

# The Network for Engineering With Nature: Developing Future Practice and Practitioners

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**Engineering With Nature** 



N-FWN



## **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





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### **Dune: A Tale of Ecological Potential, 1965**

*"The real wealth of a planet is in its landscape..."* Liet-Kynes, planetary ecologist of Arrakis





Frank Herbert, 1920-1986

Dunes near Florence, Oregon

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Dune, first edition cover, 1965

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### **Ecological Engineering, 1962**

*Ecological engineering: "*the practice of joining the economy of society to the environment symbiotically by fitting technological design with ecological *self design." HT Odum, 2003* 



Port Aransas Nature Preserve



Available online at www.sciencedirect.com

ECOLOGICAL ENGINEERING

Ecological Engineering 20 (2003) 339-361

#### Concepts and methods of ecological engineering

Howard T. Odum<sup>a</sup>, B. Odum<sup>b,\*</sup>

Entronmental Engineering Sciences, P.O. Box 116459, University of Florida, Gatuesville, F.L.32611-6450, USA \* 2160 NII: 9th Ave., Gatuesville, F.L.32603, USA Received 14 June 2002, accepted 4 August 2003

Abstract

Ecological engineering was defined as the practice of joining the economy of society to the environment symbiotically by fining technological design with ecological net/distign. The boundary of ecological engineering systems includes the ecosystems that self organize to fit with technology, whereas environmental engineering designs normally stop at the end of the pipe. For example, the coastal marsh wildlife sanctuary at Port Aranasa, Texas, developed when municipal wastewaters were released on bare sands. The energy hemerative concept provides principles for planning spatial and temporal organization that can be

h examples that include maintaining biodiversity with multiple le like Biosphere 2, wetland filtration of heavy metals, overgrowth stication of ecosystems, closing material cycles, and controlling

ergy hierarchy; Emergy; Transformity; Emdollars; Maximum powe



Engineering is sometimes described as the study and practice of solving problems with technological designs. The sketch in Fig. 1a shows the environment and the economy coupled symbiotically by exchange of materials and services. Environmental engineering develops the technology for connecting society to the environment. But the technology is only half of the interface with environment. The other half of the interface is provided by the ecosystems as they self organize to adapt to the special conditions. Ecological engineering takes advantage of the ecosystems as they combine natural resources and outputs from the economy to generate useful work.



Howard T. Odum, 1924-2002

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### Design with Nature, 1969

"McHarg's emphasis is not on either design or nature by itself, but upon the preposition *with*, which implies human cooperation and biological partnership. He seeks, not arbitrarily to impose design, but to use to the fullest the potentialities—and with them, necessarily, the restrictive conditions—that nature offers."

Lewis Mumford, Introduction to Design with Nature

"Between the sea and man stood two barriers, the one natural, the other its human surrogate: dune and dike" McHarg, *Design with Nature* 







## **Engineering With Nature**<sub>®</sub>

...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
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners

www.engineeringwithnature.org

<image>









Natural and Nature-Based Infrastructure at a Glance GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS: STORM INTENSITY, TRACK AND FORWARD SPECIAL AND SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY



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## **Engineering With Nature**<sub>®</sub> **Overview**

### Engineering With Nature<sub>®</sub> began in 2010

- Guided by a strategic plan
- Engaging across sectors
   >50 workshops, technical meetings, etc.
- Established through Proving Grounds
   Galveston, Buffalo, Philadelphia
- Informed by focused R&D
- Demonstrated with field projects
- Advanced through partnering
- Shared by strategic communications
- Marking progress
  - 2013 Chief of Engineers Environmental Award in Natural Resources Conservation
  - ► 2014 USACE National Award-Green Innovation
  - ► 2015, 2017 WEDA Awards; 2017 DPC Award









### www.engineeringwithnature.org

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## **EWN**<sub>®</sub> for Triple Wins

### **Multi-Function Benefits**

- Engineering On or For nature becomes engineering With nature
- **Bridging organizational** missions and sectors to expand the value proposition for solutions
- **Diversifying the financing of** solutions to produce economic, environmental, and social value





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### Horseshoe Bend Island, Atchafalaya River





**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

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Quantifying Wildlife and Navigation Benefits of a Dredging

Integrated Environmental Assessment and Management



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### **EWN**<sub>®</sub> Applied to Tyndall Air Force Base Rebuild



Nature-Based Solutions along the Mississippi Gulf Coast



### The EWN<sub>®</sub> Approach: Innovation in Practice

- **Policy development** 
  - **Engagement with policymakers**
  - **USACE** policy/procedure development
- Engagement, partnering, and teaming
  - Within USACE, e.g., EWN Proving Grounds
  - With other organizations inside and outside government
- Research
  - **Innovations in practice**
  - Taking the "long view"
  - Establishing future targets and conditions
  - **Tools for delivery**
- **On-the-ground projects and demos** 
  - Across the spectrum of applications and project development (i.e., from planning to operations)
- **Strategic communications** 
  - Individual research papers
  - Visionary products, e.g., EWN Atlas
  - Education, e.g., academic curricula, training

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### The Power of Co-Development and Demonstration

### **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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### **EWN**<sub>®</sub> Research and Development Projects

- 1. Incorporating EWN into Existing Infrastructure
- 2. Developing Engineering Guidance for Natural and Nature-Based Features
- 3. Synthesizing Beneficial Use of Dredge Material (BUDM) Efforts Undertaken by USACE into EWN ProMap
- 4. Maximizing the Long-Term Function of Coastal Islands Derived from EWN Efforts
- 5. Characterizing Engineering Performance of NNBF Combined with Conventional Measures
- 6. Wave Attenuation of Coastal Mangroves During Extreme Water Levels at Near Prototype Scale
- 7. EWN CSTORM Modeling Toolkit
- 8. Implementing Sustainable Dredged Sediment Management Practices for Supporting Coastal Wetlands
- Building an Engineering With Nature Business Case for Natural and Nature Based Features
- 10. EWN Atlas Volume 2
- 11. EWN through Landscape Architecture





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## International Guidelines on the Use of Natural and Nature-Based Features for Flood Risk Management

Goal: Draw together collection international expertise, across sectors, to develop guidelines for using NNBF for flood risk management while expanding and diversifying project value through economic, environmental and social benefits.

- Publish NNBF technical guidelines spring 2021:
  - Multi-author: government, academia, NGOs, engineering firms, construction companies, etc.
  - Addressing the full project life cycle
  - Guidelines in 4 Parts
    - Overarching Topics
    - Coastal Applications
    - Fluvial Applications
    - Conclusions



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## International Guidelines on the Use of Natural and Nature-Based Features for Flood Risk Management

#### **NNBF** Guidelines Structure

- Chapter 1. Introduction
- Chapter 2. Principles, Outcomes, and Frameworks
- · Chapter 3. Engaging Communities and Stakeholders in Implementing Natural and Nature-Based Features
- Chapter 4. Planning and Implementing Natural and Nature-Based Features Using a Systems Approach
- Chapter 5. NNBF Performance
- Chapter 6. Benefits and Costs of NNBF
- Chapter 7. Adaptive Management
- · Chapter 8. Introduction to NNBF in Coastal Systems
- · Chapter 9. Beaches and Dunes
- · Chapter 10. Coastal Wetlands and Tidal Flats
- Chapter 11. Islands
- Chapter 12. Reefs
- Chapter 13. Plant Systems, Submerged Aquatic Vegetation, and Kelp
- · Chapter 14. Enhancing Structural Measures for Environmental, Social, and **Engineering Benefits**
- Chapter 15. Introduction to Fluvial Section
- Chapter 16. Fluvial Systems and Their Influence on Flood Risk Management
- Chapter 17. Challenges and Benefits of Natural and Nature-Based Features in Fluvial Systems

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- · Chapter 18. Description of Fluvial Natural and Nature-Based Features
- Chapter 19. Fluvial Natural and Nature-Based Features Case Studies



## **Engineering With Nature**<sub>®</sub> Atlases



"Engineering With Nature is an important initiative for the U.S. Army Corps of Engineers." James Dalton, USACE Director Civil Works <u>Volume 1</u> 56 Projects, 27 USACE

<u>Volume 2</u> 62 Projects 23 USACE



"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

#### www.engineeringwithnature.org

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### **EWN**<sub>®</sub> Podcast: Season 1

www.engineeringwithnature.org

https://podcasts.apple.com/ca/podcast/ewn-engineering-with-nature/id1528233207

1. Celebrating the 10-Year Anniversary of Engineering With Nature® Guest: Todd S. Bridges, Ph.D., Senior Research Scientist (ST), Environmental Science, and National Lead, Engineering With Nature Initiative, US Army Corps of Engineers

**2. Using Natural Forces and Sediment to Restore Coastal Marsh Habitat** Guest: **Jeff Corbino**, Chief, Environmental Function, Operations Division -Technical Support Branch, New Orleans District, US Army Corps of Engineers

3. Using Natural Infrastructure to Increase Resilience for Military Installations Guest: Brigadier General Patrice Melancon, Executive Director of the Program Management Office, Tyndall Air Force Base, US Air Force

4. Characterizing Storm and Flood Risk Reduction Benefits Derived from Mangroves During Extreme Weather Events Guest: Tori Tomiczek, Ph.D., Assistant Professor, School of Naval Architecture and Ocean Engineering, United States Naval Academy

**5.** Collaborating to Create Wildlife Habitat While Restoring Islands and Improving Community Resilience Guest: Paula Whitfield, Research Ecologist, National Centers for Coastal Ocean Science, National Oceanic and Atmospheric Administration



6. Assessing the Value of Natural and Nature-Based Features in Coastal Storm and Flood Risk Reduction Guest: Mike Beck, Ph.D., Research Professor and Head of the Coastal Resilience Lab, University of California at Santa Cruz

**7.** Incorporating EWN into Coastal Texas Resilience and Restoration Guest: Edmond Russo, Ph.D., P.E., Deputy District Engineer for Planning, Programs and Project Management, Galveston District, US Army Corps of Engineers

8. Protecting Fragile Coasts and Improving Community Resilience Guest: Monica Chasten, Project Manager, Operations Division, Philadelphia District, US Army Corps of Engineers

**9.** Collaborating with Industry to Promote Natural Infrastructure Guests: Don McNeill, Director of Natural Infrastructure Initiative, Caterpillar, Inc. and Mike Donahue, Ph.D., Vice-President of Water Resources and Environmental Services. AECOM

**10.** Collaborating with Academia to Develop Future Practice and Practitioners Guests: Brian Bledsoe, Ph.D., Director of University of Georgia's Institute for Resilient Infrastructure Systems and Todd S. Bridges, Ph.D., Senior Research Scientist (ST), Environmental Science, and National Lead, Engineering With Nature Initiative, US Army Corps of Engineers

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## The Spectrum

### "Wild and Free-Flowing Nature"

### "Tamed and Constrained Nature"



Duwamish River, WA 1800s



### Achieving Nature-Engineering Balance

- Societal values
- Policy legacies and time lags
- The process of innovation
- Collaboration across boundaries



Duwamish River, WA today



San Joaquin Valley, CA today

San Joaquin Valley, CA 1800s

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## NETWORK FOR ENGINEERING WITH NATURE<sub>®</sub>

## **Network for Engineering With Nature**

- Introduce N-EWN
- Our lines of effort
- Example R&D projects and educational initiatives
- Vision for how N-EWN will grow and evolve
- How to get involved

N-EWN

## Vision for N-EWN

- Large scale network is needed for innovation / knowledge acceleration
- Driven primarily by research community
- Aligning research with the needs of practice
- Grounding research in real projects
- EWN curricula and training
- Experiential learning for students systems thinking, crossdisciplinary training
- Types of partners
  - Research academic, private
  - Industry practitioners
  - Users and project owners
- Freely flowing communication and knowledge sharing
- Shorten road to implementation



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## Institute for Resilient Infrastructure Systems UNIVERSITY OF GEORGIA

### Vision

Natural and conventional infrastructure working together for thriving communities, businesses and natural systems.

### Mission

- Advance the integration of natural and conventional infrastructure systems to strengthen long term resilience to flooding, sea level rise, drought, and other disruptions.
- Empower communities and businesses to discover wise infrastructure solutions that maximize social, economic, and environmental benefits.
- Support informed decision making through interdisciplinary expertise, cutting edge tools and techniques, and collaborative partnerships.



College of Engineering College of Agricultural and Environmental Marine Extension and Georgia Sea Grant **Sciences College of Public Health Carl Vinson Institute of Government** Odum School of Ecology **College of Environment and Design** Warnell School of Forestry and Natural Franklin College of Arts and Sciences Resources (including Anthropology, Geology, Skidaway Institute of Oceanography Geography, Marine Science, Psychology) School of Social Work Ecologists Civil, Mechanical, Environmental, & **Hydrologists Computer Engineers**  Anthropologists Psychologists Natural resource economists Geologists Landscape architects **Marine Scientists and Oceanographers** Meteorologists **Foresters**  Social workers Lawyers

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### Four Pillars of N-EWN

#### METHODS AND STANDARDS

Rigorous methods, standards and tools are needed to effectively plan, design, construct and operate natural infrastructure at different scales.



#### ASSESSING BENEFITS AND COSTS

Natural infrastructure provides communities with a broad array of economic, environmental and social benefits. Improved approaches are needed to evaluate, quantify and forecast these benefits to support planning and decision making.

### MONITORING PERFORMANCE AND OUTCOMES

Technically sound, efficient, and applicable methods are needed to track natural infrastructure performance over time, develop the evidence base for future designs and investments, ensure compliance with policy and inform project operations and adaptive management.





#### INTEGRATING PEOPLE AND POLICY

Providing infrastructure that supports human wellbeing and equitably meets the needs of diverse communities, requires integration of human values, attitudes, beliefs, and policies with modern communication and collaboration practices.

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### **Projects underway**

- Characterizing USACE natural and nature-based features (NNBF) projects
- Developing and implementing a holistic framework for monitoring natural and nature-based solutions
- Factors enabling or restraining system-scale use of naturebased solutions
- NI lifecycles: function, resilience, maintenance, and lifespans
- NNBF project evaluation processes: past, present, and future of evaluation metrics of natural and nature-based infrastructure
- Influence of extent and location of NI on animals and watersheds
- Paired extremes, avoided losses: pre/post disaster monitoring of natural and nature-based features
- Risk perception as a driver of adoption and use of nature-based solutions
- Scaling NI: determining the sizes and combinations of NI to reduce coastal and riverine flood hazards
- The role of social equity in executing nature-based solutions
- Spatial prioritization of natural infrastructure to maximize benefits for people and nature



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## **Project Example: Developing Methods and Standards**

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New tools, techniques and guidance are needed to effectively plan, design, construct and operate natural infrastructure at different scales

Spatial Prioritization of Natural Infrastructure to Maximize Benefits for People and Nature

 Developing a natural infrastructure landscape prioritization tools coupled with a multicriteria decision analysis framework to enable users to define desired objectives, determine constraints, and then visualize and evaluate areas for potential NI applications that meet target objectives



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## Project Example: Assessing Benefits and Costs

Natural infrastructure provides communities with a broad array of economic, environmental and social benefits. Improved approaches are needed to evaluate, quantify and forecast these benefits to support planning and decision making

Natural Infrastructure Project Evaluation Processes: Evaluation Metrics of Natural Infrastructure

 Summarize and compare evaluation methodologies used by relevant federal agencies and other organizations involved in developing NI as well as best practices in BCA to improve current evaluation policies and practices with special attention to benefit transfer practices.



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## Project Example: Monitoring Performance and Outcomes

Improved methods are needed to track natural infrastructure performance over time, develop the evidence base for future designs, ensure compliance with policy and inform project operations and adaptive management

Developing and Implementing a Holistic Framework for Monitoring NI Projects

- Creating a flexible framework for designing effective, cost-efficient monitoring programs for NNBS projects
- Field-testing the framework with real-world projects and developing training materials to make the approach widely accessible



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## Project Example: Integrating People and Policy

Providing infrastructure that supports human wellbeing and equitably meets the needs of diverse communities requires integration of human values, attitudes, beliefs, perceptions and policies with modern communication and collaboration practices

# Risk perception as a driver of natural infrastructure use

- Examining how people perceive environmental risks and benefits, and how those perceptions affect willingness to adopt natural infrastructure
- Discovering how risk perceptions influence designers and managers' decisions about natural infrastructure
- Identifying current statutory and regulatory limitations related to natural infrastructure

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rontiers

in Ecology and Evolution

## Interdisciplinary and cross-sectoral publications



Available online at www.sciencedirect.com ScienceDirect



Challenges to realizing the potential of nature-based solutions

Donald R Nelson<sup>a,b</sup>, Brian P Bledsoe<sup>b,c</sup>, Susana Ferreira<sup>b,d</sup> and Nathan P Nibbelink<sup>b,e</sup>



#### Evaluating Resilience Co-benefits of Engineering With Nature<sup>®</sup> Projects

BRIEF RESEARCH REPORT published: 01 June 2020

doi: 10.3389/fevo 2020 0

Margaret H. Kurth<sup>1,2</sup>, Rahim Ali<sup>1,2</sup>, Todd S. Bridges<sup>1</sup>, Burton C. Suedel<sup>1</sup> and Igor Linkov<sup>1\*</sup>

Viewpoint

From hubris to humility: Transcending original sin in managing hydroclimatic risk



Donald R. Nelson<sup>a,b,\*</sup>, Brian P. Bledsoe<sup>b,c</sup>, J. Marshall Shepherd<sup>b,d</sup>

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## **N-EWN Educational Initiatives**

- Building the practitioner
- Socio-ecological understanding for engineers / engineering understanding for scientists – undergraduate and graduate curricula
- Government and industry internships and coops
- UGA Engineering Education Transformations Institute – empathy for humanitarian and conservation engineering
- American Society of Civil Engineers training and outreach with current and future practitioners
- Webinars, short courses, training through academia, USACE, ASCE, etc.



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## **N-EWN Educational Initiatives**

- Interdisciplinary graduate curricula, e.g. UGA ICON Ph.D. program
  - Systems thinking / interdisciplinary competencies
  - Ecological understanding for engineers but also engineering for social and environmental scientists
- Combine online instruction of existing courses with new courses in nature-based solutions and systems thinking, emphasizing cross-disciplinary training and communication
- Certificate programs IRIS working toward a new online certificate program in nature-based solutions and infrastructure
- Cross-university instruction, e.g. ERDC UGA U of Antwerp
- Embed graduate students in USACE project delivery teams

#### ICONIntegrative Conservation TRAINING AGILE SCIENTISTS TO ADDRESS 21<sup>st</sup> CENTURY SOCIO-ECOLOGICAL CHALLENGES



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## **EWN / NI Courses at UGA**

- ICON 8500 Nature-based infrastructure for sustainable water management in the Anthropocene - Spring 2019
  - Instructors: Nate Nibbelink (Forestry & Natural Resources), Dr. Don Nelson (Anthropology), Brian Bledsoe (Engineering), Susana Ferreira (Economics)
- ENGR 8900 Nature-based Infrastructure Engineering and Design - Spring 2020 – co-taught with ERDC instructors:
  - Todd Bridges
  - Tosin Sekoni
  - Brian McFall
  - Joe Gailani
  - Brook Herman
  - Candice Piercy
  - Safra Altman
  - Jeff King
  - Kyle McKay
- CVLE 8110 Environmental River Mechanics Fall 2020
   Kyle McKay, Brian Bledsoe, Chris Haring





### Learning objectives and competencies

- Systems thinking competency: recognize and understand relationships; analyze complex systems; how systems are embedded within different domains and different scales; and deal with uncertainty.
- Anticipatory competency: understand and evaluate multiple futures – possible, probable and desirable; apply the precautionary principle; assess the consequences of actions; and deal with risks and changes.
- Collaboration competency: learn from others; understand and respect the needs, perspectives and actions of others (empathy); understand, relate to and be sensitive to others (empathic leadership); deal with conflicts in a group; and facilitate collaborative and participatory problem solving.
- Integrated problem-solving competency: overarching ability to apply different problem-solving frameworks to complex resilience problems and develop viable, inclusive and equitable solution options that promote sustainable development, integrating the abovementioned competences.







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## **Overarching N-EWN goals**

- Mainstream EWN and bring natural infrastructure to scale
- Place natural infrastructure on equal footing with conventional approaches
- Facilitate the social dynamics of innovation
- Expand the value of the network of projects and actions undertaken at the system scale





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## **N-EWN Partnerships**

- Substantive commitment integration of research, education, practice, communication / outreach
- Desire to work and share across institutions and organizations
- Recognize need for cross-sector collaboration
- Test beds learning by doing e.g., addressing perceptions, private lands, and permitting
- Facilitating full scale project implementation
- Working hard to bridge disciplinary boundaries
- Diversifying funding and business models, e.g. public / private, collaborative proposals



# Get in touch

Learn more and join our mailing list at www.n-ewn.org

Follow us on Twitter and Instagram:

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ewn-usace@usace.army.mil



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