What are nature-based solutions?

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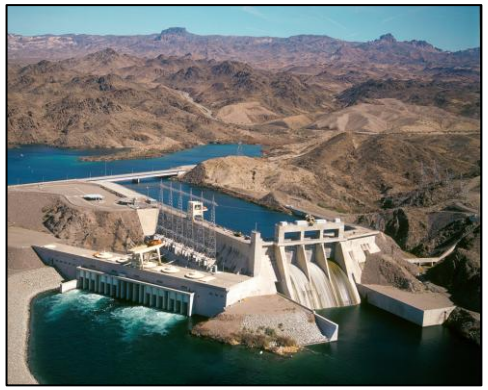
Agenda

- Convergence of infrastructure and conservation globally
- A paradigm shift toward nature-based solutions
- Ideas for accelerating the paradigm shift

What has been the global approach to infrastructure planning?



Resilient design

Expansion of project purposes

Mitigation hierarchy

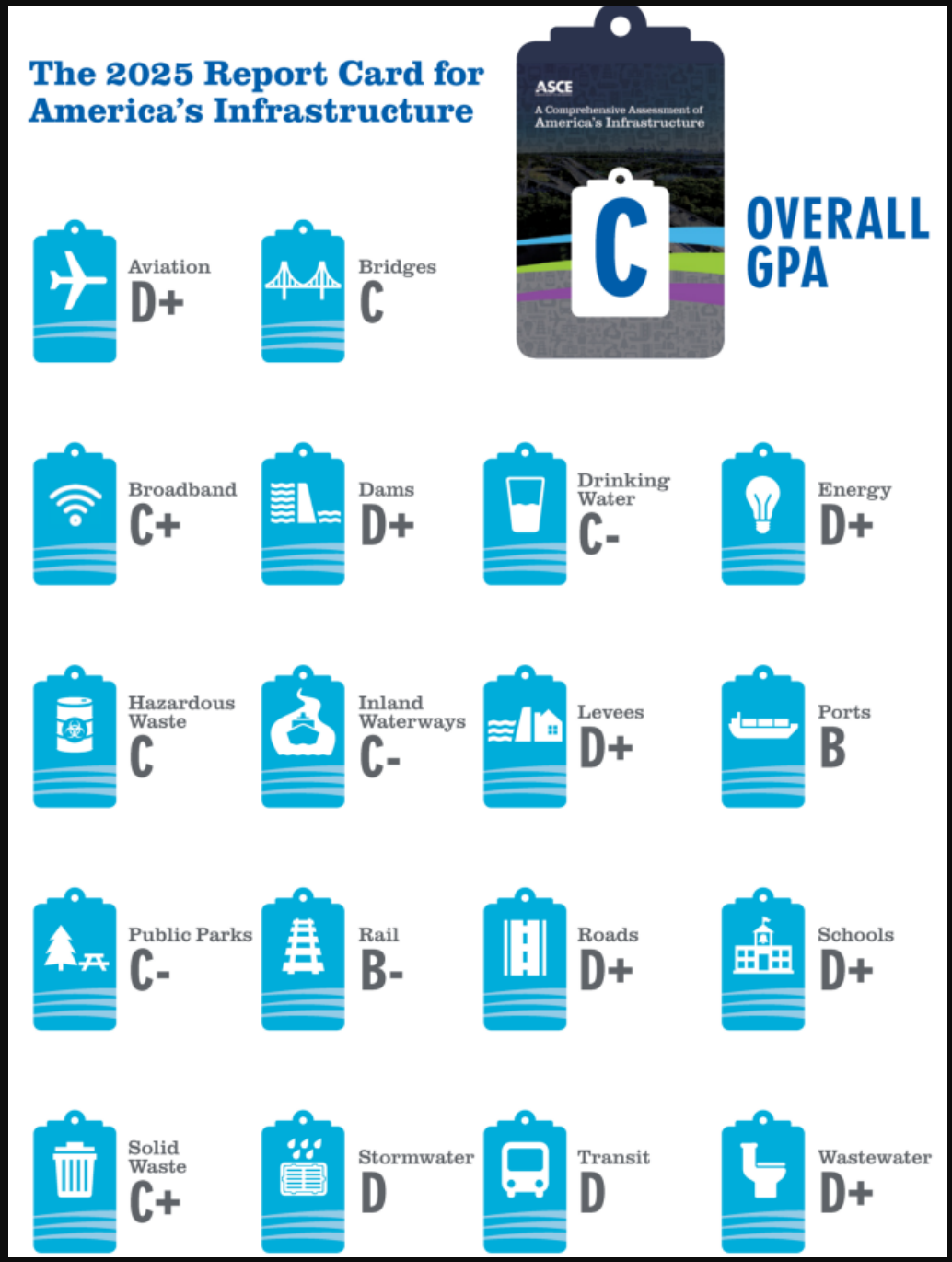
Control of nature

Prior to 1970 | **1970s–1980s** | **1990s–2000s** | **2010s–2020s**

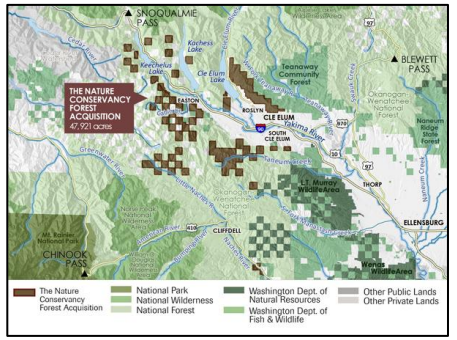
Figures: Davis Dam (Reclamation), stream mitigation project (USACE), Cape Fear River fish bypass (Frank Yelverton), www.delawarelivingshorelines.org

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)



What has been the global approach to biodiversity conservation?



Nature for itself

Nature despite people

Nature for people

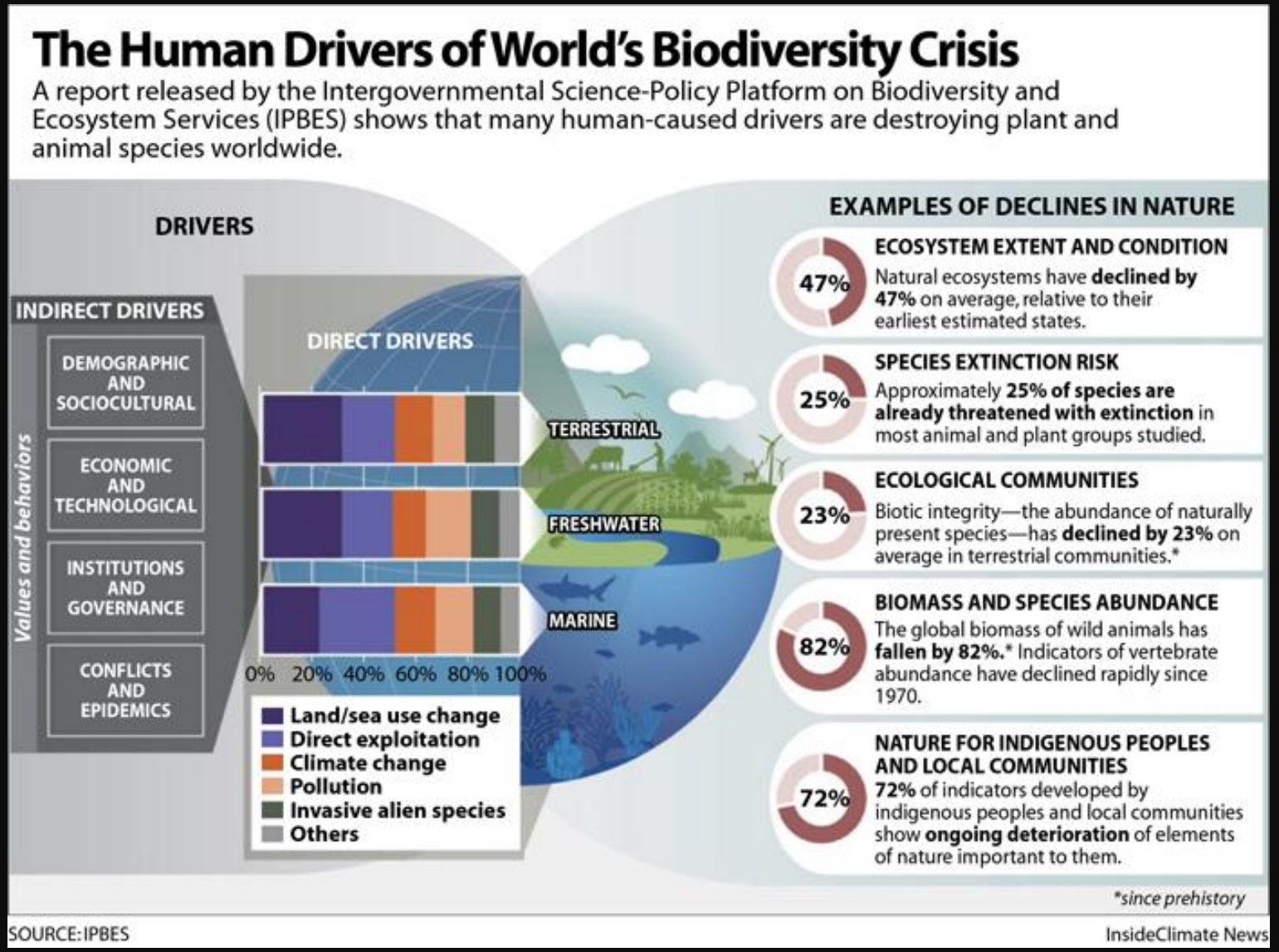
People and nature

Prior to 1970 | **1970s–1980s** | **1990s–2000s** | **2010s–2020s**

Figures: Yosemite National Park (NPS), Cuyahoga River fires (EPA), ecosystem services summary (Metro Vancouver), Washington's Eastern Cascade Mountain Range (TNC)

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)



Convergence of the historic arcs of these fields of practice

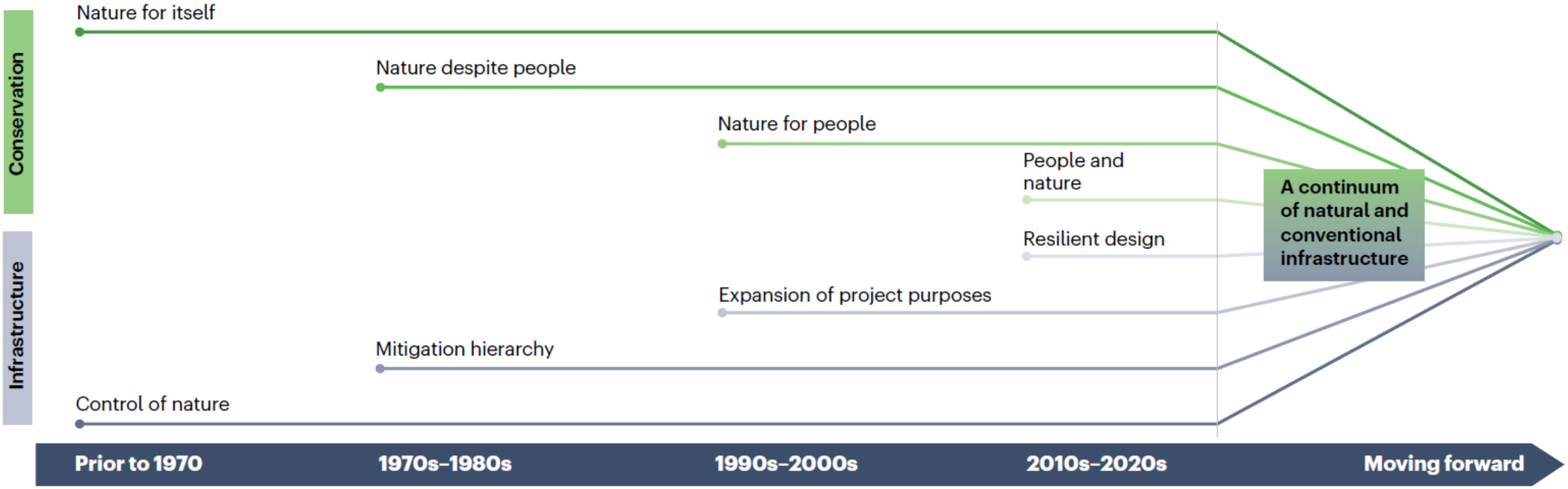


Figure: McKay et al. (2023, *Nature Reviews Earth & Environment*)

A paradigm shift may be underway

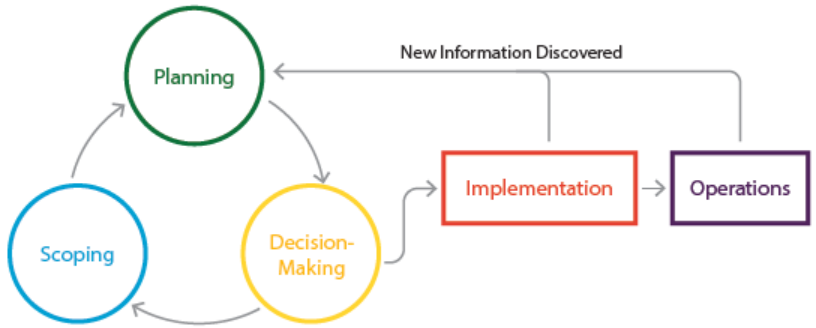
A Conventional Framing of Infrastructure	An Emergent Approach to Infrastructure
Infrastructure performs engineering functions and services	Infrastructure performs engineering functions and services
Fewer objectives centered on an organization's mission	Many objectives with a multi-purpose framing
Independent 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
Typically leads to more conventional, "grey" infrastructure	**Merges conventional infrastructure with natural systems**

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
- …



Figures: levee toe wood (Joanna Curran), UK Green Approaches in River Engineering, Engineering with Nature, NNBF Guidelines

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

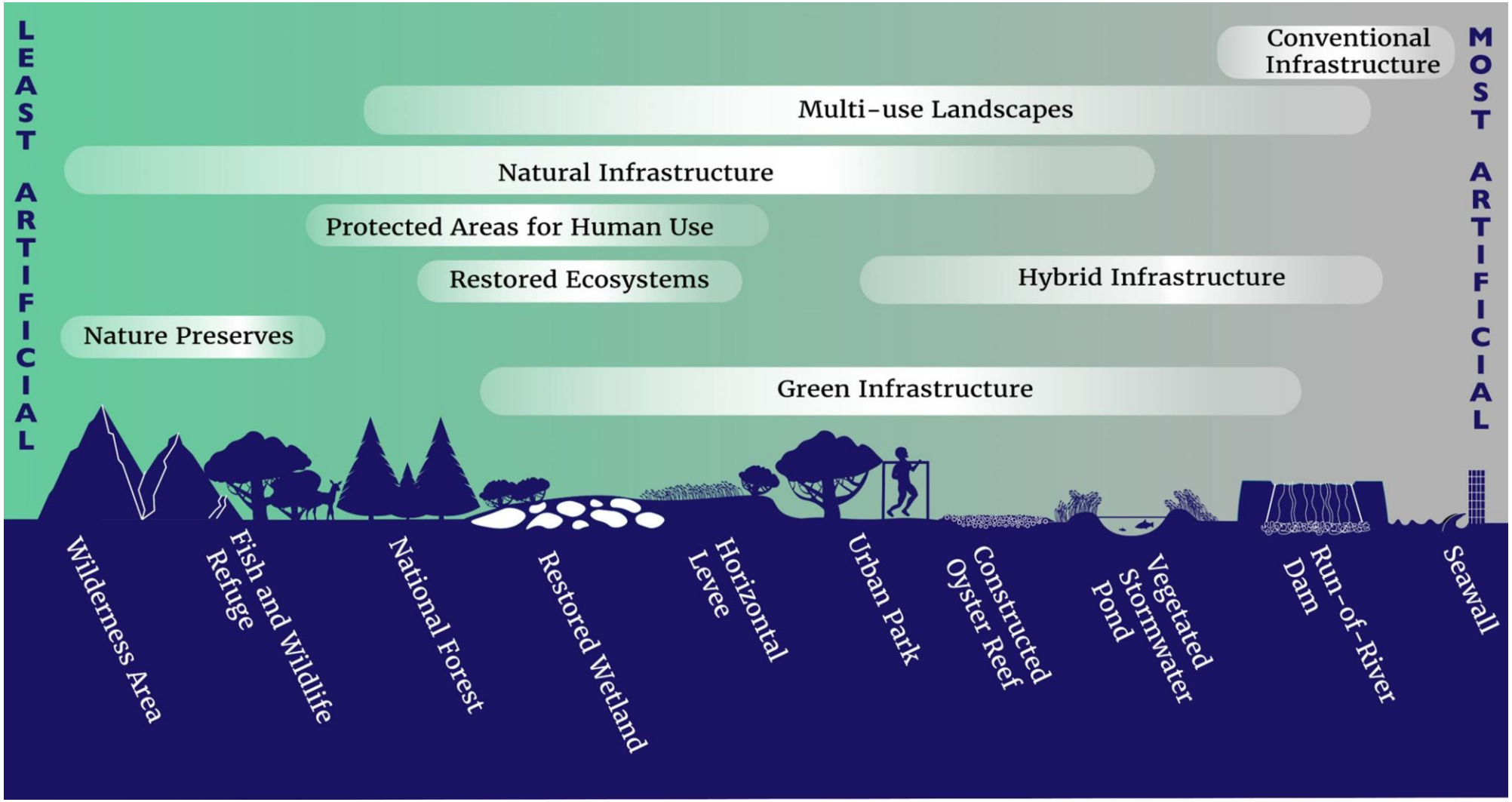
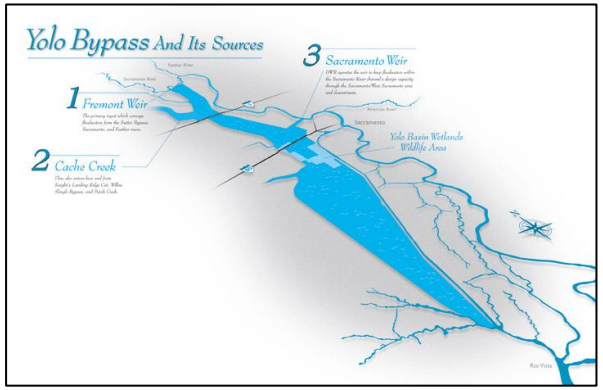
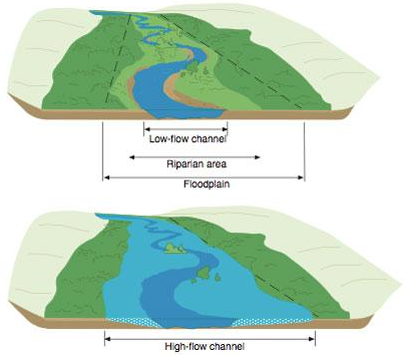


Figure: van Rees et al. (2023, *PNAS*)

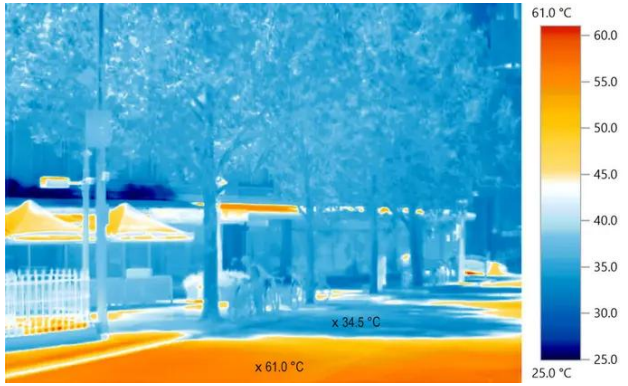
A little bit of myth-busting around nature-based solutions

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

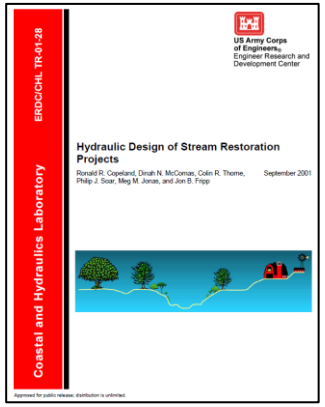


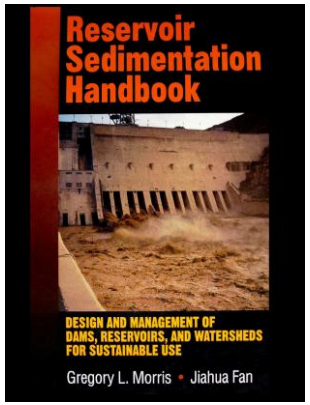


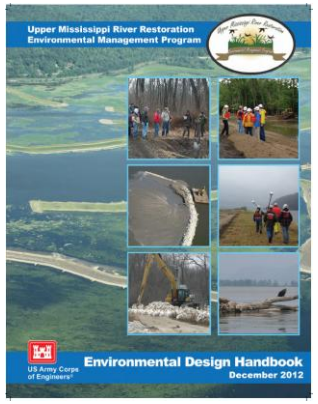
Are NBS only for one area of application? Nope.



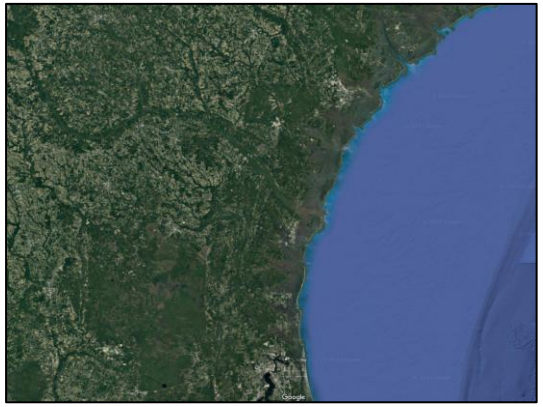
Are there engineering guidelines?
Yes. Many go back decades.







Does NBS always imply design?
Not necessarily.



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)

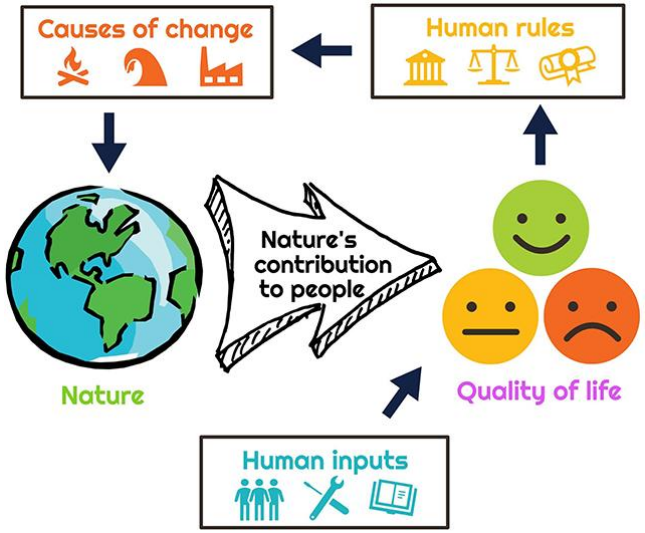
Accelerating the shift #1:
Creating a multi-institutional framework for collaboration

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



Concepts from van Rees et al. (2023, *PNAS*) and Suedell et al. (2022, *Journal of Environmental Management*)

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?

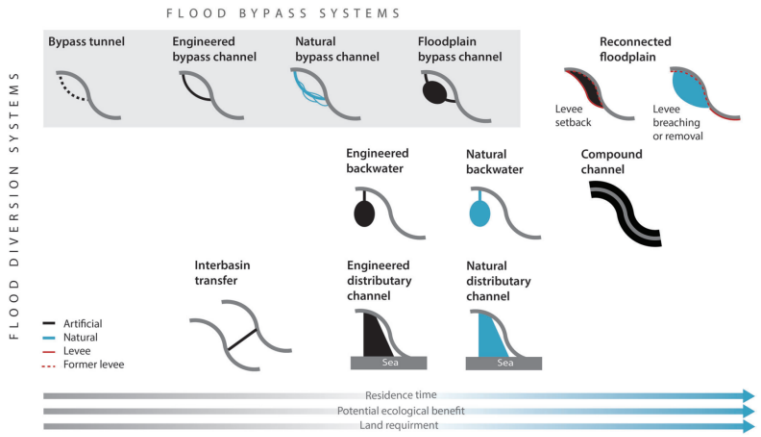
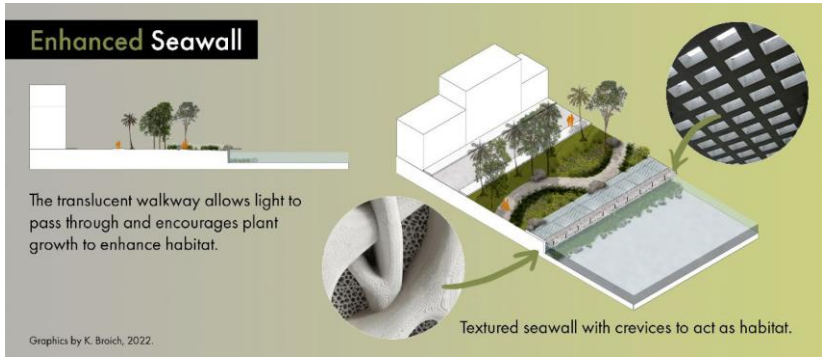
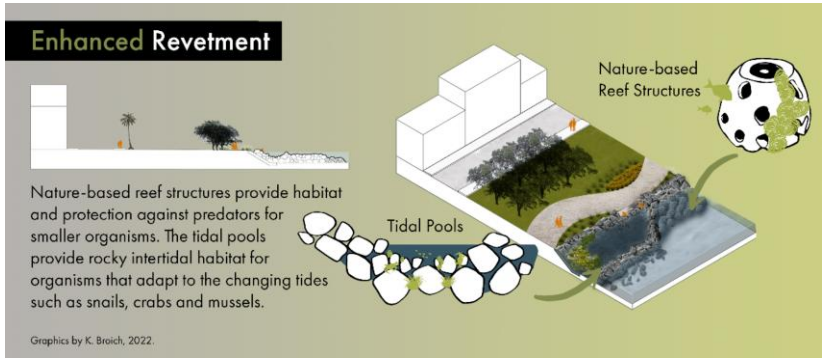


FIGURE 1 A typology of flood diversions, based on increasing residence time, potential ecological benefit and land requirements, and on whether the diverted water flows back into the mainstem downstream (a bypass), back through the main channel upon flood recession (a backwater), into another river system 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





Figures: Bridges et al. (2021), Serra-Llobet et al. (2021, WIREs Water), Dolatowski et al. (2024, ERDC TR-24-9)

Accelerating the shift #4: Embracing hybrid systems

Components

Scoping

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

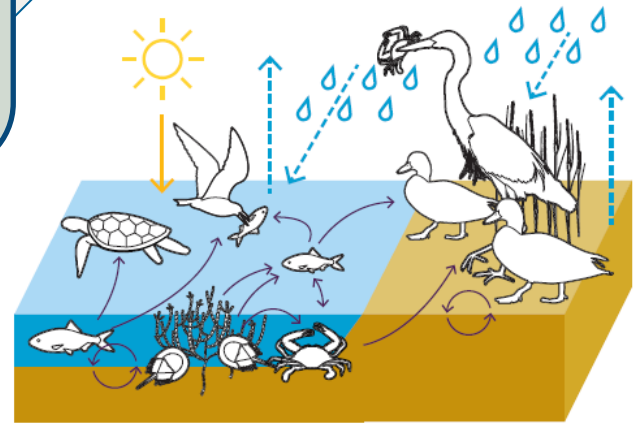
Design

- 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!

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