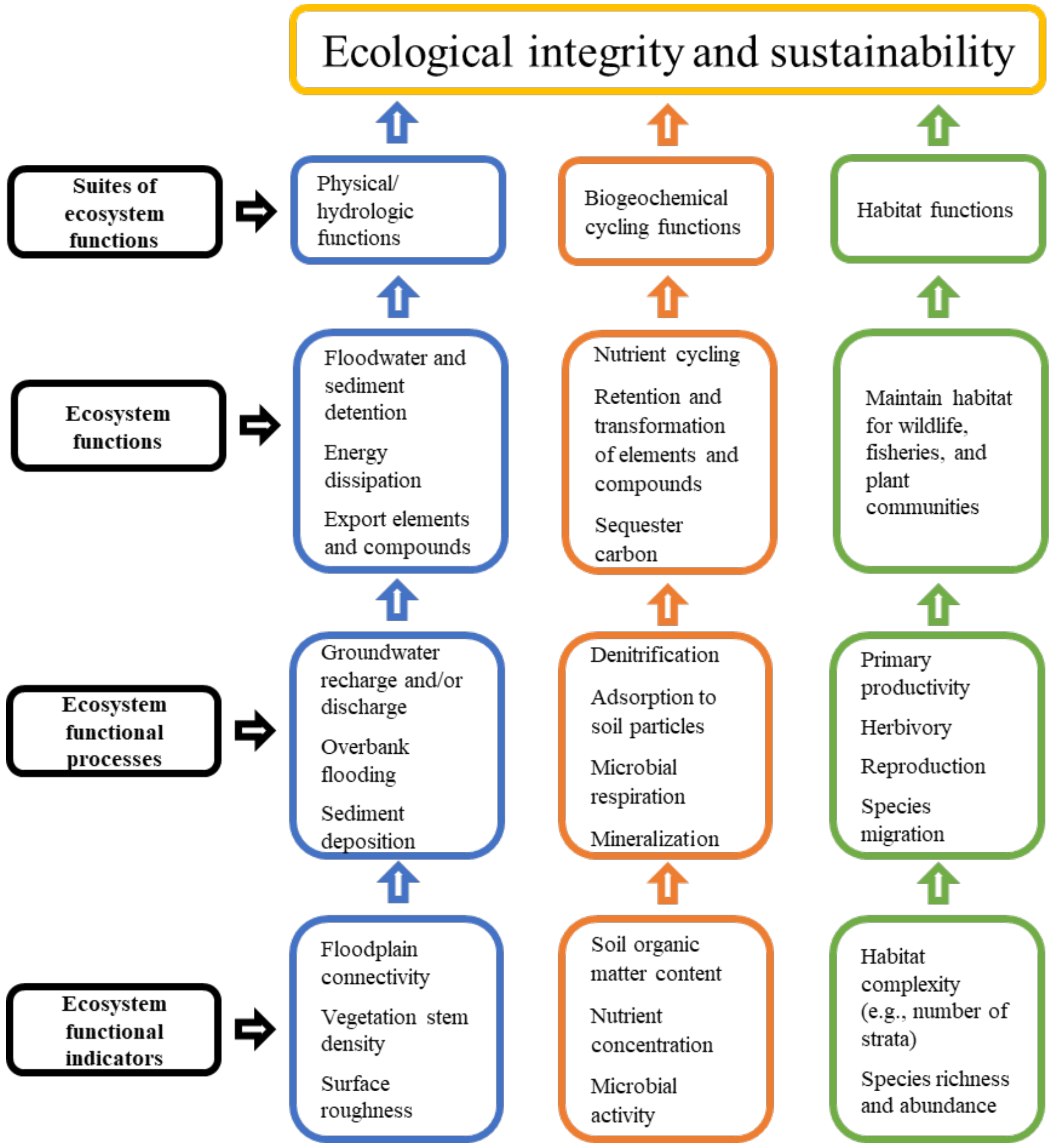
-Functional responses differ across physical, habitat, & biogeochemical drivers



Linking long-term BU outcomes with EGS:

Four-tiered approach

1. Review historic data for indicator of ecosystem function
   - Bird use → habitat
   - Soil C → nutrient cycling
2. Identify multiple ecological functional indicators in each target habitat (e.g., low marsh, dune)
   - Direct and indirect measures
3. Assign functions based on indicators
4. Apply EGS framework (Waigner et al. 2020)



Linking long-term BU outcomes with EGS:

Ecological functions	Ecological indicators
Physical functions	
Floodwater and sediment detention - the capacity of the ecosystem to temporarily store water and sediment following rain events, overbank flooding, & high tides.	Inundation and soil saturation, microtopographic relief, vegetation stem density, sediment deposits, stratified soil layers, soil bulk density
Energy dissipation - the capacity of the ecosystem to attenuate and decrease energy from wind and waves	Inundation and soil saturation, vegetation stem density, roughness, sediment deposits, water marks, drift deposits, algal mats
Export elements and compounds - the capacity of the ecosystem to export dissolved and particulate organic carbon, nutrients, sediment, and other materials to down-stream or down gradient areas	Inundation and soil saturation, water stained leaves, soil organic matter content, drainage patterns, field indicators of hydric soils

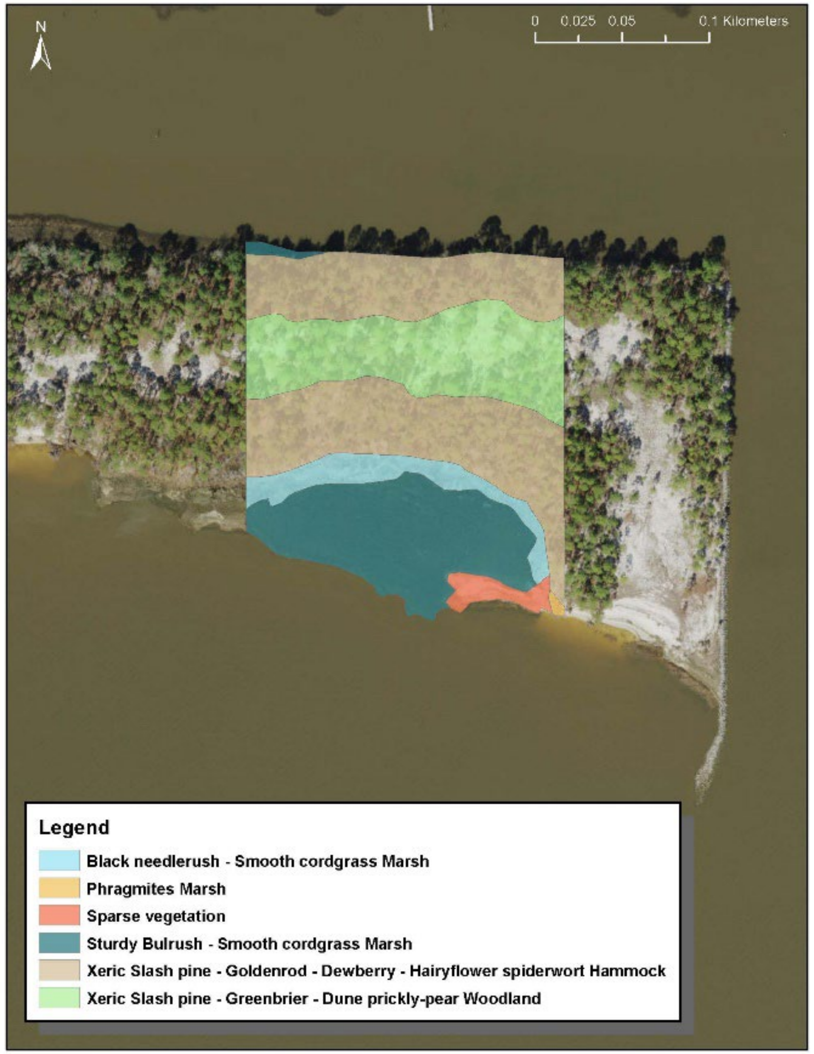
Linking long-term BU outcomes with EGS:

Functions	Indicators
Biogeochemical functions	
Nutrient cycling - The capacity of an ecosystem to convert nutrients from inorganic forms to organic forms and back through biogeochemical processes such as photosynthesis and microbial decomposition	Organic material production and storage, inundation and soil saturation, soil organic matter accumulation, field indicators of hydric soils
Retention and transformation of elements and compounds - the capacity of an ecosystem to temporarily or permanently store and transform metals, organic chemicals, and other substances through processes such as adsorption to soil particles, oxidation, reduction, and microbial degradation	Inundation and soil saturation, soil organic matter accumulation, field indicators of hydric soils, presence of reduced iron, oxidized rhizospheres along living roots
Sequester carbon - The capacity of an ecosystem to accumulate soil organic matter and store carbon, providing a long-term sink for greenhouse gases	Inundation and soil saturation, soil organic matter accumulation, below ground biomass, field indicators of hydric soils

Linking long-term BU outcomes with EGS:

Functions	Indicators
Habitat functions	
Maintain habitat for wildlife, fisheries, and plant communities - the capacity of an ecosystem to provide the environment necessary to support the characteristic fish and wildlife species during part of their life cycles	Direct observations of faunal utilization, vegetative structural complexity, species richness and abundance, evidence of succession

Ecological functions	Study locations and target habitat types													
	Bolivar Peninsula, TX				Drake Wilson Island, FL			Buttermilk Sound, GA			Nott Isla., CT	Pointe Mou., MI	Miller Sands,	
	Low marsh	High marsh	Herbaceous upland	Woody upland	Low marsh	High marsh	Woody upland	Low marsh	High marsh	Unvegetated upland	Upland meadow	Freshwater marsh	Upland meadow	Tidal marsh
Floodwater and sediment retention	X	X			X	X		X	X			X		X
Energy dissipation	X	X			X	X		X	X			X		X
Export elements & compounds	X	X			X	X		X	X			X		X
Nutrient cycling	X	X	X	X	X	X	X	X	X		X	X		X
Retention and transformation of elements and compounds	X	X			X	X		X	X			X		X
Sequester carbon	X	X			X	X		X	X			X		X
Maintain habitat for wildlife, fisheries, and plant communities	X	X	X	X	X	X	X	X	X	X	X	X	X	X



Linking long-term BU outcomes with EGS:

Physical/hydrologic functions

Floodwater and sediment detention
- Ecosystem sustainability
- Navigation maintenance
- Water purification

Energy dissipation
- Hazard mitigation
- Ecosystem sustainability
- Navigation maintenance

Export elements and compounds
- Ecosystem sustainability
- Food, raw goods, and materials provisioning

Habitat functions

Maintain habitat for wildlife, fisheries, and plant communities
- Recreation and aesthetics
- Cultural, spiritual, and educational support
- Ecosystem sustainability
- Food, raw goods, and materials provisioning
- Hazard mitigation
- Climate regulation
- Navigation maintenance
- Water purification

Biogeochemical cycling functions

Nutrient cycling
- Food, raw goods, and materials provisioning
- Ecosystem sustainability
- Water purification

Retention and transformation of elements and compounds
- Water purification
- Hazard mitigation

Sequester carbon
- Climate regulation

Linking long-term BU outcomes with EGS:

Wetland habitats provided the greatest variety of ecosystem functions → more EGS

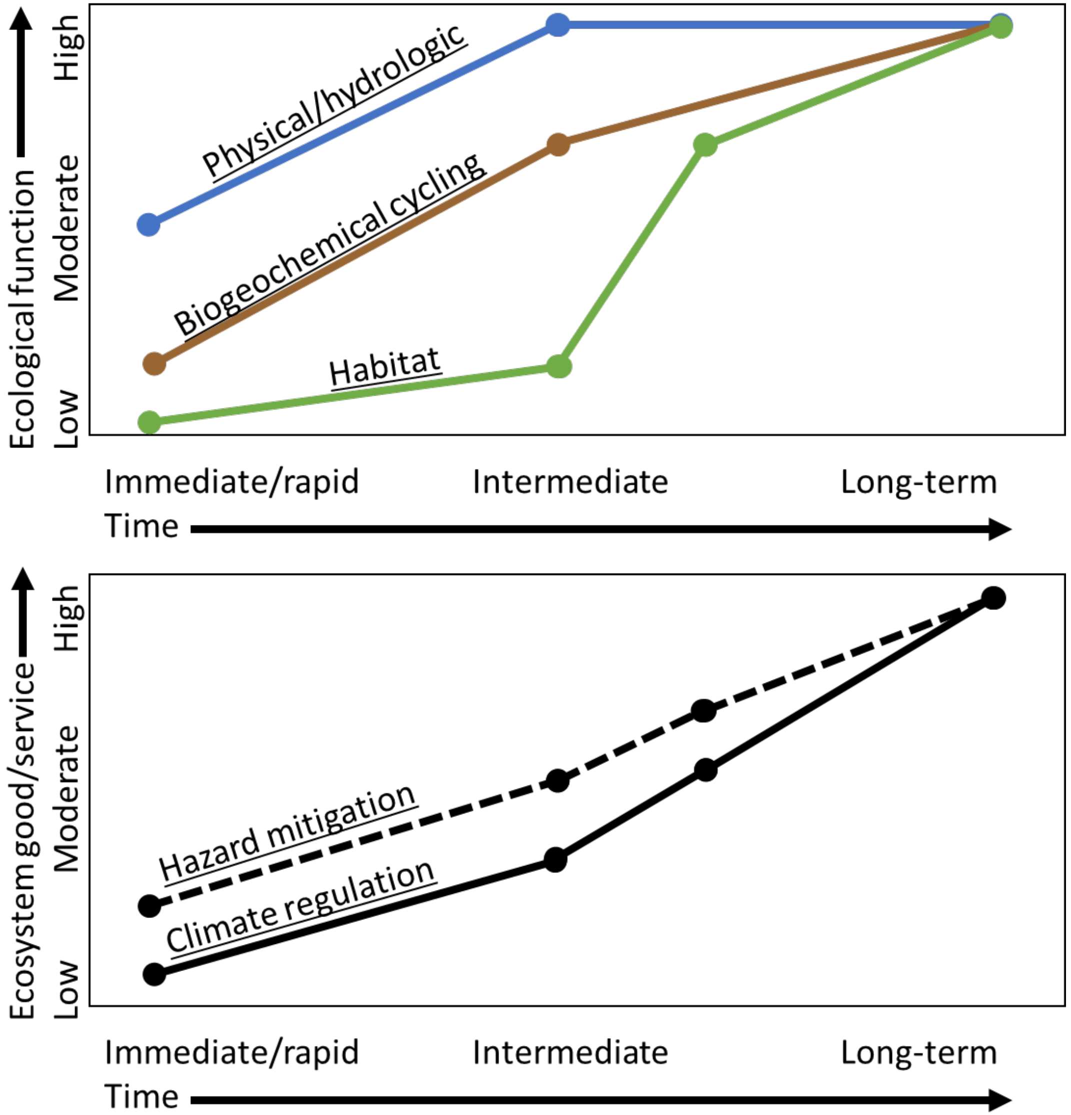
Opportunities to maximize functions and EGS through design and management

Ecosystem goods and services categories	Study locations and target habitat types														
	Bolivar Peninsula, TX				Drake Wilson Island, FL			Buttermilk Sound, GA			Nott Isla., CT	Pointe Mou., MI	Miller Sands, OR		
	Low marsh	High marsh	Herbaceous upland	Woody upland	Low marsh	High marsh	Woody upland	Low marsh	High marsh	Unvegetated upland	Upland meadow	Freshwater marsh	Upland meadow	Tidal marsh	Dune
Ecosystem sustainability	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hazard mitigation	X	X			X	X		X	X			X		X	
Navigation maintenance	X	X			X	X		X	X			X		X	
Cultural, spiritual and educational support												X			
Recreation and aesthetics	X	X					X			X	X	X	X		
Food, raw goods, and materials provisioning	X	X						X	X			X		X	
Water purification	X	X			X	X		X	X			X		X	
Climate regulation	X	X			X	X		X	X			X		X	

Linking long-term BU outcomes with EGS:

Types of functional drivers influences EGS trajectory

Again, opportunities to maximize through project features, objectives



40 years of wetland functional and EGS benefits

Conclusions:

1) The target habitats have persisted for >40 years

2) Wetland conditions continue to improve, but have not (and may not) reach reference conditions

3) Despite this, the projects provide valuable functions, goods and services although the magnitude of some outcomes differ from reference conditions

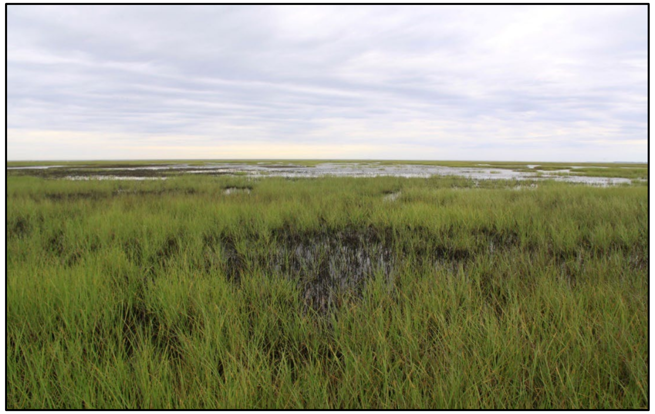
4) Linking functions with EGS

Recommendations:

4) We *should* use natural processes to create sustainable wetlands

5) We *should* focus on maximizing the available functions and benefits

6) We *should not* focus on mimicking natural conditions to determine success/failure



Berkowitz JF, Beane NR, Hurst NR, Jung JF, Philley KD. 2022. A multidecadal assessment of dredged sediment beneficial use outcomes Part 1: Ecological Outcomes. Journal of Dredging. 20(1):54-75 westerndredging.org/journal

Berkowitz JF, Hurst NR, Beane NR, Philley KD, Jung JF. 2022. A multidecadal assessment of dredged sediment beneficial use outcomes Part 2: Ecosystem functions, goods, and services. Journal of Dredging. 20(1):54-75 westerndredging.org/journal

Berkowitz JF, Beane NR, Hurst NR, Jung JF, Philley KD. 2021. An assessment of Long-Term, Multipurpose Ecosystem Functions and Engineering Benefits Derived from historical Dredged Sediment Beneficial Use Projects. ERDC TR-21-4

Berkowitz JF, Hurst NR. 2022. New initiatives improve wetland restoration outcomes: Engineering with Nature and the use of Natural and Nature-Based Features. Wetland Science and Practice. 40(2):28-32 https://members.sws.org/wetland-science-and-practice

Bell et al., 2021. Overcoming Barriers To Beneficial Use Of Dredged Material In The US. Journal of Dredging. 19(2)

Berkowitz JF, Szimanski D. 2020. Documenting Engineering with Nature® implementation within the US Army Corps of Engineers Baltimore District – completed projects and opportunities for chronosequence analysis. ERDC/TN EWN-20-3

Berkowitz JF. 2019. Quantifying functional increases across a large-scale wetland restoration chronosequence. Wetlands. 39(3):559-573 doi.org/10.1007/s13157-018-1103-9

Foran CM, Burks-Copes KA, Berkowitz J, Corbino J, Suedel BC. 2018. Quantifying wildlife and navigation benefits of a dredging beneficial use project in the lower Atchafalaya River: A demonstration of Engineering With Nature®. Integrated Environmental Assessment and Management. 14(6):759-768. doi.org/10.1002/ieam.4084

Berkowitz JF, Green L*, Vanzomeren CM, White JR. 2016. Evaluating soil properties and potential nitrate removal in wetlands created using an Engineering With Nature based dredged material placement technique. Ecological Engineering. 97:381–388 doi.org/10.1016/j.ecoleng.2016.10.022

Bridges et al. 2014. Engineering with nature promotes triple-win outcomes. Terra et Aqua, 135(2), pp.17-23.

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