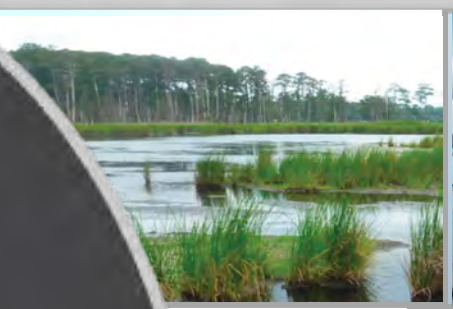
Engineering With Nature®



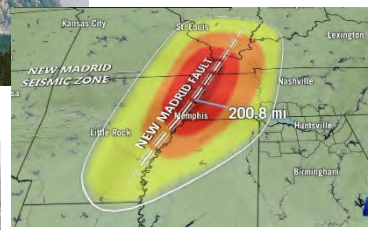

Dr. Todd S. Bridges
Senior Research Scientist (ST), Environmental Science
National Lead, USACE Engineering With Nature®
US Army Corps of Engineers
Todd.S.Bridges@usace.army.mil

Honolulu Climate Change Commission
15 June 2021


The Multi-Hazard World

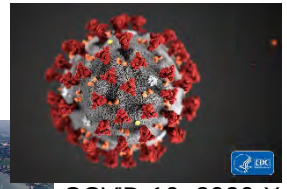

Mt. Saint Helens, 1980


David Johnston, USGS

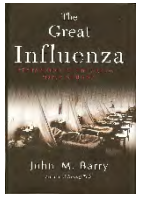


New Madrid Seismic Zone


San Francisco, 1906

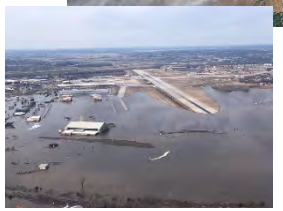

COVID-19, 2020-X


HABs, Lake Erie; 2008-2017

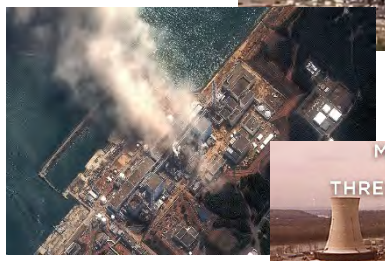


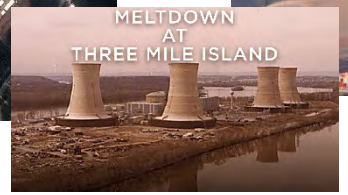
H1N1, 1918-1919


Dust Bowl, 1930s


Offutt AFB, 2019


Beirut, Lebanon; 2020


Fukushima, 2011



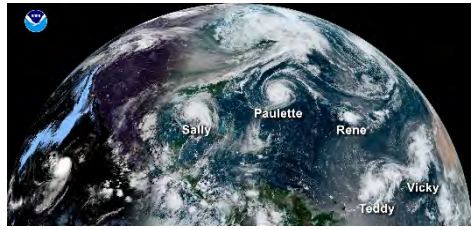
Three Mile Island, 1979


Deepwater Horizon, 2010


Camp Fire; CA 2018


Banqiao dam failure; China, 1975

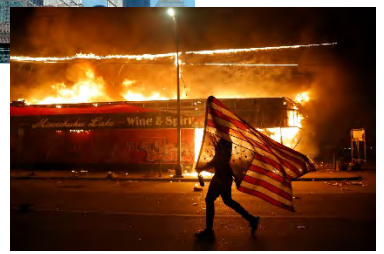

Hurricane Katrina, 2005



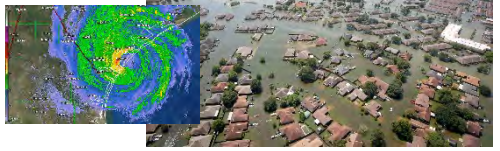
2020 record-setting storm season


9/11

Medfly “bio-attack”; CA, 1989


Civil unrest, 2020

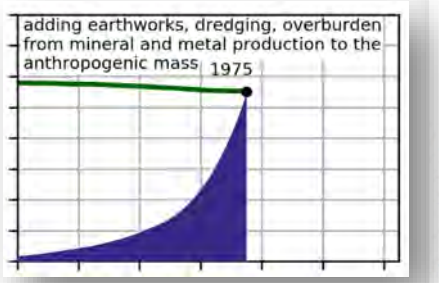

Flood of 1927; Tallulah, LA


Hurricane Harvey; landfall and Houston, 2017

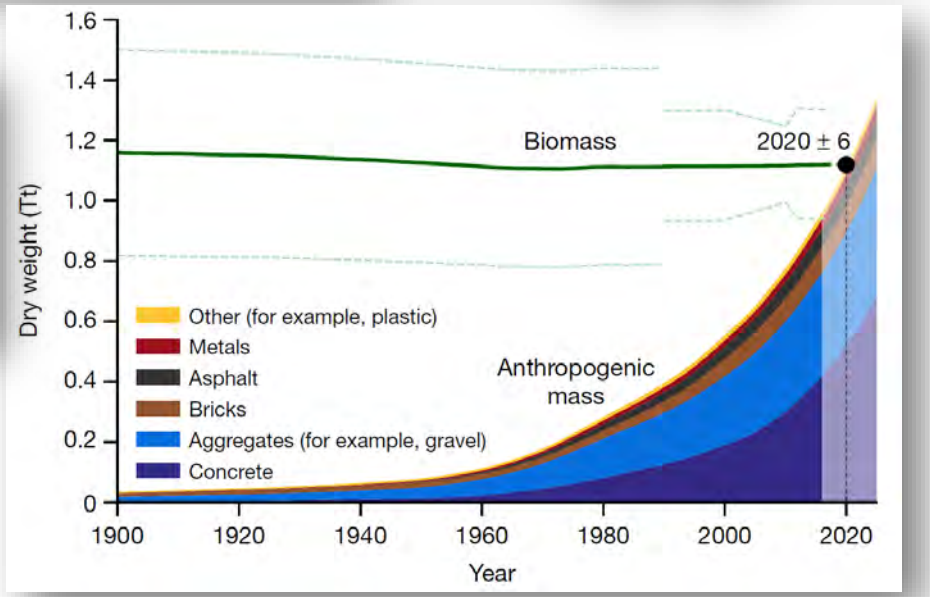
US Army Corps of Engineers • Engineer Research and Development Center

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
- 4,500 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



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:

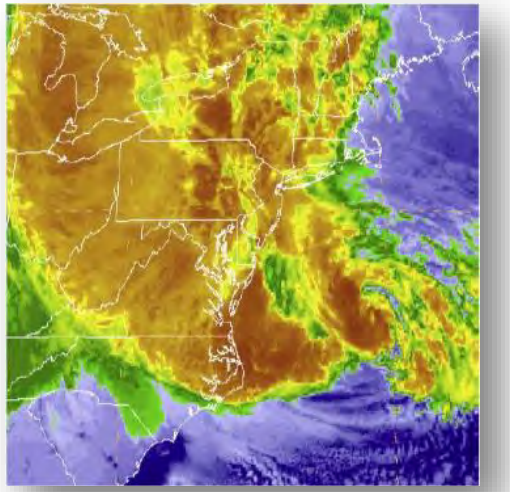
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Increase and diversify infrastructure value
- Science-based collaboration to organize and focus interests, stakeholders, and partners

"The mission of US Army Corps of Engineers is to deliver vital public and military engineering services; partnering in peace and war to strengthen our nation's security, energize the economy and reduce risks from disasters. Engineering With Nature supports this mission which is why it will always be an important initiative for the Corps." LTG Scott A. Spellman, 55th Chief of Engineers, Commanding General, USACE

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

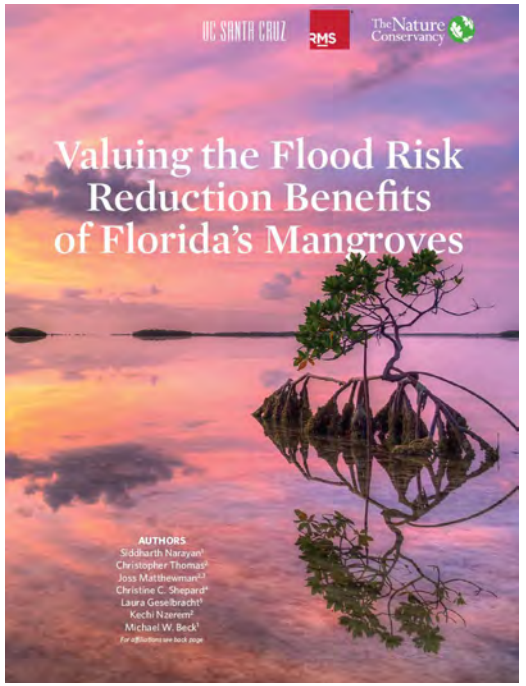
October 2016

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

Leveraging Nature for Engineering Value: *Mangroves*

Flood Risk Value of Florida Mangroves:

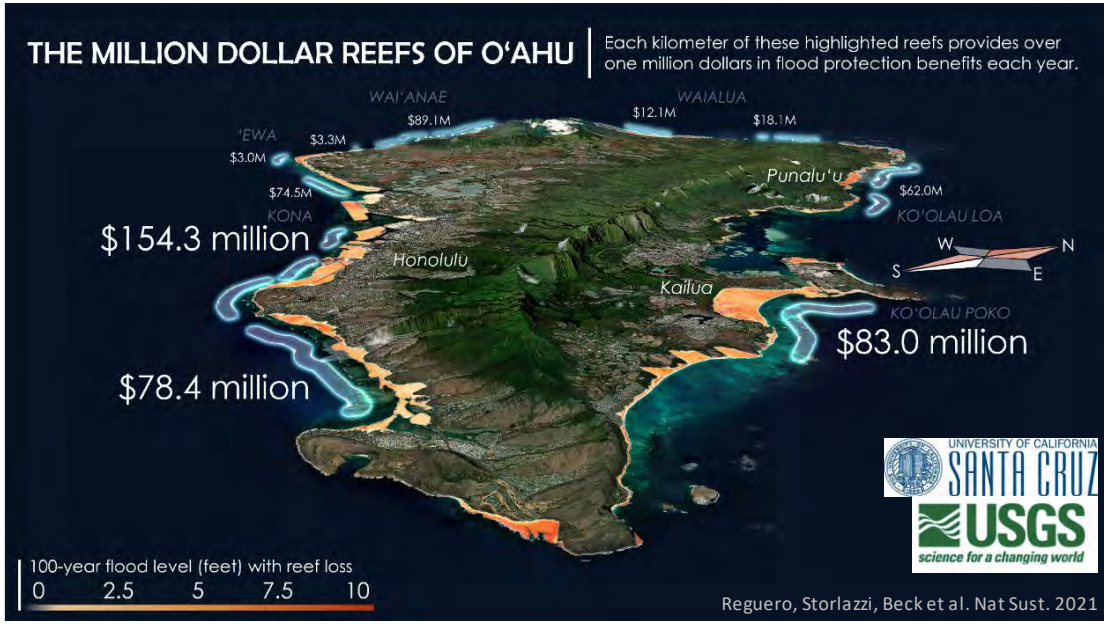
- Used an insurance industry catastrophe model to quantify the flood reduction benefits of mangroves across Florida
- During Hurricane Irma:
  - Mangroves averted $1.5 billion dollars in flood damages to properties
    - 25% savings in counties with mangroves
  - >600,000 people living behind mangrove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

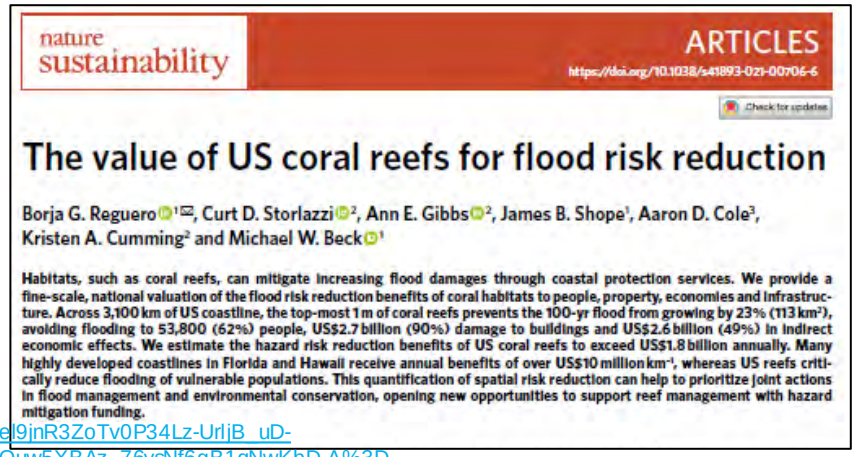


Leveraging Nature for Engineering Value: *Coral Reefs*

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

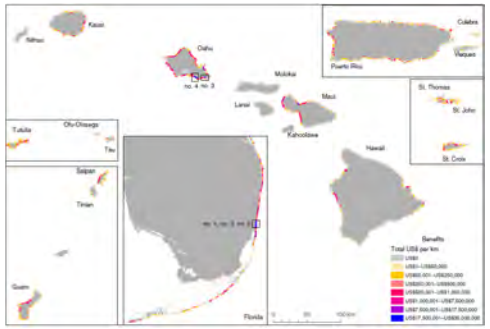



nature sustainability ARTICLES
https://doi.org/10.1038/s41893-021-00706-6

The value of US coral reefs for flood risk reduction

Borja G. Reguero[1], Curt D. Storlazzi[2], Ann E. Gibbs[2], James B. Shope[1], Aaron D. Cole[3], Kristen A. Cumming[2] and Michael W. Beck[1]

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 1 m 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.

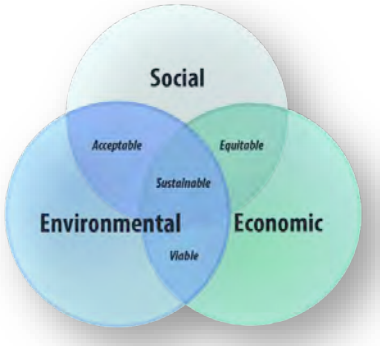


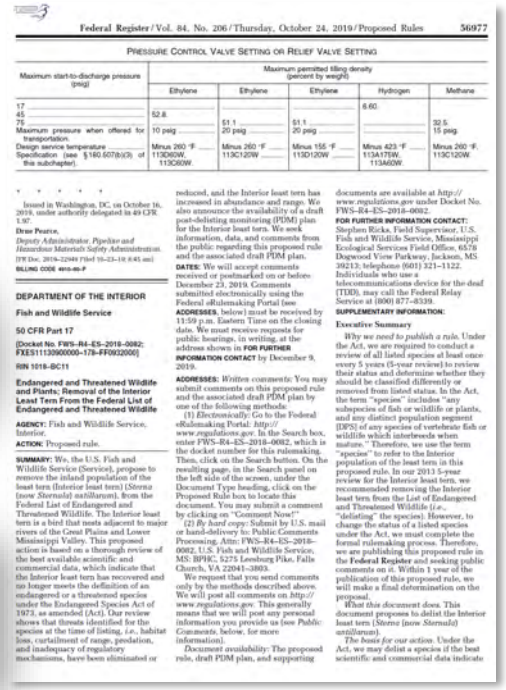
https://www.nature.com/articles/s41893-021-00706-6.epdf?sharing_token=okXPN9-3ruX1jz_oEfQdrNRgN0jAjWel9jnR3ZoTv0P34Lz-UrljB_uD-zEphe5yVw5H6pLrLbdyEo9uxURsA1vaOBZYqElSlkfmfDYbeII1BcoZ0xZ9MDHv4a4G9NO31nT1-vVMdJuUiZvbQuw5XBAz_76ysNf6gB1qNwKbD-A%3D

Nature-Based Solutions

Diversified Value

- Engineering
  - E.g., reduced flood risk, infrastructure maintenance
- Economic
  - E.g., increased property values, recreation
- Environmental
  - E.g., sustainable habitat, biodiversity
- Social
  - E.g., human health, community resilience




Federal Register / Vol. 84, No. 206 / Thursday, October 24, 2019 / Proposed Rules 56977

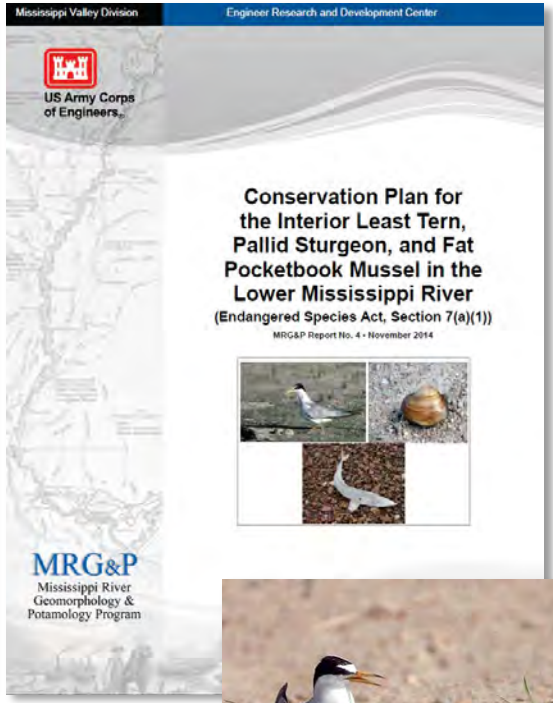
PRESSURE CONTROL VALVE SETTING OR RELIEF VALVE SETTING

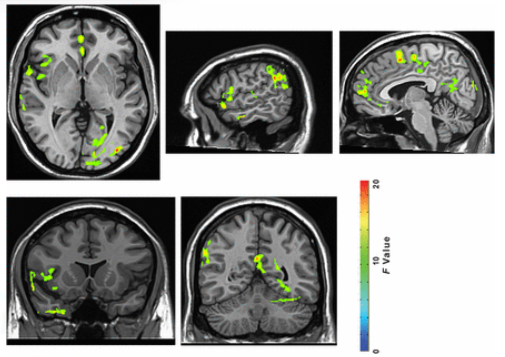
DEPARTMENT OF THE INTERIOR

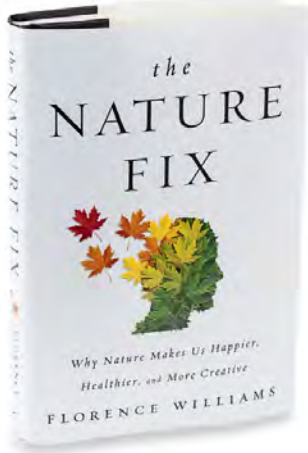
Fish and Wildlife Service

50 CFR Part 17

Endangered and Threatened Wildlife and Plants; Removal of the Interior Least Tern From the Federal List of Endangered and Threatened Wildlife





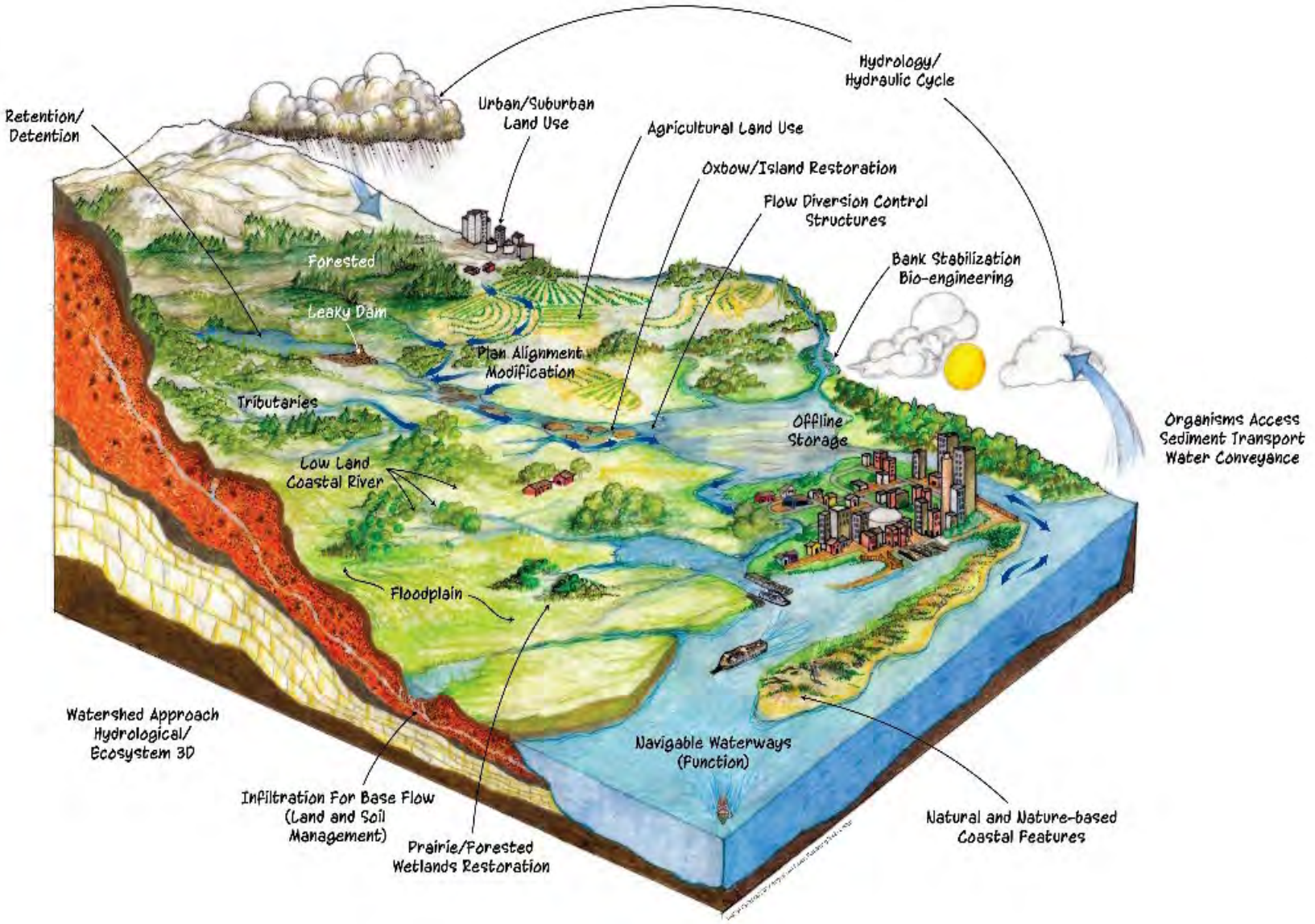


Nature experience reduces rumination and subgenual prefrontal cortex activation

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

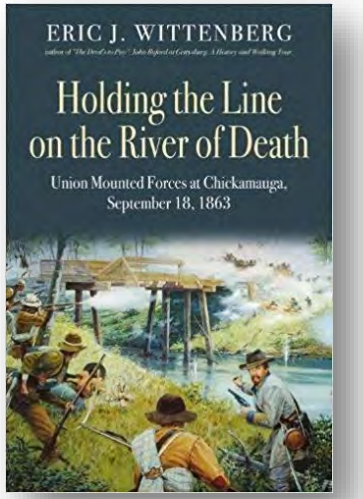
PNAS July 14, 2015 112 (28) 8567-8572; first published June 29, 2015 https://doi.org/10.1073/pnas.1510459112

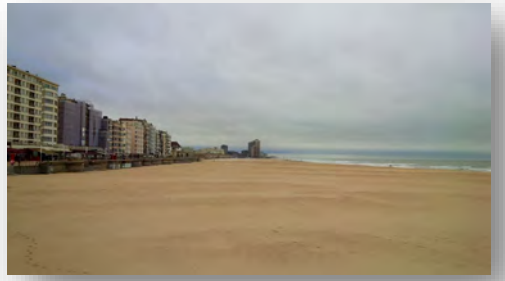
A Systems View of Solutions

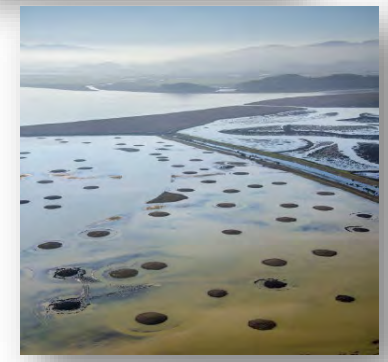


Overarching Strategies

- Hold the Line, "Hard"
  - Galveston Seawall
  - Coast of Belgium
- Retreat
  - Savannah Lighthouse
  - Hamilton, Sears Point, CA
  - Belgium, Scheldt River Estuary
- Advance
  - New wetland, mangrove, island construction
  - New Jersey Bay Bays
  - Sabine to Galveston







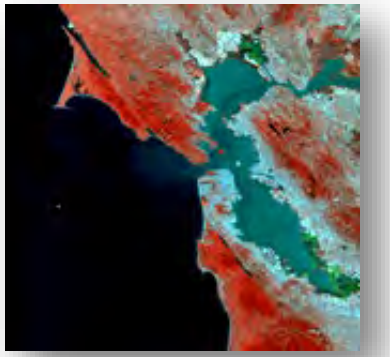
Upstream Intervention in the UK: *Spreading out the Flow*

Puyallup River, WA: Soldier's Home Levee and Floodplain

April 2006

June 2016

Hamilton and Sears Point Wetlands; San Pablo Bay, CA

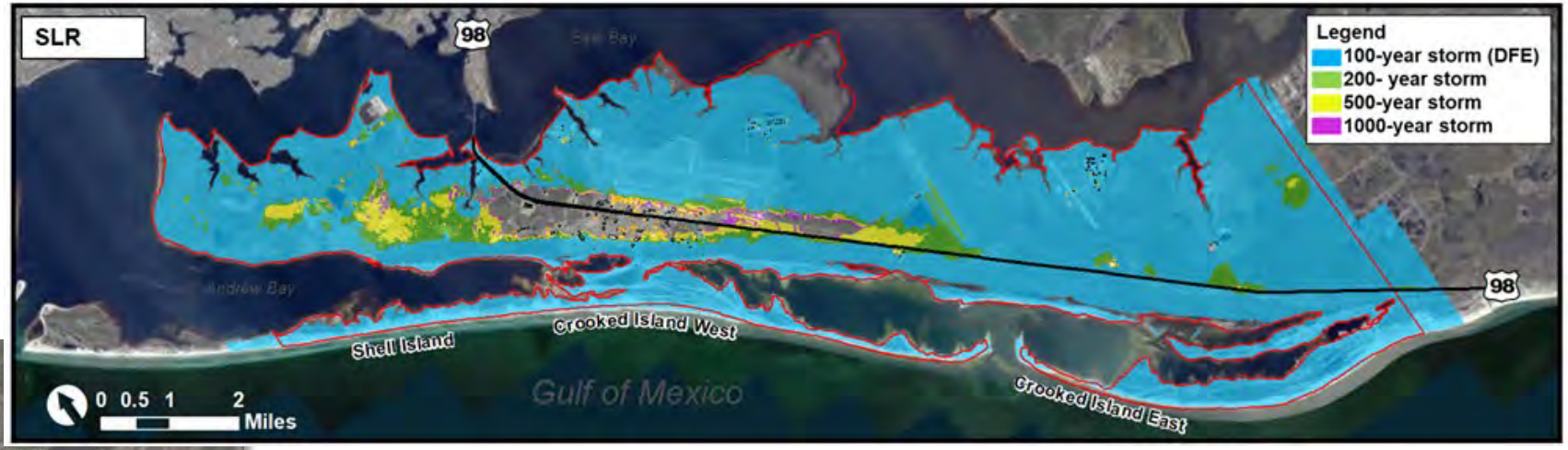


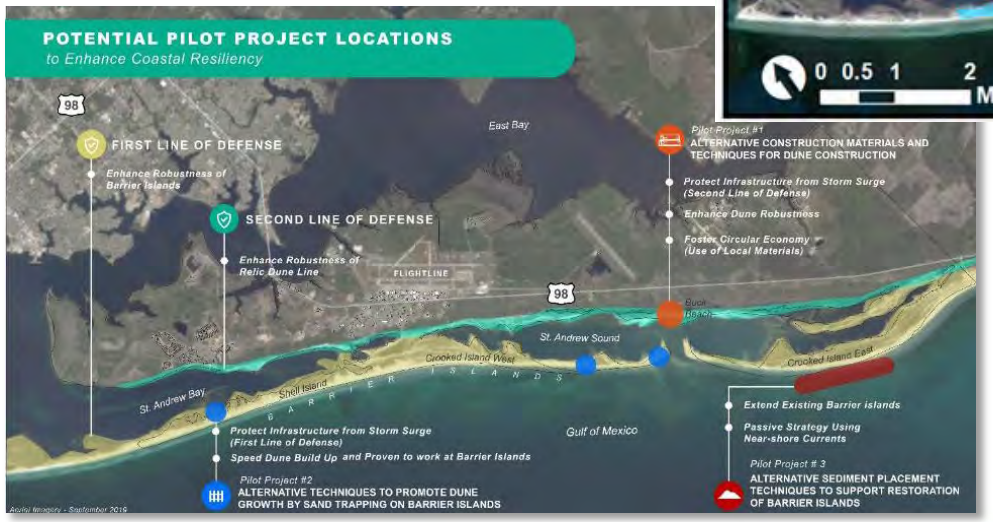
Hamilton Army Airfield; 6 mcy BU, 500 acres
Sonoma Land Trust; 1,000-acre tidal restoration

Fort Pierce City Marina, Florida

EWN® Applied to Tyndall Air Force Base Rebuild

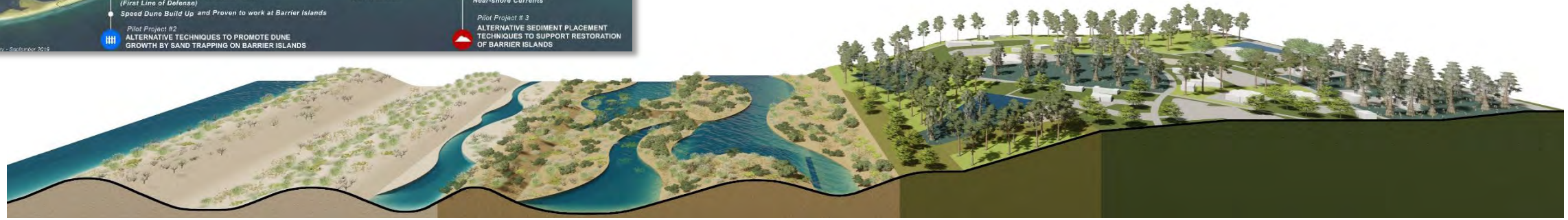
Hurricane Michael, 10-11 OCT, 2018





Tyndallcoastalresilience.com

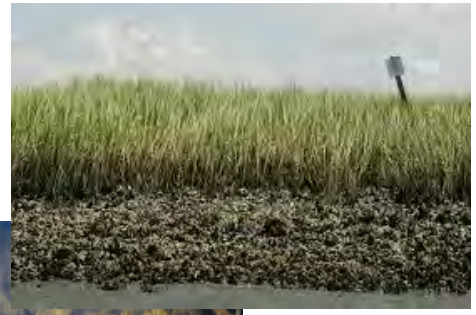
EngineeringWithNature.org,
EWN Podcast Episode 3, BG Melancon

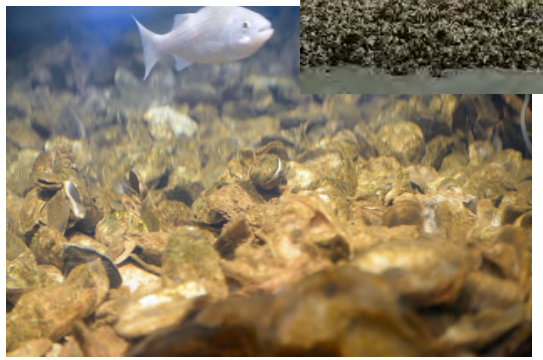


Defense Advanced Research Projects Agency (DARPA): REEFENSE

- **Program Vision**: Develop hybrid biological and engineered reef-mimicking structures to mitigate wave and storm damage that increasingly threaten DoD personnel and infrastructure
- **Program Funding**: $50M over 5 years
- **ERDC Role**: Leading Independent Verification & Validation Team
- 3 Technical Areas
  - Structure Design and Structure
  - Adaptive Biology
  - Ecosystem Engineering
- 5 Year Program
  - Pre-design and Deployment (18 months)
  - Ecosystem Optimization (18 months)
  - Environmental Resilience (24 months)
- 2 Reef Habitats
  - Oyster
  - Coral

Lum, 2014





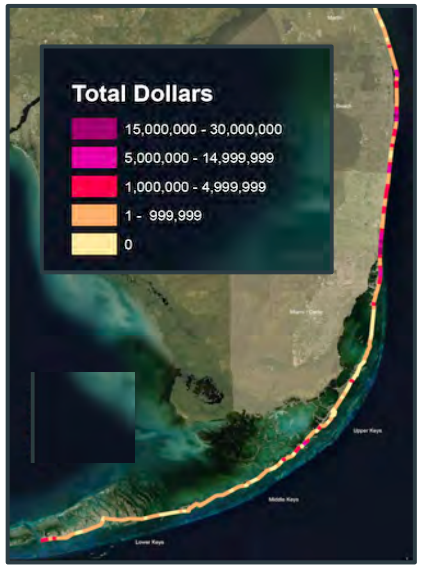
MDGovPics, 2013

EWN®

REEFENSE

US Coral Reef Task Force

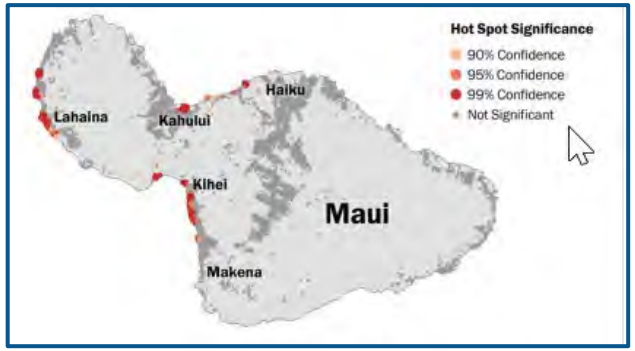
- **Mission**: USCRTF was established in 1998 to preserve and protect coral reef ecosystems.
- **USACE Role**: USACE is a Task Force member & supporting the "restoration and intervention" working group (RIWG).
- **RIWG Initiative:** Team is creating a handbook for community-based coral reef restoration projects that reduce flood risk, including:
  - Site Selection
    (risk – exposure – opportunities - impact)
  - Project Scoping
    (cost benefit analysis – alternatives analysis - maintenance)
  - Application Development
    (scope – budget – schedule - data documentation – match – administration)
- **Stakeholder Engagement:** testing the handbook with State and local partners for effectiveness and usability.
- **Project Partners:** FEMA, NOAA, USACE, USGS, UC Santa Cruz.



Annual hazard risk reduction value of theoretical restoration along Florida's reef tract.

Source: https://doi.org/10.3133/ofr20211054

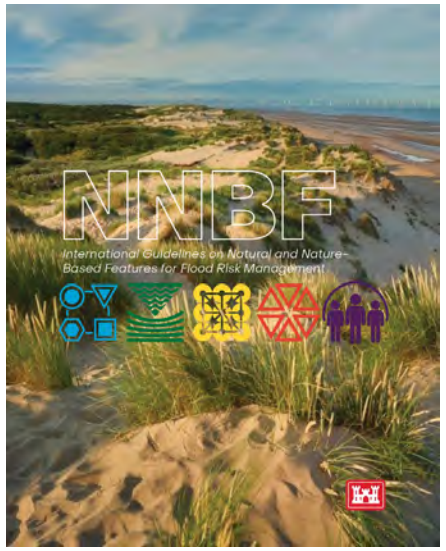
Optimal locations for restoration on Maui.

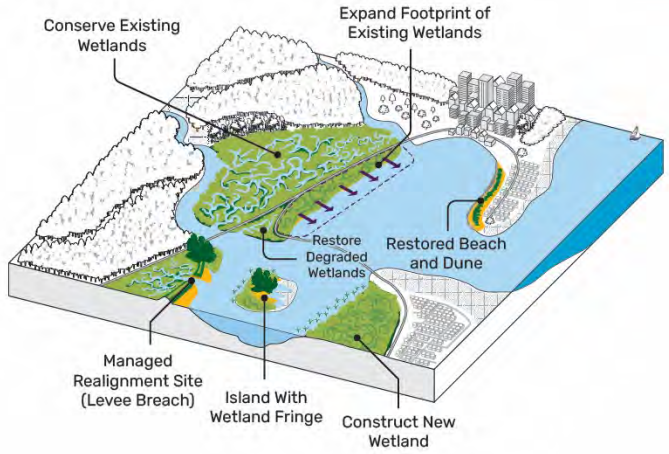


Source: https://www.fema.gov/case-study/mapping-risk-reduction-benefits-coral-reef-conservation

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

NNBF Guidelines Table of Contents





NNBF Guidelines

- Publication summer 2021
- 1,000 pages
- >170 authors and contributors from >70 organizations and 10 countries

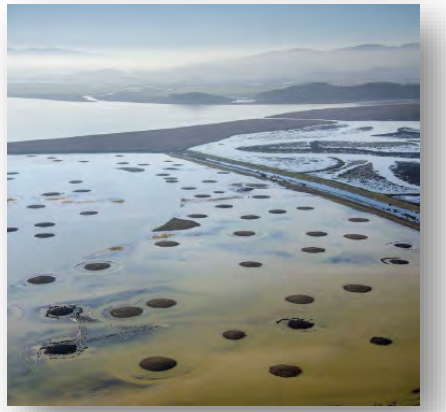
www.engineeringwithnature.org

US Army Corps of Engineers • Engineer Research and Development Center

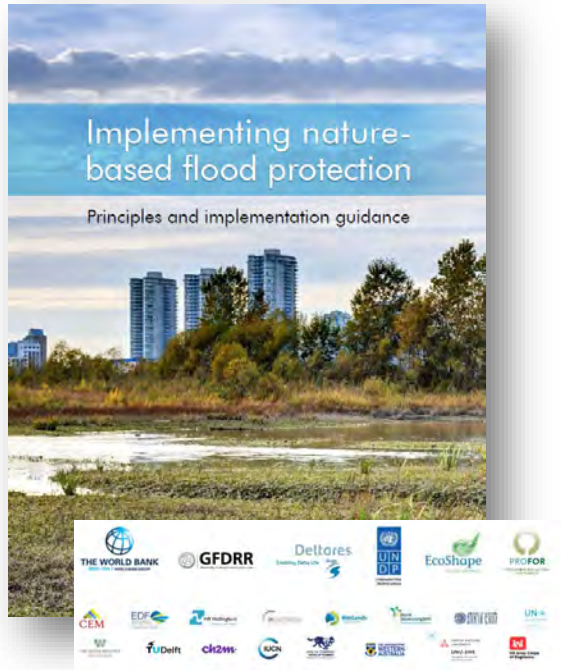
Nature-Based Solutions

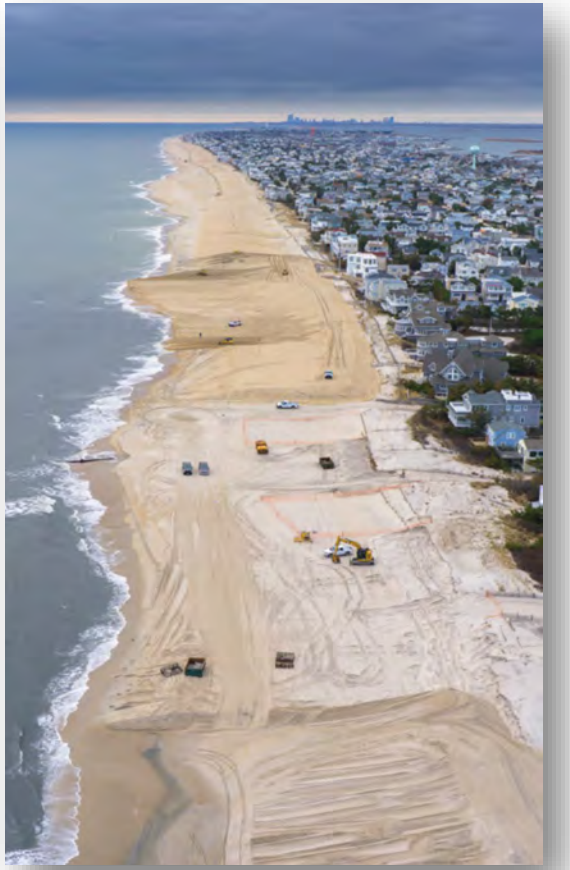
Conserving, restoring, and engineering nature for the benefit of people and ecosystems

- **Project delivery**—"faster, cheaper"
- **Project performance**—complete solutions
- **Adaptability**—scalable, phaseable, 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



EWN®
Engineering With Nature





The Spectrum

"Wild and Free-Flowing Nature" — *"Tamed and Conquered Nature"*

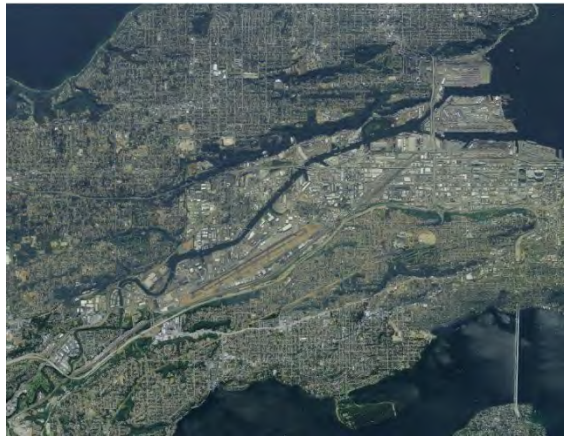
Duwamish River, WA 1800s

San Joaquin Valley, CA 1800s

Achieving Nature-Engineering Balance

Priorities for Advancing EWN

- 21st century vision for water infrastructure
- Policy and its implementation supporting the vision
- Modernized approach to community and stakeholder engagement
- Comprehensive approach to benefits evaluation
- Incremental development of engineering guidance



Duwamish River, WA today

San Joaquin Valley, CA today