

# What are nature-based solutions?



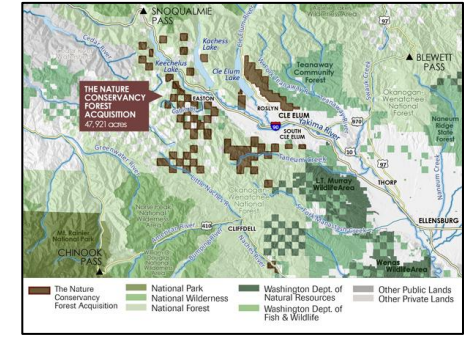
**Kyle McKay, Ph.D., P.E.**  
**Woolpert, Inc.**  
**New York, New York**  
**September 2025**

# Agenda

- Convergence of infrastructure and conservation globally
- A paradigm shift toward nature-based solutions
- Applicability to navigable rivers, ports, and harbors
- Ideas for accelerating the paradigm shift



# What has been the global approach to biodiversity conservation?



Nature for itself

Nature despite people

Nature for people

People and nature

Prior to 1970

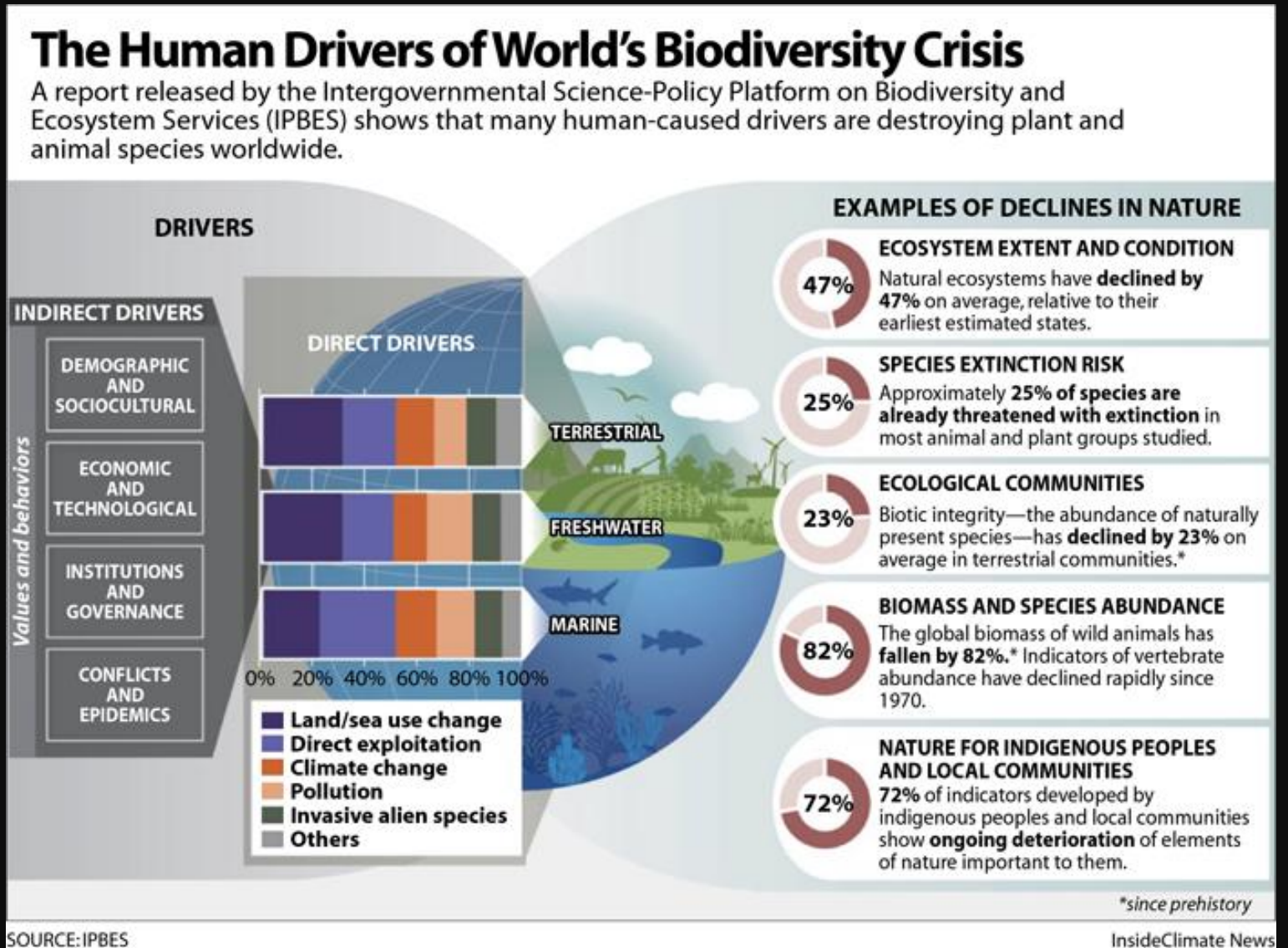
1970s–1980s

1990s–2000s

2010s–2020s

# Is conservation working?

- None of the UN's 2020 biodiversity targets have been met (Obura et al. 2021)
- Extinctions occur at a pace orders of magnitude higher than background rates (IPBES 2019, Brauman et al. 2020)
- Annual spending on conservation would need to increase 6-7 fold to meet international goals (Deutz et al. 2020)



# What has been the global approach to infrastructure planning?



Resilient design

Expansion of project purposes

Mitigation hierarchy

Control of nature

**Prior to 1970**

**1970s–1980s**

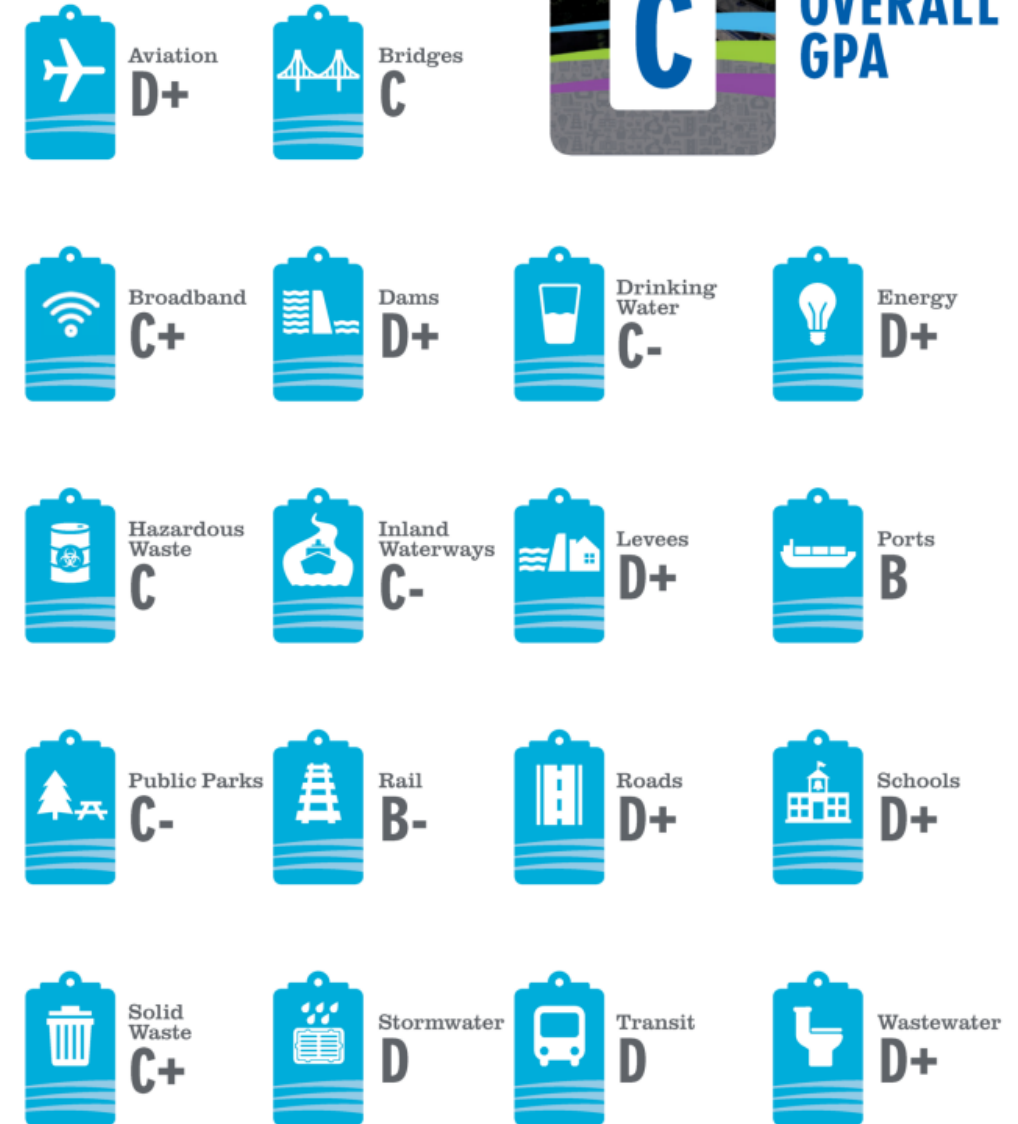
**1990s–2000s**

**2010s–2020s**

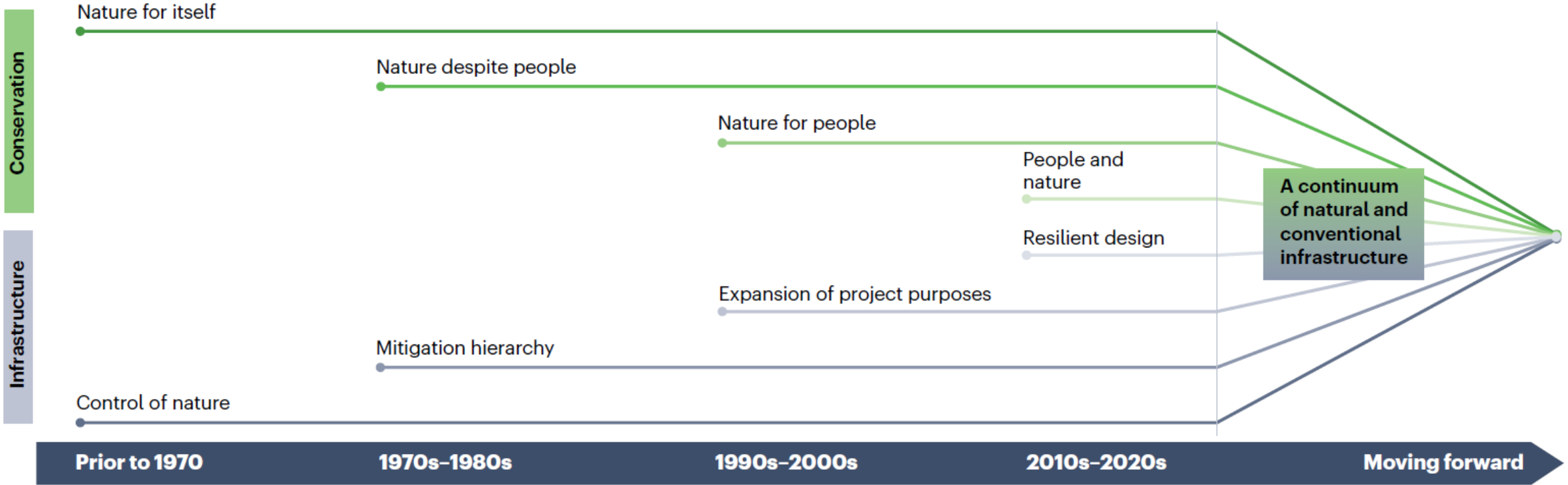
# Are infrastructure goals being met?

- Aging infrastructure
  - Increasing operations and maintenance
  - Rising fragility
  - Shifting societal needs
- New infrastructure
  - Increasing public safety
  - Improving quality of life
  - Growing populations
- Annual global spending on infrastructure (~\$2.7T, GI Hub 2021)

## The 2025 Report Card for America's Infrastructure



# Convergence of the historic arcs of these fields of practice



# A paradigm shift may be underway

<b>A Conventional Framing of Infrastructure</b>	<b>An Emergent Approach to Infrastructure</b>
Infrastructure performs engineering functions and services	Infrastructure performs engineering functions and services
Fewer objectives centered on an organization's mission	Many objectives with a multi-purpose framing
Independent funding => independent projects	Leveraged funding => systems outcomes
Ecosystems and social outcomes are treated as constraints or happy coincidences	Ecological and social benefits are included in the goals
Technical experts from a few disciplines develop alternatives	Technical experts lead alternative development, but other voices participate
<b>Typically leads to more conventional, "grey" infrastructure</b>	<b>Merges conventional infrastructure with natural systems</b>

# What shall we call this paradigm shift?

## A set of physical assets:

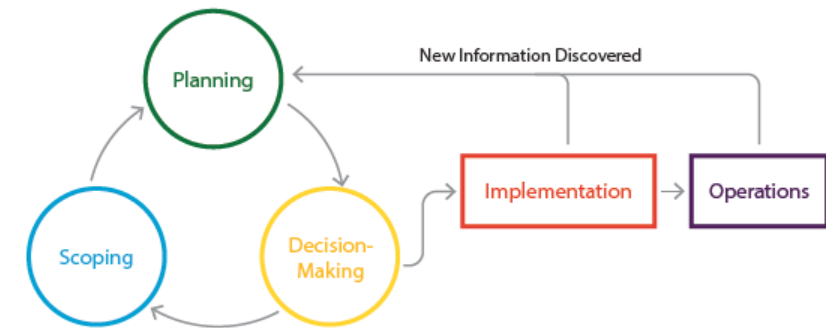
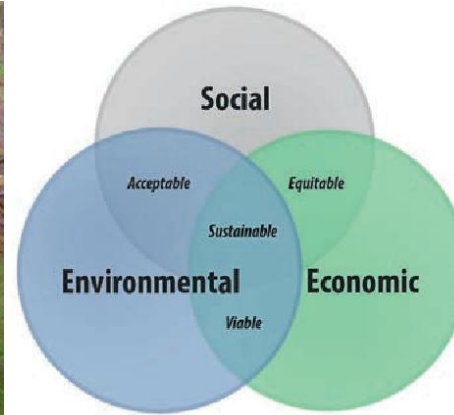
- Natural infrastructure
- Nature-based solutions
- Natural and nature-based features
- Green / blue infrastructure
- “Soft” defenses
- “Alternative” designs
- ...

## A discipline or practice:

- Ecological engineering
- Restoration ecology
- Integrative conservation
- Landscape architecture
- Ecological design
- ...

## A philosophy or initiative:

- Engineering with Nature
- Working with Nature
- Participatory design
- Multi-purpose planning
- Participatory action research
- ...



# Defining nature-based solutions (in policy)

UNEP (2022): Nature-Based Solution (NbS) are “actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits”

- Slightly different definitions internationally
- Umbrella term for natural infrastructure, green infrastructure, and ecosystem-based adaptation
- Typically refers to applications beyond infrastructure



Figure: Cliff Cave chevrons, Mississippi River (Eddie Brauer)

# Defining natural infrastructure (in practice)

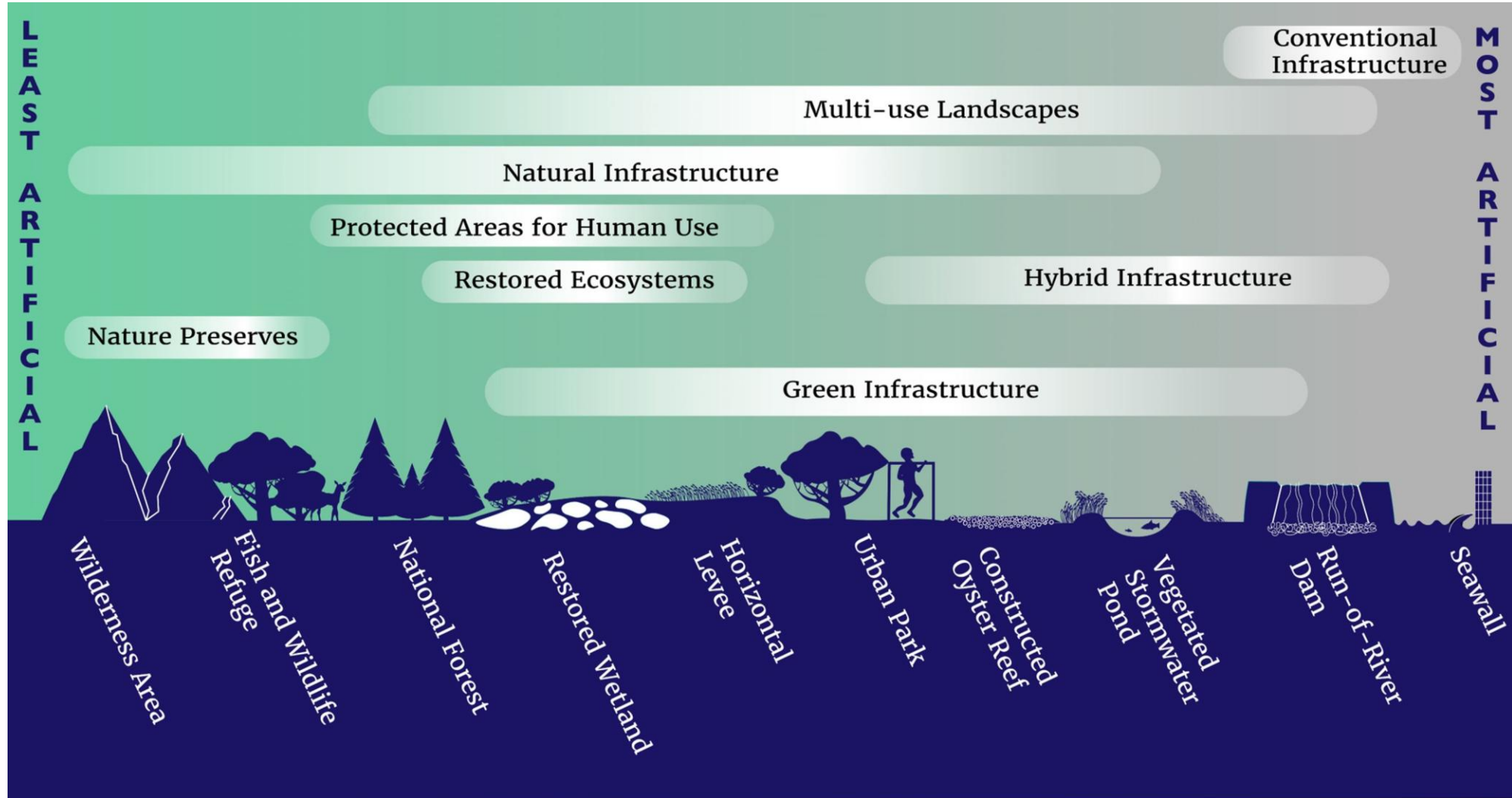
(Loosely) defined by several common characteristics, not all of which may be met by any particular feature:

- Performs infrastructure services
- Consists (at least in part) of natural or living materials
- Provides environmental and social benefits beyond typical purposes
- Enhances resilience through self-adjustment



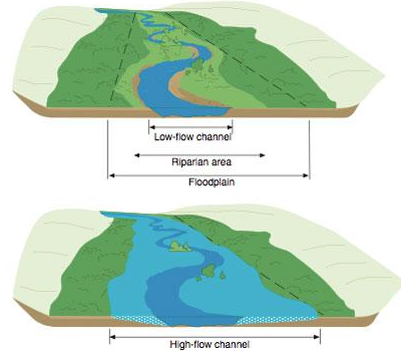
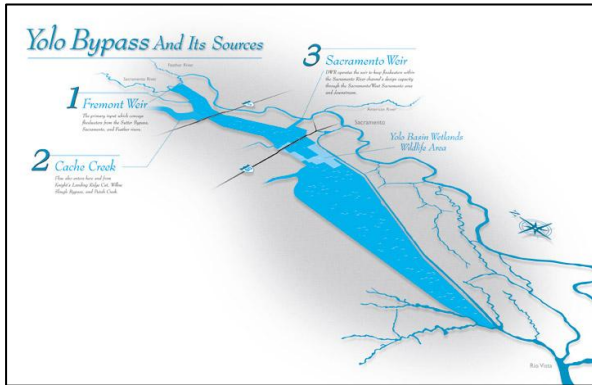
Figure: Managed reconnection of the Illinois River and floodplain at the Emiquon Preserve, Illinois, USA (Photo by Doug Blodgett, The Nature Conservancy)

# Nature-based solutions are a spectrum of green, grey, and hybrid options

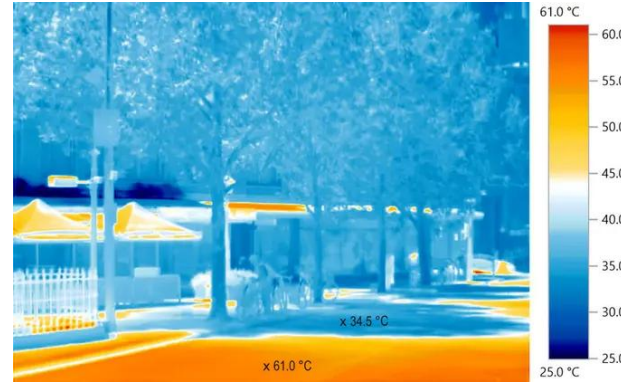


# A little bit of myth-busting around nature-based solutions

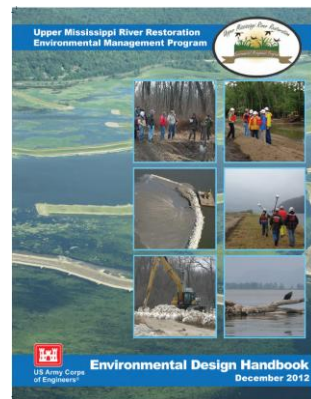
Is natural infrastructure new?  
No! But the scale of the need is.



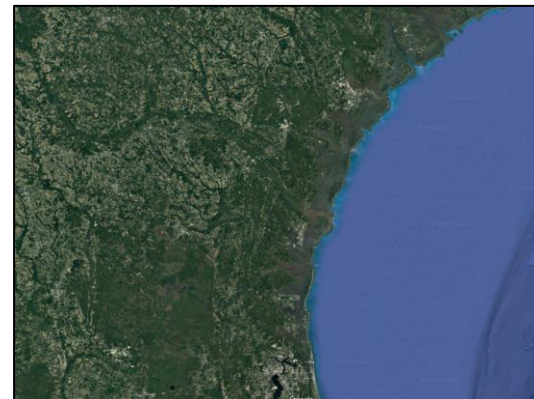
Are NBS only for one area of application? Nope.



Are there engineering guidelines?  
Yes. Many go back decades.



Does NBS always imply design?  
Not necessarily.



# What does this mean for navigation systems?

- Reconsidering our relationship with sediment
- Thinking of shorelines as multi-functional landscapes
- “Greening the grey” in terms of materials and small-scale changes

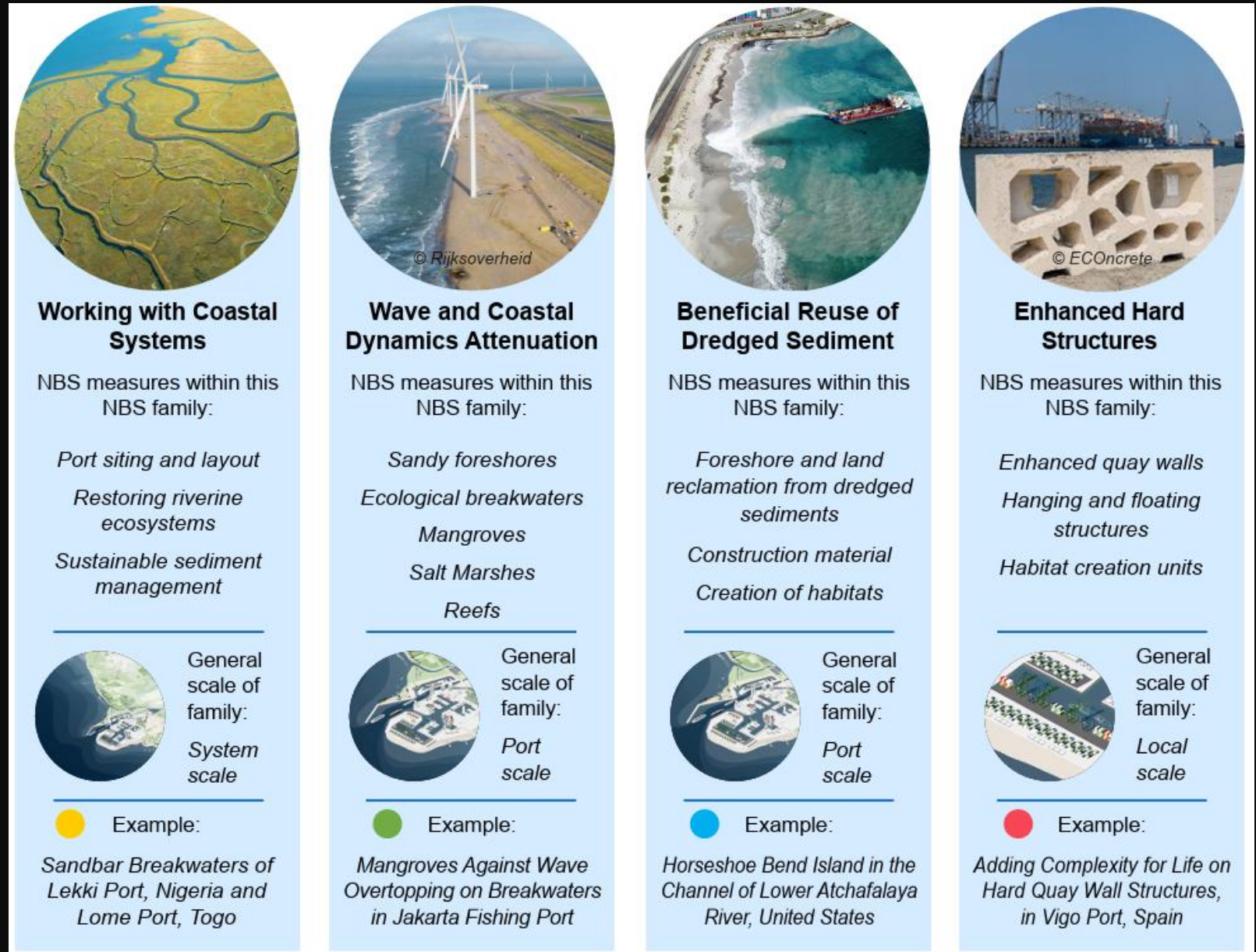


Figure: Four main strategies for NBS in ports (World Bank 2025)

# Sustainable sediment management

## Management of sediment at the watershed scale



## Considering the channel and the port as coupled systems



## Beneficial use of dredged material

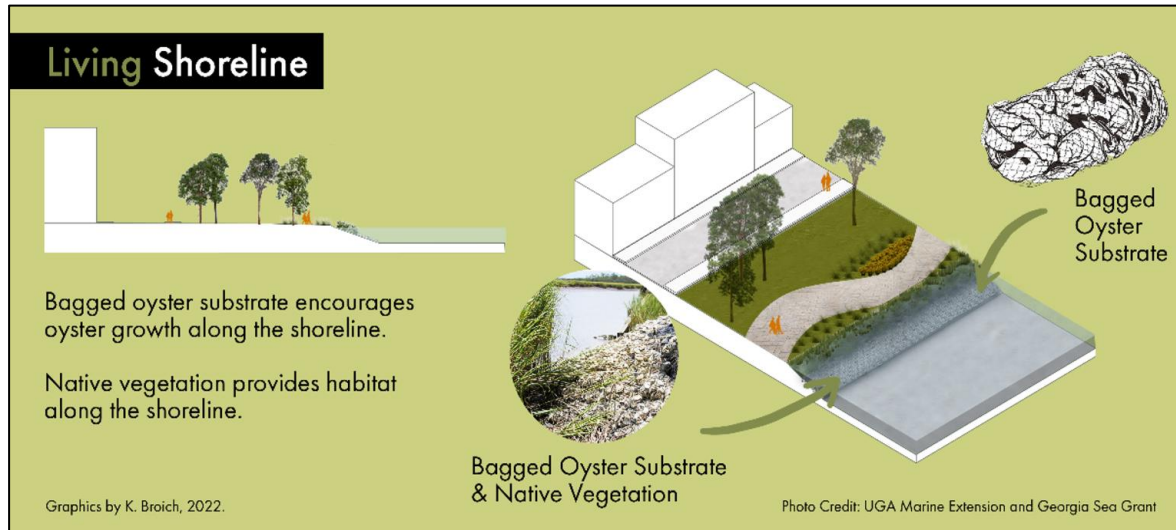


# Shorelines as multi-use landscapes



# Small changes to design elements add up to big ecological effects

## Living Shoreline



Bagged oyster substrate encourages oyster growth along the shoreline.

Native vegetation provides habitat along the shoreline.

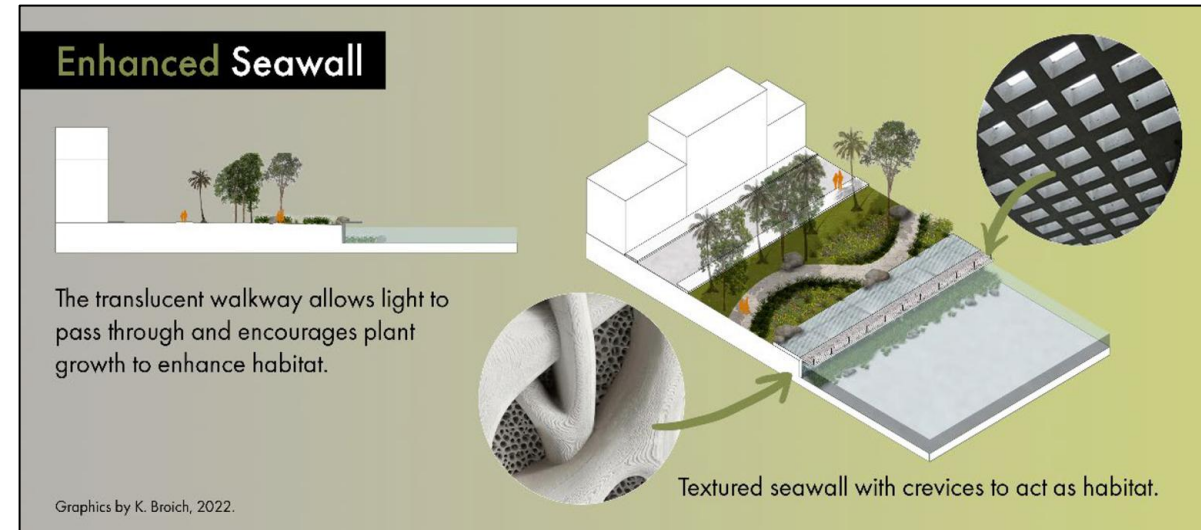
Bagged Oyster Substrate

Bagged Oyster Substrate & Native Vegetation

Photo Credit: UGA Marine Extension and Georgia Sea Grant

Graphics by K. Broich, 2022.

## Enhanced Seawall

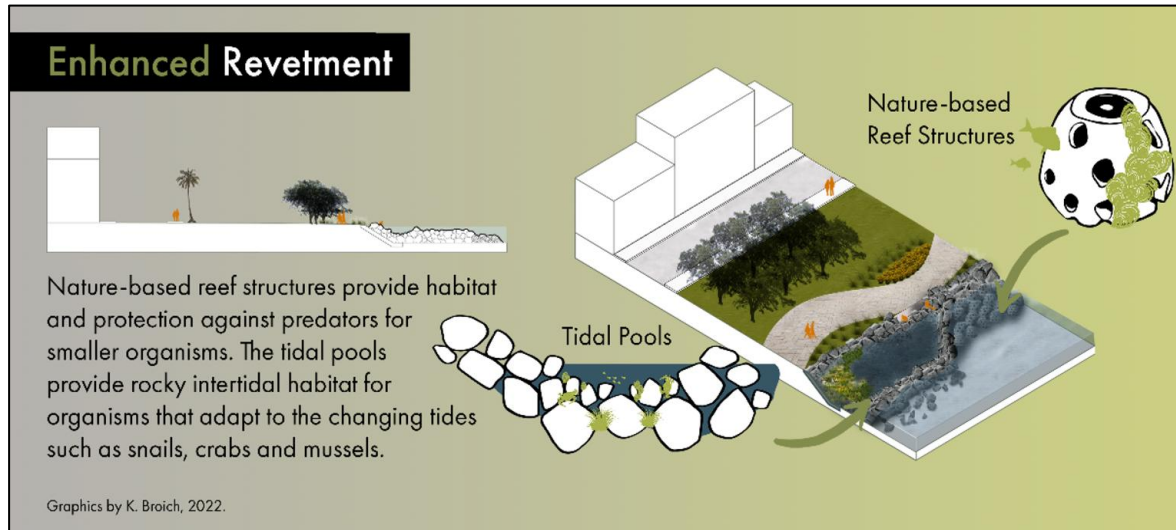


The translucent walkway allows light to pass through and encourages plant growth to enhance habitat.

Textured seawall with crevices to act as habitat.

Graphics by K. Broich, 2022.

## Enhanced Revetment



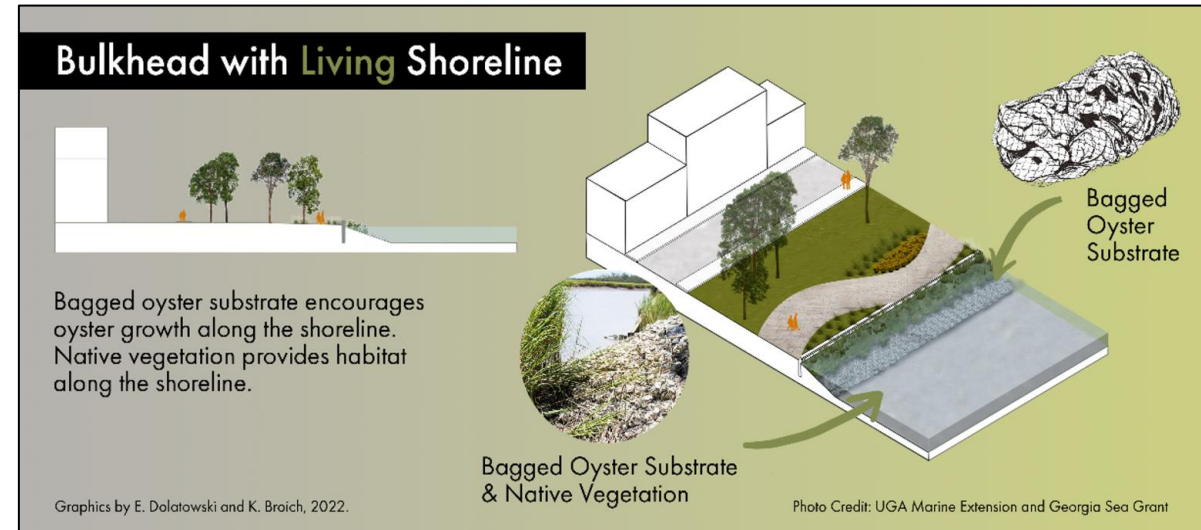
Nature-based reef structures provide habitat and protection against predators for smaller organisms. The tidal pools provide rocky intertidal habitat for organisms that adapt to the changing tides such as snails, crabs and mussels.

Nature-based Reef Structures

Tidal Pools

Graphics by K. Broich, 2022.

## Bulkhead with Living Shoreline



Bagged oyster substrate encourages oyster growth along the shoreline. Native vegetation provides habitat along the shoreline.

Bagged Oyster Substrate

Bagged Oyster Substrate & Native Vegetation

Photo Credit: UGA Marine Extension and Georgia Sea Grant

Graphics by E. Dolatawski and K. Broich, 2022.

# How do we accelerate this paradigm shift?

- Creating a boundary institution to develop the science and transition it to practice
- Reimagining infrastructure for a biodiversity future
- Work toward hybrid green-grey designs
- Developing design standards to facilitate best practices



Figure: Reed gabions on the Rhine River (PIANC WG 128)

# Accelerating the shift #1: Creating a multi-institutional framework for collaboration



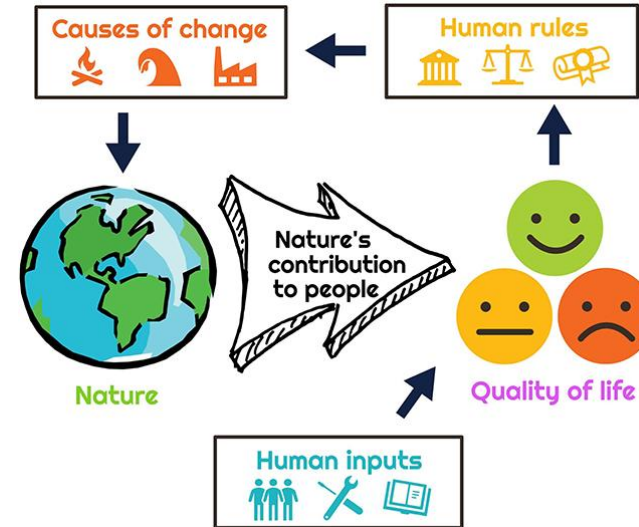
**NETWORK FOR  
ENGINEERING  
WITH NATURE**

A network of vested organizations creating a resilient future through built and natural infrastructure that work together to improve societal well-being by sustainably delivering more value and benefits to people and ecosystems.



# Accelerating the shift #2: View biodiversity as an asset, rather than a constraint or a liability.

Liabilities	Assets
Debts owed	Items of value
Can be given up for other assets	Are harder to trade-off
Are counted as costs	Provide long-term benefits



# Accelerating the shift #3: Expanding design standards at different scales

## High-level guidelines:

- What are NBS?
- What is the planning process?
- How do we engage people in the process?

## Alternatives analysis:

- What are common objectives for this particular problem?
- What is the menu of options?
- How are costs and benefits evaluated?

## Performance-based design:

- What design levers can be turned?
- What are performance thresholds?
- How can small additions and accommodations be made?

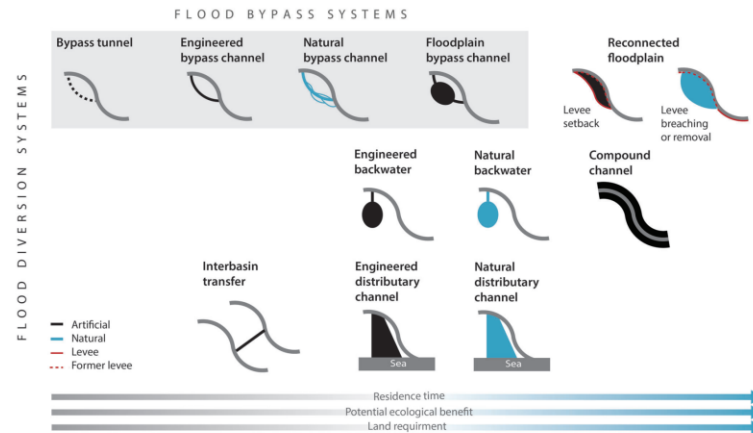
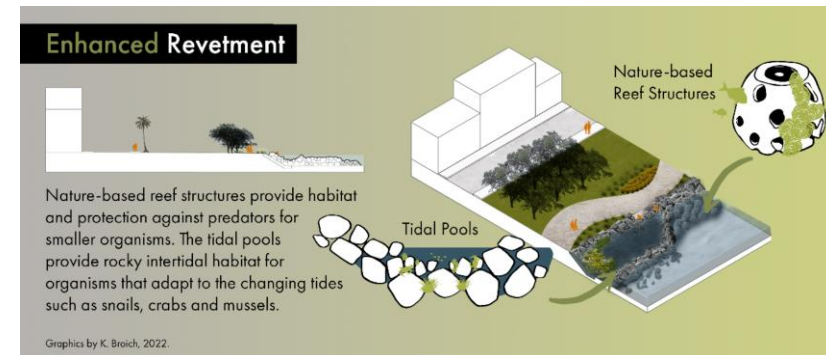


FIGURE 1 A typology of flood diversions, based on increasing residence time, potential ecological benefit and land requirements, and on whether the diverted water flows back into the mainstem downstream (a bypass), back through the main channel upon flood recession (a backwater), into another river system entirely (an interbasin diversion), or into the sea via a separate channel (a distributary). Also shown are cases of floodwaters being accommodated on floodplains, such as natural floodplains (reconnected floodplains), and created floodplains (compound channels). Location along gradients of residence time, potential ecological benefit and land requirements are approximate



# Accelerating the shift #4: Embracing hybrid systems

Components



## Scoping

- Expand design to explicitly include primary and secondary outcomes
- Spend more time characterizing risk tolerance

## Design

- Design alternatives starting from green and grey baselines
- Create systems with complementary forms of resilience

## Analysis

- Assess performance over a range of conditions
- Expand the basket of assessment tools

Systems



# Thanks for your time!

Kyle McKay, Ph.D., P.E.  
New York, NY

[kyle.mckay@woolpert.com](mailto:kyle.mckay@woolpert.com)



WOOLPERT

