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Editorial: Natural and nature-based features for flood risk management

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Editorial on the Research Topic
Natural and nature-based features for flood risk management

Introduction

Flood risk mitigation and management are among the great societal challenges of our time. Around the world humans, communities, infrastructure, and ecosystems in coastal areas are facing the reality of rising sea levels, intensifying storm impacts, accelerated erosion, and the resulting flood-related problems such as loss of life, loss of property, and loss of economic, social and environmental sustainability. At the same time the ever-present push for economic development of coastal regions through enhanced maritime trade, increased number of industrial and residential assets, and population growth in many coastal counties leads to heightened risk from the impact of flooding. Natural and nature-based features (NNBF) offer a strategy for mitigating and managing coastal flood risk by harnessing the inherent ability of nature and natural processes to adapt and evolve under changing conditions. The idea is to utilize NNBF either exclusively, alongside traditional ("gray") flood risk mitigation measures (such as seawalls, levees, etc.), or, ideally, in symbiosis with traditional flood risk mitigation strategies to create resilient, adaptive, and ecosystem-enhancing solutions that can improve the viability, beauty, and success of our coastal systems in a changing climate. While the topic addressed here is approached primarily from an engineering and scientific perspective, meaningful NNBF solutions for flood risk reduction require multidisciplinary collaborations beyond creative science and engineering innovations that include socio-economic and policy aspects. However, before NNBF can become one of the go-to tools for flood risk management, a detailed understanding of their mechanics under forcing conditions, evolution over time, and acceptance by designers, planners, and society is required. Therefore, fundamental and applied research on NNBF topics is now more relevant and important than ever.

The collection of 16 articles featured as part of this Research Topic addresses a variety of advances related to flood risk reduction *via* NNBF that will be critical as we move forward in making nature and natural processes an essential component in the design of systems intended to limit the impact of flooding to society. The original research articles as well as case-study reviews and engineering design framework creation provide a well-balanced mix of relevant fundamental knowledge dissemination and actionable science and engineering advances applicable to real-life

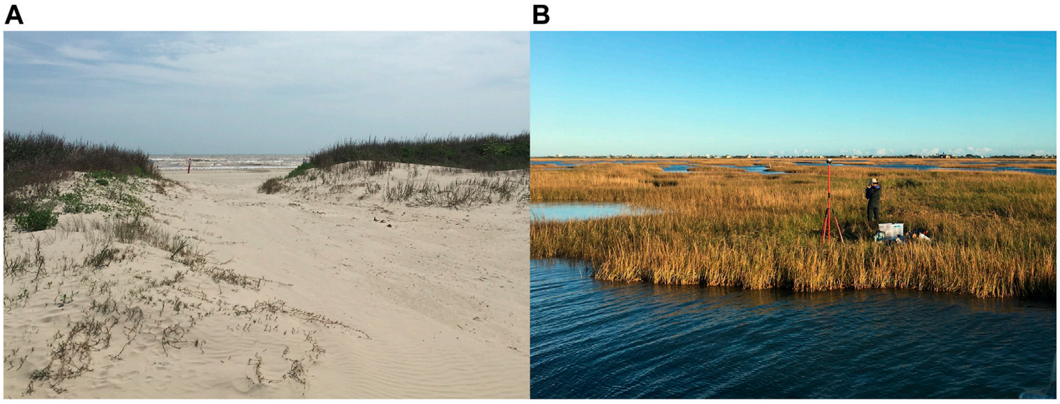

FIGURE 1
Engineered vegetated dune with cut for beach access **(A)** and researcher surveying a wetland system **(B)** as part of a scientific study on NNBF. The location of both photos is Galveston, Texas.

problem solving and coastal management. The specific NNBF addressed in this collection of articles include oyster castle breakwaters, coir logs, beach wrack material, sand trapping fences, sand spits and tidal lagoons, floating vegetated canopies, salt marshes, vegetated dune systems, mangroves, wetland vegetation, and emergent vegetation in general. An engineered vegetated dune and a wetland system, respectively, are depicted in Figure 1. Forcing mechanisms impacting the NNBF range from coastal storm waves and water level fluctuations to wind and ship wake dynamics, and several articles incorporate climate change-induced sea level rise scenarios. In this Research Topic, methodologies to advance NNBF knowledge include detailed field case study analyses, medium to large-scale physical model experiments in wave flumes and basins, as well as numerical model simulations compared to field or laboratory data to better understand NNBF utilization for erosion and flood risk mitigation. The key concepts addressed by the various authors are synthesized in the following, and contributions are placed into broader context.

Field case studies

Detailed field studies on NNBF are essential to better understand how these systems behave under real-life, full-scale conditions and varying forcing mechanisms, as well as their impacts on the environment. The field scale also encourages engagement with a variety of stakeholders and allows for assessment of the multiple benefits that projects using NNBF produce. Palinkas et al. particularly focus on the implementation, remaining challenges, and multiple benefit aspects of three coastal restoration case studies using NNBF features across geographical locations that cover the East, Gulf, and West Coasts of the United States. This case study summary sends the clear message that successful projects require a well-designed monitoring approach and an emphasis on stakeholder engagement. Creative sediment management is a major component in many NNBF systems with the aim to preserve habitat, protect against storm impacts and sea level rise, as well as to maintain navigability of coastal waterways. An example of how sand spit and tidal lagoon multifunctionality is enhanced through NNBF is presented by Dabees et al. for a case in Florida where enhanced resiliency of the overall system is a key element. Bredes et al. looked at oyster castle breakwater systems in an extensive field study along the New Jersey coastline and found that under certain conditions when these breakwaters are submerged during high water events they actually produce significant amplification of wave heights in their lee compared to attenuation when their crests are emergent. Salatin et al. investigated these data numerically. Findings like this are important to consider in the design of future living breakwater systems to avoid detrimental effects to adjacent shorelines. Impacts of extreme events on systems containing NNBF and subsequent recovery are important pieces of the puzzle when trying to understand overall system performance. The work presented by Cadigan et al. highlights differences between shoreline responses to multiple hurricanes along the southwest Louisiana coastline with and without breakwater protection. Provost et al. conducted a field study investigating the effect of wrack material washed up on the beach to help build up engineered dunes which has implications for how this naturally occurring material should be managed. NNBF are not only used to increase resilience of coastal systems from natural hazards, but have also been successfully employed to protect against vessel-induced wave energy near high marine traffic areas as investigated by Everett et al. for coir logs placed on an estuarine shoreline along the Delaware River.

Physical model experiments

While field case studies play an essential role in our understanding of NNBF performance, oftentimes it is necessary to investigate certain features in a controlled laboratory setting to isolate forcing conditions and create repeatable scenarios. Such studies allow for the identification of effects of individual parameters, investigation of trends in hydraulic response, and validation of numerical models which can then be extrapolated to a broader range of conditions. Eichmanns and Schüttrumpf quantified the aeolian sediment trapping efficiency of sand fences under various configurations in a detailed wind tunnel study. Vegetated nearshore systems fronting urban areas or coastal protection structures have been investigated for their wave energy attenuating properties. Different floating vegetated mat configurations were analyzed by Hopkins et al. in a large scale wave basin facility whereas Baker et al. conducted scaled basin tests on the effectiveness of marsh vegetation in reducing wave energy in front of a dike. The effect of various above- and below-ground dune vegetation characteristics on dune erosion were quantified in a wave flume study by Figlus et al. where real sediment and live plants at different stages of growth in a dune were subjected to storm wave forcing.

Numerical modeling

It is crucial to continue to enhance our numerical modeling capabilities to better simulate NNBF behavior under various environmental loading conditions. This is often done by calibrating or modifying existing numerical models based on field and laboratory data to advance understanding of NNBF and their use in flood and erosion risk mitigation. Mori et al. parameterized the structure of mangrove roots for optimized use in numerical modeling efforts whereas Abdolali et al. implemented wave-vegetation interaction capabilities into a spectral wave model to compute wave attenuation by spatially variable wetland vegetation fields. The work by Salatin et al. using Boussinesq-type wave modeling highlighted that complex nearshore wave transformations and wave interactions with oyster breakwaters need to be simulated carefully to avoid design situations where leeward wave energy is amplified by the NNBF (see also Bredes et al.) or other unintended consequences occur. The performance of NNBF under catastrophic events such as tsunamis is a topic that has also received increasing attention recently. To that end, von Häfen et al. improved a numerical multi-phase computational fluid dynamics model dealing with dam-break waves to simulate tsunami propagation over composite bathymetry. Huff et al. explored the utility of the Delft3D model suite to aid coastal managers assess various living shoreline and NNBF design alternatives for construction in a Texas bay system.

Engineering framework for use of NNBF

NNBF are poised to take a prominent place in designing flood risk reduction measures with a growing body of research and project experience supporting their development. For the case of emergent vegetation systems, Ostrow et al. synthesized the current state of practice and the still existing barriers to implementation. They also suggested that the knowledge on NNBF incorporating emergent vegetation is already sufficient for adequate design solutions and proposed a framework to assess such designs based on wave attenuation performance.

As we continue the work on NNBF for flood risk reduction and encourage the reader to browse the mentioned articles, we would like to take this opportunity to thank all contributing authors, research funding agencies, reviewers, and editors for their help in making this collection of knowledge advances on natural and nature-based features for flood risk management a success. The featured works will certainly spur further advances in this field and contribute to a future where we strive to be conscious stewards of the coastal systems that mean so much to all of us.

Author contributions

JF, JS, TT, and BM wrote and edited this editorial.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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