Editorial

Achieving Sustainable Outcomes Using Engineering with Nature Principles and Practices

Much has changed over the past 2 decades in the way government agencies around the world think about planning, design, and construction of infrastructure projects. Population growth, economic development, climate change, sea-level rise, and the changing character of natural disasters have introduced enormous pressures and expectations for government-funded projects aimed at providing water and transportation services, restoring communities after natural disasters, and building long-term resiliency. The United Nation (UN)'s Sustainable Development Goals (SDGs), adopted by all UN Member States in 2015, have emerged as a vital part of public and private sector efforts to manage the tremendous pressures on nature posed by increasing human demands for food, land, and water resources and security (UN 2019).

Now more than ever is the time for a concerted global focus on nature-based solutions (NBS). There is ample and growing evidence for how NBS strategies produce a range of beneficial economic, environmental, and social outcomes while ameliorating the human-induced stresses imposed on the natural environment (Oen 2019).

In the United States, the Army Corps of Engineers (USACE) has recognized the importance of designing and constructing infrastructure projects that work with nature, and in 2010 the USACE launched the Engineering With Nature (EWN) initiative. Its focus at inception was to advance sustainable and resilient projects and outcomes by the intentional alignment of engineering and natural processes to efficiently and sustainably deliver economic, environmental, and social benefits to communities and the nation. Over the past 10 years, the USACE has advanced its ability to deliver water resources and infrastructure projects that are broadly accepted by communities, reduce demands on limited natural resources, and minimize environmental impacts, while generating a diverse array of economic, environmental, and social benefits. Since 2010, the USACE's vision has been widely successful in building upon examples of best practice from past decades in the United States. In doing so, the EWN initiative has highlighted the power of broad collaboration across government, private sector, academic, and nongovernmental organizations (NGOs) to deliver such multifunctional projects. The USACE has taken this approach internationally, as well, and has begun working with partner organizations in several countries.

Success through the EWN approach is achieved by adhering to 4 principles. Project planning and design should focus the use of science and engineering to produce operational efficiencies that support sustainable delivery of project benefits. Project designs should rely on natural processes to produce benefits, to include reducing demands on limited resources, minimizing negative impacts, and creating new environmental benefits. Projects should be planned and designed to diversify the benefits produced by projects to include an expanded spectrum of economic, social, and environmental benefits. Finally, a serious investment and commitment to collaboration across sectors and organizations should be used to organize and focus special interests, stakeholders, and partners to produce more broadly acceptable and productive projects, while reducing social friction, resistance, and delays. The USACE's EWN initiative is advancing practical implementation of these 4 principles through a network of field-scale projects, demonstrations, research and development (R&D), guidance development, education, communication, and partnering.

Research and development at USACE is focused on advancing the understanding and application of NBS. One example of this R&D concerns the use of natural and nature-based features (NNBF), a type of NBS application that reduces flood risks. Natural features (e.g., reefs, barrier islands, dunes, beaches, wetlands, and maritime forests) are comparatively "longstanding" in terms of age and are created through the action of physical, biological, and chemical processes over time. Whereas, nature-based features are created by human design, engineering, and construction to mimic natural features and provide similar, if not identical, services (Bridges et al. 2015). Examples of ongoing R&D supporting NNBF includes innovative dredging technologies and practices that can be used to sustain NNBF and the development of methods for quantifying the ecosystem services and engineering benefits provided by created and/or restored islands (Herman et al. 2020). For the US Gulf Coast, research has involved the use of physical models

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of coastal wetlands and shorelines to examine the physical interactions of flood surge and waves on various NNBF engineering designs. Model results have been incorporated into the formulation of full-scale coastal protection planning and design studies for new infrastructure intended to reduce risks from flooding and extreme weather events along the Gulf Coast as well as other regions. This science-based approach to problem solving has accelerated the USACE's ability to support infrastructure investments, demonstrate the value of NNBF, and develop the technologies to construct such projects.

Communication and education represent another important element. Communication and education campaigns are helping community leaders, decision makers, and practitioners become more aware of nature's contributions to economies, human health and well-being, as well as our collective dependence on the planet's finite resources. Although interest in NBS has grown considerably in recent years, much more progress is needed to mainstream NBS concepts and practices. The USACE has hosted short courses, conferences, and other public events over the past decade where scientists, engineers, landscape architects, policy analysts, and planners can share knowledge and results of cutting-edge research. Structured engagements that bring together practitioners and decision makers interested in applying NBS strategies and techniques are vital to creating a shared understanding that leads to more informed decision making about the value of integrating natural infrastructure in the form of NBS into project designs, master plans for regions or communities, and national investments.

Technical publications in the form of peer-reviewed journal articles, technical reports, technology fact sheets, documented project case studies, informational brochures, and books are an important part of EWN communication. Among the USACE's recent accomplishments is publication of the EWN atlas (Bridges et al. 2018). The EWN atlas showcases 56 projects from around the world that illustrate NBS in practice and demonstrate what it means to "engineer with nature." Following its success, the USACE is currently developing Volume 2 of the EWN atlas and anticipates publication in fall 2020.

Disciplined collaboration is another essential ingredient for long-term advancement and success of NBS in the United States and around the world. Working with academic institutions, the USACE's EWN initiative has reached university students—from a broad range of disciplines including economics, engineering, environmental science, and ecology—who will become future community and engineering leaders and practitioners. Institutions such as the University of Georgia, Texas A&M University, and Lamar University have partnered with the USACE's EWN initiative to develop team-taught courses that introduce students to key principles and the research used to investigate and create solutions applicable to the many challenges that communities and infrastructure projects must confront today and tomorrow. A commitment to investing in education and training will help build a foundation for continuity in advancing sustainable practices.

The EWN initiative's success in the United States over the last 10 years, as well as the progress achieved in NBS practices worldwide, is the product of an expansive network of scientists, engineers, landscape architects, legislators, academics, resource managers, city planners, community organizers, civil servants, teachers, students, and others working together to harmonize traditional human engineering practices with natural systems. To date, the key elements of success include creating a positive value proposition that encourages partnering and active stakeholder engagement; forming a focused team that is broadly multidisciplinary; clearly defining the problem, opportunities, and objectives on a system-level scale; defining the roles, responsibilities, and contributions of each individual and/or organization partnering in the work; and codifying the team member's relationships and responsibilities in the form of a well-crafted project management plan.

The USACE is committed to working with governments and organizations pursuing similar sustainability and resilience outcomes for infrastructure. The world community faces many resource challenges and opportunities, and the approaches taken to engineer solutions to these will have long-lasting consequences on generations to come. In early 2021, the USACE's EWN initiative will realize another important landmark goal with the publication of international guidelines on the use of NNBF for flood risk management. Experts from 7 countries and more than 50 different public and private organizations (e.g., nonprofits, academic, private sector, and governmental) have contributed to these guidelines. We are optimistic that the marriage of NBS and engineering is a step in the right direction for the entire world.

In her book, *The Nature Fix*, Florence Williams chronicles the growing body of science that links human contact with nature to human health, well-being, cognition, and creativity (Williams 2017). Concrete and steel are strong building materials, but they can't satisfy all of our human needs.

ORCID

Burton C Suedel http://orcid.org/0000-0002-9220-9594

Jeffrey K King
Engineering With Nature Initiative, US Army Corps of Engineers, Vicksburg, Mississippi

Burton C Suedel
US Army Corps of Engineers, Vicksburg, Mississippi
Senior Editor, *Integrated Environmental Assessment and Management*

Todd S Bridges
Engineering With Nature Initiative, US Army Corps of Engineers, Vicksburg, Mississippi

REFERENCES

Bridges TS, Bourne EM, King JK, Kuzmitski HK, Moynihan EB, Suedel BC. 2018. Engineering with nature: An atlas. Vicksburg (MS): US Army Engineer Research and Development Center. 261 p. ERDC/EL SR-18-8. https://doi.org/10.21079/11681/27929

Bridges TS, Burks-Copes KA, Bates ME, Collier ZA, Fischenich CJ, Piercy CD, Russo EJ, Shafer DJ, Suedel BC, Gailani JZ et al. 2015. Use of natural and nature-based features (NNBF) for coastal resilience. Vicksburg (MS): US Army Engineer Research and Development Center. 445 p. ERDC SR-15-1. http://hdl.handle.net/11681/19336

Herman B, Swannack T, King J, Whitfield P, Davis J, Szimanski D, Bryant D, Gailani J, Whitbeck M, Golden R. 2020. Proceedings from the US Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA)–National Ocean Service (NOS): Ecological habitat modeling workshop. Vicksburg (MS): US Army Engineer Research and Development Center. 232 p. ERDC/EL SR-20-1. https://doi.org/10.21079/11681/36095

Oen A. 2019. Nature-based solutions are gaining momentum from international initiatives promoting environmental, social, and economic benefits. *Integr Environ Assess Manag* 15(6):830–831.

[UN] United Nations. 2019. The sustainable development goals report. New York (NY). 60 p.

Williams F. 2017. The nature fix. New York (NY): Norton. 280 p. ISBN: 978-0-393-24271-3.