External Perspective:
Engineering With Nature

Dr. Todd Bridges

Senior Research Scientist & National Lead for Engineering With Nature,
USACE

Engineering With Nature: Innovating for a More Resilient and Sustainable San Francisco Bay

Dr. Todd S. Bridges
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National Lead, USACE Engineering With Nature®
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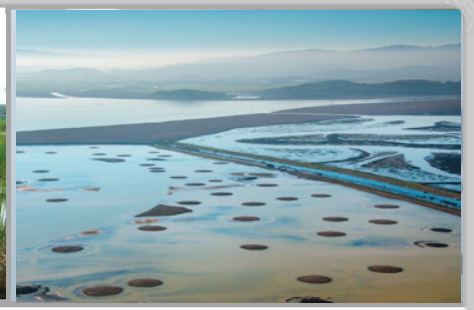
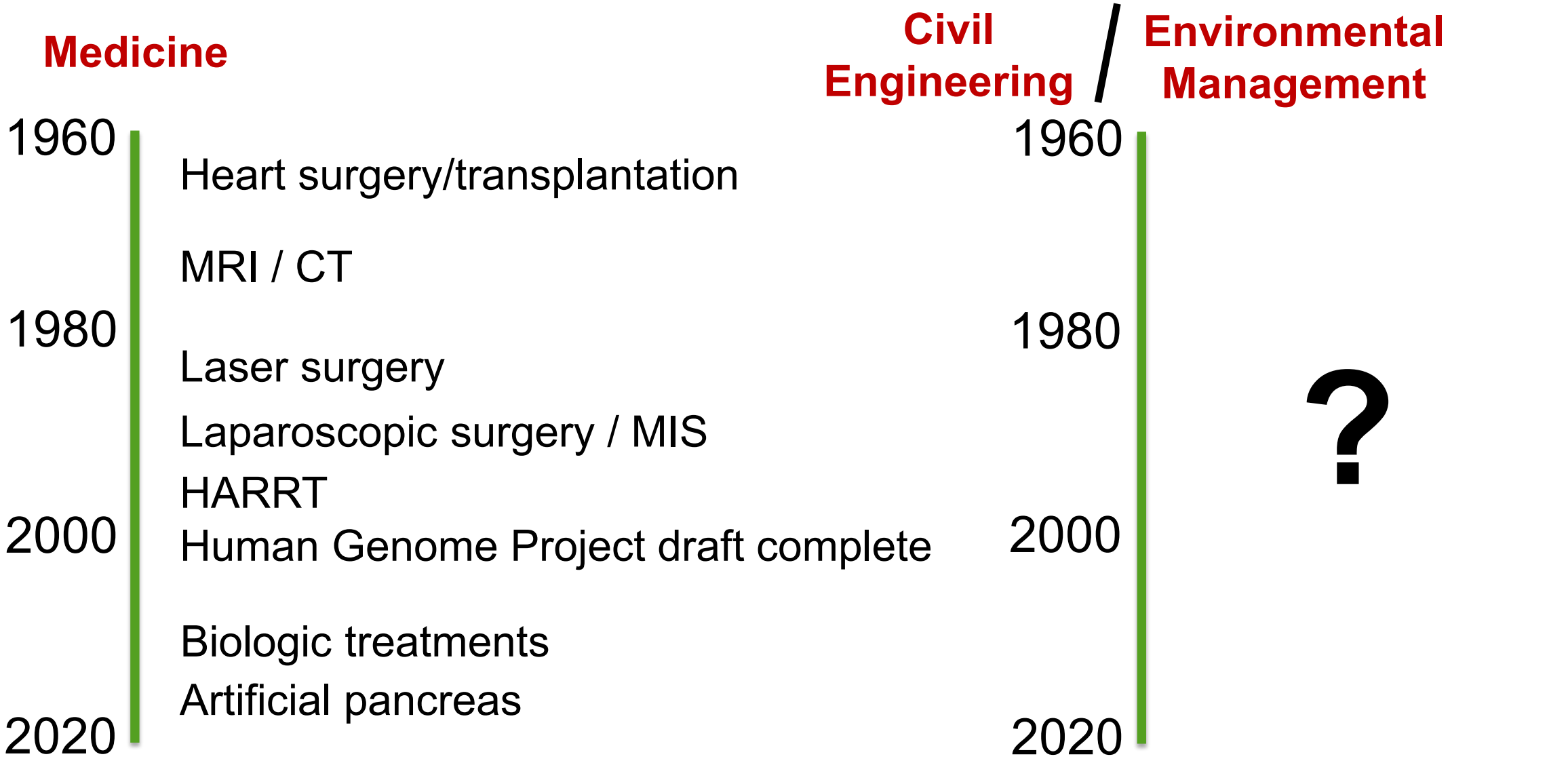
SF Bay Planning Coalition:
Dredging and Beneficial Reuse Workshop
18 October 2022



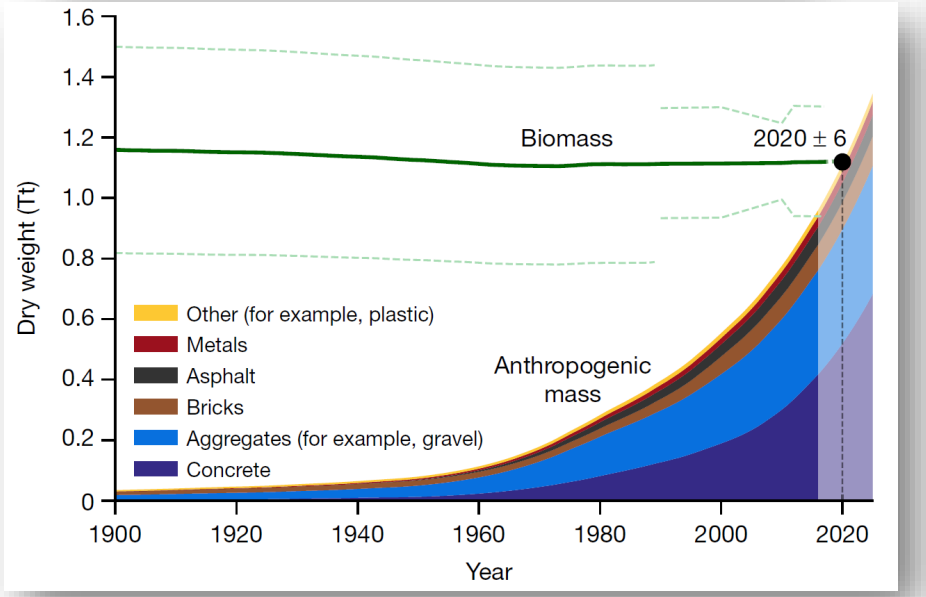
Thoughts about Innovation from Way Down Under…

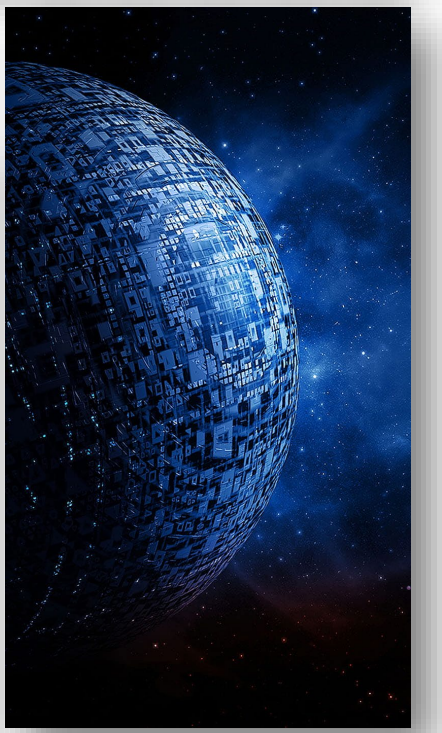
Innovation in Medicine vs. Civil / Environmental Engineering



1900-2000: The Century of Infrastructure (US)

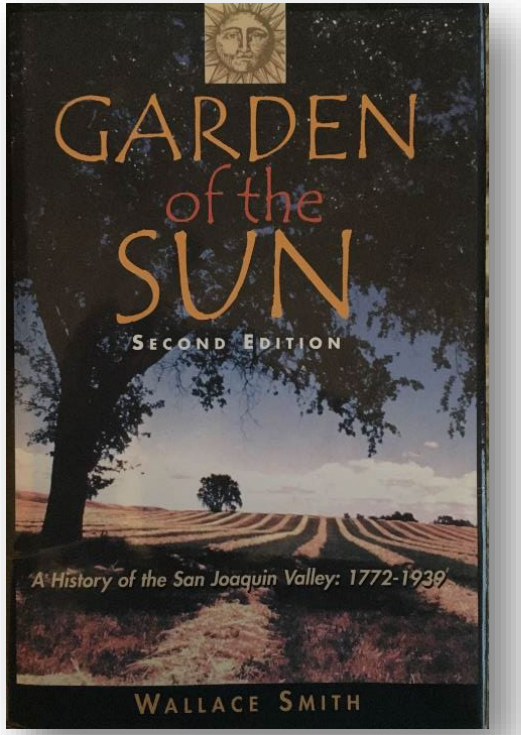
- 4,071,000 miles of roadway
  - 47,182 miles in the Interstate system
- 149,136 miles of mainline rail
- 640,000 miles of high-voltage transmission lines
- 614,387 bridges
- 90,580 dams
- >30,000 miles of flood levee
- 155,000 public drinking water systems
- ~5,000 military installations
- 926 ports, 25,000 miles of navigation channel

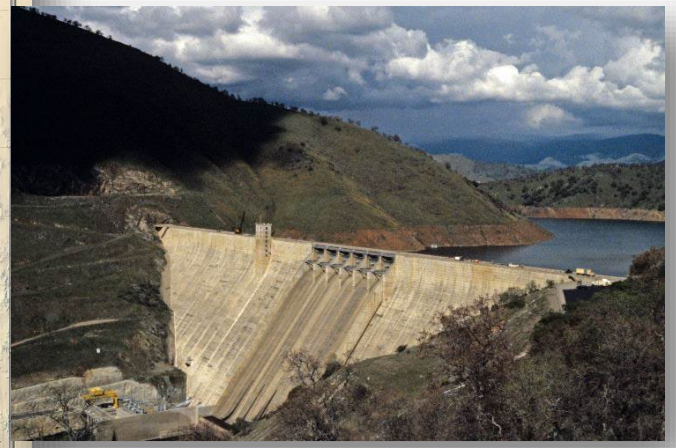




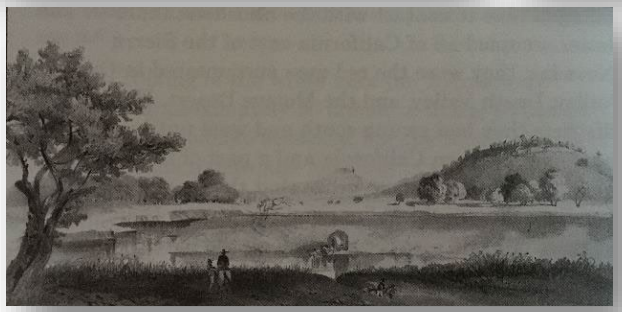
Elhacham et al. 2020. Global human-made mass exceeds all living biomass. Nature 588:442-444

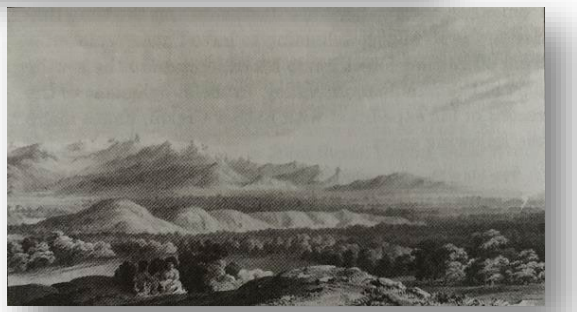
The San Joaquin Valley, California



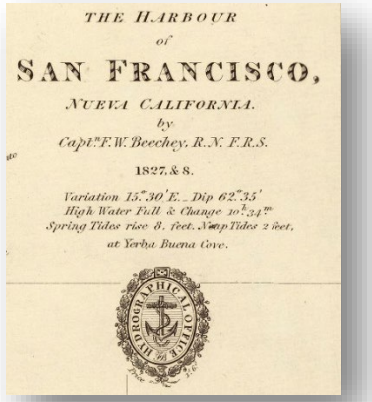



California "Satellite" Image, ca. 1851
by Mark Clark

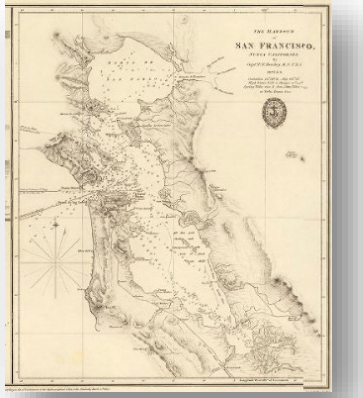


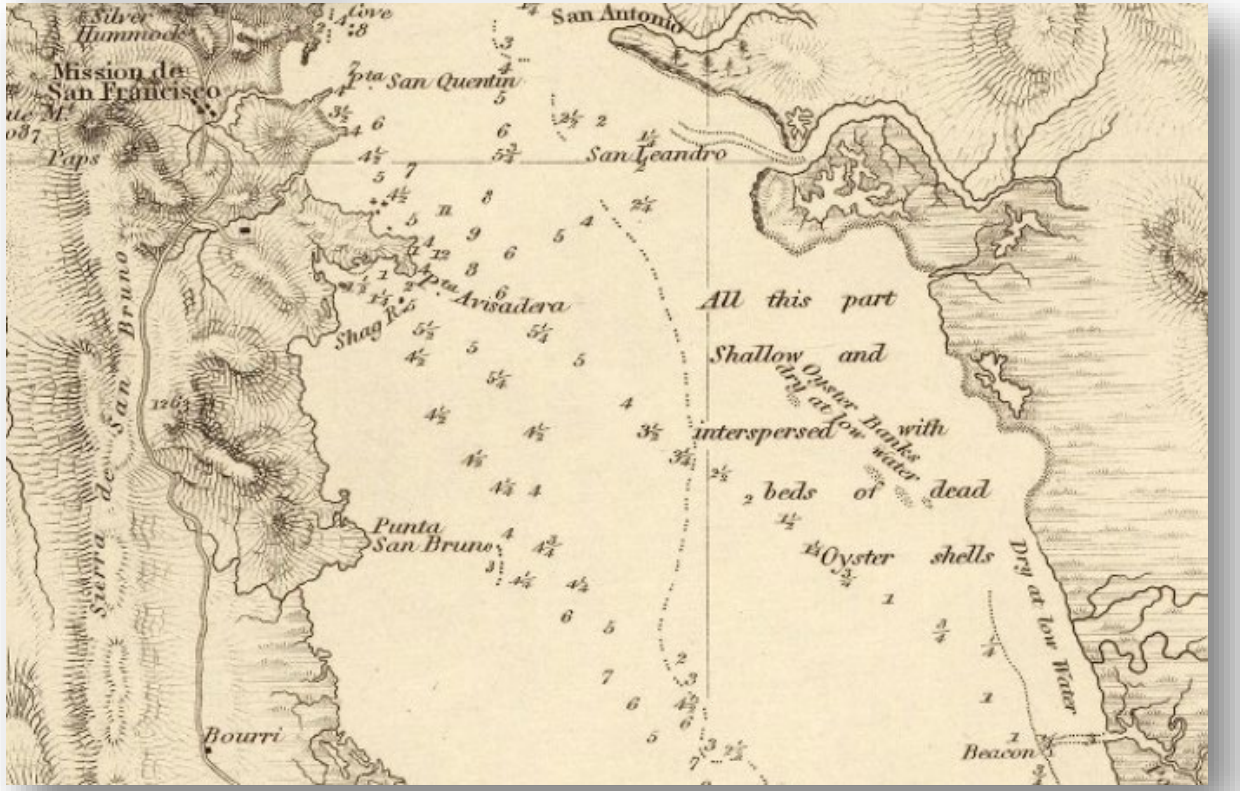


US Army Corps of Engineers • Engineer Research and Development Center

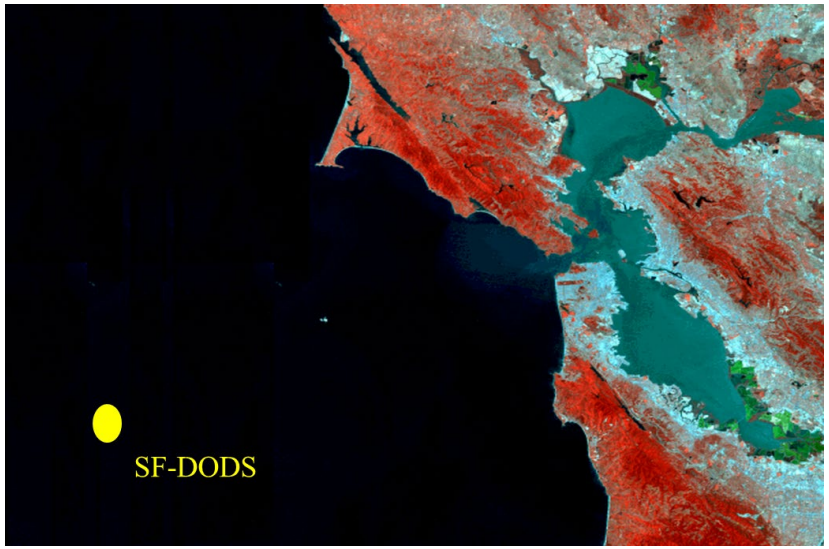

THE HARBOUR
of
SAN FRANCISCO,
NUEVA CALIFORNIA.
by
Capt.n F.W. Beechey, R.N. F.R.S.
1827. & 8.
Variation 15°.30'E. Dip 62°.35'
High Water Full & Change 10h.34m
Spring Tides rise 8. feet. Neap Tides 2 feet.
at Yerba Buena Cove.

The San Francisco Bay of 1833





San Francisco Bay



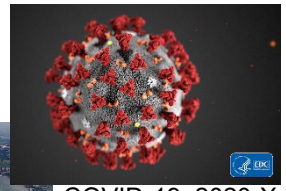
The Multi-Hazard World


Mt. Saint Helens, 1980

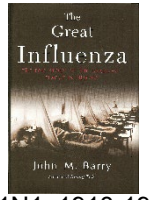

David Johnston, USGS

New Madrid Seismic Zone


San Francisco, 1906

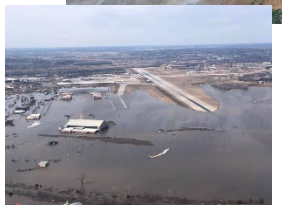

COVID-19, 2020-X

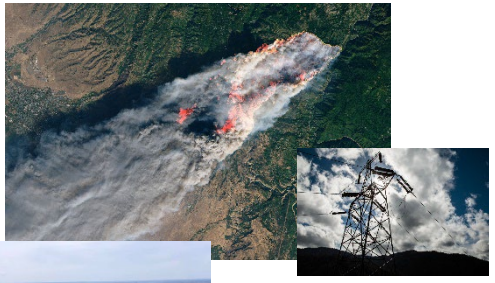

HABs, Lake Erie; 2008-2017



H1N1, 1918-1919


Dust Bowl, 1930s


Offutt AFB, 2019

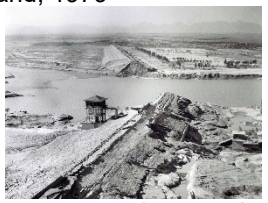

Camp Fire; CA 2018


Beirut, Lebanon; 2020


Fukushima, 2011

Three Mile Island, 1979

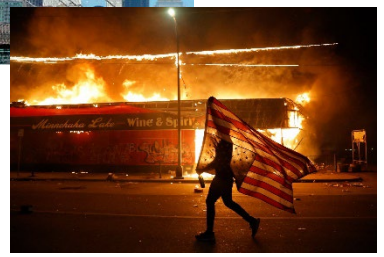

Deepwater Horizon, 2010


Banqiao dam failure; China, 1975

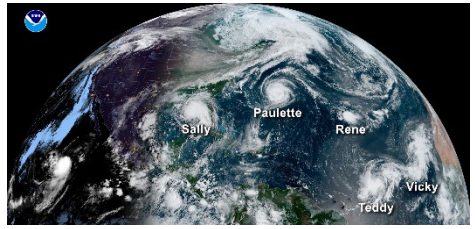

Hurricane Katrina, 2005


9/11

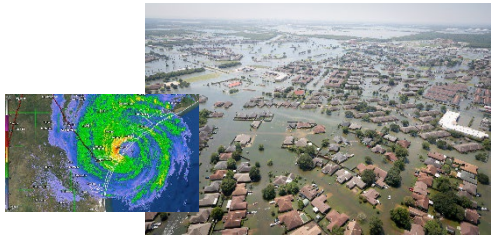
Medfly “bio-attack”; CA, 1989


Civil unrest, 2020


Flood of 1927; Tallulah, LA



2020 record-setting storm season

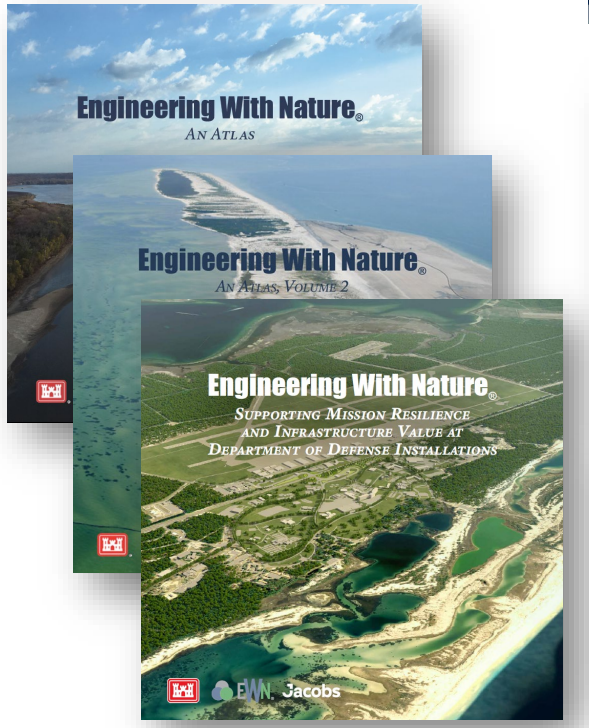

Hurricane Harvey; landfall and Houston, 2017

Engineering With Nature®

…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaboration.

Key Elements:

- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Increase and diversify infrastructure value
- Science-based collaboration to organize and focus interests, stakeholders, and partners

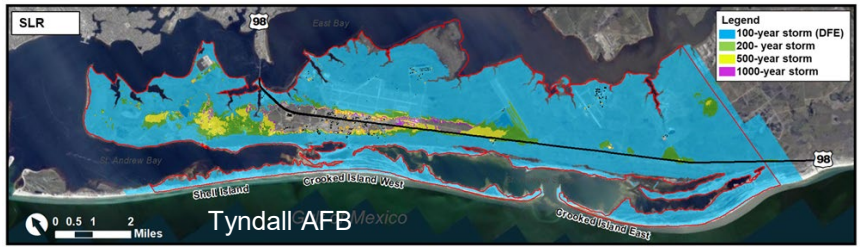


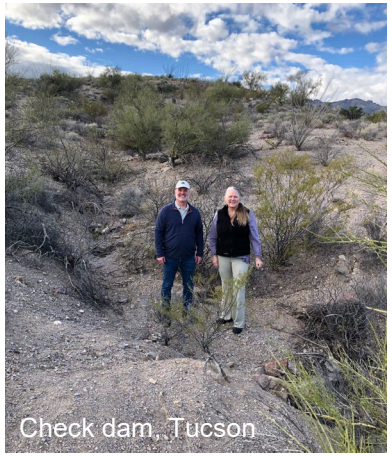
"We absolutely want to do more engineering with nature everywhere we work across the Corps, you have my commitment."

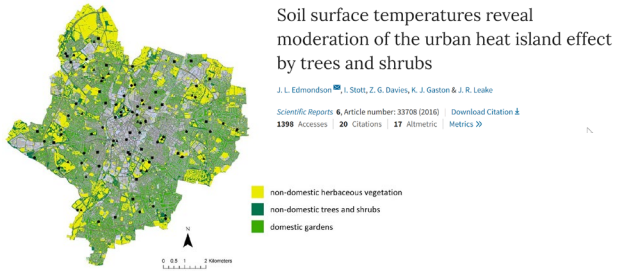
— LTG Scott A. Spellmon, 55th Chief of Engineers, to the House Committee on Transportation & Infrastructure, Water Resources & Environment Subcommittee (24 June 2021)

Nature-Based Solutions: *Conserving, restoring, and engineering nature for the benefit of people and nature*

- **Coastal Storm Risk Management**; e.g., an island-wetland complex that attenuates storm surge and waves.
- **Inland Flood Risk Management**; e.g., a restored inland floodplain that provides space for high flows.
- **Surface Heat Reduction**; e.g., creation of green space, forest restoration.
- **Drought and Wildfire Resilience**; e.g., restored native vegetation + grazing + 'slow-water' interventions + ecological forest management.
- **Water Resilience**; a constructed freshwater wetland that absorbs excess nutrients and recharges depleted groundwater aquifers.
- **Climate Change Mitigation**; e.g., restored native grasslands / plant communities that sequester carbon in soils.



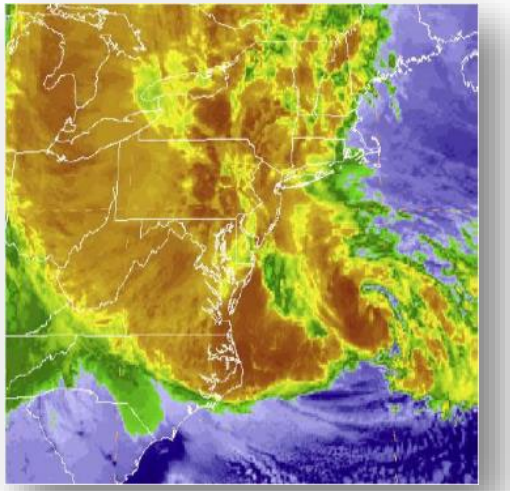




Leveraging Nature for Engineering Value: *Wetlands*

Wetland Value During Hurricane Sandy:

- Risk industry tools used to quantify the economic benefits of coastal wetlands
  - Temperate coastal wetlands averted more than $625 million in flood damages.
  - In Ocean County, New Jersey, salt marsh conservation can significantly reduce average annual flood losses by more than 20%.



COASTAL WETLANDS AND FLOOD DAMAGE REDUCTION

Using Risk Industry-based Models
to Assess Natural Defenses in the Northeastern USA

October 2016

UNIVERSITY OF CALIFORNIA SANTA CRUZ · The Nature Conservancy · Wildlife Conservation Society · LLOYD'S TERCENTENARY RESEARCH FOUNDATION

Engineering With Nature: *USACE Proving Grounds*

- Galveston District
- Buffalo District
- Philadelphia District
- Mobile District
- San Francisco District
- St. Louis District
- South Pacific Division






"Natural Infrastructure" in the *Infrastructure Investment and Jobs Act 2021*

- Billions invested in nature-based solutions
- 17+ references to "natural infrastructure" in the bill
- USACE: ~$17B in appropriations, including:
  - $2.5B for CSRM, $1B for multi-purpose
  - $2.5B for inland FRM, $750M for multi-purpose
- DOT, surface transportation NI
- DOE, hydropower and FRM NI
- BoR, Western Water Infrastructure NI
- Other supporting investments with NRCS, FEMA, NOAA, EPA, USFWS, Bureau Indian Affairs

Nature-Based Solutions: A White House Priority

2022 Earth Day EO

BRIEFING ROOM

Executive Order on Strengthening the Nation's Forests, Communities, and Local Economies

APRIL 22, 2022 • PRESIDENTIAL ACTIONS

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

WHITE HOUSE ROUNDTABLE – "KNOWLEDGE IN NATURE: HOW NATURE CAN HELP GROW A BETTER FUTURE"

BRIEFING ROOM

Executive Order on Tackling the Climate Crisis at Home and Abroad

JANUARY 27, 2021 • PRESIDENTIAL ACTIONS

America the Beautiful 30x30

Justice40 Initiative

Sec. 4. Deploying Nature-Based Solutions to Tackle Climate Change and Enhance Resilience:
"To further amplify the power of nature, including its ability to absorb climate pollution and increase resilience in all communities, today's Executive Order calls for the following:"

1) ***Report on Nature-Based Solutions***
2) ***Guidance on Valuing Nature***
3) ***First U.S. National Nature Assessment***

- A Call to Action -

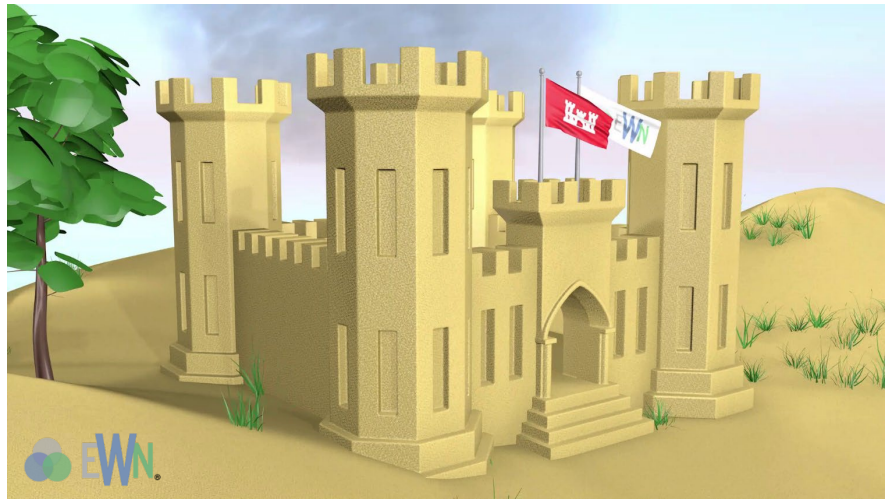
An Imperative for the 21st Century:

100% Beneficial Use of Dredged Sediment

Beneficial Use Innovation: ***There's something for everyone to do!***

- **Government Agencies Doing Dredging:** Doing business differently
- **Ports / Navigation Sector:** Multi-purpose projects
- **Regulatory Agencies:** Efficiently pursuing win-wins
- **Dredging / Engineering Companies:** Innovative engineering and operations
- **Environmental NGOs:** Facilitating P3s

The Key: Affordability, Affordability, Affordability



Beneficial Use: *Status and Opportunities*

"Beneficial use" is using dredged sediment to achieve additional benefits beyond its removal from a channel/waterway, including other economic, environmental or social benefits.

- USACE has a long track record of BU
  - ~30% of dredged material beneficially used over last 20 years (60 out of 200 mcy/yr)
    - >1.5 billion cy used in beach construction over last 100 years
    - 25,000 acres of wetlands created in south Louisiana since 1970s
- BU supports:
  - Climate change adaptation thru *Engineering With Nature*®
  - Habitat for fish and wildlife
    - Tribal equities, Threatened and Endangered Species
  - Social value to enhance resilience of communities and vulnerable/underserved populations
- BU challenges:
  - Budget constraints
  - Federal policies/regulations/business practices
  - State policies/regulations/business practices


Horseshoe Bend, Atchafalaya, LA

Middle Harbor, Port of Oakland, CA


Hamilton Wetlands, San Francisco Bay, CA


Galveston Bay, TX


Cat Island, Green Bay, WI


Thin-Layer Placement for Wetlands, Avalon, NJ

The "Federal Standard" and WRDA Section 125

Federal standard **means the dredged material disposal alternative or alternatives identified by the Corps which represent the least costly alternatives consistent with sound engineering practices and meeting the environmental standards established by the 404(b)(1) evaluation process or ocean dumping criteria. 33 CFR 335.7**

WRDA 2020, SEC. 125: BENEFICIAL USE OF DREDGED MATERIAL

- **It is the policy of the United States for the Corps of Engineers to maximize the beneficial use, in an environmentally acceptable manner, of suitable dredged material…**
- **the Secretary shall consider—(i) the suitability of the dredged material for a full range of beneficial uses; and (ii) the economic and environmental benefits, efficiencies, and impacts...**
- **The economic benefits and efficiencies from the beneficial use of dredged material considered by the Secretary under subparagraph (A) shall be included in any determination relating to the "Federal standard"…**

Applying the Full Range of Beneficial Use

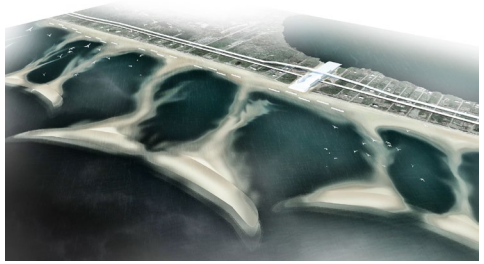
Sediment “Recharge” via Dredging

Direct Wetland “Nourishment”

Wetland Creation

Island Enhancement or Restoration

Engineering / Operational Effort



Strategic Placement

Thin-Layer Placement for Bottom Contouring

Beach and Dune Construction

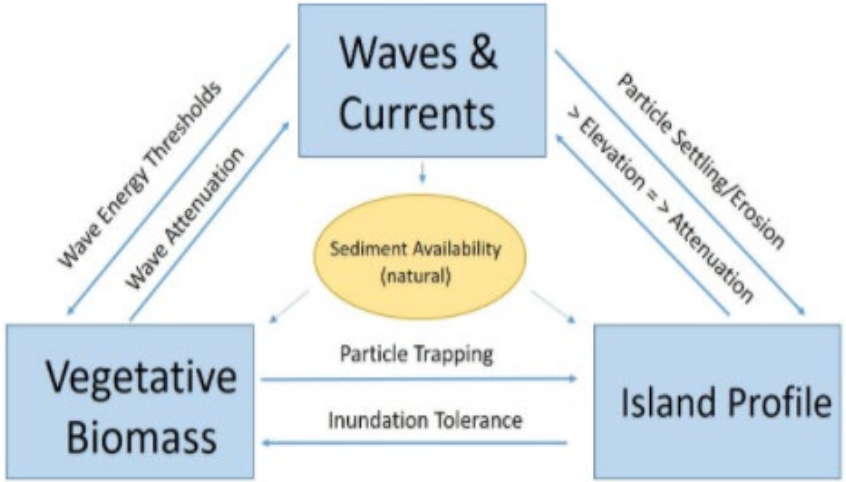
New Island Construction

Barrier Island: Deer Island, Biloxi, MS

- Biloxi Harbor Navigation Project – 3.65 m (12 ft) deep navigation channel
- Sediment beneficial use 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
- 1.5 mcm dredged material to restore southern shoreline using 4 km long wave barrier
- Strategic vegetation plantings (625,000+ plants)
- Construction of a 0.76 mcm lagoon for BU dredged material from navigation channels
- Providing significant environmental, coastal storm, and recreational benefits

Empowering Partnership: *Swan Island*

Engineering With Nature



US Army Corps of Engineers®

NOAA

U.S. FISH & WILDLIFE SERVICE

UNIVERSITY OF MARYLAND

MARYLAND DEPARTMENT OF NATURAL RESOURCES

UNIVERSITY OF GEORGIA

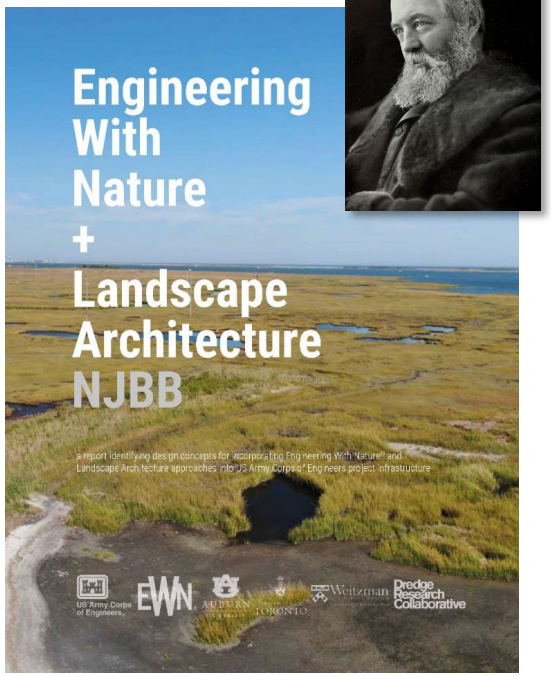
EA Engineering, Science, and Technology, Inc.

https://coastalscience.noaa.gov/project/evaluating-efficacy-of-island-restoration-and-enhancement-for-coastal-protection/

Facilitating Field Implementation: *SMIIL*

Seven Mile Island Innovation Laboratory

- Collaboration and partnership that is building first-of-their-kind NBS projects in coastal New Jersey
  - Began in conversation
  - Accelerated by a storm (Sandy)
  - Progressed through piloting
  - Now in full-scale implementation



US Army Corps of Engineers

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

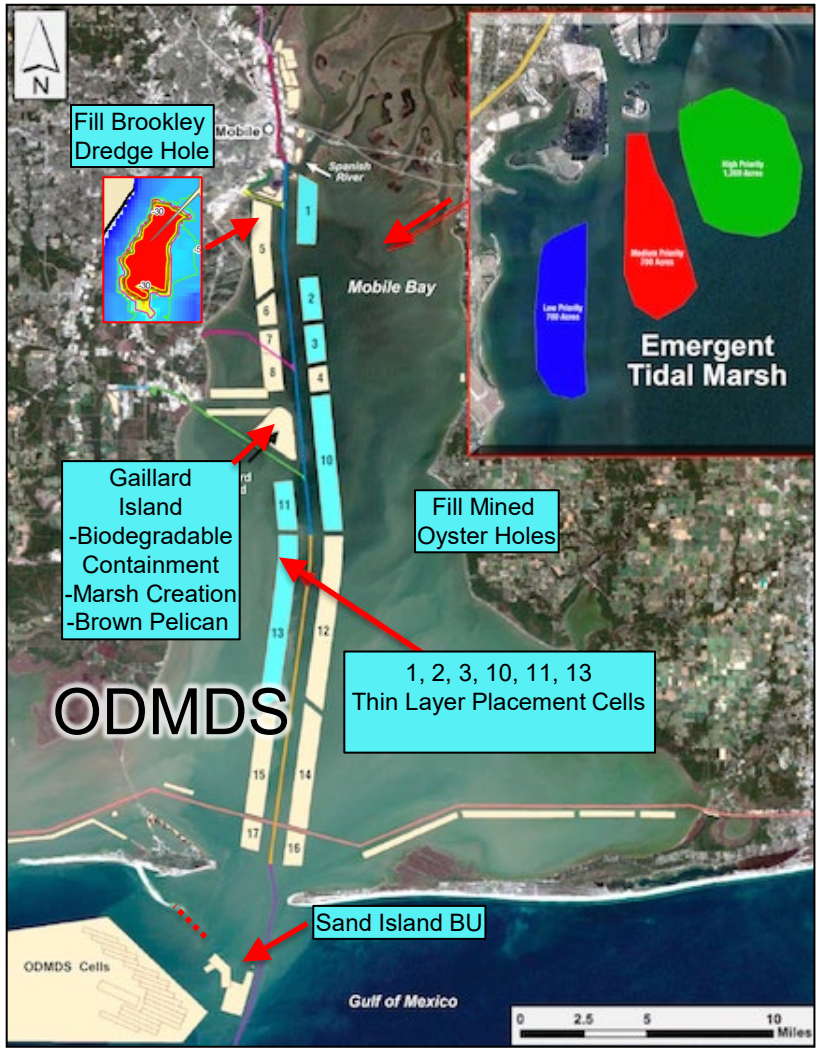
NOAA

The Nature Conservancy
Protecting nature. Preserving life.

NEW JERSEY DIVISION OF Fish and Wildlife

Wetlands INSTITUTE

Mobile Bay: *Innovation thru Science-Informed Collaboration*



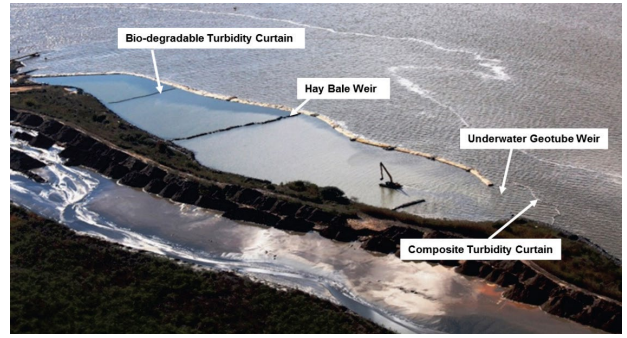
The Problem: *WRDA86*

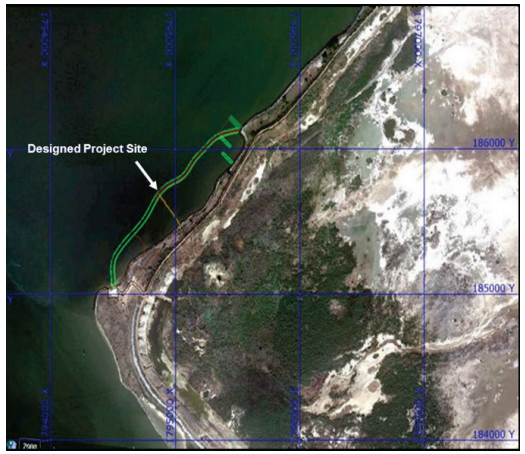
Place <u>all</u> dredged sediments in ODMDS

- 4.0 mcy/yr, hopper dredge, 20+miles
- Tripled maintenance costs

The Solution: *2014, decision reversed*

- EWN approaches and demonstration
- RSM Interagency Work Group





The Benefits: *$12M reduced operational costs + more BU!*

Thin Layer Placement in Mobile Bay Sand Island Beneficial Use Area (SIBUA)

-Downdrift benefits to Dauphin Island

-Protect lighthouse

Fill dredge holes

-Brookley Hole, Oyster Holes

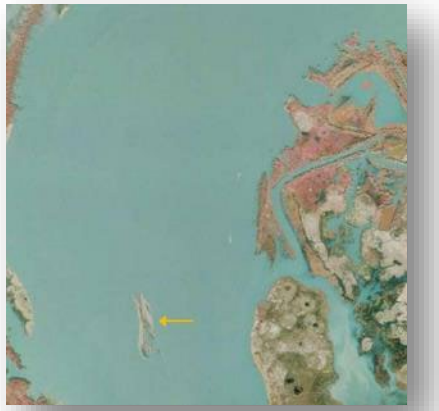
Gaillard Island

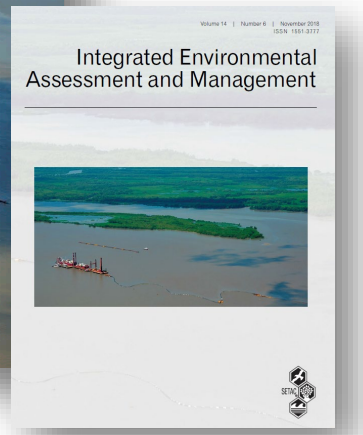
- Marsh Creation, biodegradable containment, Brown Pelican

Future in-Bay placement:

-TLP for 1000-acre emergent marsh

Documenting NBS Benefits: Horseshoe Bend Island, Atchafalaya River, Louisiana, USA





Quantifying Wildlife and Navigation Benefits of a Dredging Beneficial-Use Project in the Lower Atchafalaya River: A Demonstration of Engineering with Nature®

Christy M Foran,† Kelly A Burks-Copes,‡ Jacob Berkowitz,‡ Jeffrey Corbino,§ and Burton C Suedel‡*

Project Awards:

- 2015 Western Dredging Association Award for Environmental Excellence
- 2017 Western Dredging Association Award for Climate Change Adaption
- 2017 Dredging and Port Construction Award for Engineering with Nature
- 2020 USACE Green Innovation Award

Evaluating Benefits: BCA Policy Research

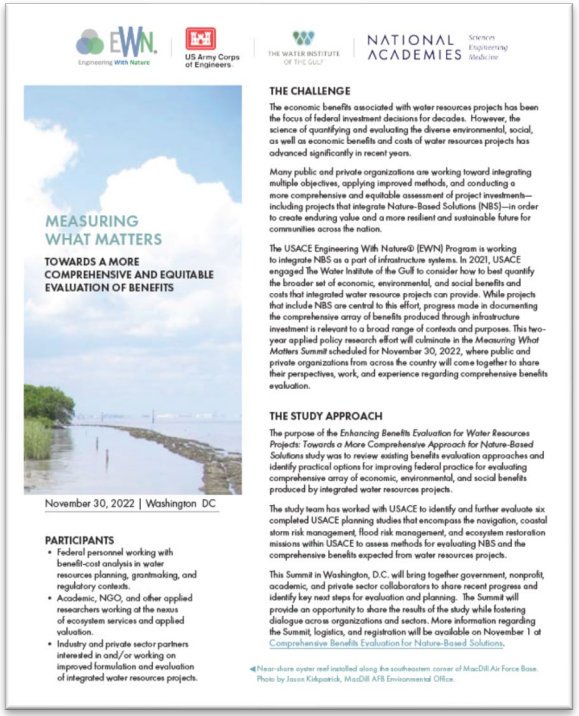
Current federal alternative evaluation process does not comprehensively value economic, environmental, and social benefits. These constraints screen out or exclude Nature-Based Solutions (NBS) and could lead to outcomes inconsistent with the Administration's priorities around community resilience and equity.

THE WATER INSTITUTE OF THE GULF

Approach:

- **Summarize** historical and current alternative evaluation policies and practices
- **Identify** 6 historical planning studies that considered NBS alternatives suitable for case study analysis
    1. *Jacksonville Harbor (NAV, South East)*
    2. *Jamaica Bay Reformulation (CSRM, North East)*
    3. *Southwest Coastal (CSRM, Gulf Coast)*
    4. *South Platte River and Tributaries (FRM, North West)*
    5. *West Sacramento (FRM, Pacific)*
    6. *South San Francisco Bay Shoreline (FRM, Pacific)*
- **Review** updated valuation methods and planning frameworks that incorporate environmental and social benefits
- **Analyze** case studies using updated methods and exploratory analysis to look beyond current policy constraints

https://ewn.erdc.dren.mil/?p=7841


MEASURING WHAT MATTERS

TOWARDS A MORE COMPREHENSIVE AND EQUITABLE EVALUATION OF BENEFITS

November 30, 2022 | Washington DC

PARTICIPANTS

THE CHALLENGE

THE STUDY APPROACH

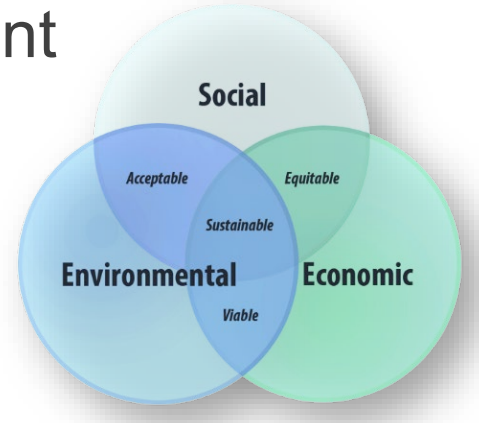
National Summit: *Measuring What Matters November 30, 2022; Washington D.C.*

Sustainability: *Sustainability is achieved by efficiently investing resources to create present and future value*

The National Environmental Policy Act (1969): “create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.”

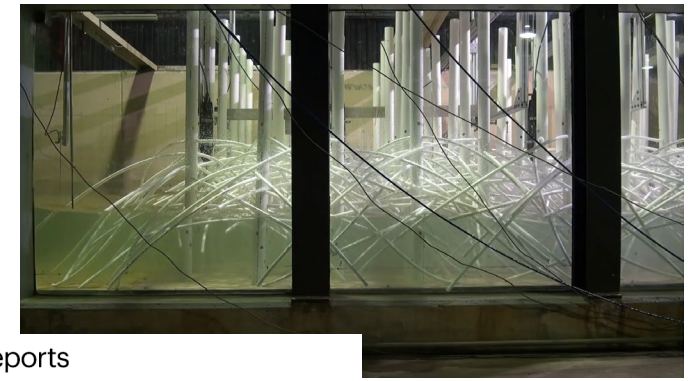
What value and for whom?

- Economic development
- Natural capital
- Biodiversity
- Human well-being
- Social equity
- Etc.

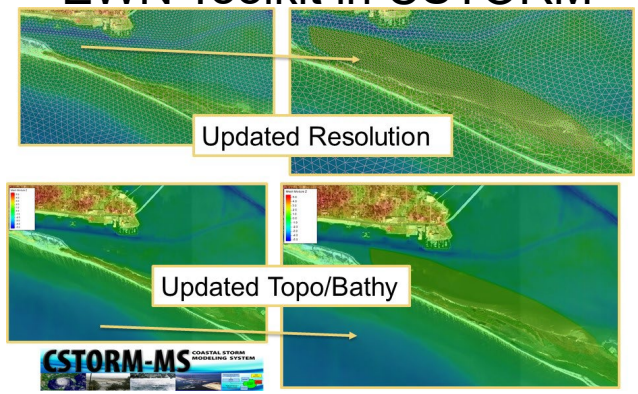


The Science of Nature-Based Solutions: *Using Multiple Lines-of-Evidence*

- Physical Modeling
- Numerical Modeling
- Natural Analogs
- Scaled Demonstration
- Experience
  - Project Monitoring
  - Traditional Ecological Knowledge
  - Engineering Judgment



EWN Toolkit in CSTORM



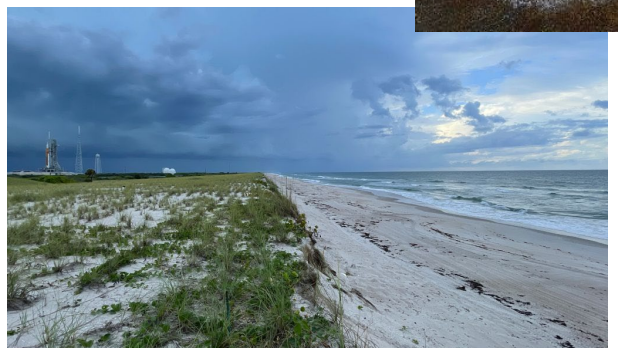
scientific reports

OPEN

Resistance, resilience, and recovery of salt marshes in the Florida Panhandle following Hurricane Michael

Katherine A. Castagno[1,2], Tori Tomiczek[3], Christine C. Shepard[4], Michael W. Beck[5], Alison A. Bowden[2], Kiera O'Donnell[1] & Steven B. Scyphers[1]

Characterizing the fragility, resistance, and resilience of marshes is critical for understanding their role in reducing storm damages and for helping to manage the recovery of these natural defenses. This study uses high-resolution aerial imagery to quantify the impacts of Hurricane Michael, a category 5 hurricane, on coastal salt marshes in the Florida Panhandle, USA. Marsh damage was classified into several categories, including deposition of sediment or wrack, fallen trees, vegetation loss, and conversion to open water. The marshes were highly resistant to storm damages even under extreme conditions; only 2% of the 173,259 km² of marshes in the study area were damaged—a failure rate much lower than that of artificial defenses. Marshes may be more resistant than resilient to storm impacts; damaged marshes were slow to recover, and only 16% of damaged marshes had recovered 6 months after landfall. Marsh management mattered for resistance and resilience; marshes on publicly-managed lands were less likely to be damaged and more likely to recover quickly from storm impacts than marshes on private land, emphasizing the need to incentivize marsh management on private lands. These results directly inform policy and practice for hazard mitigation, disaster recovery, adaptation, and conservation, particularly given the potential for more intense hurricane landfalls as the climate changes.



Huamantanga, Peru. People use and maintain 1,400-year-old amunas, canals. Credit: Diego Pérez/Forest Trends

Developing Guidance: *International Guidelines on Natural and Nature-Based Features for Flood Risk Management*

NNBF Guidelines Table of Contents

- Chapter 1. Introduction
- Chapter 2. Principles, Frameworks, and Outcomes
- Chapter 3. Community Engagement
- Chapter 4. Systems Approach
- Chapter 5. Performance
- Chapter 6. Benefits and Costs of NNBF
- Chapter 7. Adaptive Management
- Chapter 8. Introduction to Coastal Systems
- Chapter 9. Beaches and Dunes
- Chapter 10. Coastal Wetlands and Intertidal Areas
- Chapter 11. Islands
- Chapter 12. Reefs
- Chapter 13. Plant Systems
- Chapter 14. Environmental Enhancements
- Chapter 15. Introduction to Fluvial Systems
- Chapter 16. Fluvial Systems and Flood Risk Management
- Chapter 17. Benefits and Challenges of NNBF in Fluvial Systems
- Chapter 18. Fluvial NNBF
- Chapter 19. Fluvial NNBF Case Studies
- Chapter 20. The Way Forward

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

www.engineeringwithnature.org

NNBF Guidelines

- >1,000 pages, 5-year effort
- >70 multi-sector organizations
- >170 authors and contributors

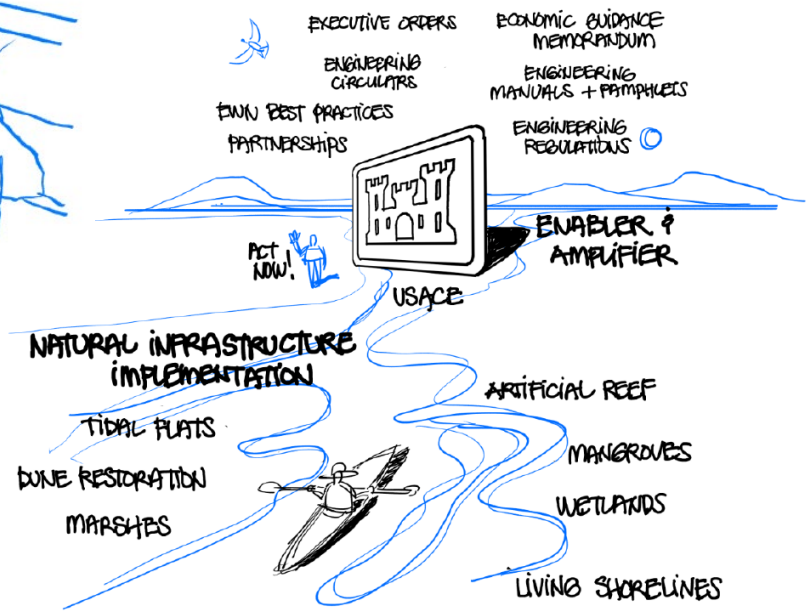
Winner, Environment Agency Flood & Coast International Excellence Award, 2022

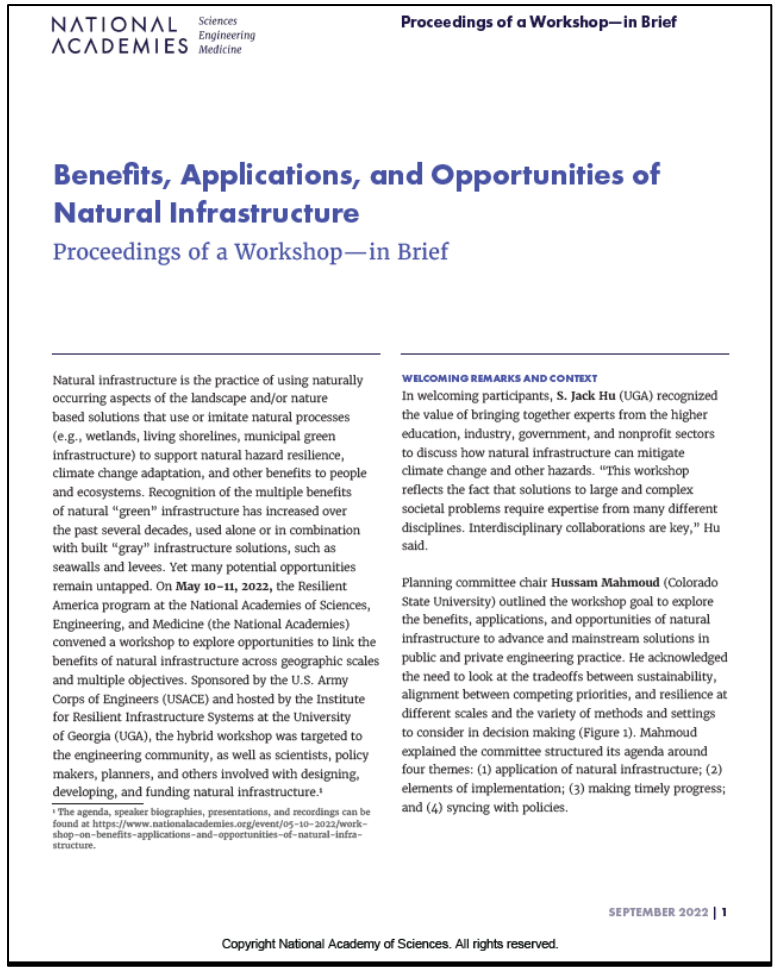
"The guidelines do not contain or represent the policy commitments or policy positions of the organizations that participated in their development. Policy development is the sole purview of each organization and the laws and procedures that govern their activities." Pages xi-xii.

National Academy of Engineering Workshop:

Workshop on Benefits, Applications, and Opportunities of Natural Infrastructure

May 10-11, 2022





NATIONAL ACADEMIES Sciences Engineering Medicine

Proceedings of a Workshop—in Brief

Benefits, Applications, and Opportunities of Natural Infrastructure

Proceedings of a Workshop—in Brief

Natural infrastructure is the practice of using naturally occurring aspects of the landscape and/or nature based solutions that use or imitate natural processes (e.g., wetlands, living shorelines, municipal green infrastructure) to support natural hazard resilience, climate change adaptation, and other benefits to people and ecosystems. Recognition of the multiple benefits of natural "green" infrastructure has increased over the past several decades, used alone or in combination with built "gray" infrastructure solutions, such as seawalls and levees. Yet many potential opportunities remain untapped. On **May 10–11, 2022,** the Resilient America program at the National Academies of Sciences, Engineering, and Medicine (the National Academies) convened a workshop to explore opportunities to link the benefits of natural infrastructure across geographic scales and multiple objectives. Sponsored by the U.S. Army Corps of Engineers (USACE) and hosted by the Institute for Resilient Infrastructure Systems at the University of Georgia (UGA), the hybrid workshop was targeted to the engineering community, as well as scientists, policy makers, planners, and others involved with designing, developing, and funding natural infrastructure.[1]

[1] The agenda, speaker biographies, presentations, and recordings can be found at https://www.nationalacademies.org/event/05-10-2022/workshop-on-benefits-applications-and-opportunities-of-natural-infrastructure.

WELCOMING REMARKS AND CONTEXT

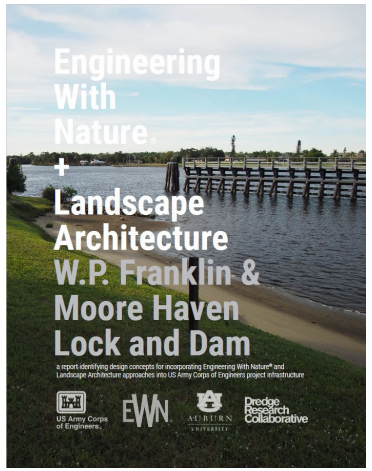
In welcoming participants, **S. Jack Hu** (UGA) recognized the value of bringing together experts from the higher education, industry, government, and nonprofit sectors to discuss how natural infrastructure can mitigate climate change and other hazards. "This workshop reflects the fact that solutions to large and complex societal problems require expertise from many different disciplines. Interdisciplinary collaborations are key," Hu said.

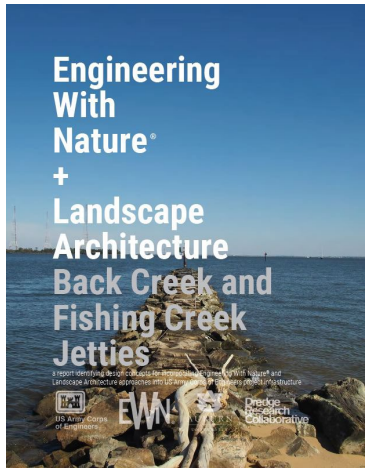
Planning committee chair **Hussam Mahmoud** (Colorado State University) outlined the workshop goal to explore the benefits, applications, and opportunities of natural infrastructure to advance and mainstream solutions in public and private engineering practice. He acknowledged the need to look at the tradeoffs between sustainability, alignment between competing priorities, and resilience at different scales and the variety of methods and settings to consider in decision making (Figure 1). Mahmoud explained the committee structured its agenda around four themes: (1) application of natural infrastructure; (2) elements of implementation; (3) making timely progress; and (4) syncing with policies.

SEPTEMBER 2022 | 1

https://www.nationalacademies.org/event/05-10-2022/workshop-on-benefits-applications-and-opportunities-of-natural-infrastructure#sectionEventMaterials

Designing for Nature-Based Solutions



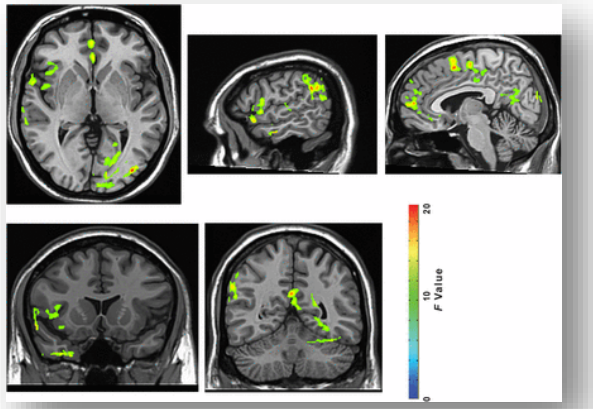


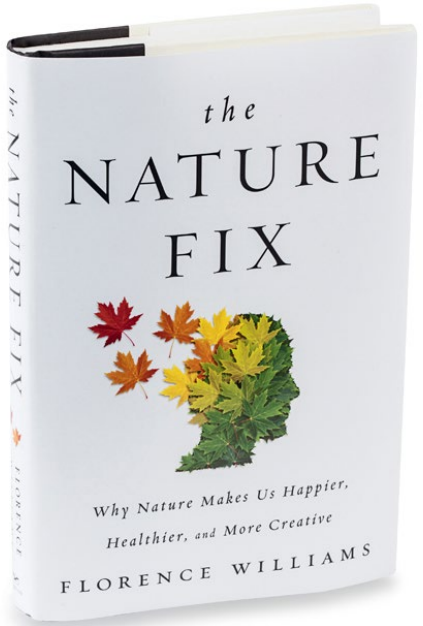
https://ewn.erdc.dren.mil/?page_id=81

US Army Corps of Engineers • Engineer Research and Development Center

Supporting People and Communities

- **Science says that nature directly supports human wellbeing!**
  - **Physical health**
    - **Blood pressure**
    - **Healing**
    - **Immunity**
    - **Etc.**
  - **Mental health**
    - **Cognitive function**
    - **Anxiety**
    - **Depression**
    - **Socialization**
    - **Etc.**





Nature experience reduces rumination and subgenual prefrontal cortex activation

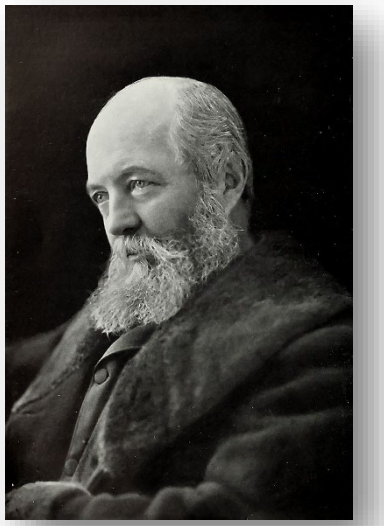
Gregory N. Bratman, J. Paul Hamilton, Kevin S. Hahn, Gretchen C. Daily, and James J. Gross

PNAS July 14, 2015 112 (28) 8567-8572; first published June 29, 2015 https://doi.org/10.1073/pnas.1510459112

scientific reports

Urban street tree biodiversity and antidepressant prescriptions

Melissa R. Marselle[1,2,3]✉, Diana E. Bowler[1,2,4], Jan Watzema[1,2], David Eichenberg[1,2,5], Toralf Kirsten[6,7] & Aletta Bonn[1,2,4]

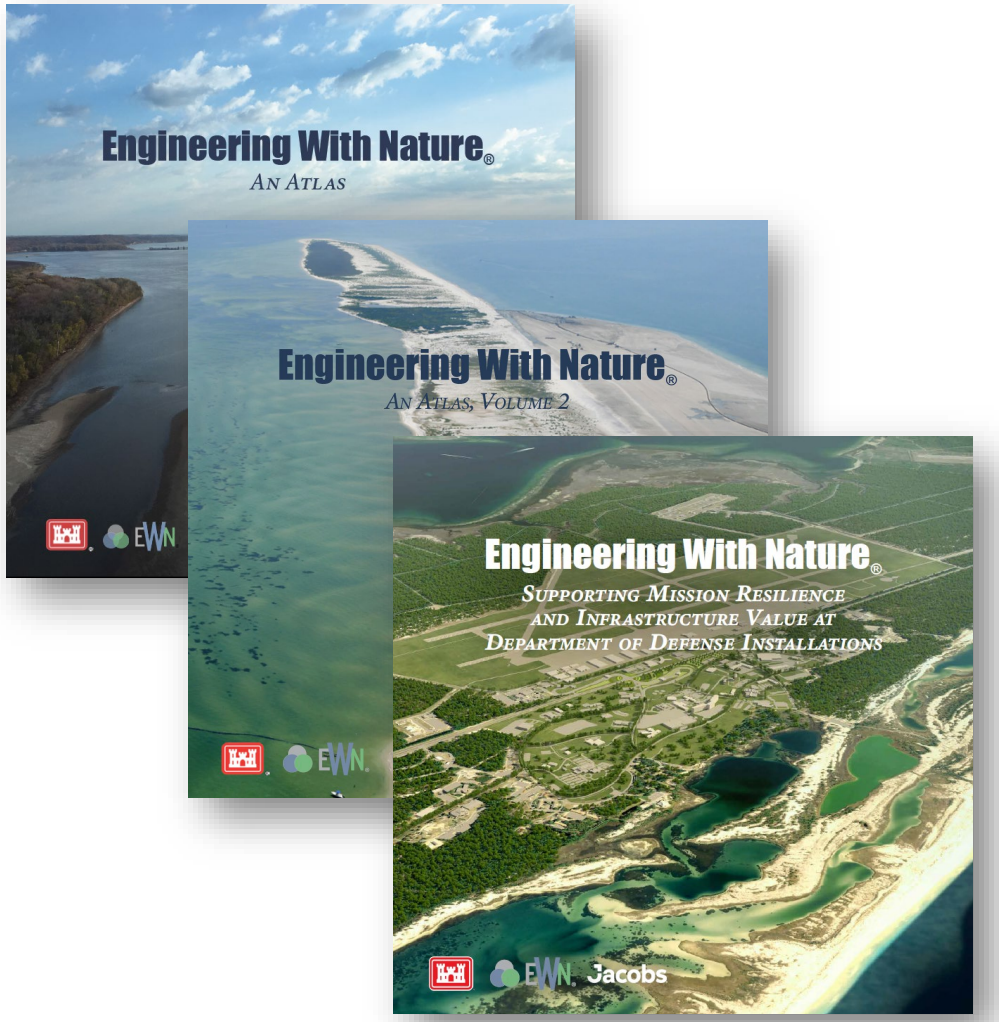


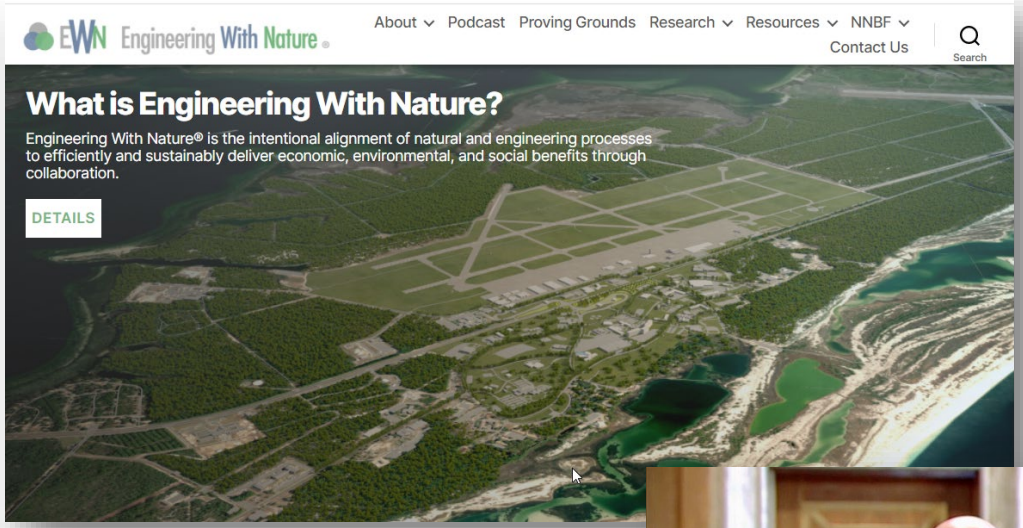
"It is a scientific fact that the occasional contemplation of natural scenes... is favorable to the health and vigor of men…" **Frederick Law Olmsted (1822-1903)**

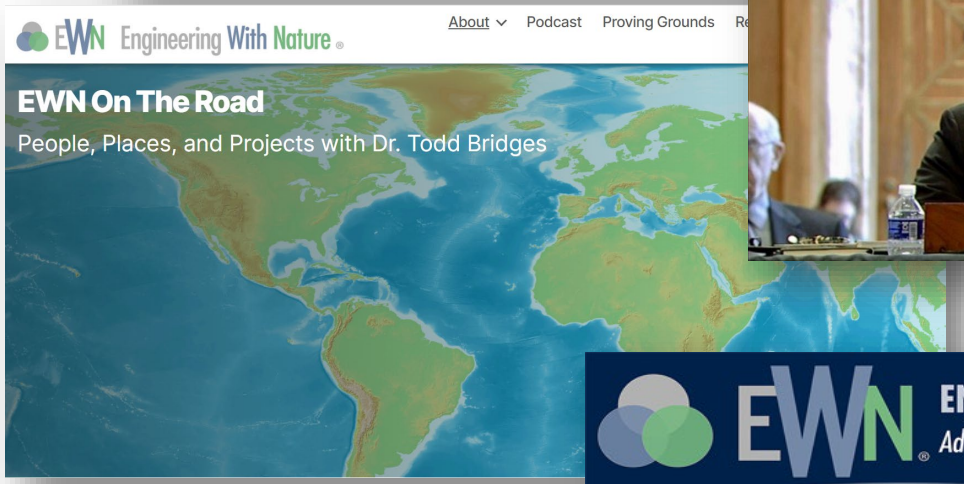
“Revolutionizing” Practice Through Nature-Based Solutions

- Policy development
  - Engagement with policymakers
  - Policy/procedure “modernization”
- Engagement, partnering, and teaming
  - Within USACE, e.g., EWN Proving Grounds
  - With other organizations inside and outside government
- Innovation
  - Creating a vision of the future
  - Establishing goals, targets and conditions
  - New science and engineering and tools for delivery
- On-the-ground projects and demos
  - Across the spectrum of applications and project development (i.e., from planning to operations)
  - Scaling up nature-based solutions
- Strategic communications
  - Individual research papers
  - Communication tools, e.g., EWN Atlas Vol 1 and 2
  - Education, e.g., academic curricula, training
  - Good Storytelling

Sparking Conversation, Thinking, and New Ideas







https://ewn.erdc.dren.mil/?p=3586

www.engineeringwithnature.org

The Evolution of Laparoscopy and the Revolution in Surgery in the Decade of the 1990s, William E. Kelly, MD, SLS President 2008

JSLS Journal of the Society of Laparoendoscopic Surgeons

"The changes in surgical endoscopy leading up to 1988 were, in fact, gradual and evolutionary. For any major change or progress to take place, many factors must fall into place. In the case of laparoscopy, dramatic technical innovations were required. Additionally, there is a season for any change, requiring a favorable and supportive philosophical environment. Authoritative institutions must be convinced of the safety and efficacy of the changes relative to the comfortable status quo. Momentum always favors inertia. Fears must be overcome: fear of making mistakes, fear of failure, fear of established procedures becoming obsolete, and fear of established authorities losing control. Successful change requires timing and a force more powerful than the status quo. The strongest force for sustainable change is a worthy goal."