

Translating Ecological Condition into Economic Value: A Monitoring-to-Accounting Framework for Coastal NbS

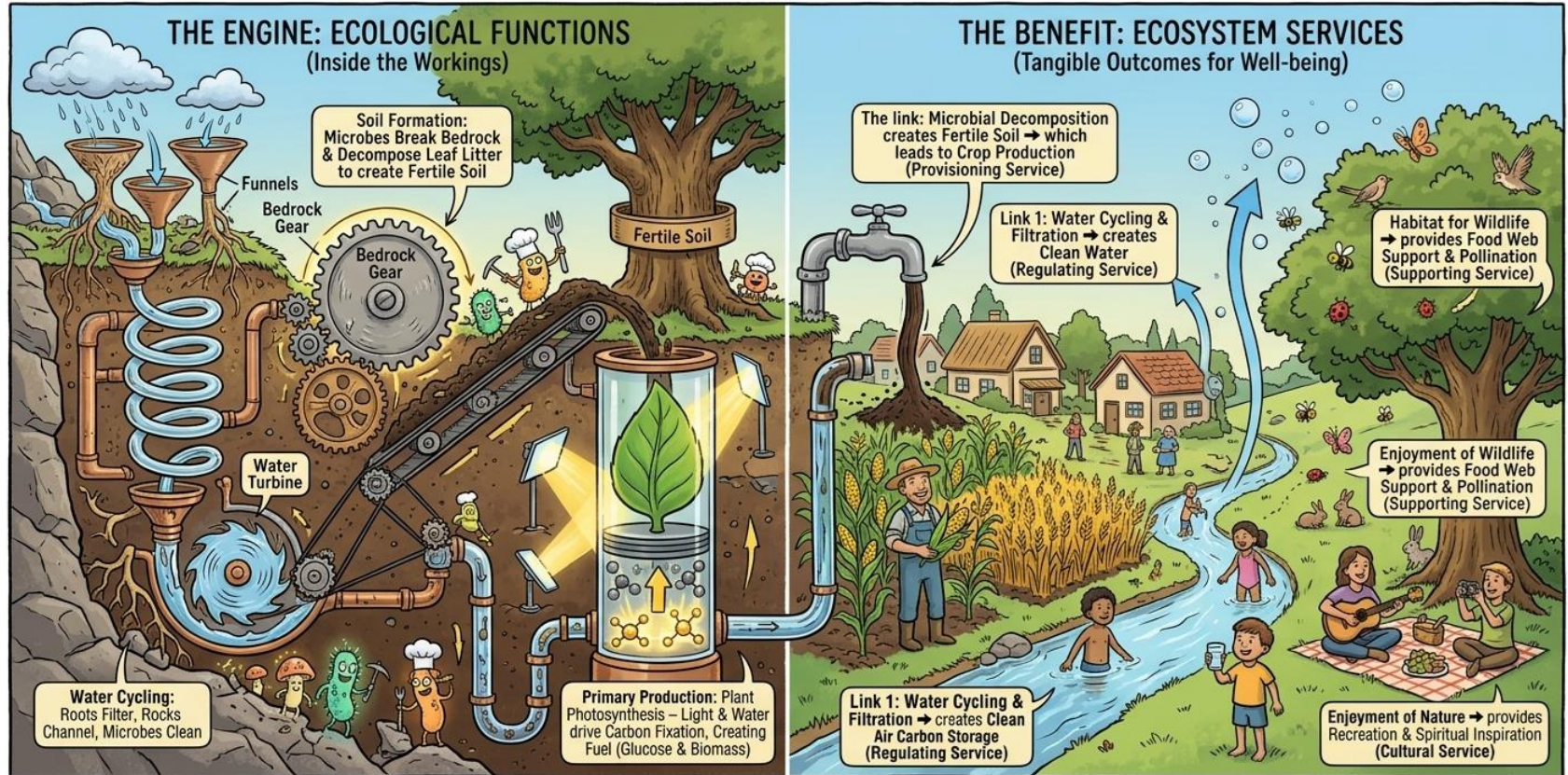


Laura Costadone

Institute for Coastal Resilience and Adaptation (ODU)



INSIDE THE NATURAL FACTORY: HOW THE ENGINE OF ECOLOGY SERVES HUMANITY



Project Goal



Develop a framework linking existing monitoring efforts to ecosystem condition, service provision, and monetary value through natural capital accounting.

Key Challenges Addressed



Measure multiple outcomes and ecosystem services



Address the gap between habitat recovery and ecosystem service delivery

How Do We define Nature-based Solution Success?

"Is success a living shoreline installed? A marsh restored? Or something we haven't been measuring at all?"

What we usually measure

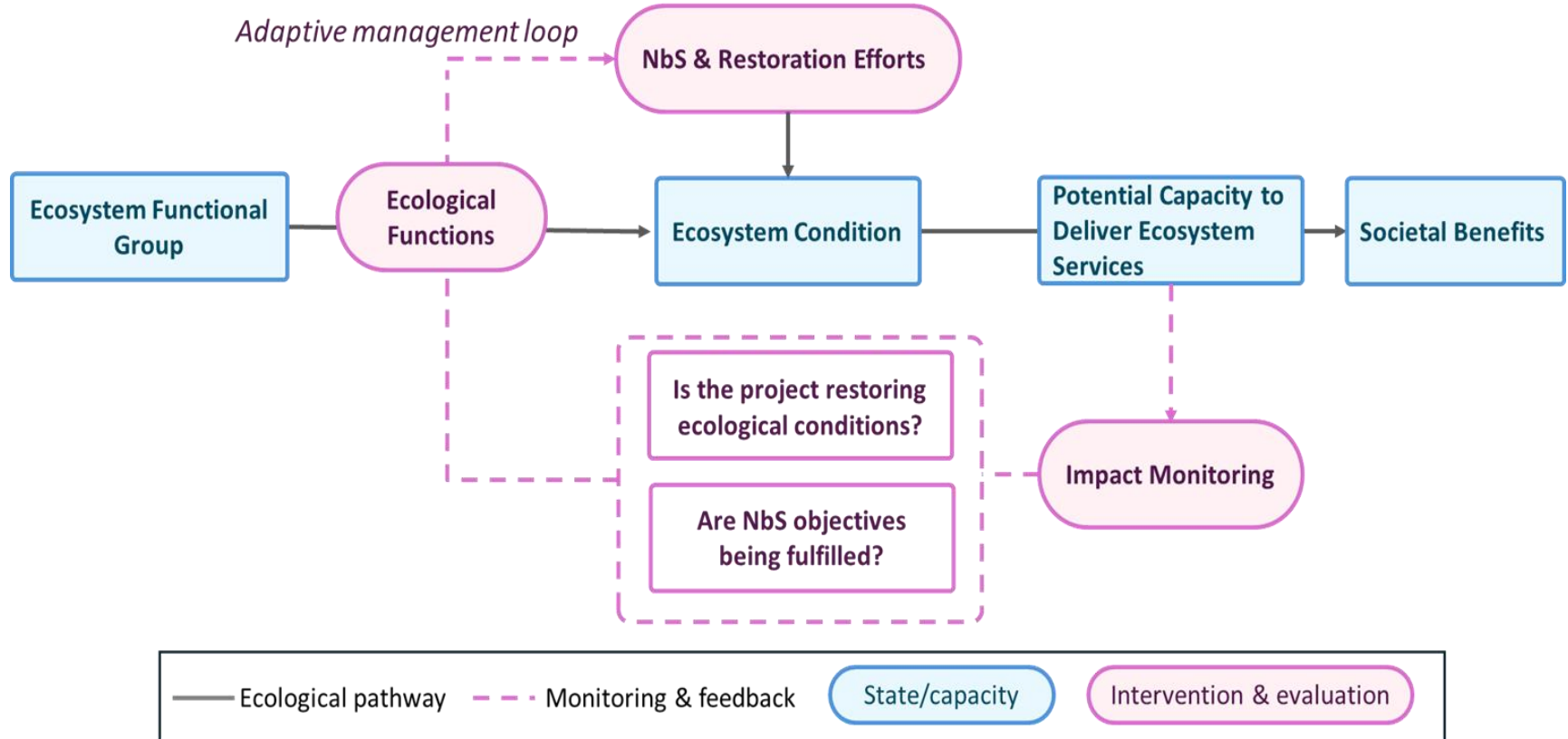
- Acres restored
- Species planted / survival rate
- Project completed on budget/
on time



None of these tell us whether the ecosystem is healthy, or what it's actually “giving” back

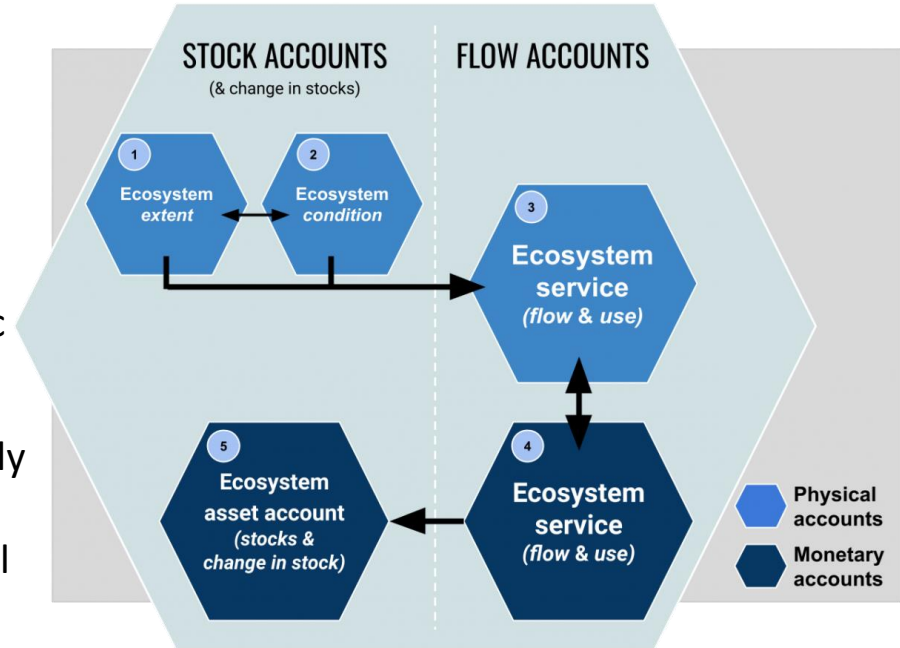


Conceptual Framework



What is Natural Capital Accounting?

- Systematically measures and tracks the extent, condition of natural assets (e.g., wetlands) and the ecosystem services they provide (e.g., water purification, carbon sequestration).
- Translates ecological monitoring data into economic terms legible beyond the scientists
- Operationalized through **SEEA-EA**, the internationally adopted framework for tracking ecosystem extent, condition, and service flows consistent with national economic accounts



Ecosystem accounts and how they relate to each other
<https://seea.un.org/ecosystem-accounting>

Why Pioneering Natural Capital Accounting

- Track changes in natural systems that may have implications across sectors
- Better understand our socio-economic reliance upon natural systems
- Assign economic value to ecosystem services
- Manage natural resources and ecosystems to ensure their economic benefits are sustained into the future



Linking Monitoring Efforts to Ecosystem Services



Scientifically grounded

Targeted review of existing NbS frameworks/Tools applicable to Chesapeake Bay coastal systems and management priorities.

Key Deliverables

- ✓ Consolidated inventory of performance indicators
- ✓ Documentation of metrics and data requirements
- ✓ Gap analysis of current NbS measurement approaches



Validated through expert engagement

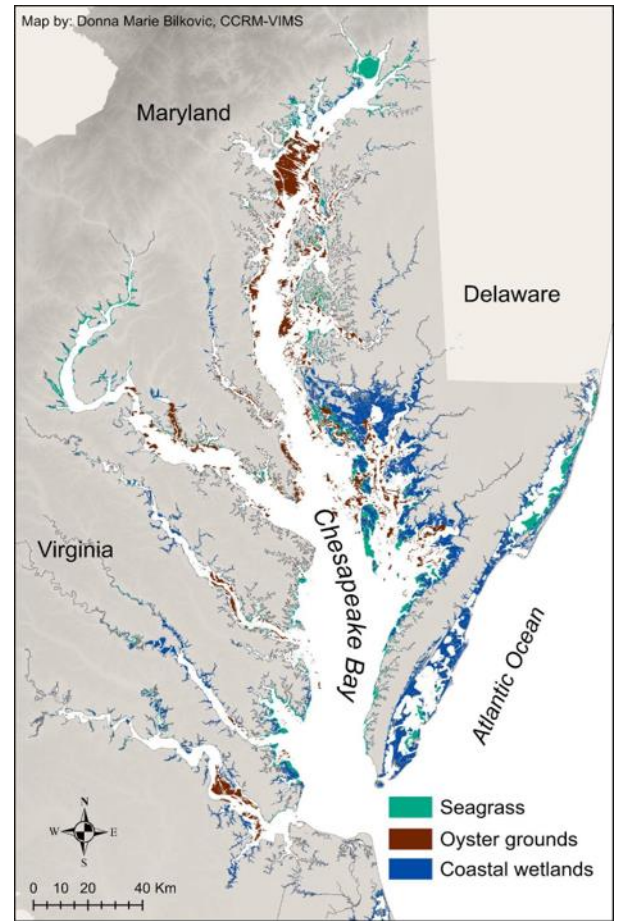
Structured outreach to experts and partner organizations to document monitoring practices and resilience priorities.

Methods & Focus

- ✓ 2 Charrette Workshops
- ✓ Identify operational constraints and opportunities
- ✓ Ensure framework reflects local context and implementation realities

Chesapeake Bay Region

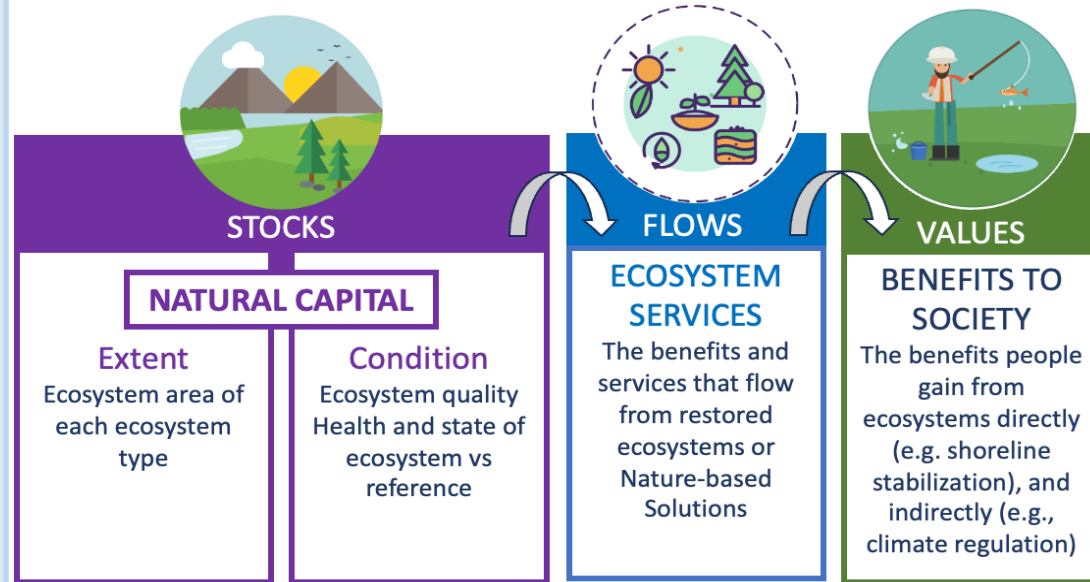
- Largest estuary in the nation- 10 million residents along the bay 'shores and tributaries
- Sustains fish, crabs, migratory waterfowl, coastal habitats, forests, agriculture, and major metro areas
- Decades of urban development and accelerating sea level rise have degraded these ecosystems
- Large-scale multi-jurisdictional restoration + smaller local efforts (e.g., living shorelines) to recover ecological function and sustain services



Map provided by CBPO Watershed Data Modeling Specialist, University of Maryland Center for Environmental Science (UMCES) (Bilkovic et al., 2019)

Restoration's Value Stays Invisible

- Restoration and NbS drive ecological change
- Its aggregate economic value remains largely invisible to budget offices, legislative bodies, and investment communities
- Absence of a consistent framework for measuring and reporting it



Proposed Theoretical Framework

1

IUCN GET Typology

Habitats are classified using the IUCN Global Ecosystem Typology — seagrass meadows, shellfish reefs, saltmarshes— providing an internationally recognized scientific vocabulary.

2

Functions → Outcomes

Ecological functions are the mechanistic pathways through which ecosystems deliver services. Monitoring assesses whether functions are being restored.

3

SEEA-EA Alignment

Indicators are compatible with natural capital accounting (SEEA-EA), treating ecosystems as assets. Monitoring data can populate municipal or regional condition accounts.

Selected Ecosystem Typology



Seagrass
Meadow



Shellfish Beds
and Reefs



Coastal Saltmarshes
and Reedbeds

Four Outcome Dimensions for Ecosystem Services

Monitoring focuses on outcomes. Every indicator is diagnostic of one of these four dimensions.

Coastal Hazard Risk Reduction

Wave
attenuation,
shoreline
stabilization,
flood buffering

Climate Mitigation

Carbon
sequestration,
blue carbon
stocks,
greenhouse gas
fluxes

Ecosystem Integrity & Function

Habitat quality,
biodiversity,
ecological
connectivity

Socioeconomic Benefits

Recreation,
cultural values,
property
protection,
livelihood
support

Characteristics of Seagrass Meadow in Good Ecological Conditions

- **Dense, continuous meadows** exhibit high shoot density, biomass, well-developed canopies, and successful reproduction.
- **Positive feedbacks** improve water clarity by reducing water movement and sediment resuspension and enhancing sediment stabilization.
- **Low epiphyte loads** maintain light availability at the leaf surface and support continued plant growth.
- **Large, well-connected SAV beds** provide complex habitat supporting diverse fish, blue crab, and other aquatic communities.



Photo credit: Chesapeake Bay Program

Ecosystem services provided by Seagrass Meadow across NBS dimensions

Ecosystem services	Coastal hazard risk reduction	Climate mitigation	Habitat quality & ecosystem integrity	Socioeconomic benefits
Water quality enhancements			●	○
Habitat support			●	○
Fisheries support			●	○
Climate regulation		●		
Shoreline protection	○			○

● Primary Linkages

○ Secondary Linkages

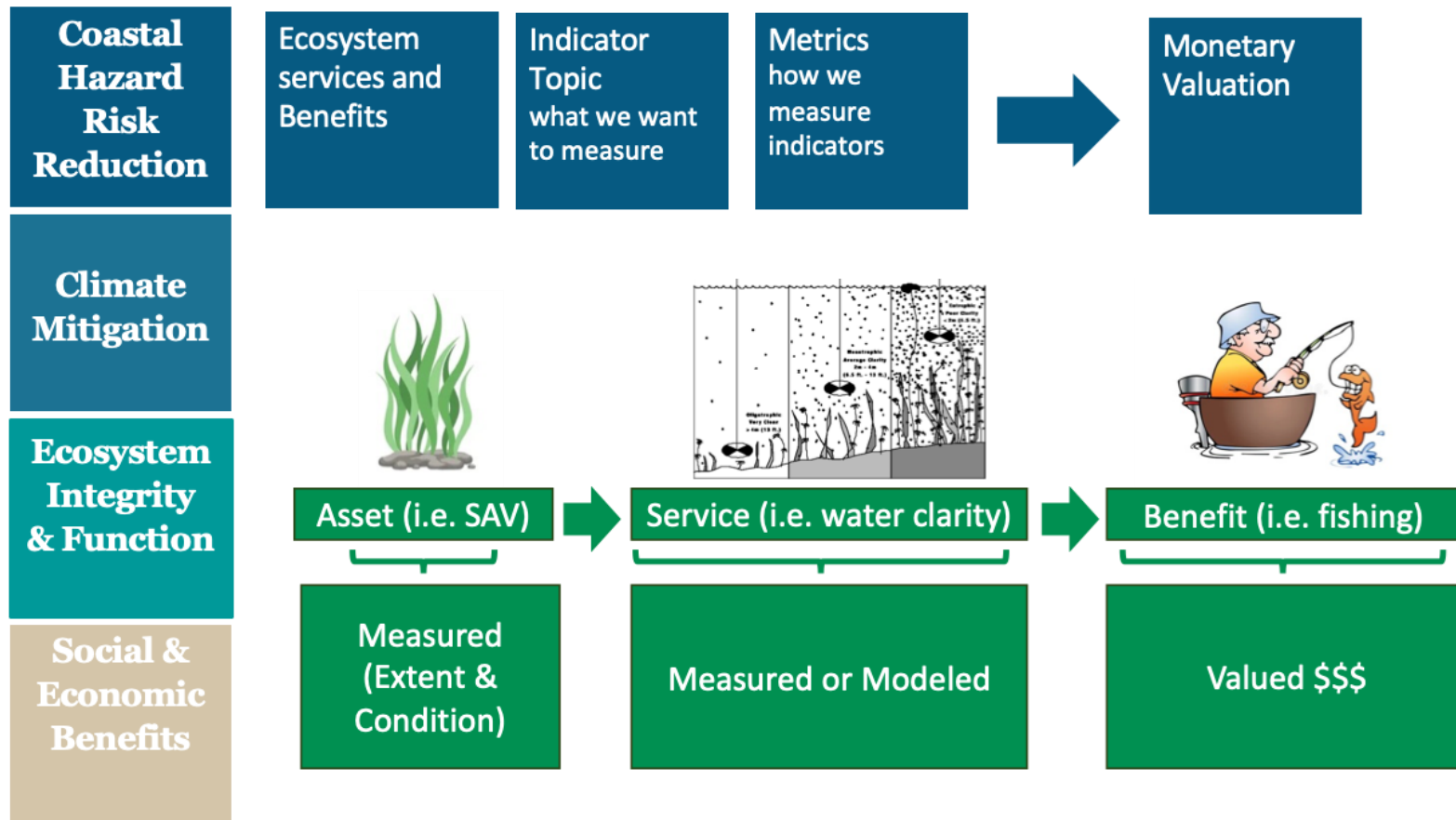
Performance Indicators and Metrics

NbS Outcome Dimension / Function–Service Pathway		Performance Indicator	Metric
	Habitat Quality & Ecosystem Integrity	Light availability	Light attenuation coefficient (K_d , m^{-1}); % surface irradiance at depth; Photosynthetically Active Radiation (PAR) ($\mu mol\ m^{-2}\ s^{-1}$)
		Water clarity	Total suspended solids (TSS, $mg\ L^{-1}$); Secchi depth (m)
		Nutrient conditions	Total nitrogen (TN, $mg\ L^{-1}$); total phosphorus (TP, $mg\ L^{-1}$)
		Phytoplankton abundance	Chlorophyll <i>a</i> ($\mu g\ L^{-1}$)
		Dissolved oxygen	Dissolved oxygen ($mg\ L^{-1}$)
	Enabling environmental conditions	Meadow extent	Area (ha); total planform field area (ha)
		Vegetation cover	SAV cover per plot (%)
		Shoot density	Number of shoots ($shoots\ m^{-2}$)
		Canopy structure	Mean shoot height (cm)
		Biomass	Aboveground dry weight ($g\ m^{-2}$); belowground dry weight ($g\ m^{-2}$)
		Species composition	Presence and relative abundance of <i>Z. mscina</i> and <i>R. maritima</i>
		Reproductive capacity	Flowering shoot density ($shoots\ m^{-2}$)
		Spatial integrity / patch dynamics	Patch size distribution (ha); fragmentation index
		Epiphyte load	Epiphyte load ($mg\ dry\ weight\ cm^{-2}\ leaf\ area$)
		Species community diversity	Shannon–Wiener diversity index (H')
	Meadow condition and structural integrity*	Juvenile blue crab abundance	Juvenile blue crab density (individuals m^{-2})
		Juvenile fish and crustacean abundance	Juvenile density of selected species (individuals m^{-2})
		Nekton biomass	Total nekton biomass per unit area ($g\ DW\ m^{-2}$)
	Habitat and fisheries support		

* Includes multiple indicators of meadow condition and structural integrity.

NbS Outcome Dimension / Function–Service Pathway		Performance Indicator	Metric
Climate Mitigation 	Carbon storage	Carbon stocks	Soil organic carbon stock to 1-m depth ($Mg\ C\ ha^{-1}$); aboveground biomass carbon ($g\ C\ m^{-2}$); belowground biomass carbon ($g\ C\ m^{-2}$)
Coastal Hazard Risk Reduction 	Wave attenuation and sediment stabilization	Wave attenuation	Incident-to-transmitted wave-energy reduction (%)
		Sediment accretion	Vertical sediment accumulation ($mm\ yr^{-1}$)
		Shoreline response	Shoreline change rate ($m\ yr^{-1}$)
Socio-economic Benefits 	Economic activity: restoration/intervention	Direct restoration employment	Number of restoration jobs supported by project
	Economic activity: recreation and tourism	Recreational expenditure change	Change in recreational activity expenditures associated with project site visitation Change in recreational fishing expenditures associated with project site visitation

Framework Structure

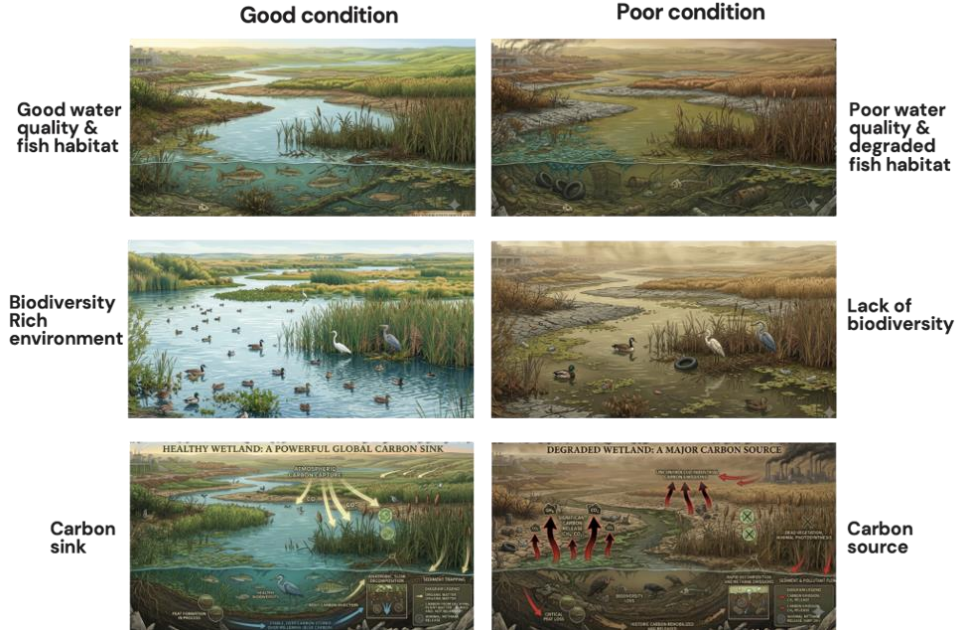


Next Steps: Provide actionable guidance in using these framework



Why This Matters?

- Ecosystem condition predicts future service flow (degraded ecosystems supply fewer services)
- Tracks societal risks by revealing hidden dependencies in sectors like agriculture, fisheries, and tourism before economic losses occur
- Standardizes environmental economics through condition indicators aligned with frameworks like SEEA
- Guides policy and finance by supporting targeted conservation investments based on baseline conditions and future scenarios



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lcostado@odu.edu

