Engineering with Nature for Coastal Resilience

Dr. Todd S. Bridges
Senior Research Scientist, Environmental Science
U.S. Army Engineer Research and Development Center,
U.S. Army Corps of Engineers
todd.s.bridges@usace.army.mil

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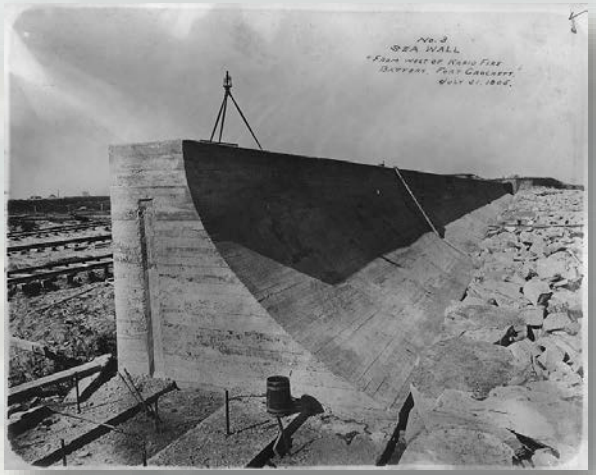
Hard Lessons from the Past

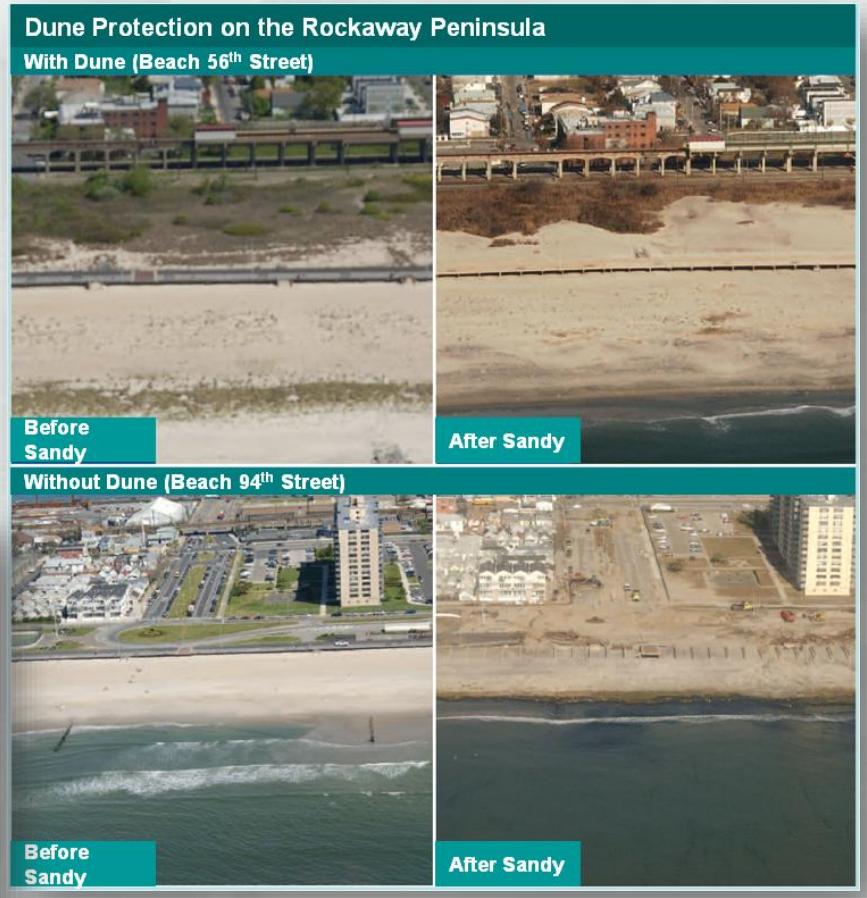
Galveston Hurricane (1900)

- Landfall 8 September 1900
- Estimated Category 4 Hurricane
  - 145 mph winds
- Estimated death toll: 6,000-12,000
- Galveston Seawall
  - Constructed:1902-1963
  - >10 miles long



Resilience Through Hard Engineering…

Nature-Based Features Perform During Hurricane Sandy



http://www.nyc.gov/html/sirr/html/report/report.shtml

In the Context of Coastal Resilience…

- What opportunities are there for achieving better alignment of natural and engineered systems?
  - Can improved alignment reduce risks to life and property?
  - What range of services can be produced through such alignment?
  - What are the science and engineering needs in order to achieve better alignment?

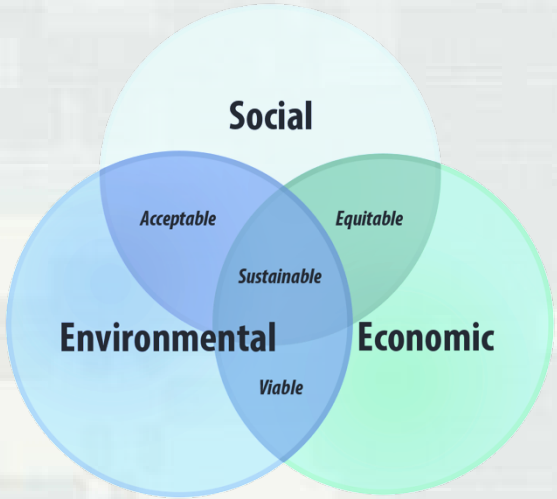
Sustainable Solutions Vision: "Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation's water resources challenges."

Engineering With Nature…

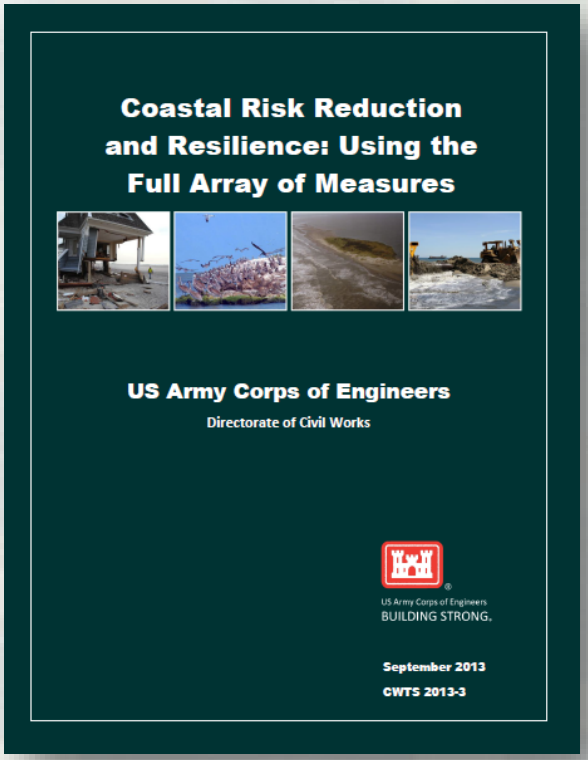
…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

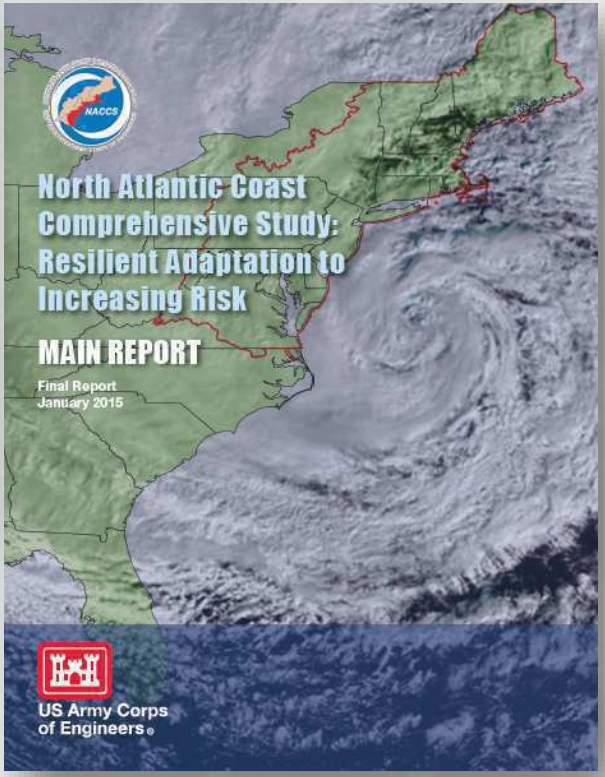
Key Elements:

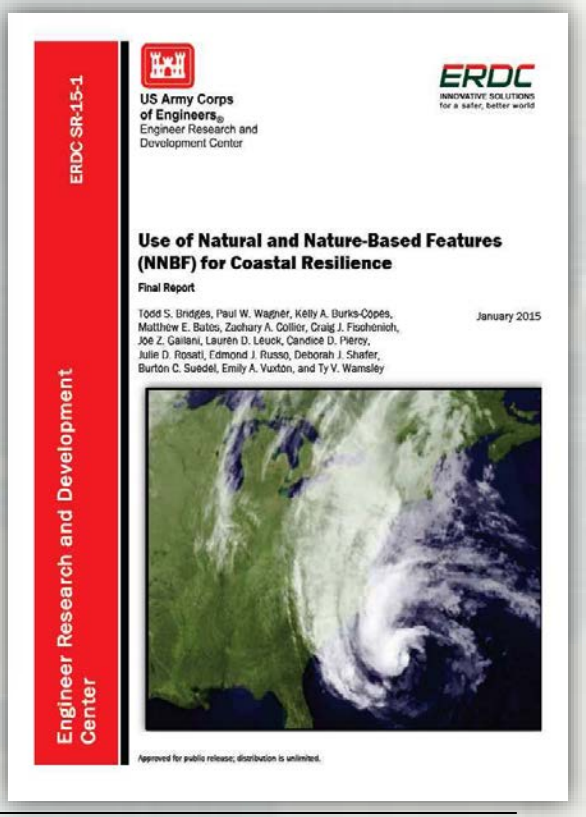
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners



The North Atlantic Coast Comprehensive Study







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http://www.nad.usace.army.mil/CompStudy

Engineering Performance: Nature-Based Features Work in Different Ways

Natural and Nature-Based Infrastructure at a Glance

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED, AND SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY

Dunes and Beaches

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Berm height and width

Beach Slope

Sediment grain size and supply

Dune height, crest, width

Presence of vegetation

Vegetated Features: Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Increase infiltration

Performance Factors

Marsh, wetland, or SAV elevation and continuity

Vegetation type and density

Oyster and Coral Reefs

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Reef width, elevation and roughness

Barrier Islands

Benefits/Processes

Wave attenuation and/or dissipation

Sediment stabilization

Performance Factors

Island elevation, length, and width

Land cover

Breach susceptibility

Proximity to mainland shore

Maritime Forests/Shrub Communities

Benefits/Processes

Wave attenuation and/or dissipation

Shoreline erosion stabilization

Soil retention

Performance Factors

Vegetation height and density

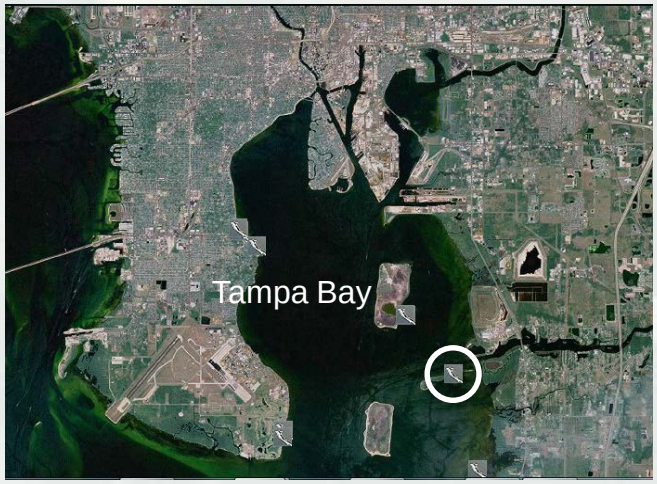
Forest dimension

Sediment composition

Platform elevation

Alafia Banks Bird Sanctuary, FL

- 8000 lb reef module breakwaters (930 ft)
- Shore protection for Audubon bird sanctuary islands
- Help restore oyster populations
- Provide habitat



www.reefball.org

Fort Pierce City Marina, Florida

Cat Island
Green Bay, Wisconsin

USACE Philadelphia District: Back Bay EWN

Mordecai Island

Stone Harbor

Avalon

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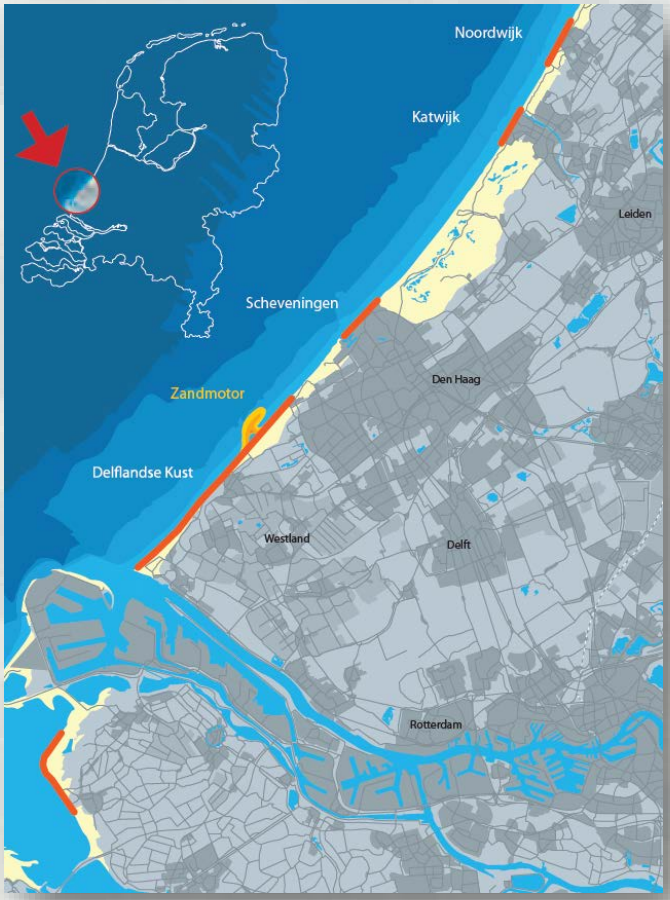
Onehunga Bay Foreshore Restoration
Auckland, New Zealand

Dutch Sand Motor



- 2011 construction
- 21.5 mcm of sand

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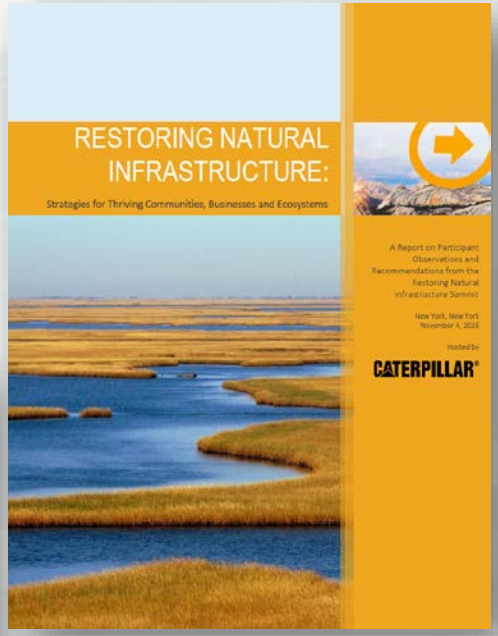
Caterpillar Corporation's *Restoring Natural Infrastructure Summit* 4 November 2015, New York City



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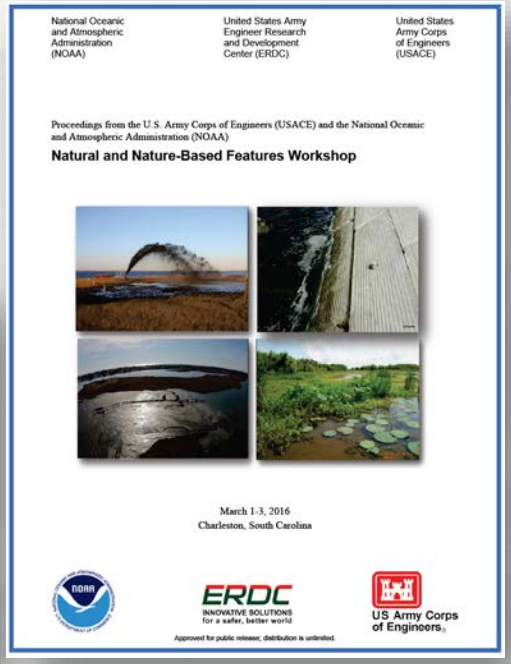
http://www.caterpillar.com/en/company/sustainability/natural-infrastructure.html

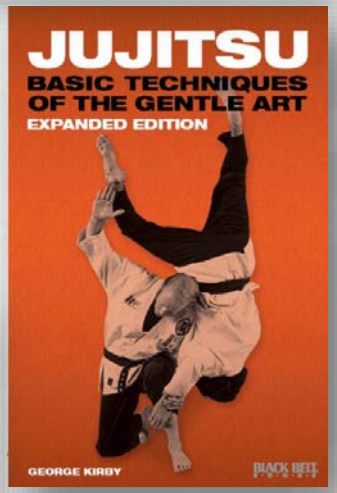
USACE – NOAA Collaboration Workshop on Natural and Nature-Based Features Charleston, SC; 1-3 March 2016

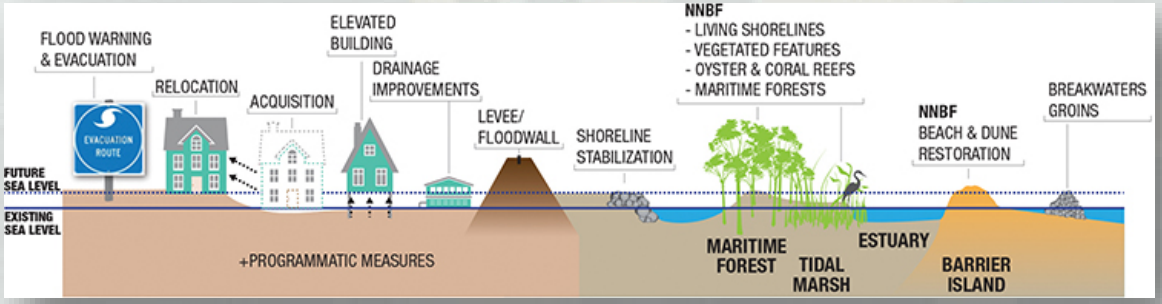


www.engineeringwithnature.org (NNBF)

Opportunities to *Engineer With Nature*

- **Strategies and Tactics**
  - ► Hold the Line
    - Use of NNBF in combination with conventional measures
  - ► Retreat
    - Managed evolution
    - “Coastal Engineering Jujitsu”
  - ► Advance / Attack
    - Adding elevation to the coastal landscape through large-scale construction of NNBF





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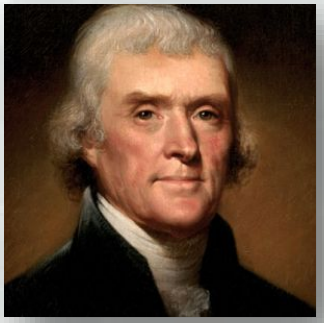

The Pursuit of Resilience…

“I endeavor to keep their attention fixed on the main objects of all science, the freedom & happiness of man.”

Thomas Jefferson to Tadeusz Kosciuszko, 1810

The Battlefield at Saratoga

"The great tacticians of the campaign were hills and forests, which a young Polish engineer was skillful enough to select for my encampment.” Major General Horatio Gates