

NNBF

International Guidelines on Natural and Nature-Based Features for Flood Risk Management



The Need and Opportunity for NNBF



Puerto Rico | May 2022



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The Need and Opportunity for NNBF

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Co-Authors: Jeffrey K. King, USACE, United States; Jonathan D. Simm, HR Wallingford, United Kingdom





The Multi-Hazard World



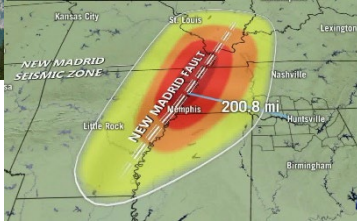
Mt. Saint Helens, 1980



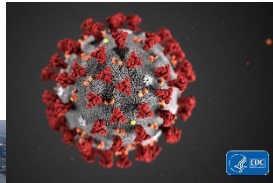
David Johnston, USGS



San Francisco, 1906



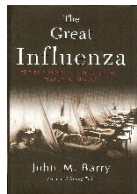
New Madrid Seismic Zone



COVID-19, 2020-X



HABs, Lake Erie; 2008-2017



H1N1, 1918-1919



Beirut, Lebanon; 2020



Fukushima, 2011



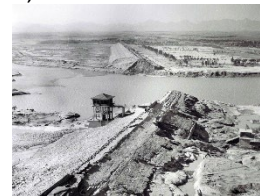
Three Mile Island, 1979



Deepwater Horizon, 2010



Banqiao dam failure; China, 1975



Hurricane Katrina, 2005



Flood of 1927; Tallulah, LA



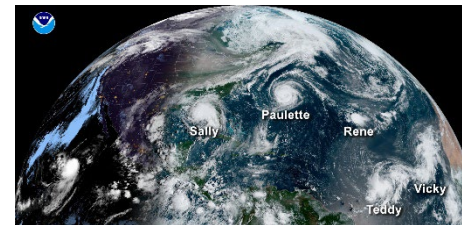
Dust Bowl, 1930s



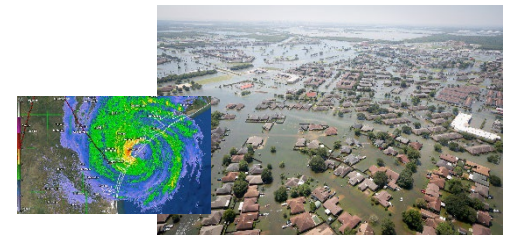
Offutt AFB, 2019



Camp Fire; CA 2018



2020 record-setting storm season



Hurricane Harvey; landfall and Houston, 2017



9/11



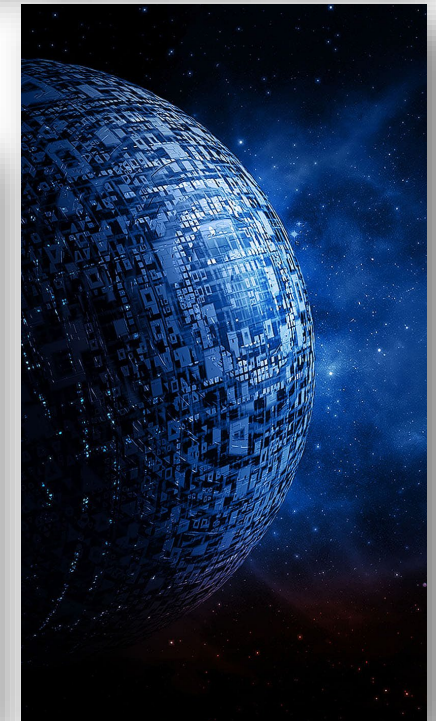
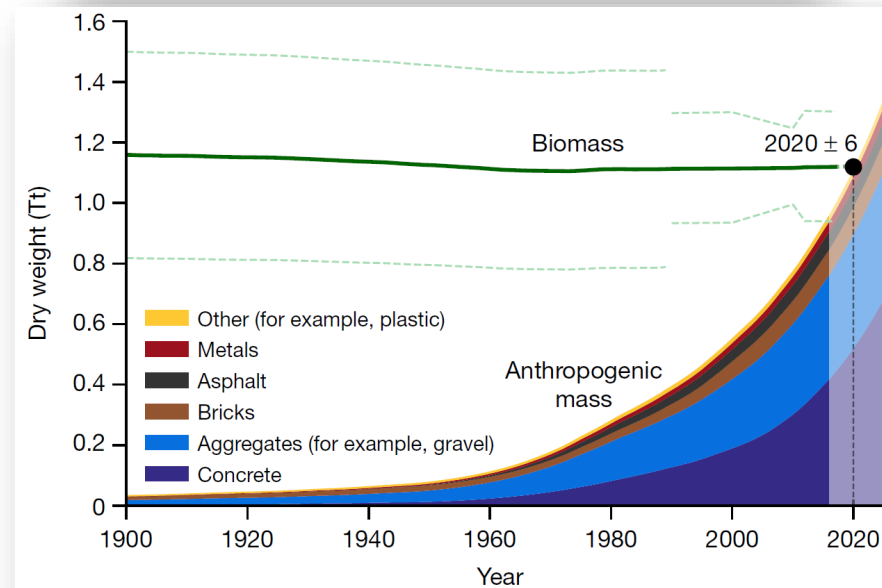
Civil unrest, 2020



Medfly "bio-attack"; CA, 1989

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



The LA “River”

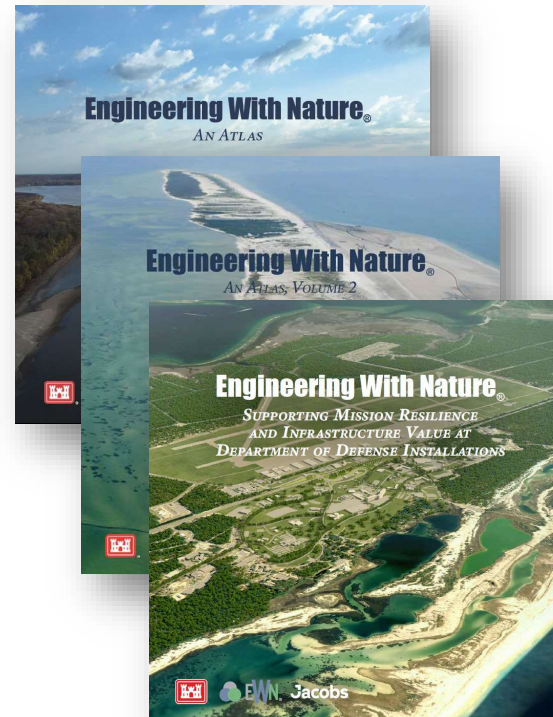


Engineering With Nature.®

...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)

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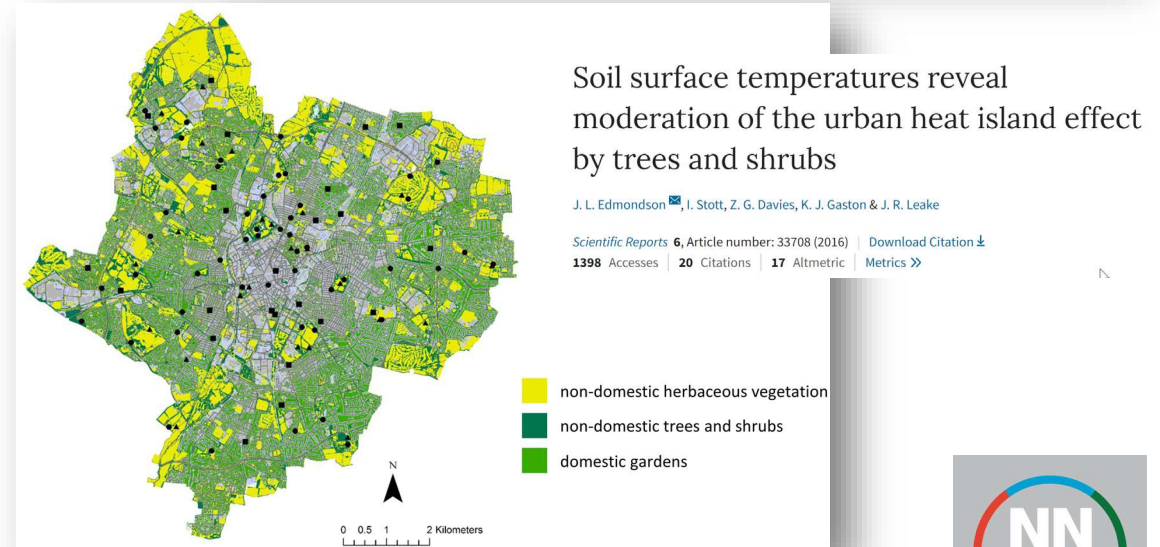


Nature-Based Solutions:

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

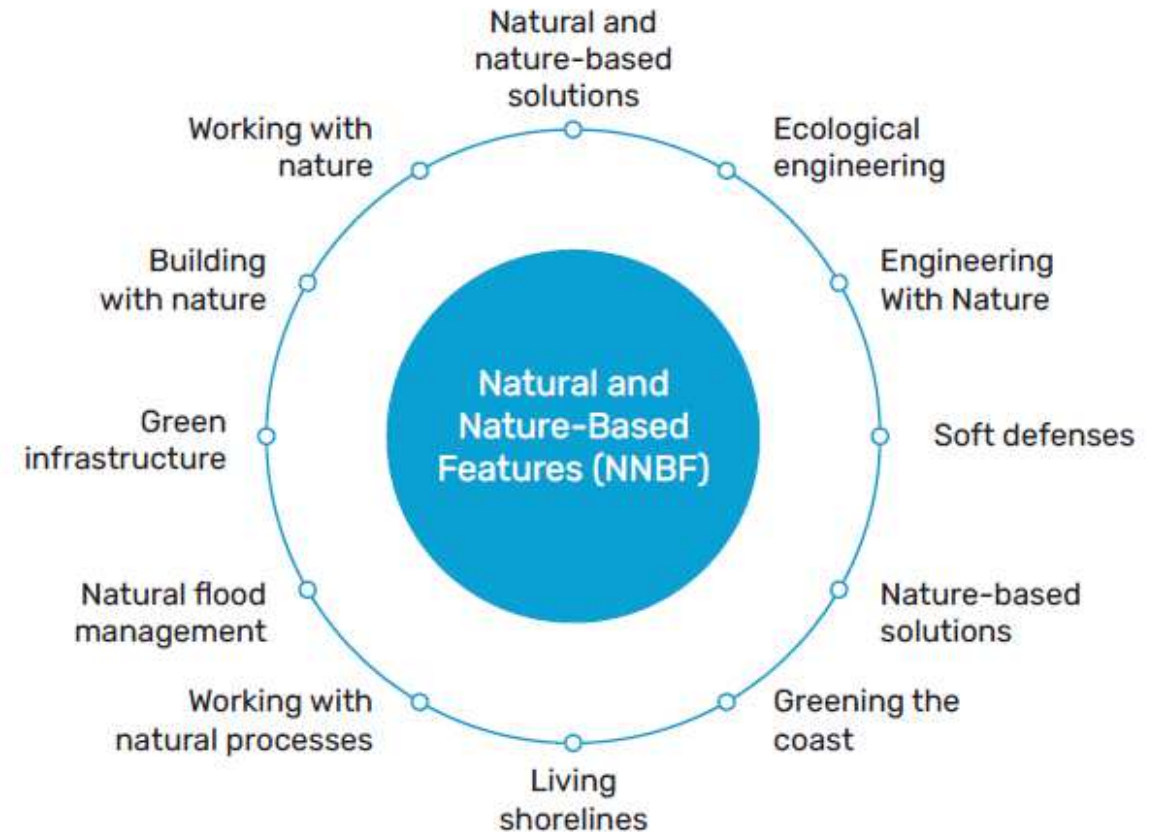
An Example: Trees as Infrastructure!

- 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



Natural and Nature-Based Features (NNBF)

- Flood Risk Management refers to actions taken to reduce future damage to people and property caused by flooding and erosion in coastal and fluvial systems.
- NNBF refers to the use of landscape features to produce flood risk management benefits and other economic, environmental, and social benefits (known as co-benefits).
 - E.g., beaches, dunes, wetlands, reefs, islands, other



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.erdcdren.mil/?page_id=4351

NNBF Guidelines

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



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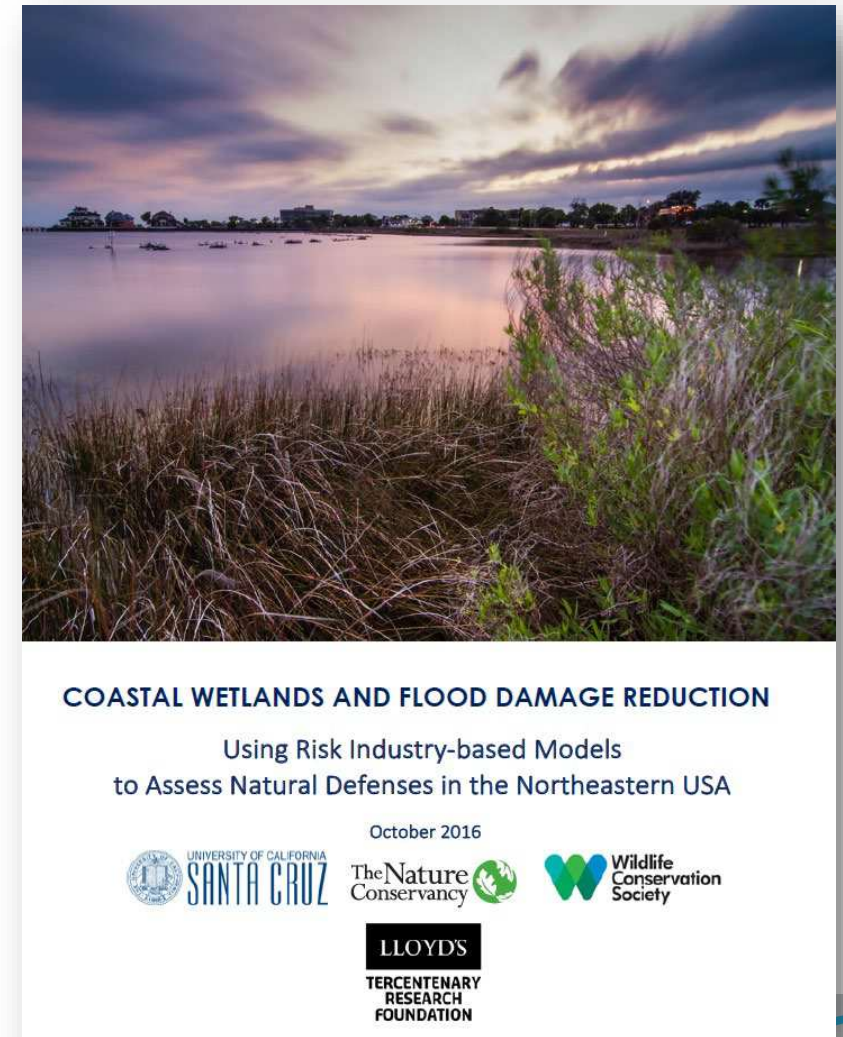
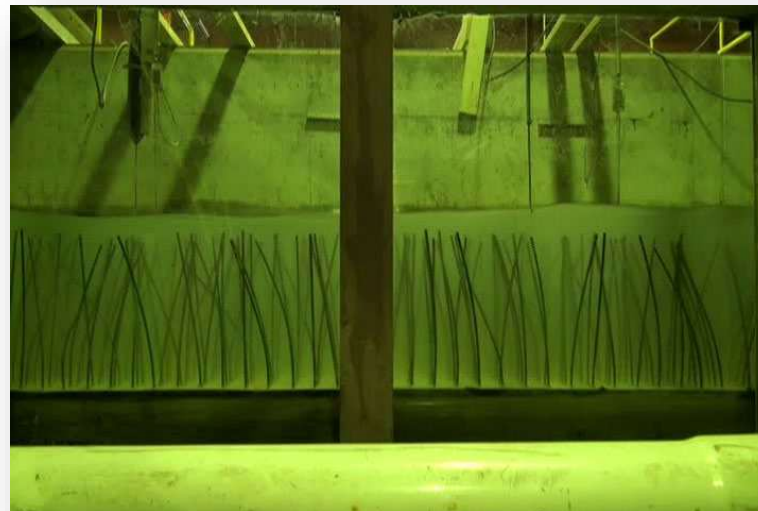
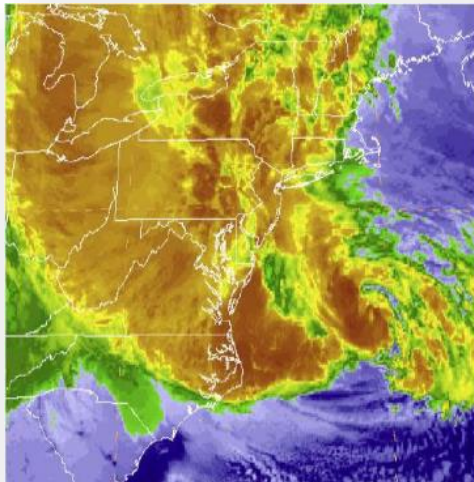
"The guidelines do not contain or represent the policy commitments or policy positions of the organizations that participated in their development. Policy development is the sole purview of each organization and the laws and procedures that govern their activities." Pages xi-xii.



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%.

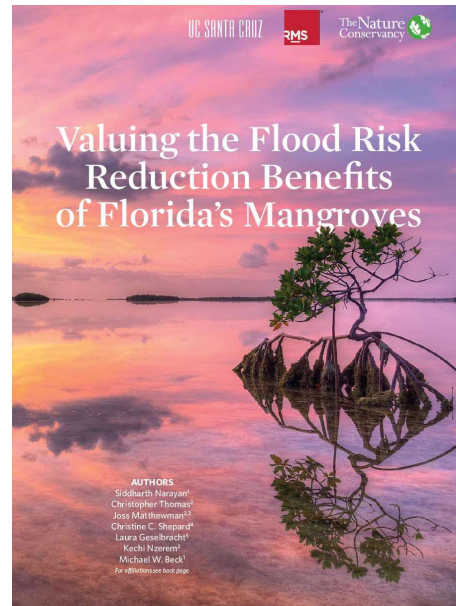


Leveraging Nature for Engineering Value: *Mangroves*

Florida Mangroves Study:

- Used an insurance industry catastrophe model to quantify the flood reduction benefits of mangroves across Florida
- During Hurricane Irma:
 - Mangroves averted \$1.5 billion dollars in flood damages to properties
 - 25% savings in counties with mangroves
 - >600,000 people living behind mangrove forests saw reduced flooding across Florida

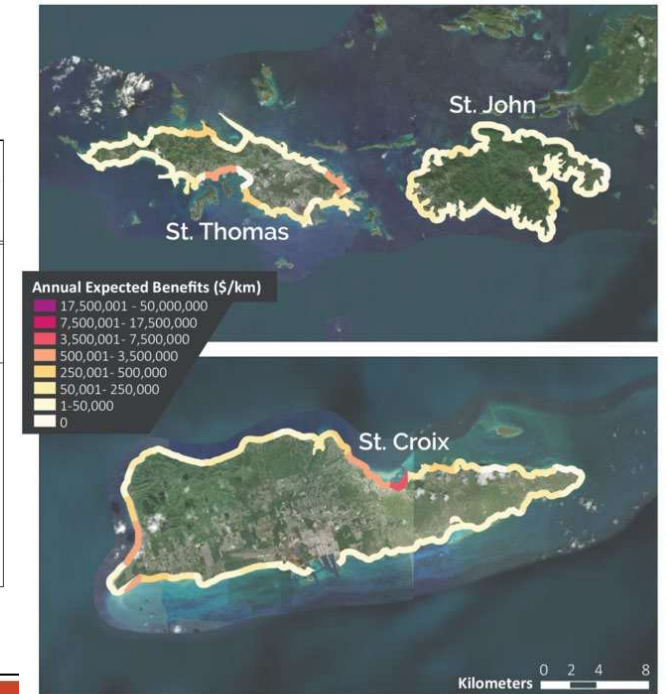
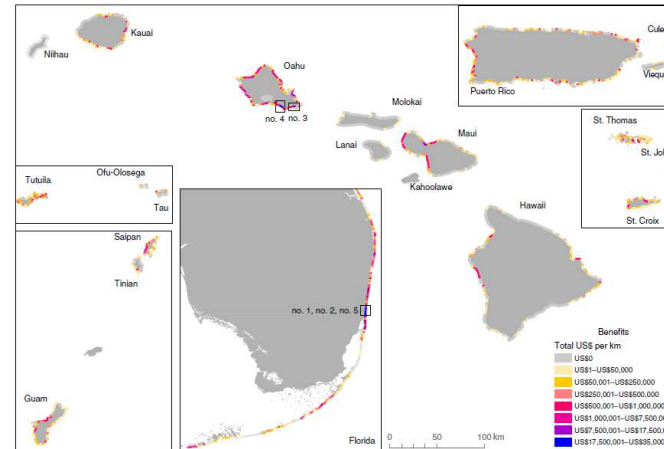
Menendez et al., 2020. *The Global Flood Protection Benefits of Mangroves*.
<https://www.nature.com/articles/s41598-020-61136-6>



Leveraging Nature for Engineering Value: *Coral Reefs*

Coral Reefs and Flood Risk Reduction Value:

- Coral reefs line >3,100 km of US and US Trust Territory shorelines
 - Provide >\$1.8B in annual flood risk reduction benefits
 - Highly developed coastlines in FL and HI receive annual benefits of \$10M per km of coral reef
- Loss of the top-most meter of coral reefs:
 - An additional 50,000 people would experience flooding
 - \$3B in additional damage to structures



The annual expected benefits (\$/km) coral reefs provide in coastal flood reduction.

nature sustainability

The value of US coral reefs for flood risk reduction

Borja G. Reguero¹, Curt D. Storlazzi², Ann E. Gibbs², James B. Shope¹, Aaron D. Cole³, Kristen A. Cumming² and Michael W. Beck¹

Habitats, such as coral reefs, can mitigate increasing flood damages through coastal protection services. We provide a fine-scale, national valuation of the flood risk reduction benefits of coral habitats to people, property, economies and infrastructure. Across 3,100 km of US coastline, the top-most 1m of coral reefs prevents the 100-yr flood from growing by 23% (113 km²), avoiding flooding to 53,800 (62%) people, US\$2.7 billion (90%) damage to buildings and US\$2.6 billion (49%) in indirect economic effects. We estimate the hazard risk reduction benefits of US coral reefs to exceed US\$1.8 billion annually. Many highly developed coastlines in Florida and Hawaii receive annual benefits of over US\$10 million km⁻¹, whereas US reefs critically reduce flooding of vulnerable populations. This quantification of spatial risk reduction can help to prioritize joint actions in flood management and environmental conservation, opening new opportunities to support reef management with hazard mitigation funding.

https://www.usgs.gov/centers/pcms/c/science/value-us-coral-reefs-risk-reduction?qt-science_center_objects=0&qt-science_center_objects

https://www.nature.com/articles/s41893-021-00706-6.epdf?sharing_token=okXPN9-3ruX1jz_oEfQdrNRgN0jAjWel9jnR3ZoTv0P34Lz-UrIjB_uD-ZEph5yVw5H6pLrLbdyEo9uxURsA1vaOBZYqEISikfmfDYbell1BcoZ0xZ9MDHv4a4G9N031nT1-vVMduUiZvbQuw5XBAZ_76ysNf6gB1qNwKbD-A%3D





Yolo Bypass And Its Sources



The Yolo Bypass, California (1911)



Sacramento Weir



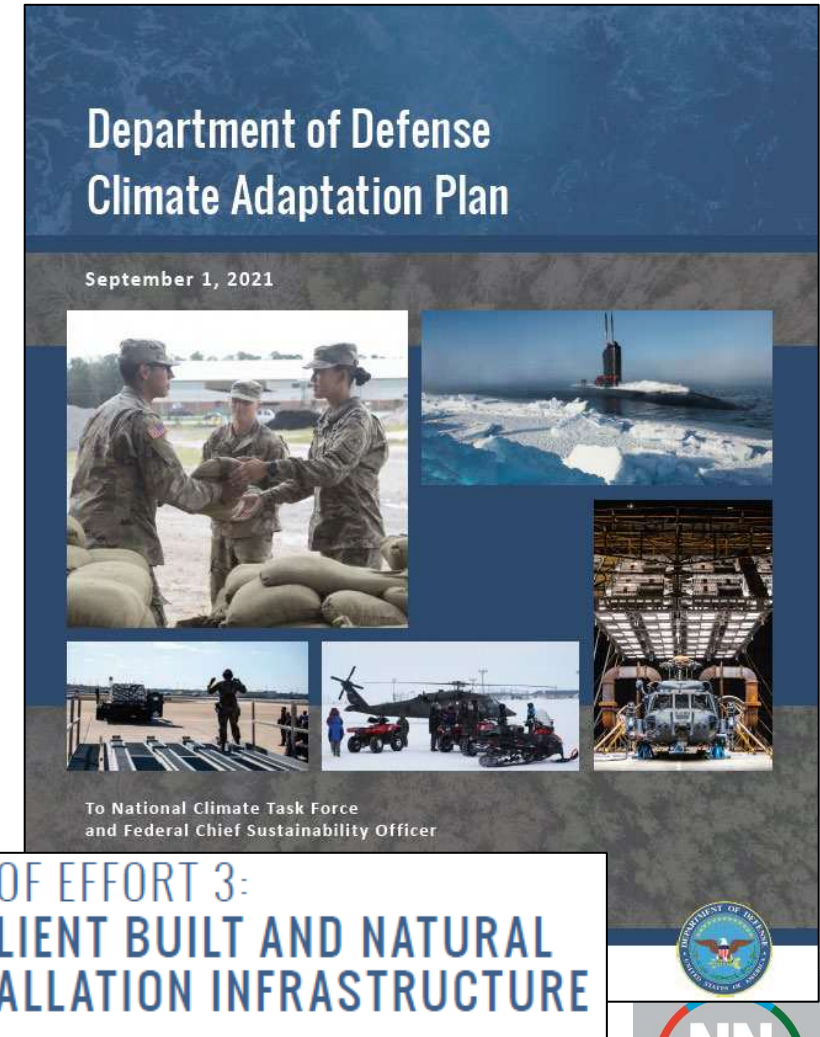
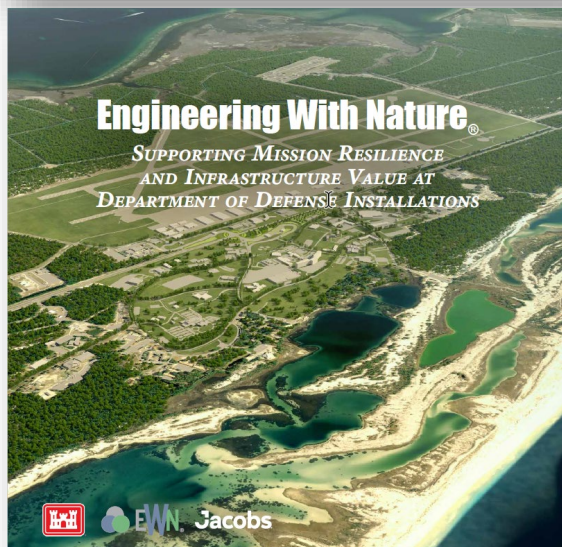
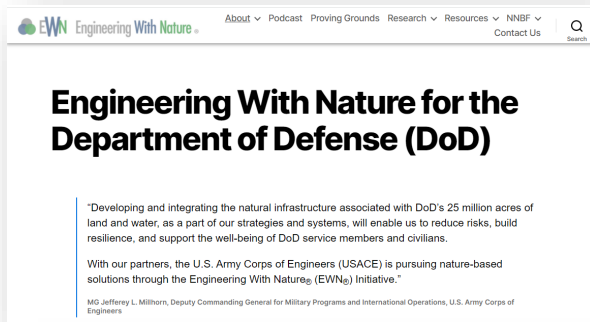
Yolo Bypass Wildlife Area



Yolo Bypass, 2017

Military Installation Resilience: Built + Natural Infrastructure

“Built and natural infrastructure are both necessary for successful mission preparedness and readiness.”



www.engineeringwithnature.org » About

“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



BRIEFING ROOM

Executive Order on Tackling the Climate Crisis at Home and Abroad

JANUARY 27, 2021 • PRESIDENTIAL ACTIONS



OFFICE OF SCIENCE AND TECHNOLOGY POLICY

WHITE HOUSE ROUNDTABLE –

“KNOWLEDGE IN NATURE:
HOW NATURE CAN HELP
GROW A BETTER FUTURE”

*America the Beautiful
30x30*

Justice40 Initiative

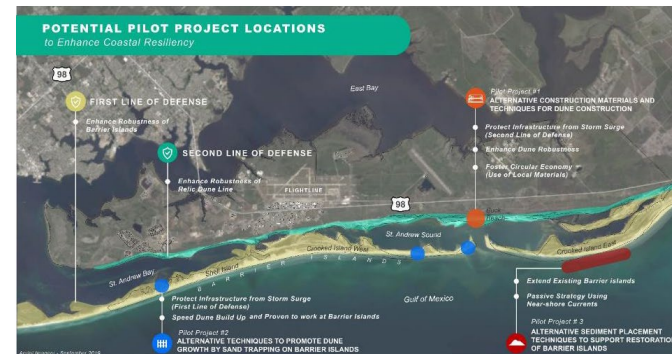
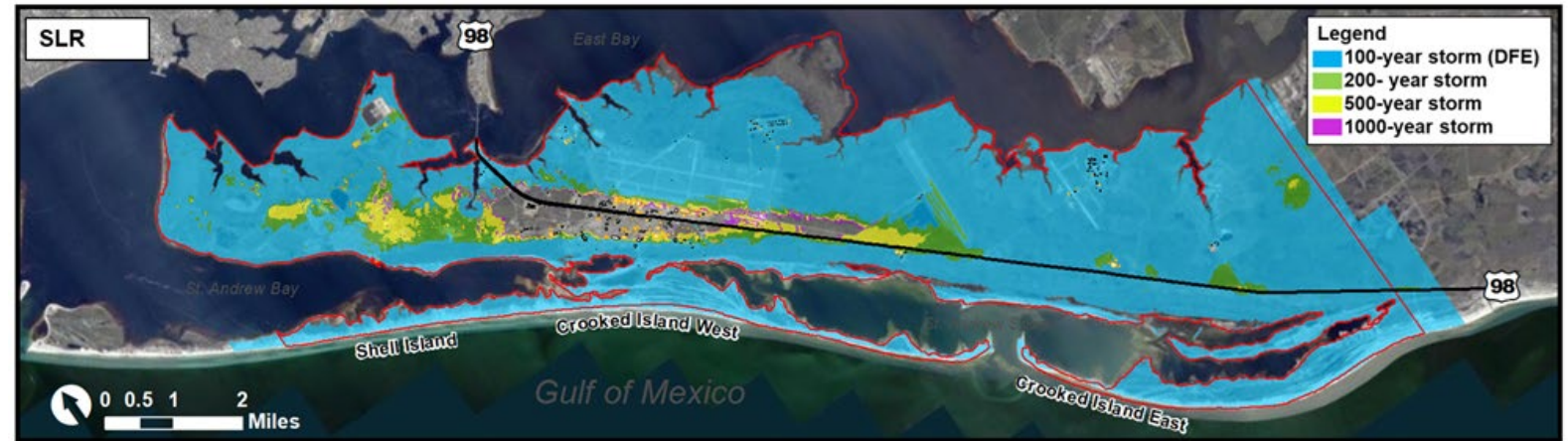
Sec. 4. Deploying Nature-Based Solutions to Tackle Climate Change and Enhance Resilience:
“To further amplify the power of nature, including its ability to absorb climate pollution and increase resilience in all communities, today’s Executive Order calls for the following:”

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

EWN® Applied to Tyndall Air Force Base for Coastal Resilience

"By exploring a diverse menu of nature-based solutions we are in a better position to sustain, restore, and modernize natural infrastructure, ensuring the capability of Air Force lands to support the mission of the installation."

- Lieutenant Colonel Brandy Smart, Commander of the 325th Civil Engineer Squadron



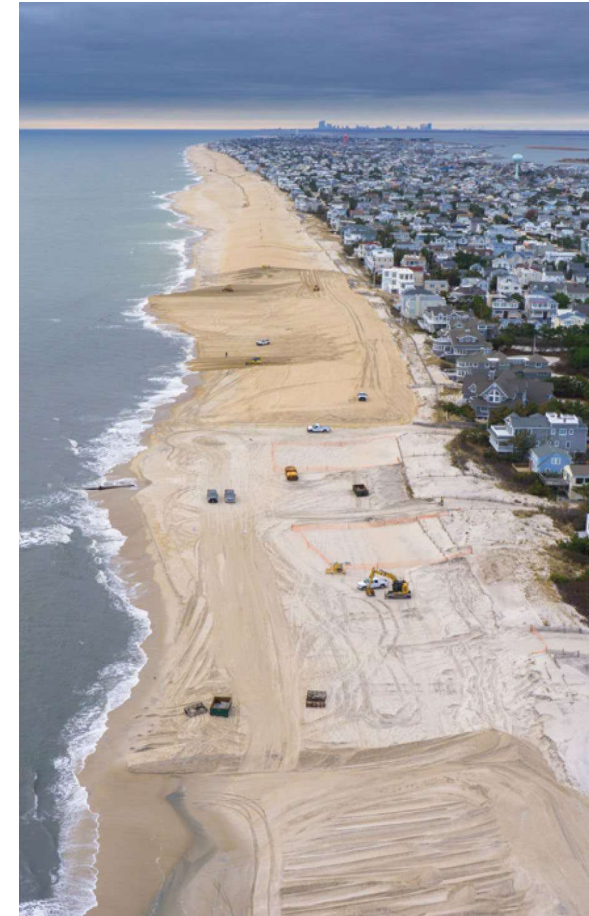
Tyndallcoastalresilience.com

Winner of 2021
UK Environment Agency Flood & Coast
International Excellence Award



NNBF: Overarching Observations

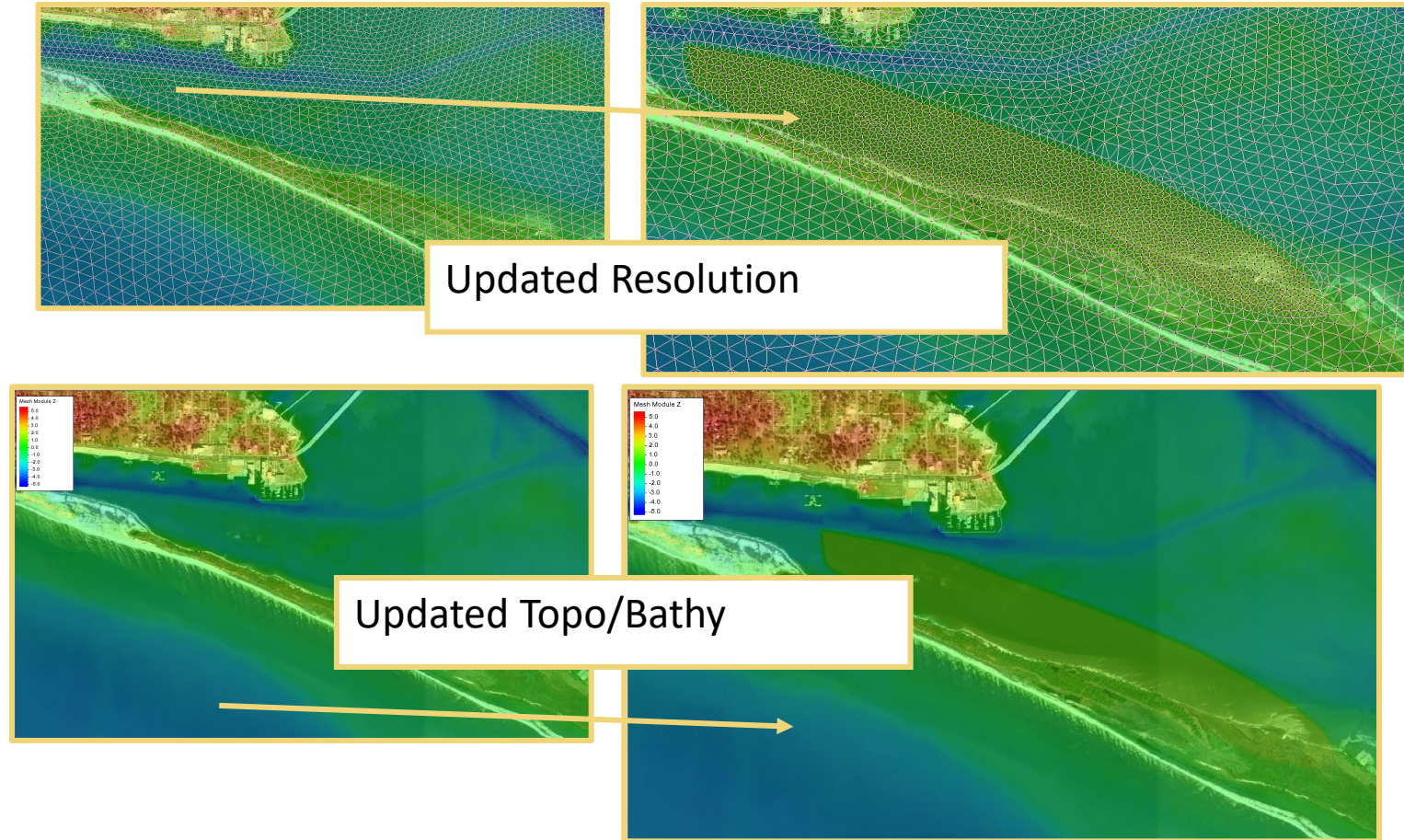
- Natural features and landscapes have always contributed to flood resilience.
- The function and success of FRM measures and systems are related to scale.
- Sustainable FRM systems will include combinations of conventional, natural, and nature-based elements.
- The flexibility and adaptability of NNBF are useful for achieving flood resilience.
- NNBF can increase and diversify the value provided by infrastructure.
- Innovation in practice will be key to addressing future problems and opportunities.
- Policies need to be developed to guide and expand the use of NNBF.
- Coordination, collaboration, and partnership will fuel successful implementation of NNBF.





The EWN[®] Toolkit for: Coastal Storm (CSTORM) Modeling System

- Rapid representation of natural and nature-based features (NNBF) within a coastal and fluvial numerical model background.
- Geospatially rectified background image (i.e., from satellite or similar) to reference while working in the mesh editing environment.
- A simple set of tools for creating polygons, and layers of polygons, to represent NNBF.
- Each EWN feature has an options tab or drop-down menu to adjust parameters for that feature (i.e. density of vegetation, Manning's n values, and bathymetry) that will be stored in a look up table.

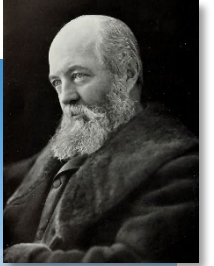
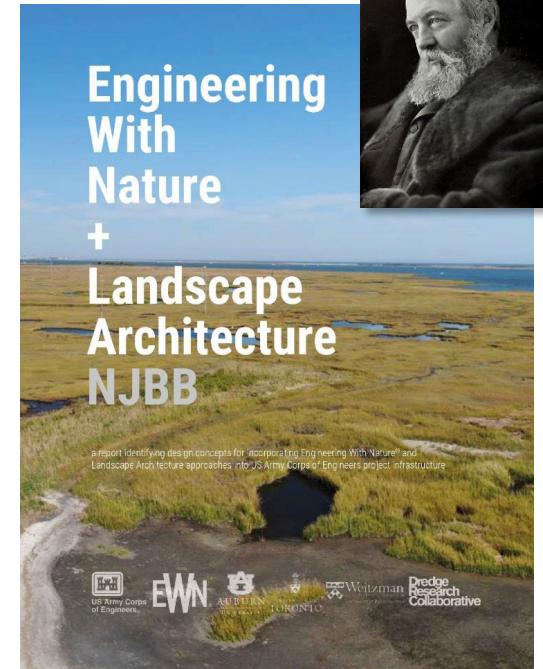




The Power of Partnership: *SMILL*

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

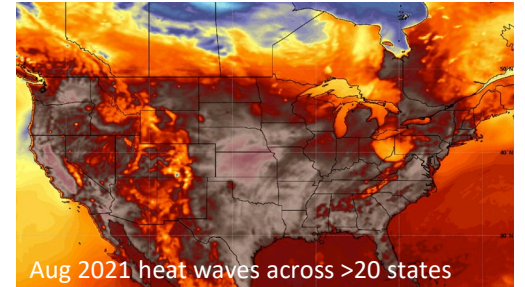


US Army Corps
of Engineers®



Nature-Based Solutions

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



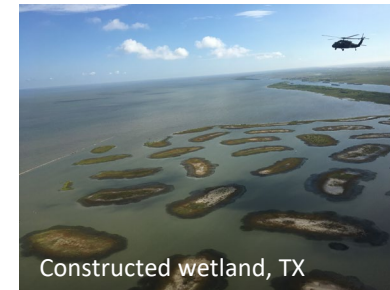
- **Project delivery**—"faster, cheaper"
- **Project performance**—complete solutions
- **Adaptability**—scalable, phase-able, flexible
- **Sustainability**—self-repair
- **Value to the Nation**—multi-functional benefits
- **Diversified investment**—diversified value → diversified partnerships
- **Social license**—community and stakeholder support and participation
- **Regulatory efficiency**—resolving conflict through win-win solutions



Camp Fire, CA; 2018



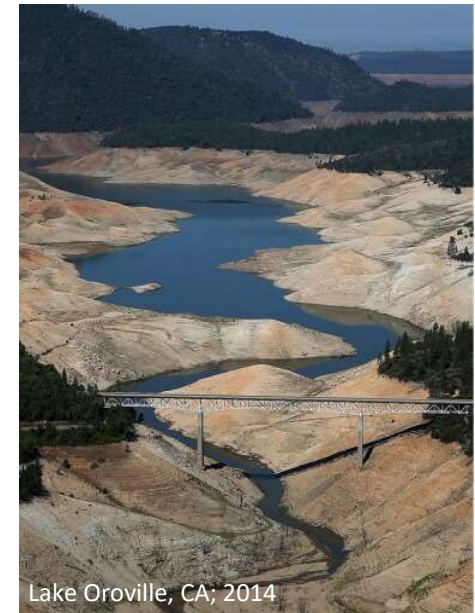
Forest recovery; MT



Constructed wetland, TX



San Joaquin River National Wildlife Refuge, CA



Lake Oroville, CA; 2014



“Wild and Free-Flowing Nature”

The Spectrum

“Tamed and Conquered Nature”



Duwamish River, WA 1800s



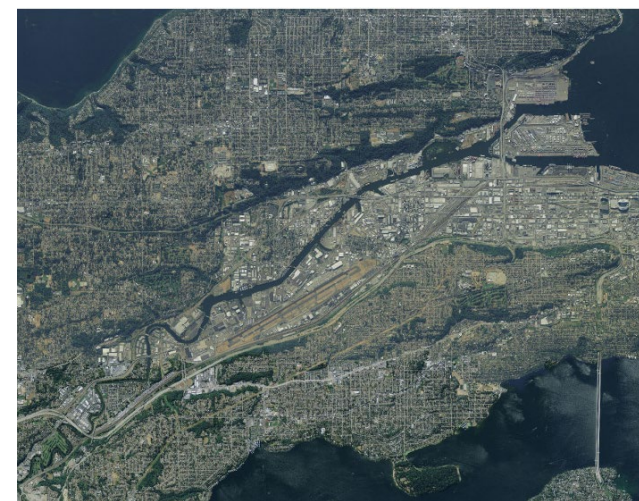
San Joaquin Valley, CA 1800s

“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

Questions?

EngineeringWithNature.org



Download

- Executive Summary (70 pages)
- International Guidelines on NNBF for Flood Risk Management (1,000 pages)

