



U.S. ARMY

Engineering With Nature for Sustainable and Resilient Infrastructure

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CMANC
18 May 2022



US Army Corps
of Engineers



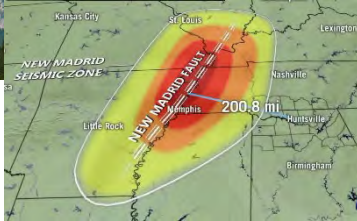
The Multi-Hazard World



Mt. Saint Helens, 1980



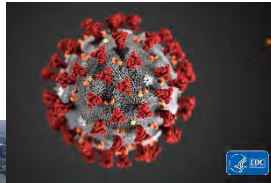
David Johnston, USGS



New Madrid Seismic Zone



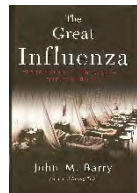
San Francisco, 1906



COVID-19, 2020-X



HABs, Lake Erie; 2008-2017



H1N1, 1918-1919



Dust Bowl, 1930s



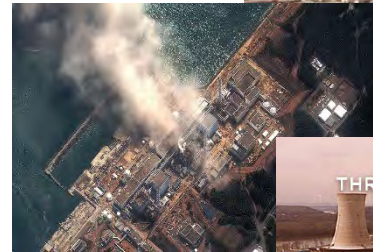
Camp Fire; CA 2018



Offutt AFB, 2019



Beirut, Lebanon; 2020



Fukushima, 2011



Three Mile Island, 1979



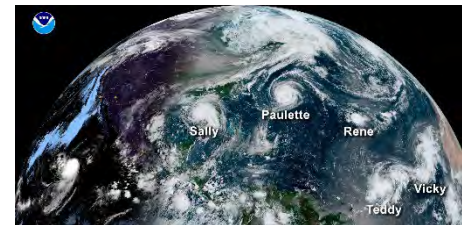
Deepwater Horizon, 2010



Banqiao dam failure; China, 1975



Hurricane Katrina, 2005



2020 record-setting storm season



9/11

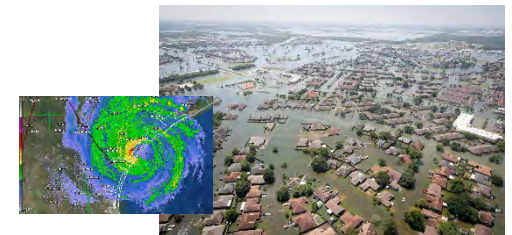


Civil unrest, 2020

Medfly "bio-attack"; CA, 1989

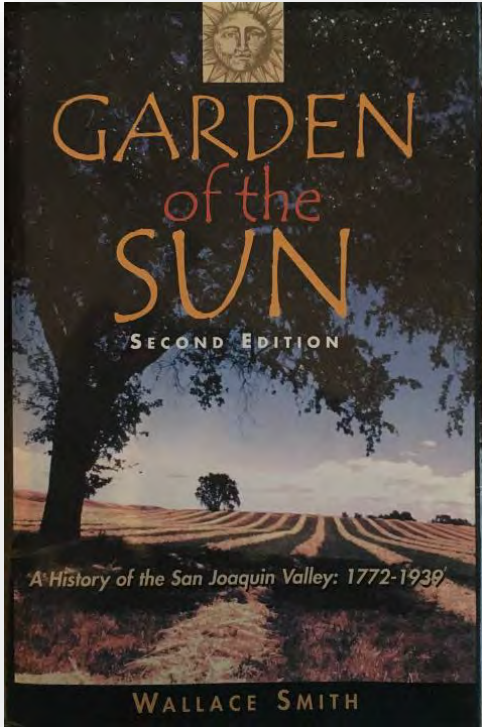


Flood of 1927; Tallulah, LA



Hurricane Harvey; landfall and Houston, 2017

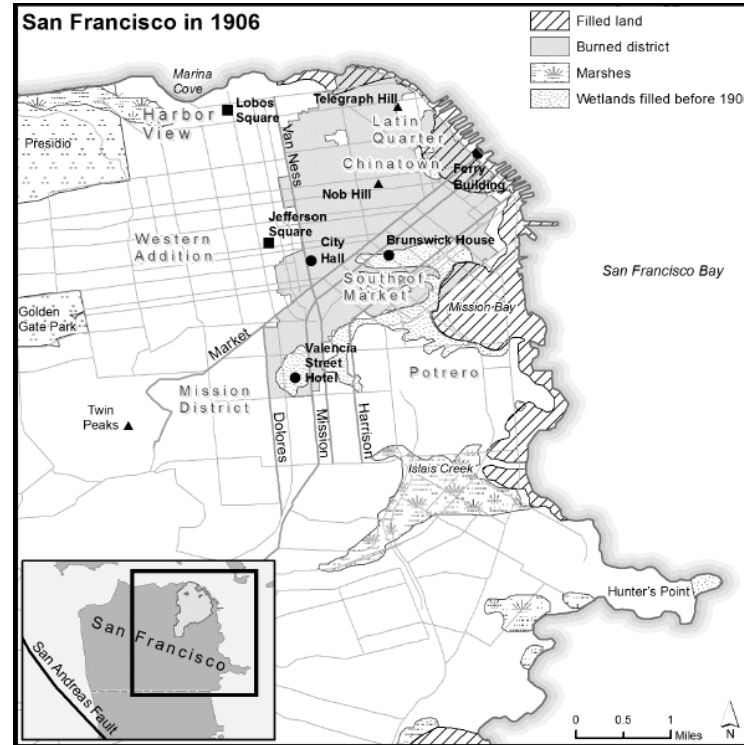
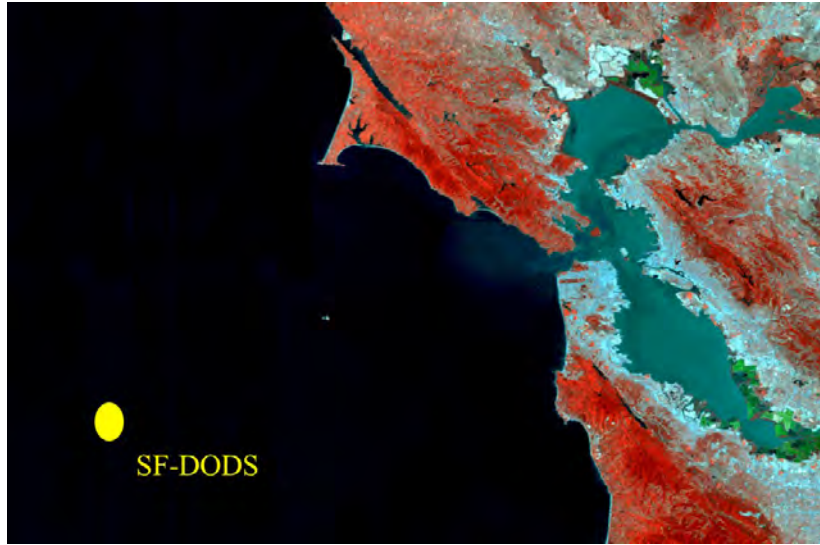
The San Joaquin Valley, California



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

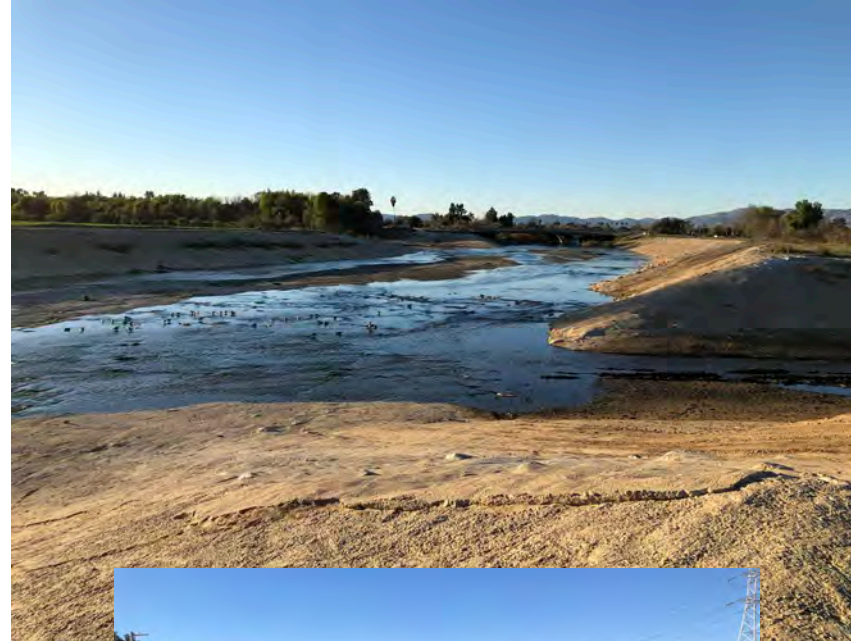


San Francisco Bay



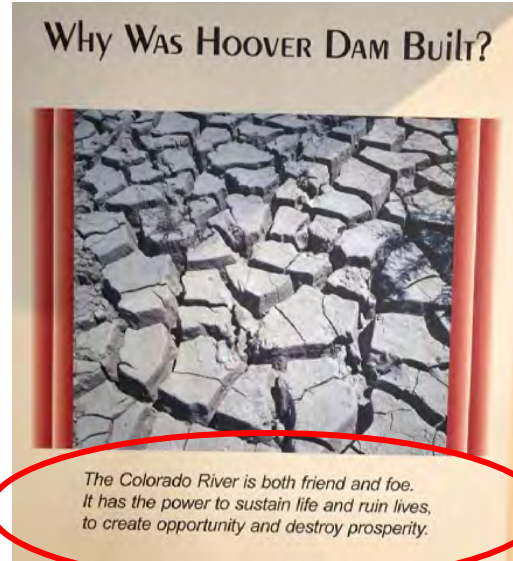
US Army Corps of Engineers • Engineer Research and Development Center

The LA “River”



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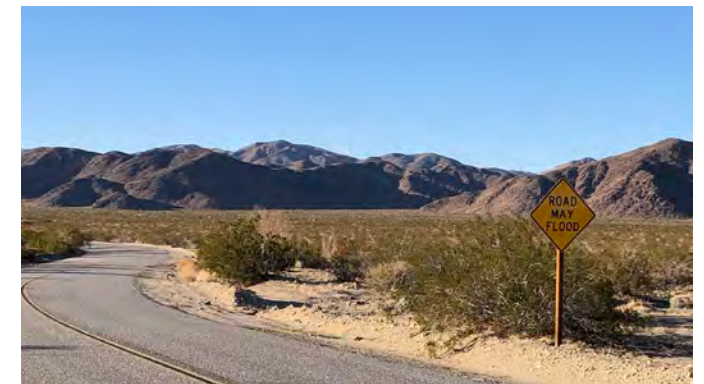
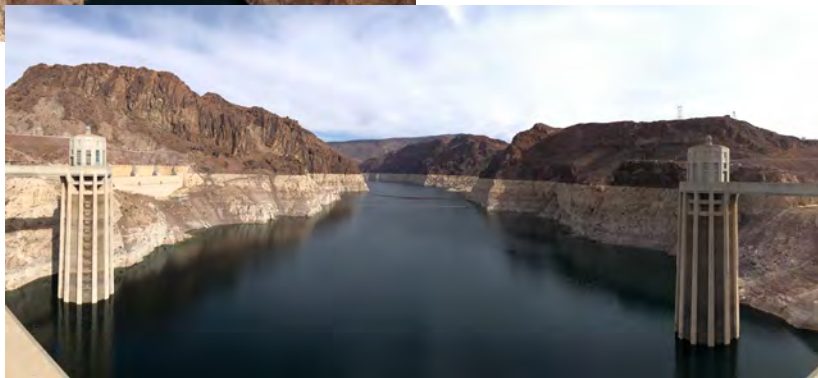
The West's Climate Change Conundrum



Rapid intensification of the emerging southwestern North American megadrought in 2020-2021

A. Park Williams^{1,2}, Benjamin I. Cook^{2,3} and Jason E. Smerdon²

A previous reconstruction back to 800 CE indicated that the 2000-2018 soil moisture deficit in southwestern North America was exceeded during one megadrought in the late-1500s. Here, we show that after exceptional drought severity in 2021, ~19% of which is attributable to anthropogenic climate trends, 2000-2021 was the driest 22-yr period since at least 800. This drought will very likely persist through 2022, matching the duration of the late-1500s megadrought.

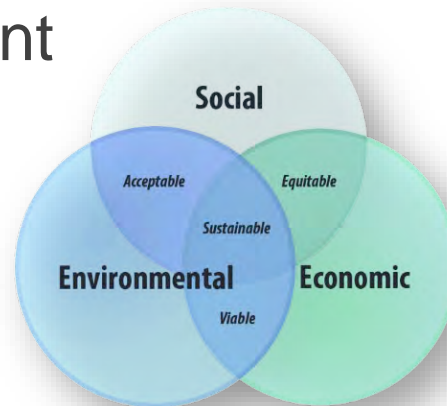


Sustainability: *Sustainability is achieved by efficiently investing resources to create present and future value*

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.



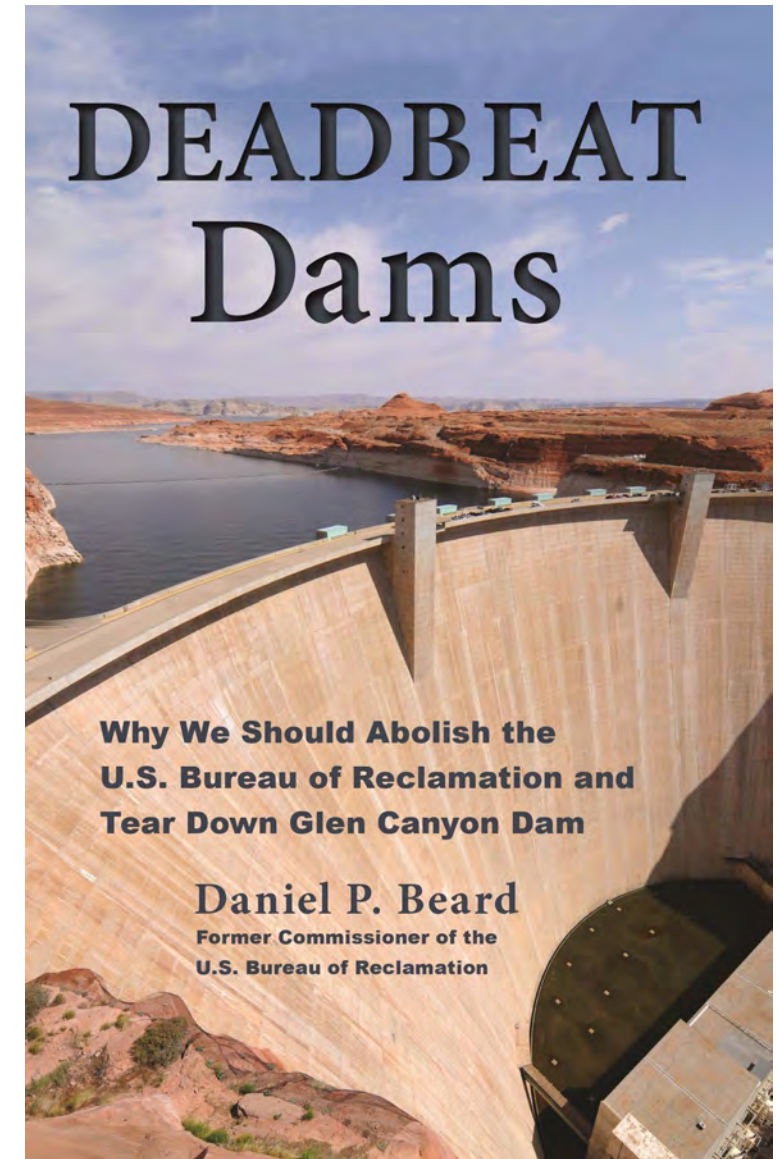
The Need for Innovation

“The unwillingness to change and be innovative has been a sad characteristic of water professionals for decades... We are innovative and creative people, except when it comes to water.”

“We have little history of innovation, little history of experimentation. We run out the same old solutions year after year, decade after decade. We don’t experiment; we don’t test the limits.”

“If there’s a flood, how do our experts propose to handle the problem? Their first response is to build a levee to protect the populated areas”

“If we want more water to supply future needs, what’s the approach suggested by our experts and politicians? Build a dam and reservoir.”



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.”

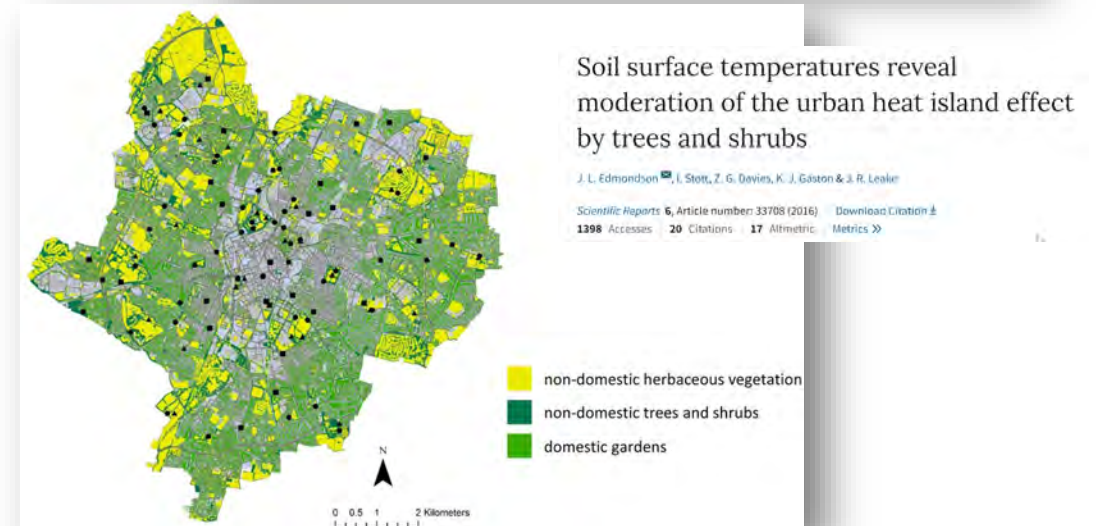
— LTG Scott A. Spellmon, 55th Chief of Engineers, to the House Committee on Transportation & Infrastructure, Water Resources & Environment Subcommittee (24 June 2021)

Nature-Based Solutions:

Conserving, restoring, and engineering nature for the benefit of people and nature

An Example: Trees as Infrastructure!


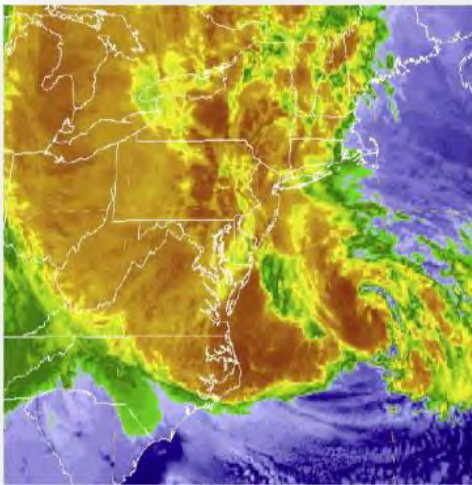
- Shaded surfaces can be 20-45°F cooler
- Evapotranspiration plus shading can reduce peak summer temperatures by 2-9°F
- Reducing wind speed and winter heat loss from buildings by 10-50%
- Improve local air quality
- Increase water infiltration, reducing surface water run-off



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**

Yolo Bypass And Its Sources



The Yolo Bypass, California (1911)



Groundwater Recharge: *Gilbert Riparian Preserve*



US Army Corps of Engineers • Engineer Research and Development Center

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

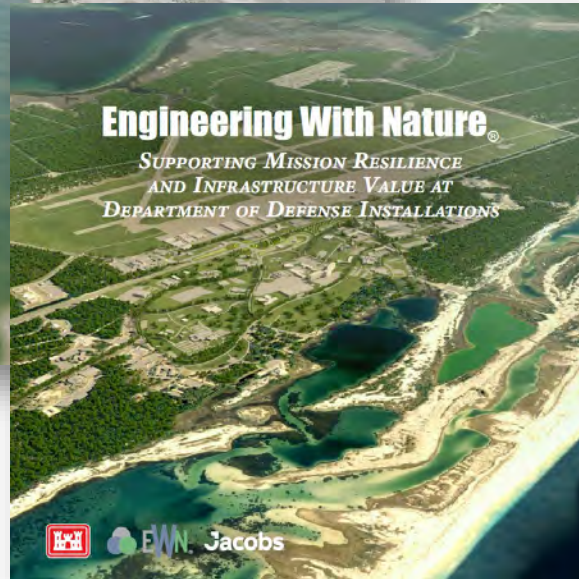
***America the Beautiful
30x30***

Justice40 Initiative

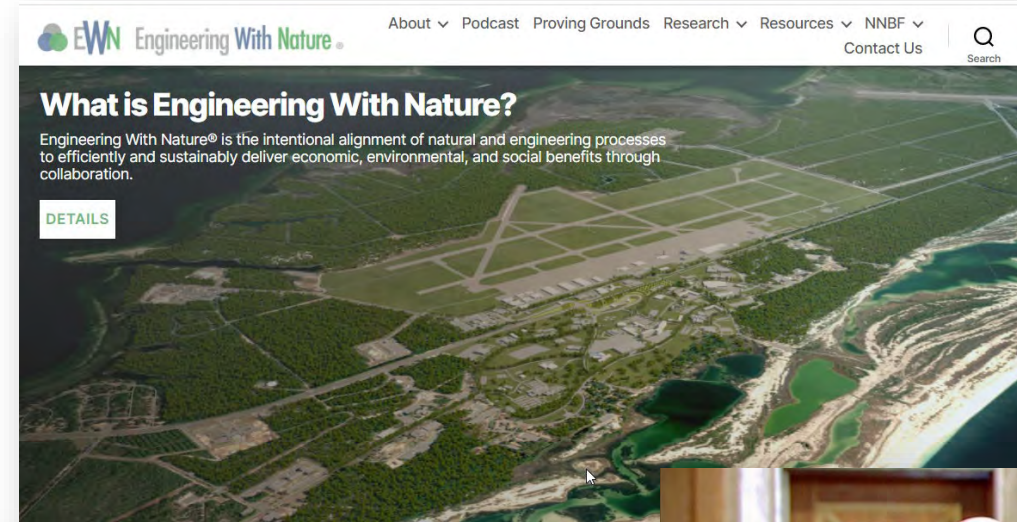
***Sec. 4. Deploying Nature-Based Solutions to Tackle Climate Change and Enhance Resilience:
“To further amplify the power of nature, including its ability to absorb climate pollution and increase resilience in all communities, today’s Executive Order calls for the following:”***

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

Sparking Conversation, Thinking, and New Ideas



www.engineeringwithnature.org

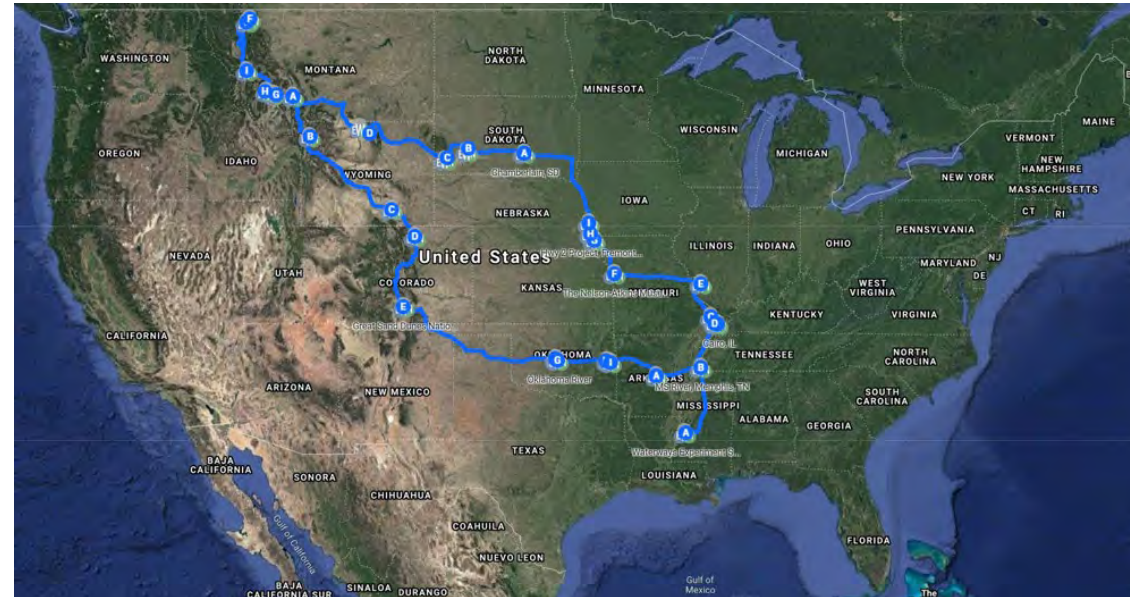


<https://ewn.erdcdren.mil/?p=3586>



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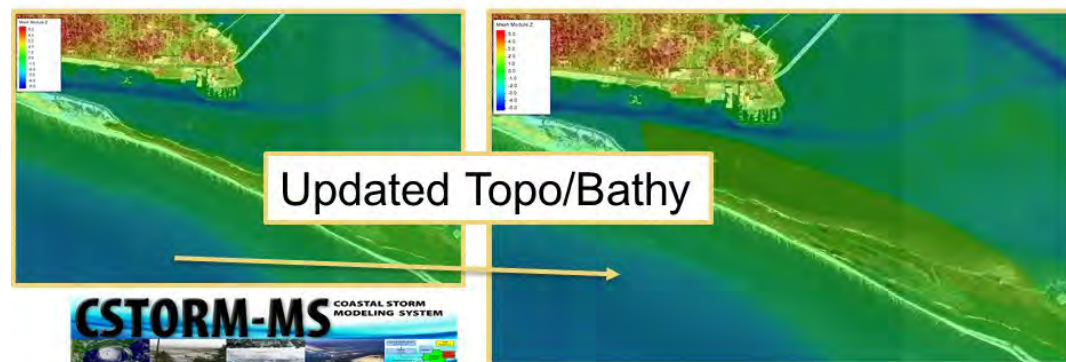
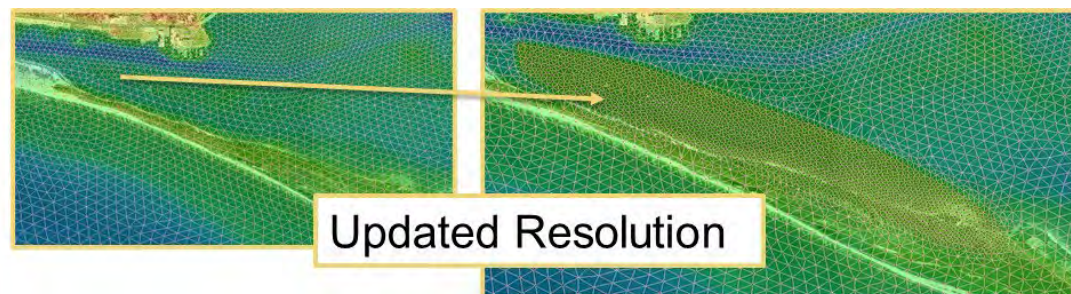
EWN On the Road: *The Heartland Tour* 5,500 miles



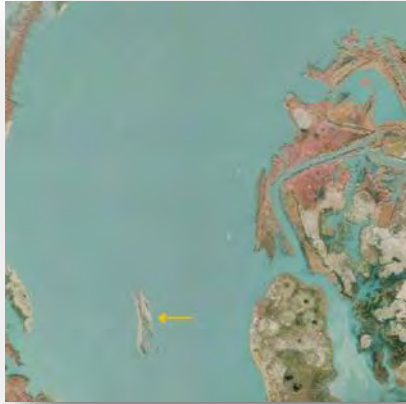
Advancing Technical Tools

Numerical and Physical Modeling

EWN Toolkit for CSTORM



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



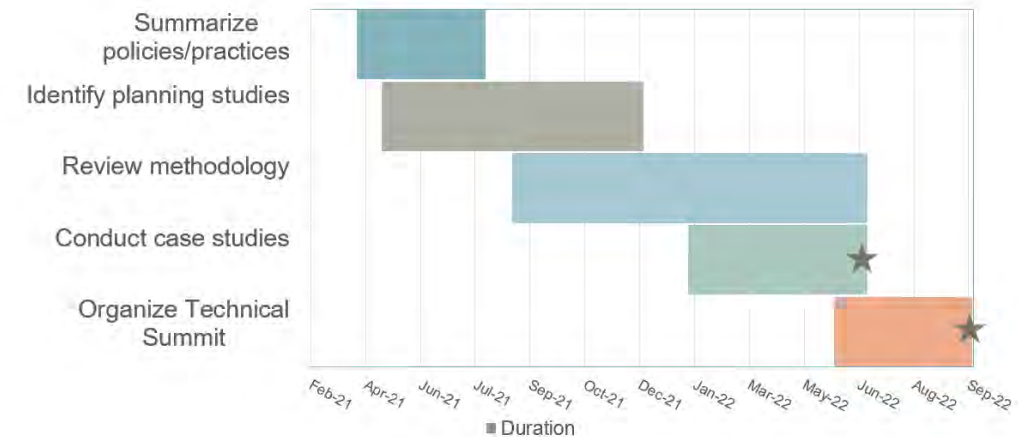
THE WATER INSTITUTE
OF THE GULF*

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.

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

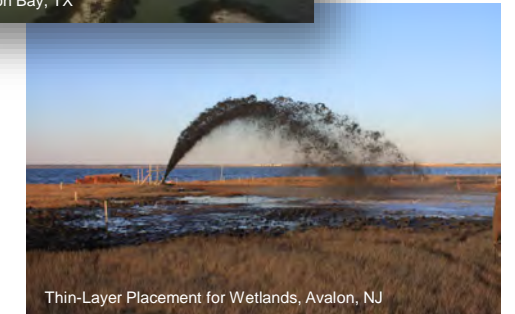
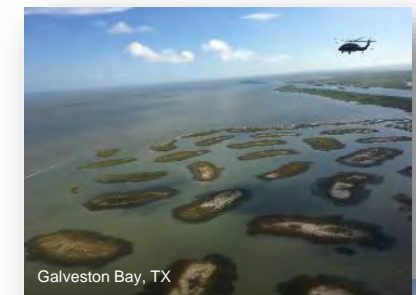
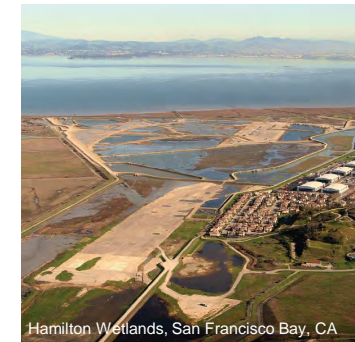
SCHEDULE AND PROGRESS



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



Beneficial Use and the “Federal Standard”

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"



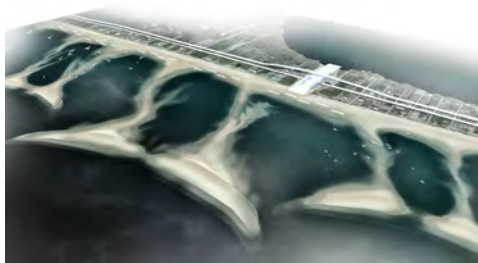
Wetland Creation



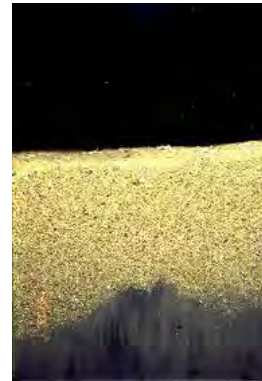
Island Enhancement or
Restoration



Engineering / Operational Effort



Strategic Placement



Thin-Layer Placement
for Bottom Contouring



Beach and Dune
Construction



New Island Construction

- A Call to Action -

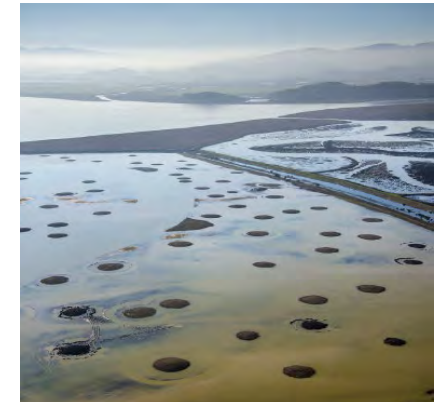
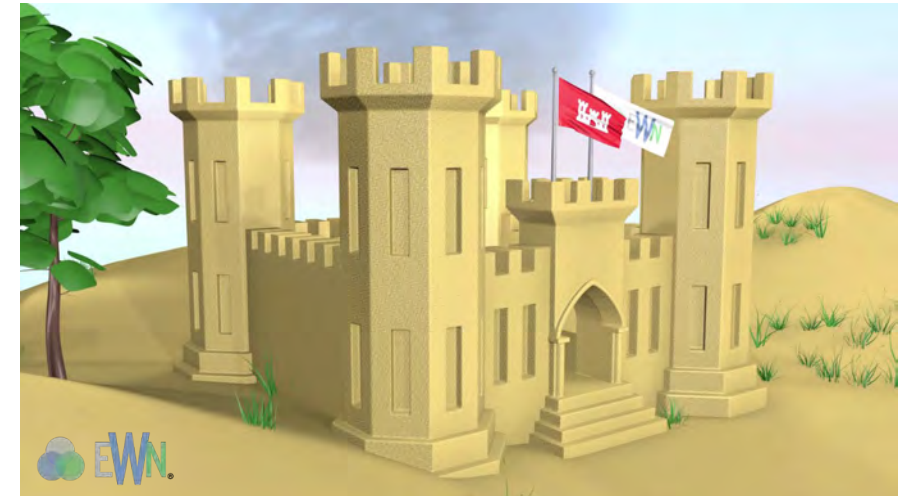
An Imperative for the 21st Century:

“Revolutionary” Amounts of Beneficial Use

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



Barrier Island: Deer Island, Biloxi, MS

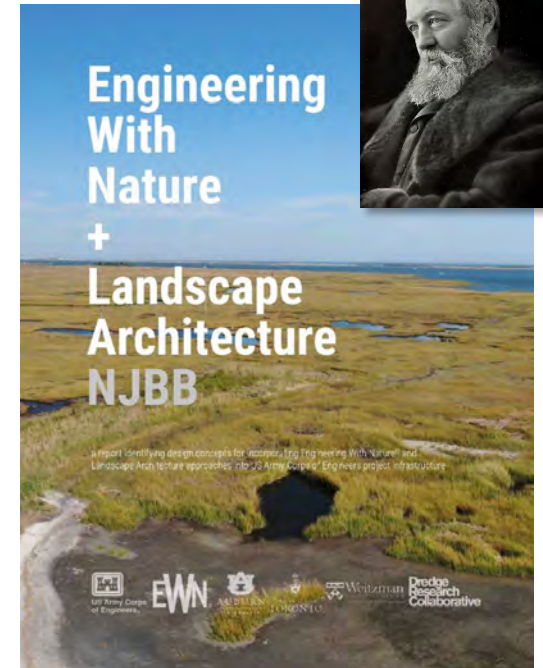
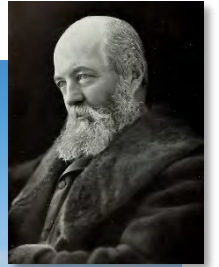
- Biloxi Harbor Navigation Project – 3.65 m (12 ft) deep navigation channel
- Sediment beneficial use to restore marsh, create terrestrial and aquatic habitat, provide a more resilient shoreline for future storm events, create long term disposal capacity
- Hurricanes over time destroyed forests, significantly 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



Supporting Field Application: SMILL

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

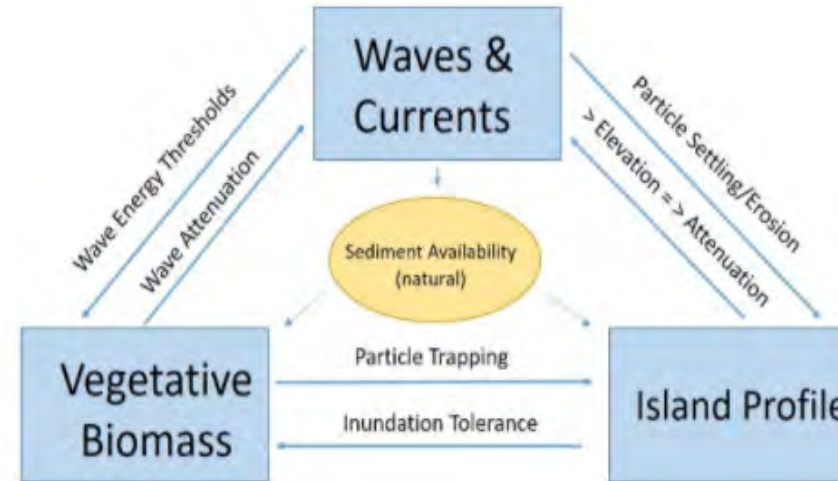


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The Power of Partnership: *Swan Island*



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EA Engineering, Science,
and Technology, Inc.

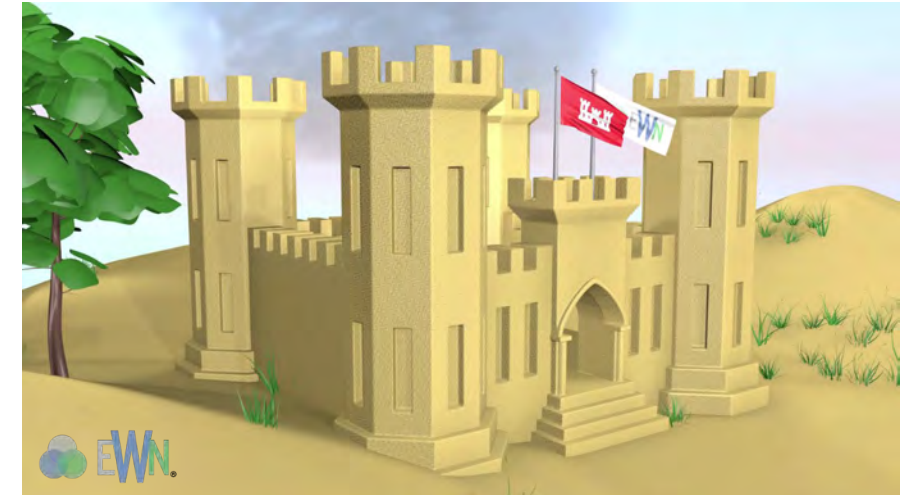


<https://coastalscience.noaa.gov/project/evaluating-efficacy-of-island-restoration-and-enhancement-for-coastal-protection/>

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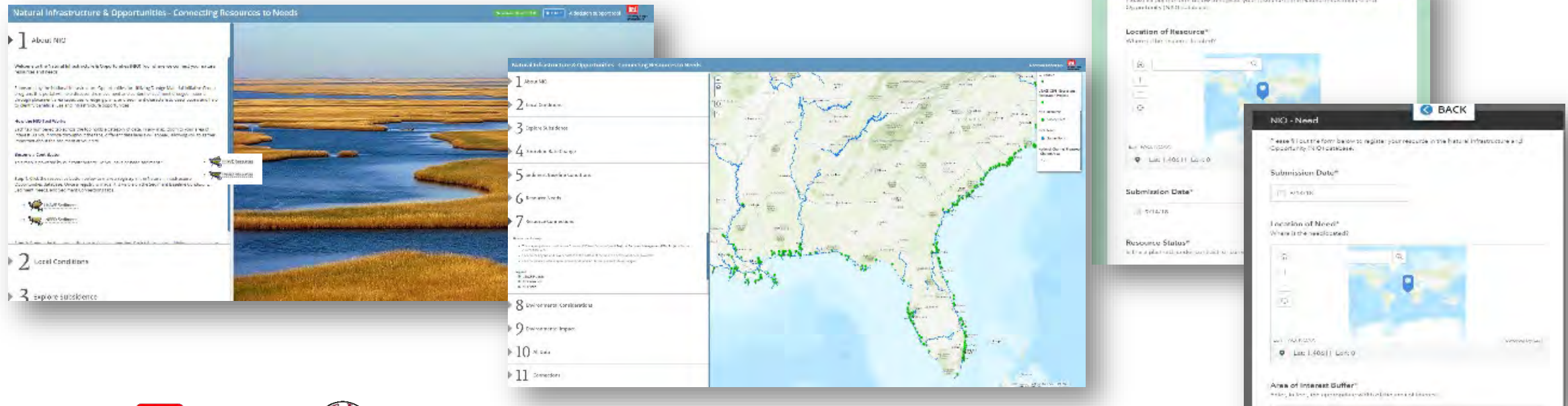
“Revolutionizing” Practice Through Nature-Based Solutions

- **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



Natural Infrastructure Opportunities Tool (NIOT)

The public facing *Natural Infrastructure Opportunities Tool*, developed in collaboration with the Natural Infrastructure Initiative, focuses on identifying natural infrastructure and beneficial use opportunities. Through map-based visualizations of environmental, geomorphic and sediment conditions, as well as upcoming USACE projects, and an interface for users to add their resource needs and resource availability, this portal will help discover natural infrastructure connections and inspire innovative opportunities.



Partners:



<https://ewn.el.erdc.dren.mil/tools.html>

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.erd.dren.mil/?page_id=4351

NNBF Guidelines

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




www.engineeringwithnature.org




“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: *Natural Infrastructure, May 10-11, 2022*







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SEARCH 

Benefits, Applications and Opportunities of Natural Infrastructure: A Workshop

SHARE    

- About
- Upcoming Events
- Description
- Committee
- Sponsors
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The National Academies will host a workshop on the benefits, applications, and opportunities of natural infrastructure. This includes aspects of the natural landscape, from mangroves and marshes to municipal green infrastructure. The workshop will explore natural infrastructure applications and efficacy in natural hazard resilience, climate change adaptation, and sustainable, multi-purpose infrastructure to advance and mainstream natural infrastructure and nature-based solutions in public and private engineering practice. Speakers will include experts in engineering of natural and traditional infrastructure, sustainability, resilience, social sciences, and economics. The objective is to build recognition, understanding, support, and awareness of the applications of natural infrastructure.

 [Provide feedback on this project](#)

Upcoming Events

WORKSHOP

MAY 10

MULTIDAY EVENT | MAY 10-11, 2022

[Workshop on Benefits, Applications, and Opportunities of Natural Infrastructure](#)

Some Questions and Thoughts About “Guidance”

- **Guidance for what applications?**
 - Flooding, heat, drought, wildfire, etc.
- **What are the requirements (elements) of the guidance?**
 - Design, construction, monitoring, adaptation, O&M, etc.
- **What level of prescription?**
 - “Cookbook engineering guidance leads to cookie-cutter engineering solutions”
- **How to sync technical guidance with existing and evolving policies?**
 - There is a wide interface between policy and technical guidance
 - Across programs and organizations
- **How to make timely step-wise progress?**
 - Assemble, organize, and share technical resources
 - Partner for progress
 - Learn by doing and communicating



Supporting Education and Progress: The Network for Engineering With Nature (N-EWN)

- Multi-sector network supporting innovation
 - Types of partners: public and private sector
 - Research – gov't, academic, private
 - Industry practitioners
 - Project owners
- Aligning research with the needs of practice
- Grounding approach in real projects
- EWN education: curricula and training
- Experiential learning for students – systems thinking, cross-disciplinary training
- Freely flowing communication and knowledge sharing
- Accelerate implementation



**US Army Corps
of Engineers.**



*Institute for Resilient
Infrastructure Systems*
UNIVERSITY OF GEORGIA



**Mayor's Office of
Climate Resiliency**



TRIBAL NATIONS TECHNICAL
CENTER OF EXPERTISE



THE WATER INSTITUTE
OF THE GULF™



The UNIVERSITY of OKLAHOMA



**Arizona State
University**



NCCOS

NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE



**UNIVERSITY of
FLORIDA**

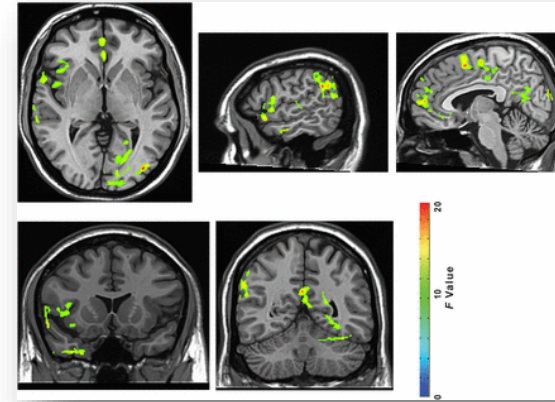
CENTER FOR COASTAL SOLUTIONS

www.engineeringwithnature.org; <https://n-ewn.org/>

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The Human Dimension

- 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

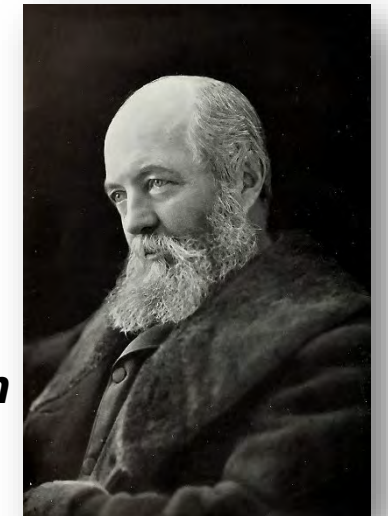
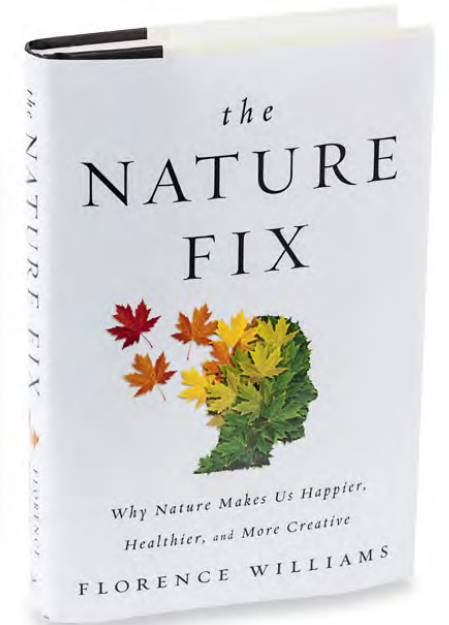
Gregory N. Bratman, J. Paul Hamilton, Kevin S. Hahn, Gretchen C. Daily, and James J. Gross
 PNAS July 14, 2015 112 (28) 8567-8572; first published June 29, 2015 <https://doi.org/10.1073/pnas.1510459112>

scientific reports

Urban street tree biodiversity and antidepressant prescriptions

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“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)



The Spectrum

“Wild and Free-Flowing Nature”

“Tamed and Conquered Nature”



Duwamish River, WA 1800s



San Joaquin Valley, CA 1800s

“Not either / or, but and”

(Structural vs. Natural)

Conserved Nature
 Engineered Nature-Based Solutions
 +
 Engineered Structures

 Lasting, Sustainable, Resilient Systems



Duwamish River, WA today



San Joaquin Valley, CA today

Comprehensive Resilience: Economic, Environmental, Social

