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

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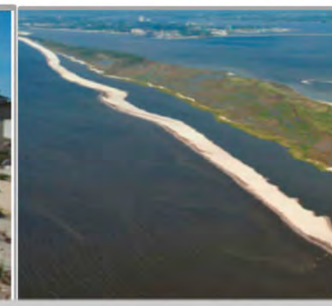
EWN Seminar
November 17, 2020



Engineering With Nature
N-EWN

US Army Corps of Engineers

UNIVERSITY OF GEORGIA

Institute for Resilient Infrastructure Systems
UNIVERSITY OF GEORGIA

ERDC

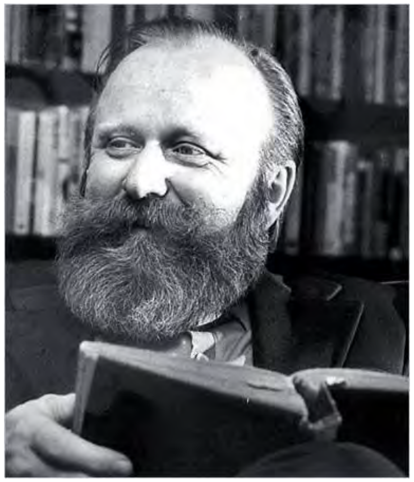
1900-2000: The Century of Infrastructure (US)

- 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

Dune: A Tale of Ecological Potential, 1965

Dune, first edition cover, 1965

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



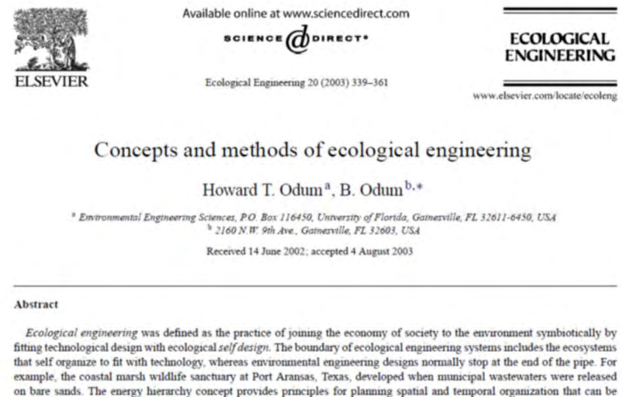
Frank Herbert, 1920-1986

Dunes near Florence, Oregon

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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Ecological Engineering 20 (2003) 339–361

ECOLOGICAL ENGINEERING

www.elsevier.com/locate/ecoleng

Concepts and methods of ecological engineering

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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 fitting technological design with ecological *self design.* 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 Aransas, Texas, developed when municipal wastewaters were released on bare sands. The energy hierarchy concept provides principles for planning spatial and temporal organization that can be

h examples that include maintaining biodiversity with multiple

e like Biosphere 2, wetland filtration of heavy metals, overgrowth

stication of ecosystems, closing material cycles, and controlling

nergy hierarchy; Emergy; Transformity; Emdollars; Maximum power

erved.

1.1. Definitions

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.

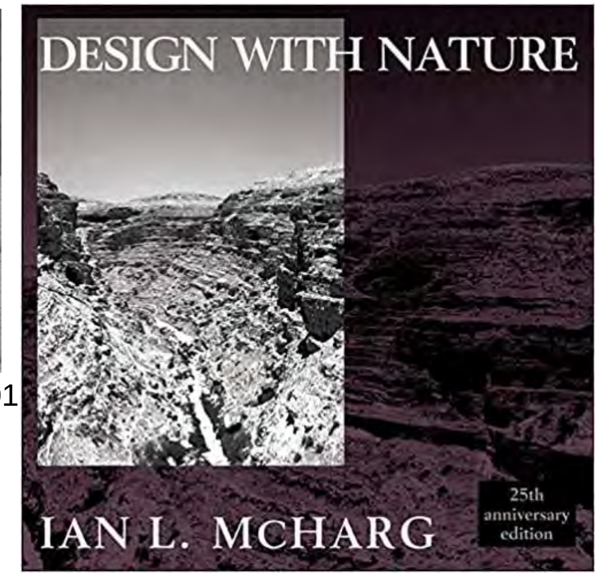
Howard T. Odum, 1924-2002

Design with Nature, 1969

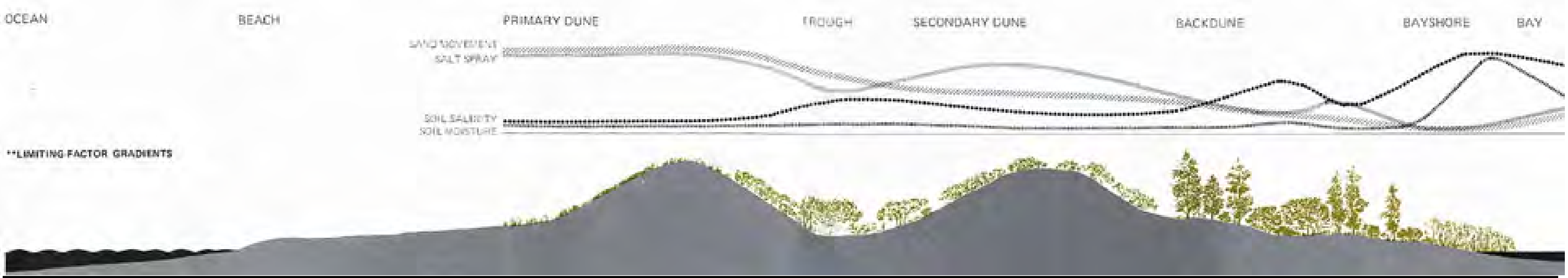
"McHarg's emphasis is not on either design or nature by itself, but upon the preposition ***with***, which implies human cooperation and biological partnership. He seeks, not arbitrarily to impose design, but to use to the fullest the potentialities—and with them, necessarily, the restrictive conditions—that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

Lewis Mumford, Introduction to *Design with Nature*

Ian McHarg, 1920-2001



"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®

…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

Engineering With Nature® Overview

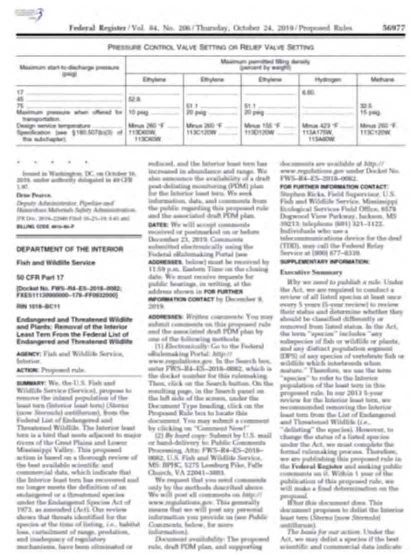
- *Engineering With Nature®* began in 2010
  - Guided by a strategic plan
  - Engaging across sectors
    - >50 workshops, technical meetings, etc.
  - Established through Proving Grounds
    - Galveston, Buffalo, Philadelphia
  - Informed by focused R&D
  - Demonstrated with field projects
  - Advanced 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

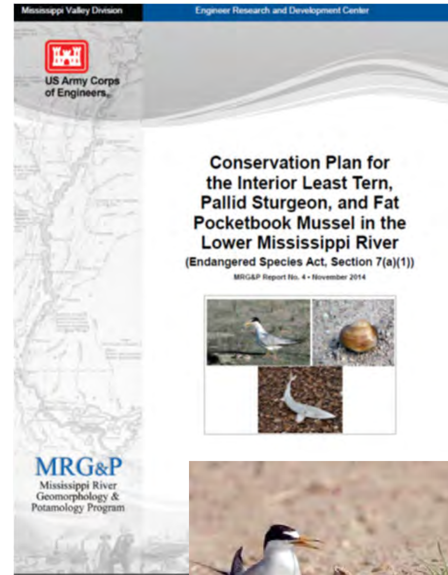
www.engineeringwithnature.org

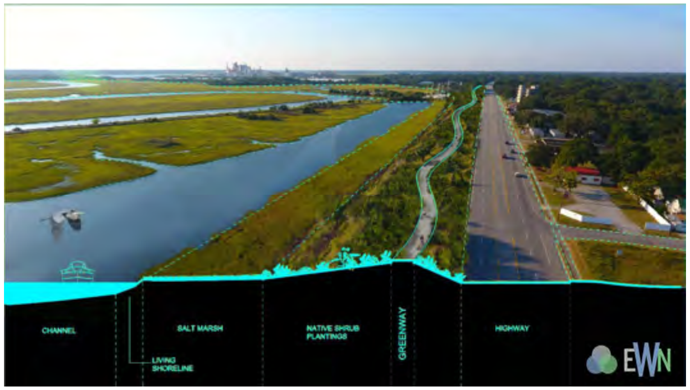
EWN® for Triple Wins

Multi-Function Benefits

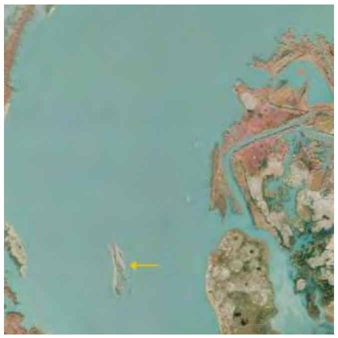
- Engineering On or For nature becomes engineering With nature
- Bridging organizational missions and sectors to expand the value proposition for solutions
- Diversifying the financing of solutions to produce economic, environmental, and social value

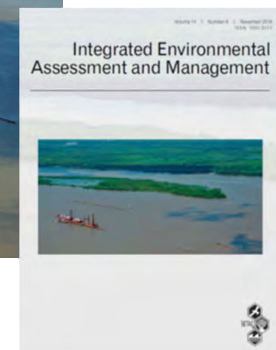






Horseshoe Bend Island, Atchafalaya River





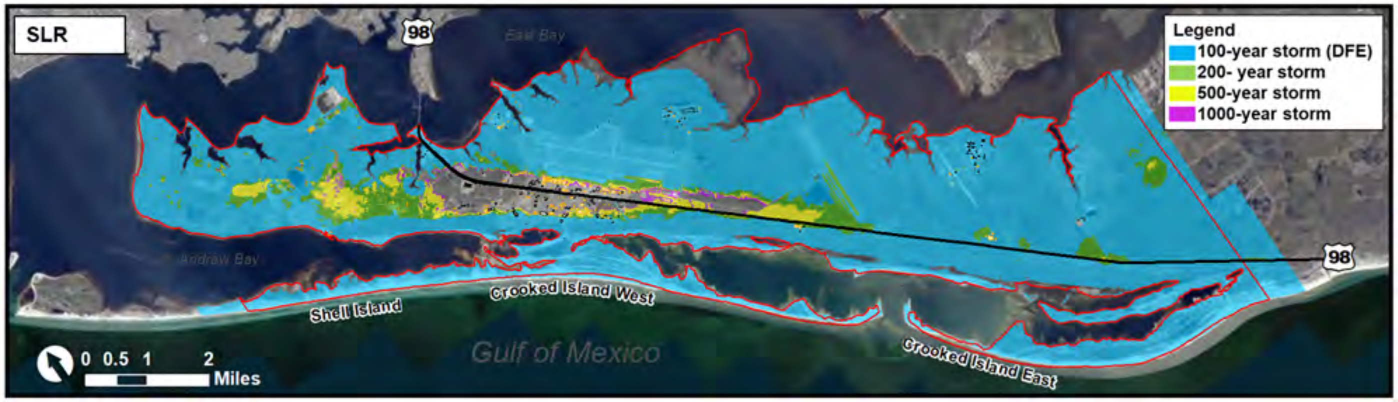
Quantifying Wildlife and Navigation Benefits of a Dredging Beneficial-Use Project in the Lower Atchafalaya River: A Demonstration of Engineering with Nature®

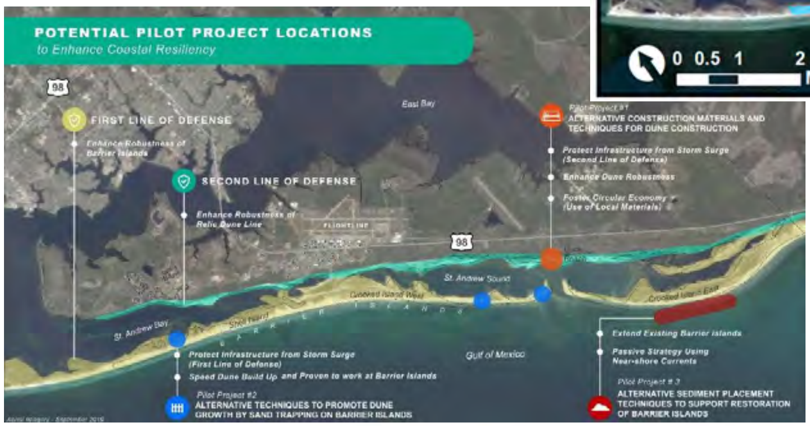
Christy M Foran, Kelly A Burks-Copes, Jacob Berkowitz, Jeffrey Corbino, and Burton C Suedel

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**

EWN® Applied to Tyndall Air Force Base Rebuild

Hurricane Michael, 10-11 OCT, 2018

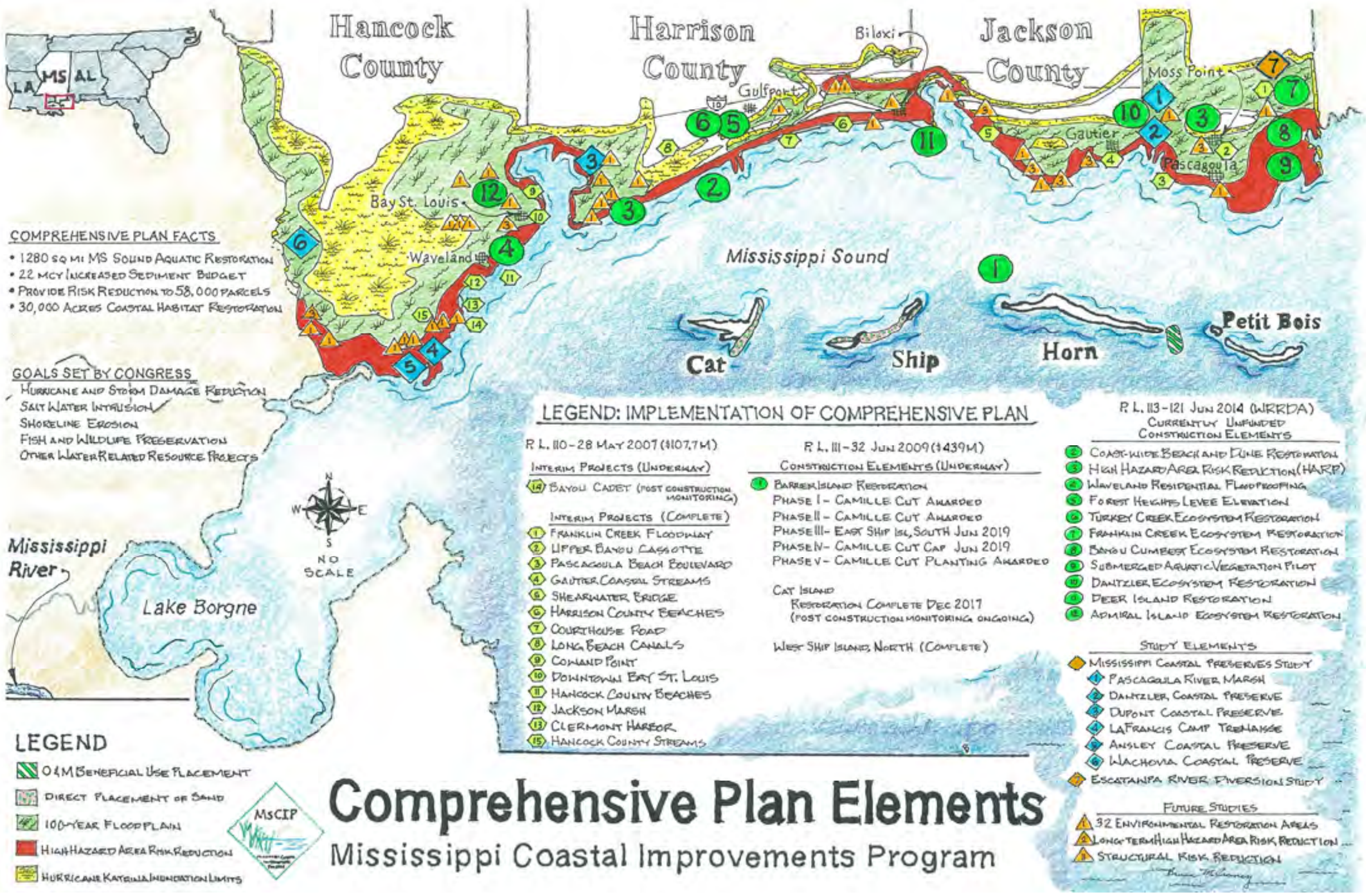


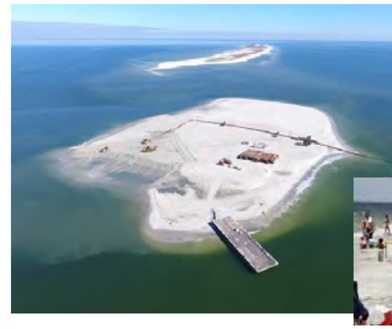


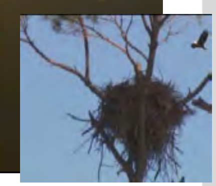
Tyndallcoastalresilience.com

EngineeringWithNature.org,
EWN Podcast Episode 3, BG Melancon

Nature-Based Solutions along the Mississippi Gulf Coast







The EWN® 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

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

EWN® 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
9. Building an Engineering With Nature Business Case for Natural and Nature Based Features
10. EWN Atlas Volume 2
11. EWN through Landscape Architecture

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.

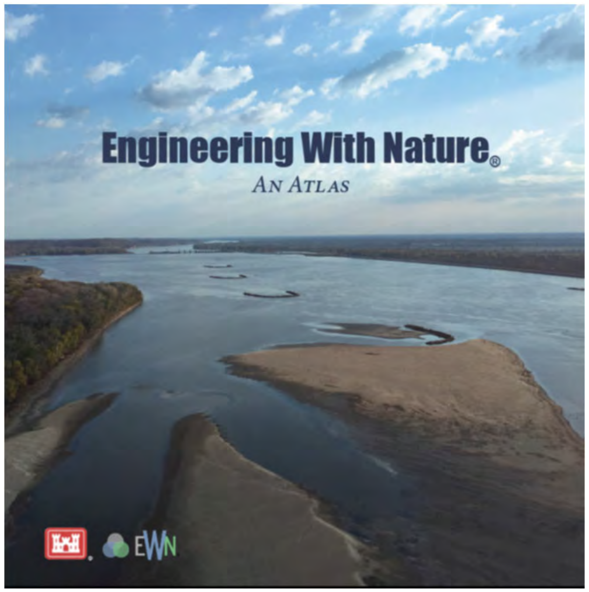
- Publish NNBF technical guidelines spring 2021:
  - Multi-author: government, academia, NGOs, engineering firms, construction companies, etc.
  - Addressing the full project life cycle
  - Guidelines in 4 Parts
    - Overarching Topics
    - Coastal Applications
    - Fluvial Applications
    - Conclusions

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

Engineering With Nature® Atlases



<u>Volume 1</u>
56 Projects,
27 USACE

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

"Engineering With Nature is an important initiative for the U.S. Army Corps of Engineers." James Dalton, USACE Director Civil Works

"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

EWN® 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

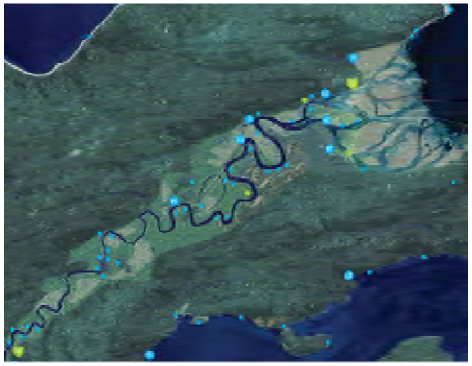
9. Collaborating with Industry to Promote Natural Infrastructure
Guests: **Don McNeill**, Director of Natural Infrastructure Initiative, Caterpillar, Inc. and **Mike Donahue**, Ph.D., Vice-President of Water Resources and Environmental Services, AECOM

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

The Spectrum

"Wild and Free-Flowing Nature"

"Tamed and Constrained Nature"



Duwamish River, WA 1800s

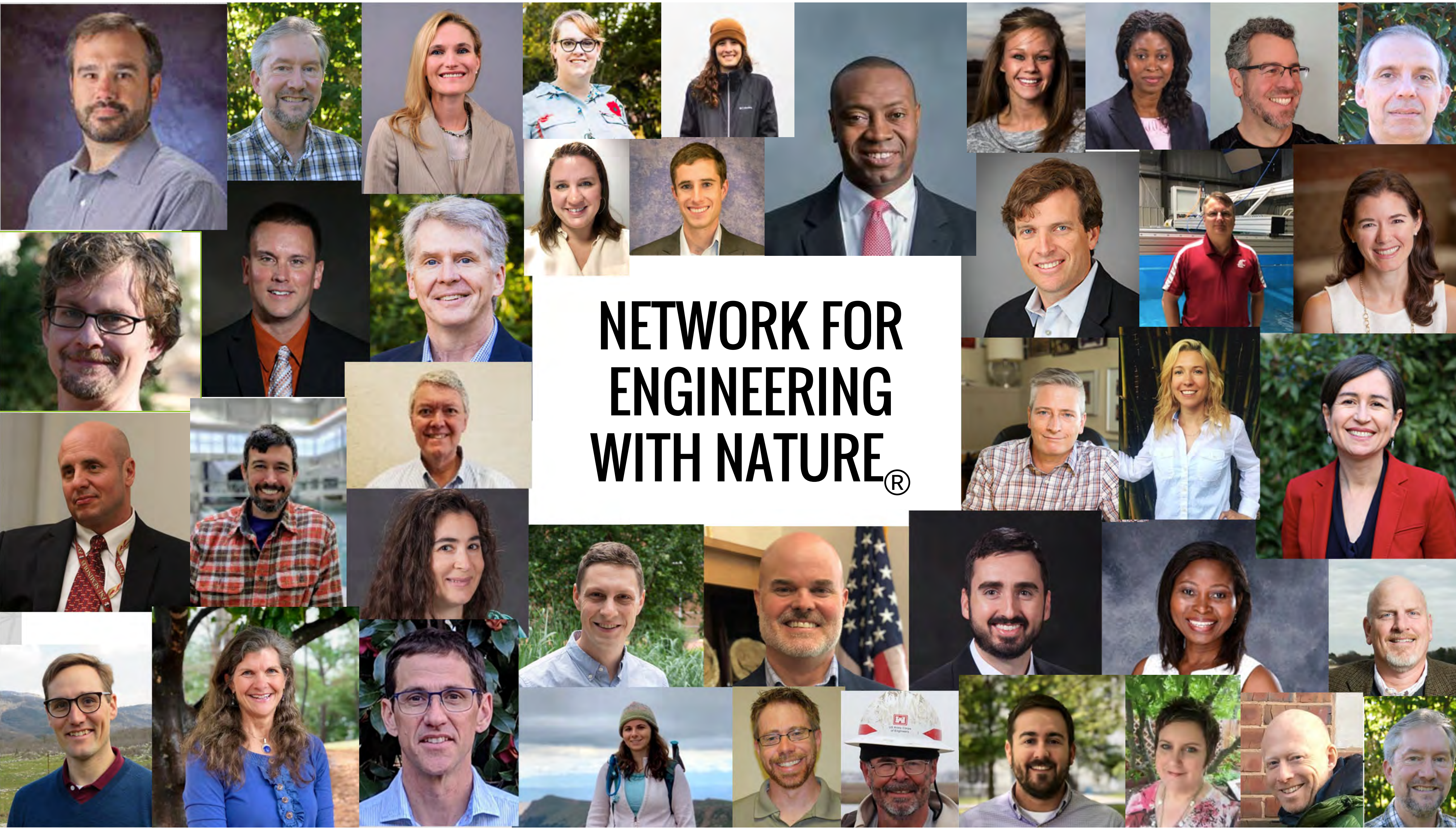
San Joaquin Valley, CA 1800s

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


NETWORK FOR
ENGINEERING
WITH NATURE®

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, cross-disciplinary training
- Types of partners
  - Research – academic, private
  - Industry practitioners
  - Users and project owners
- Freely flowing communication and knowledge sharing
- Shorten road to implementation

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.

Institute for Resilient Infrastructure Systems
UNIVERSITY OF GEORGIA

- College of Engineering
- College of Agricultural and Environmental Sciences
- Carl Vinson Institute of Government
- College of Environment and Design
- Franklin College of Arts and Sciences (including Anthropology, Geology, Geography, Marine Science, Psychology)
- Marine Extension and Georgia Sea Grant
- College of Public Health
- Odum School of Ecology
- Warnell School of Forestry and Natural Resources
- Skidaway Institute of Oceanography
- School of Social Work

- **Ecologists**
- **Hydrologists**
- **Anthropologists**
- **Natural resource economists**
- **Landscape architects**
- **Meteorologists**
- **Social workers**
- **Civil, Mechanical, Environmental, & Computer Engineers**
- **Psychologists**
- **Geologists**
- **Marine Scientists and Oceanographers**
- **Foresters**
- **Lawyers**


N-EWN
DEVELOPING METHODS AND STANDARDS
ASSESSING BENEFITS AND COSTS
MONITORING PERFORMANCE AND OUTCOMES
INTEGRATING PEOPLE AND POLICY

Four Pillars of N-EWN

METHODS AND STANDARDS	ASSESSING BENEFITS AND COSTS	MONITORING PERFORMANCE AND OUTCOMES	INTEGRATING PEOPLE AND POLICY
Rigorous methods, standards and tools are needed to effectively plan, design, construct and operate natural infrastructure at different scales.	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.	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.	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.

Projects underway

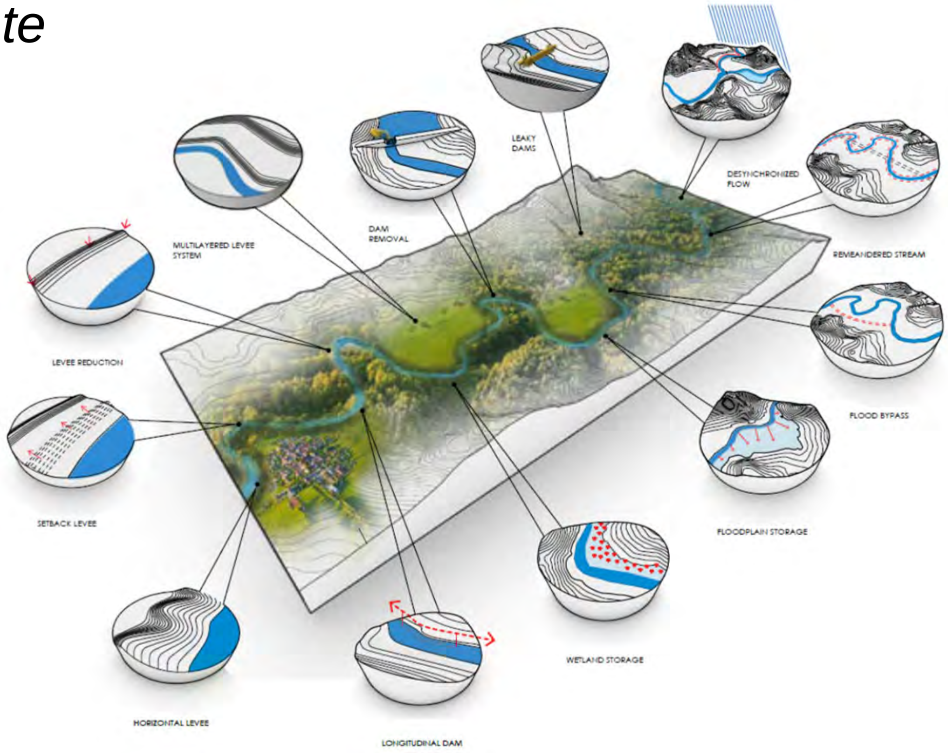
- Characterizing USACE natural and nature-based features (NNBF) projects
- Developing and implementing a holistic framework for monitoring natural and nature-based solutions
- Factors enabling or restraining system-scale use of nature-based solutions
- NI lifecycles: function, resilience, maintenance, 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

Project Example: Developing Methods and Standards

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 multi-criteria 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



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.

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

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

Interdisciplinary and cross-sectoral publications

ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Current Opinion in Environmental Sustainability

Challenges to realizing the potential of nature-based solutions

Donald R Nelson[a,b], Brian P Bledsoe[b,c], Susana Ferreira[b,d] and Nathan P Nibbelink[b,e]

frontiers in Ecology and Evolution
BRIEF RESEARCH REPORT
published: 01 June 2020
doi: 10.3389/fevo.2020.00149

Evaluating Resilience Co-benefits of Engineering With Nature® Projects

*Margaret H. Kurth[1,2], Rahim Ali[1,2], Todd S. Bridges[1], Burton C. Suedel[1] and Igor Linkov[1]**

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Contents lists available at ScienceDirect
Anthropocene
journal homepage: www.elsevier.com/locate/ancene
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Viewpoint

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

Donald R. Nelson[a,b,*], Brian P. Bledsoe[b,c], J. Marshall Shepherd[b,d]

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 co-ops**
- **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.**

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

ICON Integrative Conservation PhD Program
TRAINING AGILE SCIENTISTS TO ADDRESS 21st CENTURY SOCIO-ECOLOGICAL CHALLENGES

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.

Education for
Sustainable Development Goals
Learning Objectives

AMERICAN SOCIETY OF CIVIL ENGINEERS

American Ecological Engineering Society

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

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

N-EWN

Get in touch

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

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@network4ewn

Email us:

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ewn-usace@usace.army.mil