Engineering with Nature for Natural Infrastructure

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Value and Use of Natural Systems

Following Hurricane Sandy:

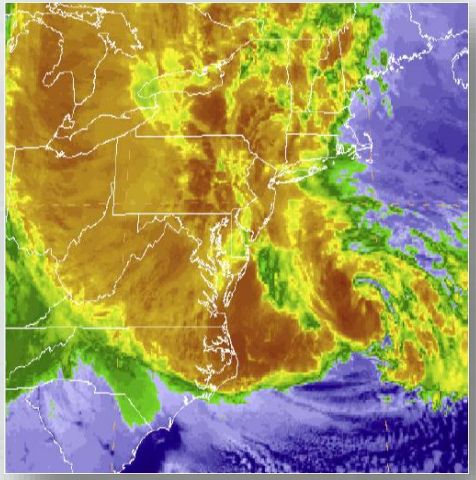
- Risk industry-based tools used to quantify the economic benefits of coastal wetlands
  - Temperate coastal wetlands saved more than $625 million in flood damages.
  - In Ocean County, New Jersey, salt marsh conservation can significantly reduce average annual flood losses by more than 20%.

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



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Creating Value through Alignment…

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

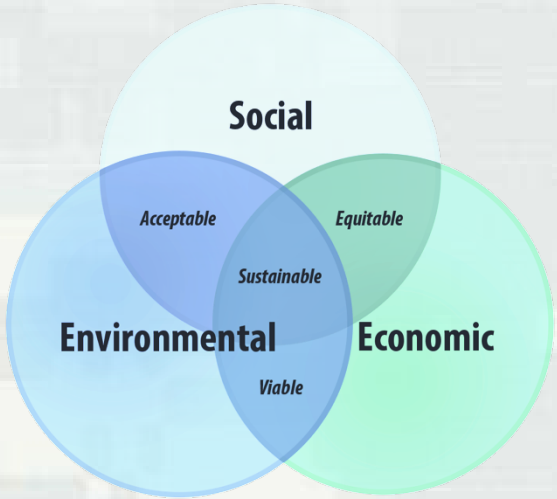
Sustainable Solutions Vision: "Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation's water resources challenges."

Engineering With Nature…

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

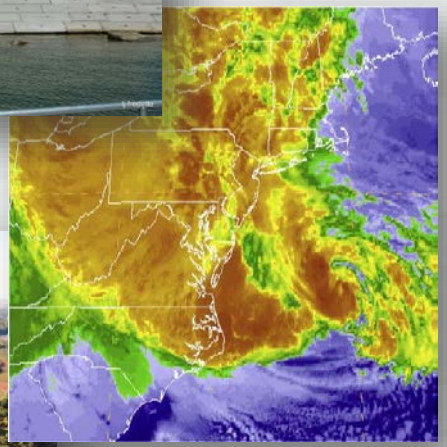
Key Elements:

- 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



EWN Across USACE Mission Space

- Navigation
  - Strategic placement of dredged material supporting habitat development
  - Habitat integrated into structures
  - Enhanced Natural Recovery
- Flood Risk Management
  - Natural and Nature-Based Features to support coastal resilience
  - Levee setbacks
- Ecosystem Restoration
  - Ecosystem services supporting engineering function
  - “Natural” development of designed features
- Water Operations
  - Shoreline stabilization using native plants
  - Environmental flows and connectivity



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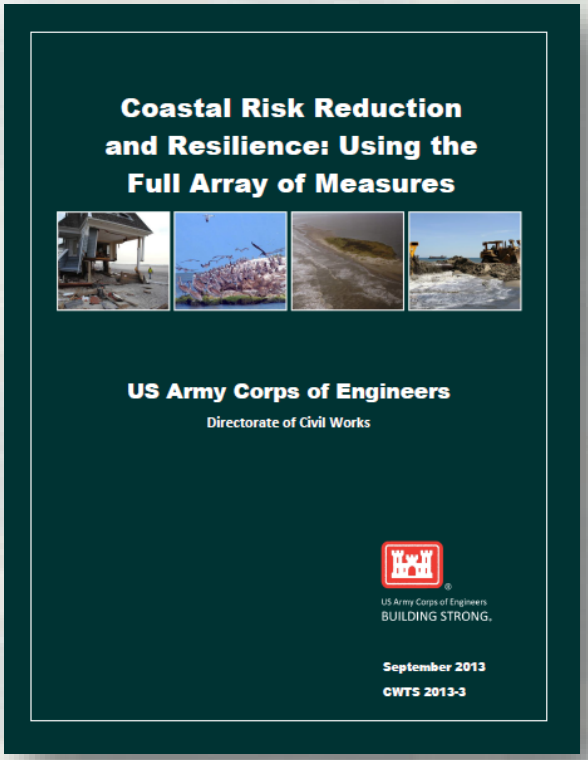
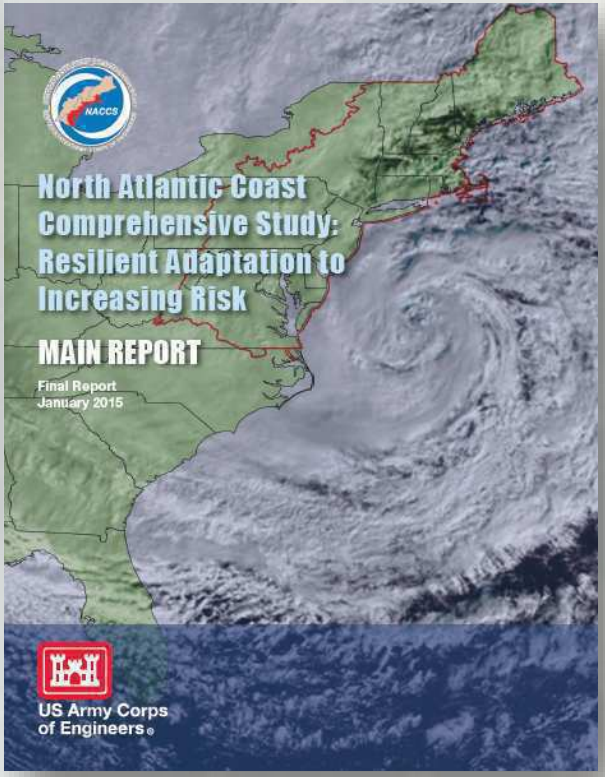
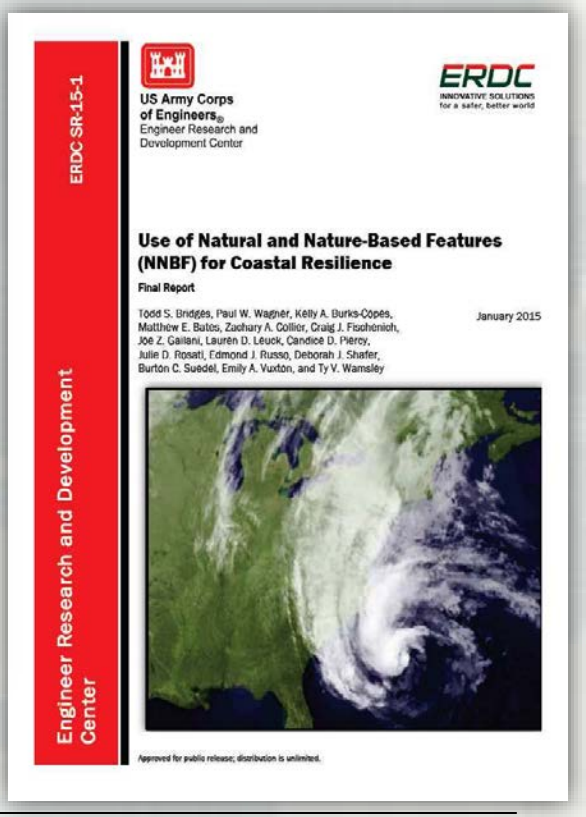
The North Atlantic Coast Comprehensive Study







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

Natural and Nature-Based Features Evaluation and Implementation Framework

ORGANIZATIONAL ALIGNMENT

EVALUATION

IMPLEMENTATION

Iterate as Needed

Identify and Organize Stakeholders, Partners and Authorities

Define Physical and Geomorphic Setting

Assess Vulnerability and Resilience

Identify NNBF Opportunities
- Formalize NNBF Objectives
- Identify NNBF Alternatives
- Define NNBF Performance Metrics

Evaluate NNBF Alternatives
- Tier 1
- Tier 2
- Tier 3

Advance through Tiers as Appropriate

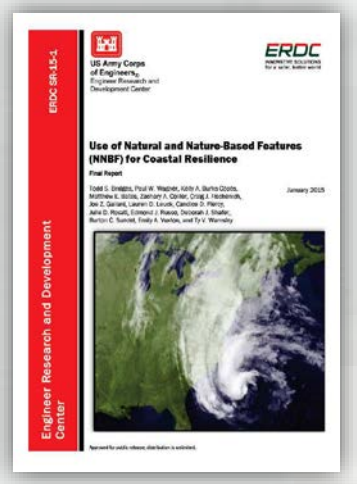
Select NNBF Alternatives

Design Implementation Plan: Elaborate Operational and Engineering Practices

Implement NNBF Alternative

Monitor for Performance and Assess Ecosystem Goods and Services

Feedback



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

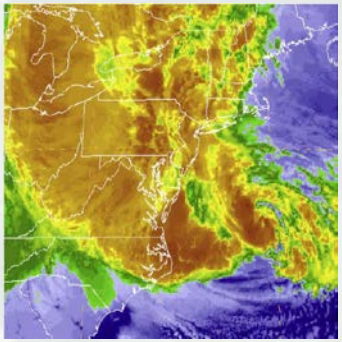
Performance Factors

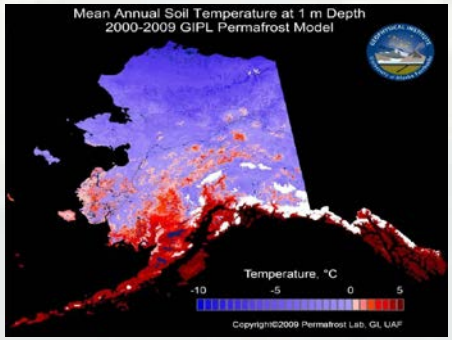
Vegetation height and density

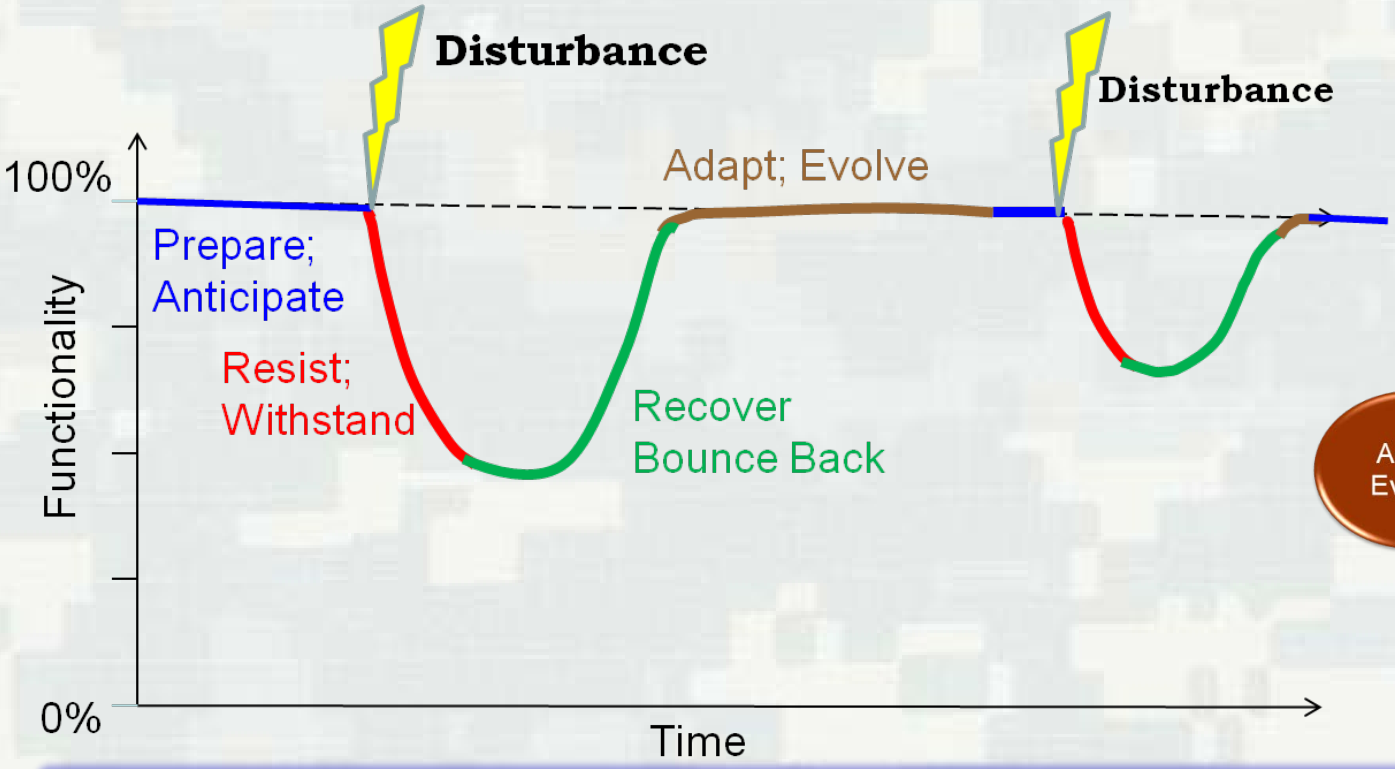
Forest dimension

Sediment composition

Platform elevation



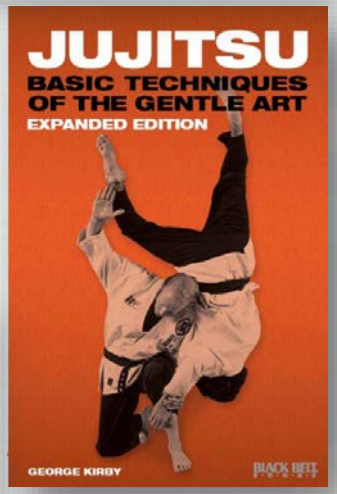


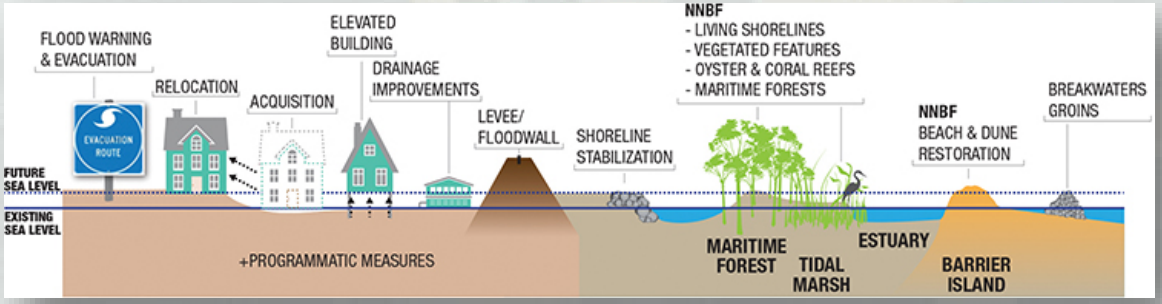


Resilience: the ability of a ***system*** to **Prepare for**, **Resist**, **Recover**, and **Adapt** to achieve functional performance under the stress of disturbances through time.

Opportunities to *Engineer With Nature* for Resilience

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





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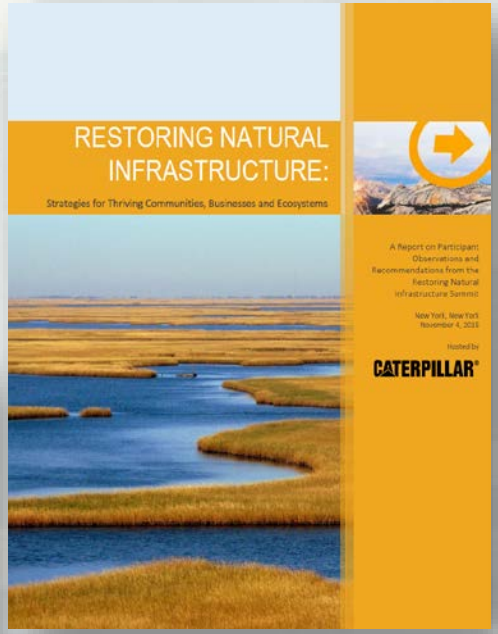
Cat Island
Green Bay, Wisconsin

Noordwaard

Fort Pierce City Marina, Florida

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



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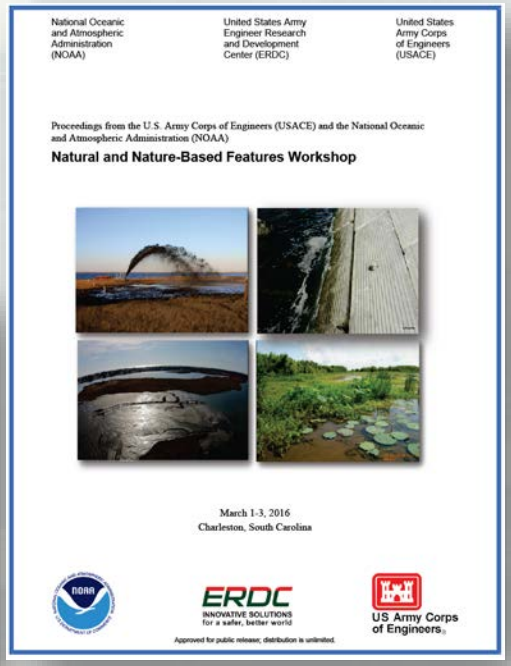
http://www.caterpillar.com/en/company/sustainability/natural-infrastructure.html

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



www.engineeringwithnature.org (NNBF)

USACE/NOAA-NMFS Collaboration Workshop on Engineering with Nature
Gloucester, MA; October 5-6, 2016

www.engineeringwithnature.org

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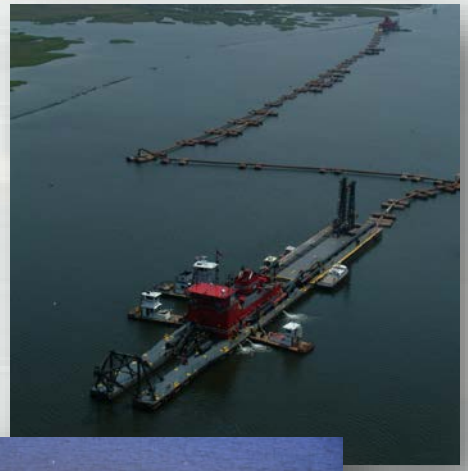
Philadelphia District, ERDC, NOAA Collaboration

Mordecai Island

International Guidelines for Use of Natural and Nature-Based Features for Sustainable Systems

- Publish coastal guidelines by 2019:
  - Multi-author: government, academia, NGOs, engineering firms, construction companies, etc.
  - Addressing the full project life cycle: planning, design, engineering, construction, and maintenance
- Use experience and momentum to initiate inland international guidelines
- Engagement with Silver Jackets?
  - Key needs? How and Who to engage?



EWN-Dutch Collaborations

- Rijkswaterstaat
  - Case studies report and project twinning
- Deltares
  - Collaboration on performance processes
- EcoShape's Building with Nature program
  - Multiple levels
- Academia
  - TU Delft
  - University of Applied Science/HZ

Other EWN Collaborations

- The Nature Conservancy
  - Several topics involving both coastal, estuarine, and inland EWN
- World Bank and UN Development Program
  - Guidelines for international investment in NNBF, developing world
- TAMU EWN Curriculum

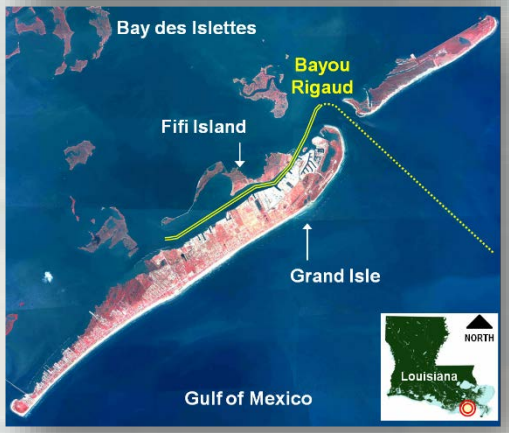
Next Steps for Science and Engineering…

- What processes and engineering requirements are critical to engineering performance and resilience?
- How will integrated solutions and systems evolve over time in dynamic environments?
- How can integrated systems be assembled to reduce long-term O&M costs in order to sustainably deliver resilience?
- How can field-scale demonstration projects be used to accelerate progress?

www.engineeringwithnature.org

Science, Engineering, Technology Research Targets

- Fundamental processes
  - Sediment transport through and around NNBF
  - Long-term engineering and environmental performance of features
  - Ecosystem Services provided by engineered features and structures
  - Processes contributing to system-scale resilience
- Modeling systems that support broad-scale application
  - Planners, stakeholders and decision-makers
  - Engineering design
  - Operations and maintenance
- Reliable, cost-efficient monitoring technologies
  - Measuring system evolution
  - Infrastructure/feature performance
- Demonstration/pilot projects to innovate, evaluate, and learn at relevant field scales
  - Facilitate necessary collaboration
  - Evolve organizational culture and practice
  - Produce credible evidence of success
  - Fuel the “power of the story”



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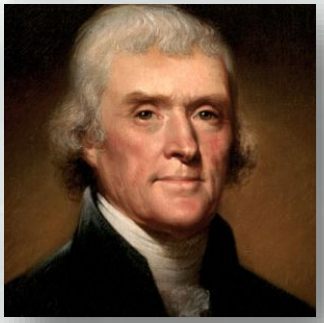

The Pursuit of Resilience…

“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