ERDC/TN EWN-20-3
September 2020

Documenting Engineering with Nature® Implementation within the US Army Corps of Engineers Baltimore District – Completed Projects and Opportunities for Chronosequence Analysis

By Jacob F. Berkowitz and Danielle Szimanski

PURPOSE: The following documents the beneficial use of dredged materials in a subset of shallow draft navigation projects conducted by the US Army Corps of Engineers (USACE) Baltimore District between 1904 and 2016. The available data demonstrates (1) the expansion of beneficial uses of dredged materials over time incorporating Engineering With Nature® (EWN) approaches and (2) provides baseline information supporting chronosequence studies of habitat restoration/creation trajectories designed to evaluate project success.

BACKGROUND: The beneficial use of dredged materials for habitat improvement and ecosystem restoration has been recognized for decades (Faulkner and Poach 1996; Craft et al. 1999), allowing for the maintenance of navigation channels while enhancing the environment (Cahoon and Cowan 1988; Yozzo et al. 2004). Common beneficial use projects include the strategic placement of dredged materials to nourish beaches, creation oyster bars, restoration of degraded wetlands, and development barrier island systems (Figure 1) (Clarke et al. 1999; Costa-Pierce and Weinstein 2002). Recently, engineering concepts have been incorporated into the beneficial use framework resulting in development of the EWN initiative (Bridges et al. 2018). The goals of EWN include aligning natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits (*https://ewn.el.erdc.dren.mil/*). A key feature of EWN involves the assessment of project outcomes and benefits (USACE 2018). Documenting project successes improves future EWN project implementation and promotes further investment in strategies that integrate engineering concepts with environmental, infrastructure protection, and other objectives (Berkowitz et al. 2017; Foran et al. 2018).

DOCUMENTING PROJECT SUCCESS: Multiple EWN projects have been implemented in the past 10 years, including efforts associated with wetlands, beaches, near-shore resources, islands, and river systems (Bridges et al. 2018). However, the lack of documentation associated with older beneficial use projects remains a challenge. Specifically, the knowledge gap between natural systems and altered landscape features limits resource manager's capacity to predict future conditions. This includes persistent questions regarding the long-term trajectory of recently established EWN projects (Figure 2) (Berkowitz 2013). As a result, chronosequence studies evaluating previously completed projects inform the expected performance of newly implemented projects and help to establish milestones for documenting project success. Chronosequence studies examine landscape features (e.g., created wetlands) of different ages to understand ecosystem processes and predict the outcomes future management activities. For example, if monitoring data show a linear increase in stem density across wetland creation projects that are 2 years, 5 years, 10 years, and 20 years post-construction, projects constructed today using similar techniques would be expected to follow a similar pattern.

Additionally, chronosequence studies support development of quantitative milestones based upon monitoring data (i.e., after "X" years, stem densities should be "Y" based on available data). Walker et al. (2010) discuss the use of chronosequence studies in the context of ecological succession. Berkowitz (2018) provides an example of this approach, establishing and applying a chronosequence to evaluate forested wetlands restored using EWN principles. The analysis documented significant increases in wetland functions over time, demonstrating that wetland habitat, hydrologic, and biogeochemical functions were progressing toward conditions observed in natural forested wetlands. The chronosequence analysis was only possible because previous studies documented the location, restoration approach, and initial site conditions present prior to project implementation.

Figure 1. Examples of beneficial use projects completed by the USACE Baltimore District using shallow-draft dredged materials including the following (clockwise from top right): (a) time series of Fishing Battery prior to construction; (b) post-construction in 2013 and (c) 2017; planting native marsh vegetation at (d) Tern Island and (e) Robbins Marsh in 2016; and the recently completed Swan Island project in August 2019.

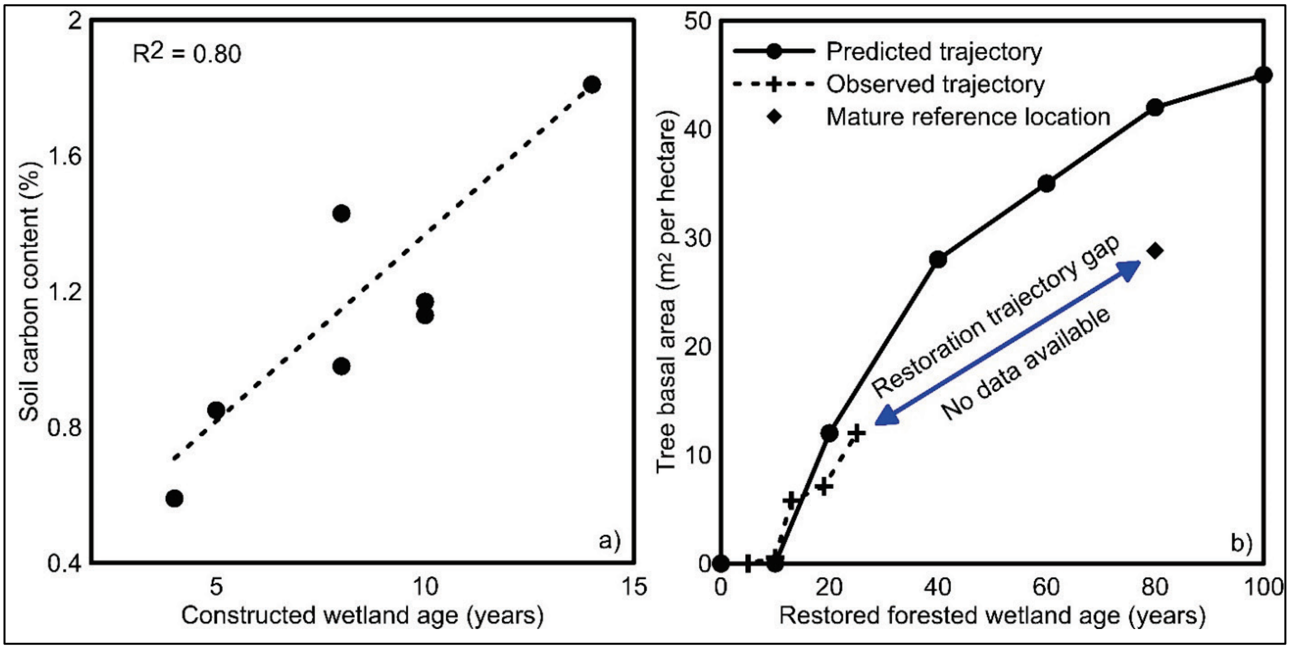

Figure 2. (a) Soil carbon increases following wetland creation using EWN principles in coastal Louisiana. Note that the linear increase in soil nutrients allows for development of restoration milestones over time. In this case, however, the limited age of created wetlands within the study area restricts the capacity to extrapolate conditions beyond 15 years (adapted from Berkowitz et al. 2017). (b) Observed and predicted restoration trajectory curves for forested wetland tree characteristics in locations restored using EWN approaches; data from mature forested wetland locations are also presented. Note that tree basal area increases with stand age as expected, but a large trajectory data gap exists between the oldest restored wetlands (i.e., 25 years post planting) and mature natural systems (>80 years old). This data gap limits the capacity to account for project life-cycle benefits, especially when utilizing new or innovative engineering techniques (adapted from Berkowitz 2018).

COMPLETED PROJECTS: The following provides baseline data for projects implemented by the USACE Baltimore District, supporting future efforts to document EWN project benefits and allowing for chronosequence analysis of previously completed projects related to the beneficial use of dredged materials. The projects considered includes shallow draft dredging projects and is not intended to be a comprehensive listing of all USACE Baltimore District dredging or beneficial use projects. Also, while these work items were described as beneficial uses of dredged materials during implementation, many of the projects discussed incorporated EWN principles or concepts during design and construction.

Between 1904 and 2016, the available data set contained information from 65 dredging projects including 25 projects that incorporated beneficial use activities. The beneficial use of dredged materials increased over time beginning in the 1980s (Figure 3), prior to which beneficial use projects either did not occur or were not documented as such. The relative proportion of projects incorporating beneficial use also increased over time with 25%, 40%, and >60% occurring during the 1980s, 1990, and post-2000 periods, respectively.

The increase in beneficial use projects was influenced by several factors, including statutory changes related to dredged material management. In 2001, the State of Maryland passed the Dredged Material Management Act of 2001 and initiated the phase out of all open water placement of dredged material within Maryland waters by 2010 (source: *USACE NAB - Poplar Island Environmental Restoration Project General Reevaluation Report (GRR) and Supplemental Environmental Impact Statement (SEIS) September 2005)*.

As a result, the development of additional dredged material beneficial use projects came out of necessity. With a high percentage of wetlands and critical habitat within the State of Maryland, creating traditional upland placement sites was challenging. Beneficial use of dredged material then became the custom for shallow-draft dredging projects from 2000 to present.

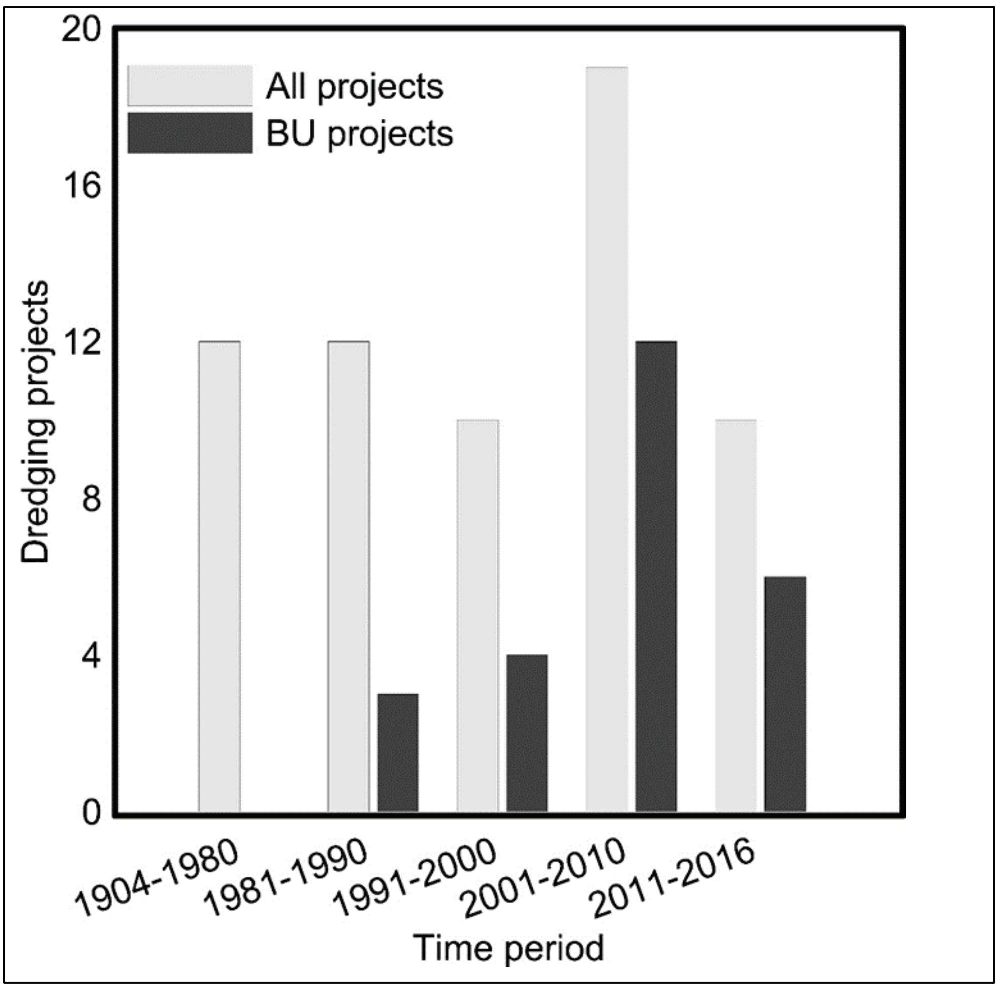

Figure 3. Temporal distribution of shallow-draft dredging and beneficial use projects conducted within the USACE Baltimore District area. Note that the abundance and relative proportion of beneficial use projects being implemented increased each decade since the 1980s.

Beneficial use project types included activities related to beaches (32% of projects), islands (28%), marshes and other wetlands (29%), and oysters (11%) (Figure 4). More than half of the beneficial use projects sought to restore or enhance existing features (e.g., beach nourishment; wetland restoration) while the remainder created new islands, marshes/wetlands, or oyster bars.

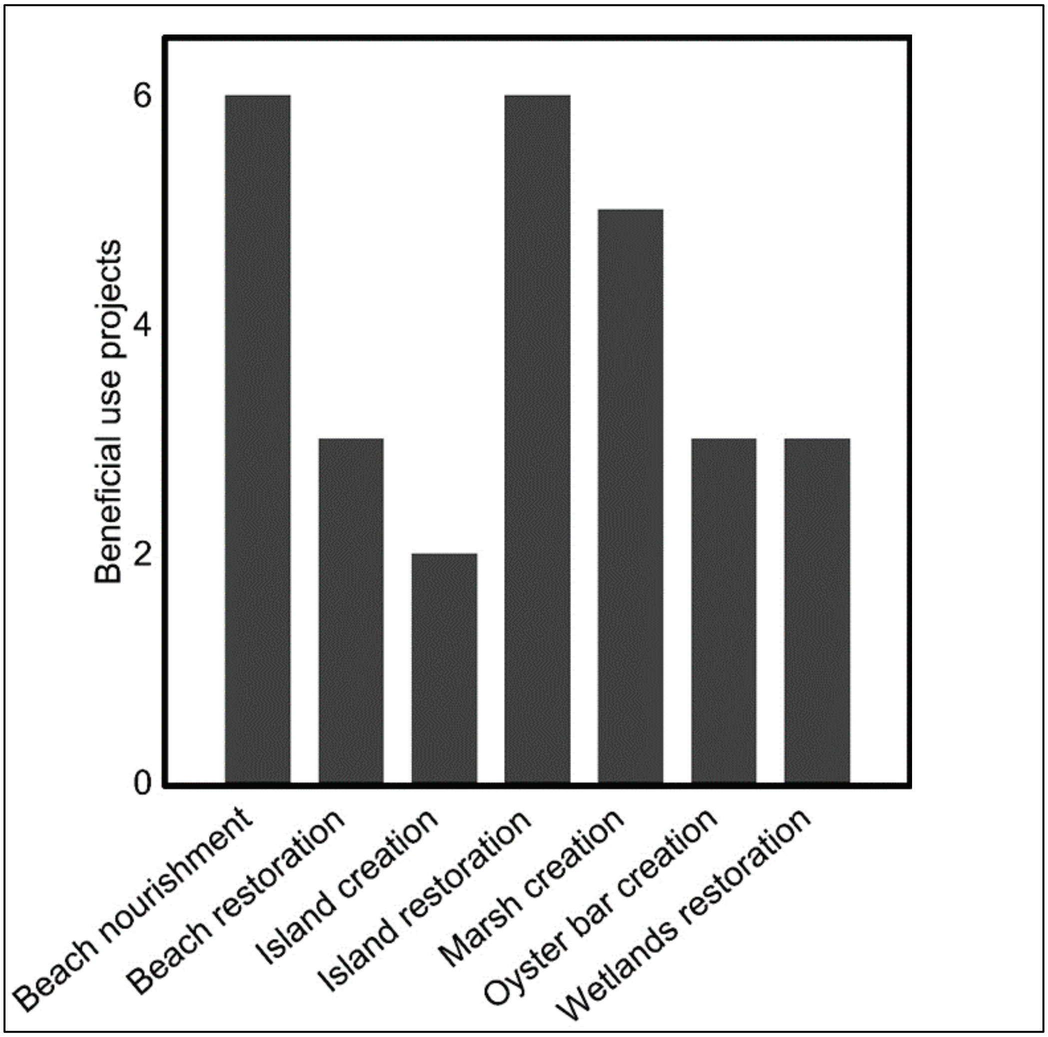

Figure 4. Distribution of beneficial use applications based upon target ecosystem (e.g., oysters, wetlands) and objective (e.g., restoration or creation).

CHRONOSEQUENCE ANALYSIS OPPORTUNITIES: The available data suggest that significant opportunities exist to conduct chronosequence analysis of beneficial use projects in the region, especially for a subset of the target ecosystems examined (Figure 5). For example, beach nourishment projects occurred six times over a 28-year implementation period between 1988 and 2016. As a result, the potential exists to revisit those project locations, which currently range in age from 3 to 31 years post construction to evaluate project outcomes, establish restoration trajectories, and relate observation to reference locations. Island restoration (six events spanning 24 years) and marsh creation (five events over 11 years) also display a number of projects implemented across a range of years.

Other project types including island creation span a substantial number of years (1989–2015) but lack intermittent data points. Conversely, some project types (e.g., oyster bar creation) occurred multiple times of just a few years. Notably, a limited number of events or a short implementation period does not preclude the value of chronosequence analysis, but it does decrease the capacity to develop intermittent trajectory milestones and/or interpret results outside of the project implementation range.

Although site conditions vary between project areas (e.g., wave energy, sediment type), the chronosequence approach has proved useful in documenting project success and establishing relationships between natural and restored/engineered systems. For example, Leewis et al. (2012) evaluated beach nourishment effects on benthic species assemblages across 13 projects spread across >400 kilometers of coastline in the Netherlands. The projects were implemented over a period of 13 years (1994–2007), and the analysis also compared the chronosequence results with four reference (i.e., unnourished) locations. Thus, the analysis allows for evaluation of project effects within managed and unmanaged systems (similar to Figure 2b). Additionally, chronosequence analysis also supports studies evaluating the impact of beneficial use project implementation vs. expected conditions if project implementation had not occurred (Rumbold et al. 2001).

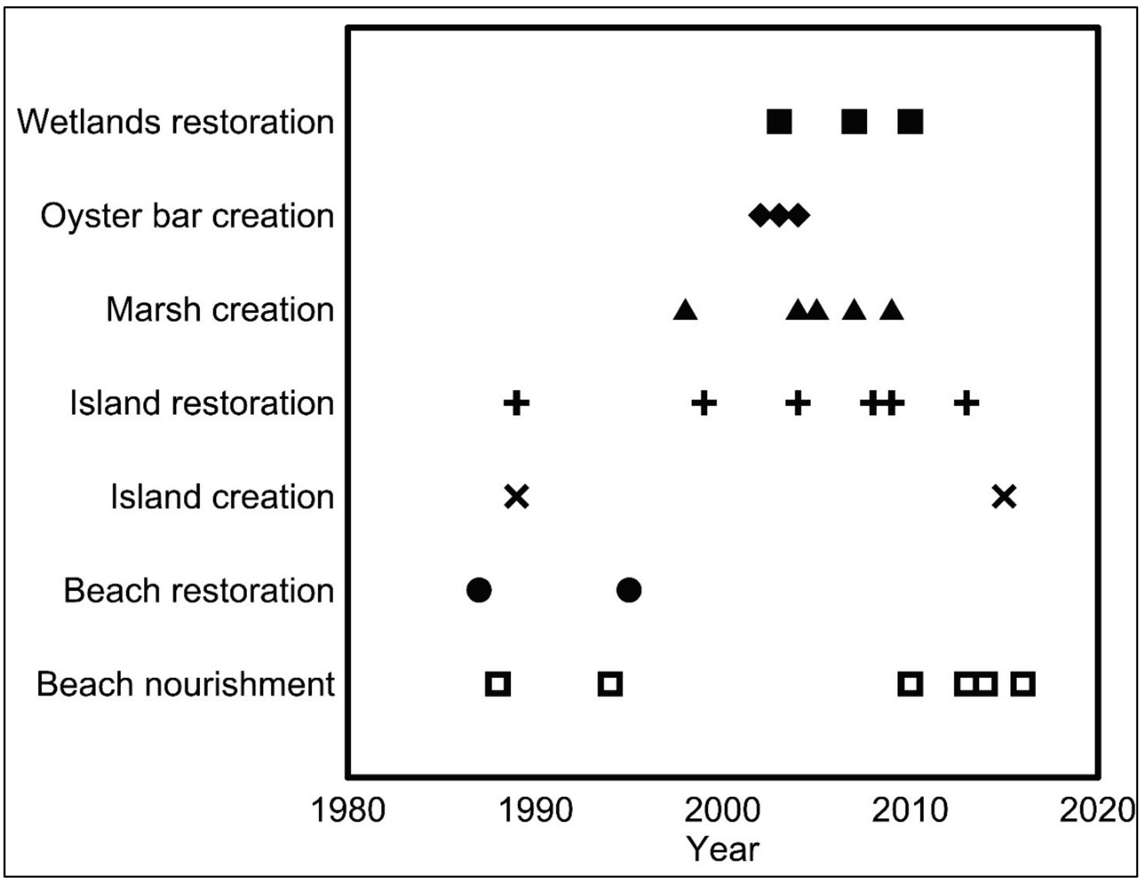

Figure 5. Distribution of beneficial use projects over time. Note that some target ecosystems (e.g., beach nourishment projects) were implemented over a number of years, suggesting the opportunity to complete chronosequence analysis. Other ecosystems (e.g., oyster bar creation) occurred within a short timeframe, limiting the data available for this type of analysis.

ONGOING WORK: Currently, USACE Baltimore District is completing an EWN island restoration project at Smith Island, MD (known as the Swan Island Project). Construction of the project was completed in July 2019. USACE Baltimore is currently working with the National Oceanic and Atmospheric Administration, the US Army Research and Development Center, the Maryland Department of Natural Resources, and the US Fish and Wildlife Service in developing a comprehensive multi-year monitoring plan. This comprehensive monitoring plan will evaluate ecological, physical, and hydrodynamic parameters before and after island restoration. Monitoring partners are assessing the impacts of the Swan Island restoration (sediment placement and planting) on near-shore benthic communities (oysters and seagrasses), intertidal marsh habitat, and long-term resilience of the island to erosion and sea level rise. Data collected in this project will directly address current information gaps surrounding both the impacts of island restoration activities on surrounding ecosystems and the protective benefits provided by these islands.

FUTURE WORK: USACE Baltimore District still intends to complete beneficial use shallow draft dredging projects in the future as long as they are not cost prohibitive. Continued monitoring, studies of post-placement work, and a shift in beneficial use culture throughout the country will help ensure these projects are appropriately funded.

SUMMARY: The USACE Baltimore District implemented a variety of beneficial use projects over recent decades that incorporated EWN concepts into project design. The proportion of projects utilizing EWN continues to expand as innovative strategies for dredged material management evolve over time. A substantial restoration trajectory gap still exists between restored/created systems and unmanaged natural areas. However, the abundance of completed projects within the USACE Baltimore District provides an outstanding opportunity to conduct chronosequence analysis to document project successes, predict conditions for milestone establishment, and inform the design of future projects to maximize environmental, navigation, and engineering benefits.

REFERENCES

Berkowitz, J. F. 2013. "Development of Restoration Trajectory Metrics in Reforested Bottomland Hardwood Forests Applying a Rapid Assessment Approach." *Ecological Indicators* 34: 600–606.

Berkowitz, J. F., S. Kim, N. Beane, D. Evans, E. Summers, B. Suedel, M. Flanagin, and J. Corbino. 2017. *A Multi-Factor Ecosystem Assessment of Wetlands Created Using a Novel Dredged Material Placement Technique in the Atchafalaya River, Louisiana*. ERDC/EL TR-17-5. Vicksburg, MS: US Army Engineer Research and Development Center.

Bridges, T. S., E. M. Bourne, J. K. King, H. K. Kuzmitski, E. B. Moynihan, and B. C. Suedel. 2018. Engineering With Nature: An Atlas. ERDC/EL SR-18-8. Vicksburg, MS: US Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/27929

Cahoon, D. R., and J. H. Cowan Jr. 1988. "Environmental Impacts and Regulatory Policy Implications Spray Disposal of Dredged Material in Louisiana Wetlands." *Coastal Management* 16: 341–362.

Clarke, D., D. Meyer, A. Veishlow, and M. LaCroix. 1999. "Dredged Material as a Substrate for Fisheries Habitat Establishment in Coastal Waters." *Oyster Reef Habitat Restoration: A Synopsis and Synthesis*, Chapter 21. Gloucester Point Virginia: Virginia Institute of Marine Science Press.

Costa-Pierce, B. A., and M. P. Weinstein. 2002. "Use of Dredge Materials for Coastal Restoration." *Ecological Engineering* 19(3): 181–186.

Craft, C., J. Reader, J. N. Sacco, and S. W. Broome. 1999. "Twenty-Five Years of Ecosystem Development of Constructed *Spartina alterniflora* (Loisel) Marshes." *Ecological Applications* 9: 1405–1419.

Faulkner, S. P., and M. E. Poach. 1996. *Functional Comparison of Created and Natural Wetlands in the Atchafalaya Delta, Louisiana*. Technical Report WRP-RE-16. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Foran C. M., K. A. Burks-Copes, J. Berkowitz, J. Corbino, and B.C. Suedel. 2018. "Quantifying Wildlife and Navigation Benefits of a Dredging Beneficial Use Project in the Lower Atchafalaya River: A Demonstration of Engineering With Nature®." *Integrated Environmental Assessment and Management* 14(6): 759–768. doi.org/10.1002/ieam.4084

Leewis, L., P. M. van Bodegom, J. Rozema, and G. M. Janssen. 2012. "Does Beach Nourishment Have Long-Term Effects on Intertidal Macroinvertebrate Species Abundance?" *Estuarine, Coastal and Shelf Science* 113: 172–181.

Rumbold, D. G., P. W. Davis, and C. Perretta. 2001. "Estimating the Effect of Beach Nourishment on *Caretta caretta* (loggerhead sea turtle) Nesting." *Restoration Ecology* 9(3): 304–310.

USACE (US Army Corps of Engineers). 2018. *Engineering With Nature Strategic Plan 2018-2023: Expanding Implementation*. Engineering With Nature Steering Team. *https://ewn.el.erdc.dren.mil/pub/EWN-StrategicPlan2018-2023FINAL.pdf*

Walker, L. R., D. A. Wardle, R. D. Bardgett, and B. D. Clarkson. 2010. "The Use of Chronosequences in Studies of Ecological Succession and Soil Development." *Journal of Ecology* 98(4): 725–736.

Yozzo, D. J., P. Wilber, and R. J. Will. 2004. "Beneficial Use of Dredged Material for Habitat Creation, Enhancement, and Restoration in New York–New Jersey Harbor." *Journal of Environmental Management* 73: 39–52.