

NETWORK FOR ENGINEERING WITH NATURE

2024

PARTNER SYMPOSIUM

ST. AUGUSTINE, FL

MAY 22-24, 2024

All-Partner Symposium

*Program
of Abstracts*

Wednesday, May 22 – Friday, May 24
Hyatt Place St. Augustine

Visit the Symposium website for more details.



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Schedule

Wednesday, May 22

7:30 – 8:00	Registration, Name Badge Pickup <i>Pre-Function Space</i>
8:00 – 10:00	Welcome Plenary, Setting Intentions <i>Coquina</i>
10:00 – 10:30	Morning Break <i>Pre-Function Space</i>
10:30 – 12:00	Poster Session <i>Ponce de Leon</i>
12:00 – 1:00	Lunch <i>Coquina</i>
1:15 – 2:45	Track 1 <i>Coquina, Anastasia, Ponce de Leon</i>
2:45 – 3:15	Afternoon Break <i>Pre-Function Space</i>
3:15 – 4:45	Track 2 <i>Coquina, Anastasia, Ponce de Leon</i>
5:15 – 7:15	Networking Happy Hour <i>Hyatt Rooftop</i>

Dinners are not provided during the Symposium, but St. Augustine is home to some great restaurants.

[Learn more about St. Augustine, including food options, on the Symposium website.](#)

Schedule

Thursday, May 23

8:00 – 8:55	Track 3 <i>Coquina, Anastasia, Ponce de Leon</i>
9:05 – 10:00	Track 4 <i>Coquina, Anastasia, Ponce de Leon</i>
10:00 – 10:30	Morning Break <i>Pre-Function Space</i>
10:30 – 11:45	Track 5 <i>Coquina, Anastasia, Ponce de Leon</i>
11:50 – 12:50	Lunch <i>Coquina</i>
12:50 – 2:05	Track 6 <i>Coquina, Anastasia, Ponce de Leon</i>
2:15 – 2:40	Closing Plenary <i>Coquina</i>
3:00 – 5:00	Field Trips <i>See program website for field trip sign-ups.</i>

Friday, May 24

8:30 – 9:15	Advisory Committee Meeting
9:15 – 9:30	Break
9:30 – 10:45	Advisory Committee Meeting
10:45 – 11:00	Break
11:00 – 12:30	Concurrent Working Group Meetings

[If viewing online, view the schedule of group meetings here.](#)

Venue Information



Please find more information about the venue at the Symposium website, including nearby resources, restaurants and information about St. Augustine.

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Multiple sessions will be taking place at once for each track. If you are hoping to catch talks in different rooms throughout the Symposium, please be courteous as you move between rooms.

Posters

Wednesday, 10:30 – 12:00

1. Evaluating the Impacts of Tidal Structures on Infrastructure Performance at Hunter Army Airfield (*Ada Agbogu, UGA*)
2. Advanced Technologies for Nature-Based Resilience and Restoration (*Matthew Campbell, Natrx*)
3. Dynamics of Florida Saltmarshes: Modeling Tidal Flow and Morphological Change (*Kailei Cao, UF*)
4. Design of Resilience Infrastructure & Environmental Impact Bond, City of Hampton, Virginia (*Lynette Cardoch, Moffatt & Nichol*)
5. Performance of Three Living Shorelines Impacted by Hurricane Idalia, Cedar Key, Florida (*Mark Clark, UF*)
6. Monitoring and Performance Evaluation of Nature Based Solutions (*Jenny Davis, NCCOS*)
7. Modeling the Influence of Ebb Tidal Delta Morphology on Longshore Sediment Transport Patterns During Hurricanes Along the North Florida Atlantic Coast (*Matheus de Assis Bose, UF*)
8. A Numerical Investigation of the Effect of Boat Characteristics Parameters on its Generated Wake (*Carola Forlini, UF*)
9. Nature-Positive Infrastructure Development: Planning for Multiple Objectives and Design Opportunities in Georgia (*Alejandra Gomez, UGA*)
10. Tracking Habitat Change in Northeastern Florida Tidal Wetlands (*Adam Hymel, UF*)
11. Green Solutions for Gray Spaces: A Case Study of the Tietê River in São Paulo, City, Brazil (*Luciana Iannone Tarcha, UGA*)
12. Optimizing Holistic NbS for Climate Resilience (*Devyani Kar, Jacobs*)
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14. Effects of Belowground Vegetation on Coastal Dune Erosion (*Jorge Laurel-Castillo, UF*)

Posters

Wednesday, 10:30 – 12:00

15. Basin-Scale Modeling of Collective Management Practices in Agriculture to Reduce Sediment and Nutrient Inputs Into Flood-control and Drinking Water Reservoirs (*Ting Liu, ASU*)
16. Scaling Up Investment in Nature-based Solutions Using Green Banks (*Sara Mason, Duke*)
17. Non-Profit/For-Profit Partnerships for Implementation of NBS at Scale (*Mary-Margaret McKinney, Native Shorelines*)
18. Developing the Next Generation of Engineering With Nature Professionals: A Presidential Dream Course on Nature-Based Solutions (*Robert Nairn, OU*)
19. A Spatial Conservation Prioritization of Coastal Freshwater Impoundments Based on Predicted Climate Impacts and Waterfowl Habitat Value (*Alexa Ouellette, UGA*)
20. Integrating Landscape Architecture and Engineering Concepts to Foster Nature-Based Solutions (*Mindy Strevig, AnchorQEA*)
21. Evaluating the Equity of Greenspace Access for Infrastructure Planning (*Caleb Sytsma, USACE ERDC*)
22. NBS in the Trinity River Floodway (*Craig Taylor, LimnoTech*)
23. Re-Imagining Infrastructure for a Biodiverse Future (*Charles van Rees and Seth Wenger, UGA*)
24. Assessing the Potential Role that Integrated Agricultural-Reservoir Systems Have on Water Quality (*Danna Villarreal, UARK*)
25. Comparative Analysis of Estimated Longshore Sediment Transport Rates with River and Dredging Fluxes in the Savannah Harbor (*Oscar Villegas, UGA*)
26. Spatiotemporal Causal Learning for Streamflow Forecasting (*Shu Wan, ASU*)
27. Challenges and Solutions for Permitting Coastal Nature-Based Solutions (*Chloe Wetzler, Duke*)
28. Quantifying the Increasing Flood Risks Produced by Legacy Levee Systems (*Elissa Yeates, UGA*)

Posters

Wednesday, 10:30 – 12:00

1. Evaluating the Impacts of Tidal Structures on Infrastructure Performance at Hunter Army Airfield

Ada Agbogu, University of Georgia

Coastal communities are threatened by many hazards such as storm surges, flooding, saltwater intrusion, and coastal erosion. These hazards frequently lead to environmental deterioration, property damage, and loss of life. As such, people living around the coasts often use gray infrastructure like seawalls and dikes for protection and shoreline stabilization. However, gray infrastructure often changes the surrounding environment and can prevent natural infrastructure adaptation to changing conditions such as sea level rise. A similar issue has occurred at Hunter Army Airfield Savannah, GA. An installed tide gate led to changes in the marsh vegetation and may substantially affect the utility of the marsh as a natural infrastructure feature. We aim to use field surveys to understand the ecological effects of the tide gate on the surrounding marsh area, and a tidal inundation model (ADCIRC) to quantify how these changes translate to the performance of the marsh ecosystem as a natural infrastructure for flood protection and erosion control. In the future, our research will document the changes in vegetation around the tide gate which will be used to modify the ADCIRC model of the changing landscape conditions. Our findings will help explain the marsh's performance as a natural infrastructure on the upstream and downstream portions of the tide gate. We will then use our hydrodynamic model to quantify the water surface elevation, and flow velocity across the HAAF tide gate area. These results aim to elucidate issues concerned with tide gate overtopping, potential erosion hotspots, and areas prone to flooding.

2. Advanced Technologies for Nature-Based Resilience and Restoration

Matthew Campbell, Natrx

Natrx, Inc. is a technology focused company that provides nature-based coastal and marine infrastructure solutions intending to promote balance between the natural and built worlds. We apply leading-edge technology to resilience and restoration initiatives, enabling landscape scale enhancement. Our platform incorporates artificial intelligence, geospatial data analytics, patented DryForming™ advanced manufacturing, and material science innovations to deliver habitat-specific resilience systems that harness and support the adaptive power of nature.

Natrx has developed a new method for creating ecologically enhanced structures, the DryForming™ manufacturing process, enabling deployment of tailored, habitat-positive solutions to address coastal risks and create positive economic contributions. DryForming™ is a highly flexible solution that offers new opportunities for coastal resilience, habitat restoration, and economic development. We present a fundamental advance in the coastal resilience toolbox with the ability to customize structures for site-specific requirements at an industrial scale.

3. Dynamics of Florida Saltmarshes: Modeling Tidal Flow and Morphological Change

Kailei Cao, University of Florida

Elevational losses in coastal saltmarshes of Florida, exacerbated by rising sea levels, present a formidable challenge. While Thin-layer sediment placement (TLP) has demonstrated efficacy in restoring elevations in temperate saltmarshes, its suitability in subtropical environments remains undetermined. The Engineering With Nature (EWN) project identifies TLP as a potential solution and endeavors to assess its effectiveness.

This study employs FUNWAVE simulations to establish a numerical framework for wetland modeling. FUNWAVE developed by Shi et al. (2012) is a fully nonlinear Boussinesq wave model, and is often used for prediction of coastal inundation incorporating tidal effects, sediment transport and morphological changes. The primary objectives include optimizing EWN solutions, evaluating their long-term efficacy, and providing feedback for complementary TLP projects. To this effect, field experiments were conducted in Cat's Paw marsh in February 2022 and July 2023, gathering wave, current, and suspended sediment data. The collected observational data will serve as inputs for FUNWAVE simulations to model flow scenarios within the marsh.

Our observations reveal significant tidal activity, and minimal boat wakes. The intricate interplay of channels and vegetation creates distinct patterns of tidal flow circulation within the marsh, which can be classified into three flooding scenarios based on tide levels relative to marsh level. The larger channels predominantly facilitate water discharge during a low flooding event (neap tide) and serve as conduits for water exchange between the marsh basin and the river. The intermediate flooding scenario witnesses formation of additional small runnels between mud flats and adjoining main flood channel. The high flooding scenario (spring tide) leads to overtopping of vegetated ridges surrounding mudflats, with water ingress from all sides. Through simulating these scenarios, our

objective is to quantify the fundamental physical forces governing wetland sediment transport. This understanding will offer insights into sediment behavior over mudflats in the saltmarshes, explore the potential integration of FUNWAVE with fine-scale modeling approaches and analyze efficacy of TLP in subtropical environments.

4. Design of Resilience Infrastructure & Environmental Impact Bond, City of Hampton, Virginia

Lynette Cardoch, Moffatt & Nichol

Moffatt & Nichol is presently engaged in the design and construction administration of 3 stormwater and tidal flood mitigation projects with the City of Hampton, all of which integrate nature-based solutions. The Big Bethel Blueway retrofits backyard drainage ditches and main drainage channel to store stormwater and create vegetated areas that improve water quality. The green features along the main channel also include a shared use recreational trail. Lake Hampton reconstructs an underperforming basin to absorb stormwater overflow from Newmarket Creek. Stormwater terraces will detail and treat runoff from surrounding neighborhoods and roads. North Armistead Road Raising provides much needed improvements to this critical corridor that serves as the primary road to Joint Base Langley-Eustis and essential for the mobility of the base workforce. M&N is leading the team for the planning, survey, geotechnical, structural and hydraulic design, along with the H&H modelling and environmental permitting.

These 3 projects arose from a long-term comprehensive resiliency effort. M&N have been engaged with the City of Hampton's flooding concerns for several years, including the Dutch Dialogues in 2015, led by David Waggoner and Jaime Ramiro (Rami) Diaz, Waggoner & Ball. This helped launch Resilient Hampton that aims to alleviate chronic stresses and enable recovery from extreme events and shocks in ways that make the community even stronger than before. For Hampton, some of the extreme events include hurricanes and nor'easters. Chronic stresses may have a milder, but more frequent impact on everyday life, such as recurrent tidal flooding that blocks a road during high tide. Resilient Hampton tackles both these issues, but in such a way that it is also improving residents' quality of life, economic viability, and environmental health. This is accomplished through the implementation of value-driven solutions that also have multiple benefits.

Through a watershed-based approach, Moffatt & Nichol and Waggoner and Ball developed a framework of community principles, goals, and values; a suite of conceptual pilot projects; and an evaluation tool that prioritized implementation. The analyses included green and blue infrastructure features for additional volume capture capacity and resulted in the above-mentioned 3 projects.

The City of Hampton funded these projects with an innovative Environmental Impact Bond (EIB), the first such use in Virginia. M&N, led by Brian Joyner, Lynette Cardoch, and Johnny Martin, developed the technical criteria package necessary for the city to issue this bond in late 2020.

5. Performance of Three Living Shorelines Impacted by Hurricane Idalia, Cedar Key, Florida

Mark Clark, University of Florida

Hurricane Idalia impacted Cedar Key, FL on August 30, 2023, with a 2.7m storm surge and waves up to 1.2m. Three living shorelines constructed in 2017 and 2020 were instrumented with wave gages during the storm, and elevation and vegetation cover were assessed pre and post storm. Wave gauges indicate wave energy attenuation during maximum incident wave exposure was between 15 and 20%. This attenuation occurred even though living shoreline elements were in water depths of 1.5-2.5m. Erosion and sediment transport was minimal in areas with well-established vegetation, while unvegetated beach areas showed significant sediment loss. Most areas of low and high marsh and mangrove vegetation were only minimally impacted during the storm. Only higher elevation dune species along one of the three shorelines sustained much damage. However, even at that location, above ground biomass that had browned and died back immediately after the storm began to recover within weeks and only a 15m section of the 260m overall shoreline required replanting. Findings show that despite the record storm surge and most dock structures being damaged or destroyed, living shoreline elements sustained only limited impacts while minimizing erosion to adjacent roads and reducing wave energy impacts to nearby structures.

6. Monitoring and Performance Evaluation of Nature Based Solutions

Jenny Davis, NOAA National Centers for Coastal Ocean Science (NCCOS)

One of the frequently referenced obstacles to widespread use of coastal nature-based solutions (NBS) is uncertainty about how NBS perform as they mature and respond to wind, waves, relative sea level rise, and other environmental stressors. Performance evaluations based on empirical monitoring data are key to increasing confidence in NBS. Toward this goal, researchers with NOAA's National Centers for Coastal Ocean Science (NCCOS) are conducting a multi-pronged effort to: 1) collate and synthesize existing global data on NBS performance; 2) document performance of historical NBS projects through field-based data collection, and 3) develop guidance for optimal monitoring and evaluation of NBS projects. Collectively, these efforts will advance the current knowledge base on long-term performance of coastal NBS and provide valuable guidance for siting and design of future projects.

7. Modeling the Influence of Ebb Tidal Delta Morphology on Longshore Sediment Transport Patterns During Hurricanes Along the North Florida Atlantic Coast

Matheus de Assis Bose, University of Florida

Ebb tidal deltas (ETD) are dynamic subaqueous landforms in the nearshore environment on the seaward side inlets, strongly influenced by waves, tides, and sediment supply. Changes in ETD morphology can influence wave transformation patterns along the coast, altering longshore sediment transport (LST) magnitude and direction at adjacent beaches. Few observations document the effects of ETD morphologic change on LST during storms. On the North Florida Atlantic coast, Anastasia Island is a barrier island situated between St. Augustine Inlet at the north end (ETD area = 5.5 km²) and Matanzas Inlet at the south end (ETD area = 0.9 km²). This study addresses how ETD morphology affects LST during Hurricanes Ian and Nicole at Anastasia Island. Using Delft3D Flow/Wave modules, our findings suggest that wave energy dissipation initiates farther from the coast at St. Augustine Inlet due to a larger ETD than Matanzas Inlet. As a result, this causes a decrease in longshore current (LC) velocity at nearby beaches during hurricanes. Both hurricanes induced bidirectional LC along the adjacent beaches during high and low tides. During Hurricane Ian, the velocity magnitude of LC was higher at the southern part of both inlets. During Hurricane Nicole, velocities were greater north of the inlets. Differences may be attributed to the wave directions associated with each hurricane, which show a 28 DEGREE difference. Understanding the relationship among ETD morphology, tides, waves, and LST is critical for predicting and planning for the impacts of future storms along this heavily populated portion of Florida's coast.

8. A Numerical Investigation of the Effect of Boat Characteristics on Its Generated Wake

Carola Forlini, University of Florida

The acceleration of coastal development has given rise to an increased influx of vessel traffic in the waterways of coastal communities. In Florida, known for its water-based tourism and recreation, this traffic is mostly small recreational boats. This surge in vessel movement creates intermittent wave patterns, leading to the disturbance of sediment, erosion of wetlands, and an escalation in water turbidity. One of the complexities of this wake climate is that no two wakes are the same. Their characteristics depends critically on the parameters that characterize the shape, and the navigation patterns, of the boats that generate them. To understand the wake climate impact on the wetland ecosystem, an accurate characterization of the composition of the traffic (boat shape and navigation pattern) is essential.

This study employs a numerical investigation utilizing FUNWAVE-TVD, a phase-resolving nearshore numerical wave model that solves fully nonlinear Boussinesq-type wave equations. The primary objective is to gain insights into how geometric parameters—such as boat length, width, and draft—and dynamic parameters—specifically the depth/length Froude number—affect the structure of the wake. Preliminary findings indicate that the boat's cross-sectional area plays a pivotal role in defining the power associated with distinct wake components. These results contribute to a more comprehensive understanding of the intricate relationship between vessel characteristics and the resultant wake dynamics in coastal environments.

9. Nature-Positive Infrastructure Development: Planning for Multiple Objectives and Design Opportunities in Georgia

Alejandra Gomez, University of Georgia

Transportation infrastructure is crucial to economic growth, but it faces challenges from wildlife-vehicle collisions (WVCs) that impact both biodiversity and safety. In the context of climate change and biodiversity loss, a paradigm shift is prompting infrastructure stakeholders to not only prevent damage but also actively promote nature. This includes integrating nature and biodiversity considerations as part of project design or accompanying it with substantial ecological restoration and enhancement efforts. Holistic mitigation strategies are necessary due to the economic and life costs of WVCs. One potential solution is converting culverts into underpasses to reduce WVC occurrences while addressing water and debris conveyance, road safety, ecosystem connectivity, and wildlife conservation. Our study investigates the benefits of innovative culvert design in averting climate change, advancing safety, and promoting ecological connections. Additionally, it targets exact locations in Georgia for optimal culvert upgrades.

Utilizing a watershed-scale approach, our team created a spatial prioritization framework that identifies optimal areas in Georgia for reducing wildlife-vehicle collisions (WVC). This framework takes into account landscape variables that affect WVC frequency and mitigation, improving terrestrial underpasses with culverts, by using a series of metrics such as flood vulnerability assessment, culvert condition and stream channel stability. Utilizing spatial Multi-Criteria Decision Analysis (MCDA), we localize areas in Georgia that combine WVC reduction with ecological and engineering benefits.

Our findings introduce a spatial framework that enables multi-stakeholder assessments for mitigating WVC. This framework prioritizes the maintenance or replacement of hydraulic structures. Additionally, we provide an MCDA tool that allows stakeholders to weigh variable criteria and suggest designs and adaptations for hydraulic structures.

10. Tracking Habitat Change in Northeastern Florida Tidal Wetlands

Adam Hymel, University of Florida

Tidal wetlands in northeastern Florida are a complex mosaic of habitat types (e.g., smooth cordgrass, black mangroves, red mangroves, soft rush, oyster reefs, and oyster rakes) influenced by hydrological, geophysical, and ecological drivers. The scales of these influences range broadly and thus create a dynamic ecosystem with changes in habitat types from the macro (kilometer) scale down to the micro (sub-meter) scale. However, natural and anthropogenic drivers are quickly pushing these changes out of equilibrium resulting in drastic changes in wetland structure. Field observations cannot capture these changes simultaneously and thus need remote sensing for comprehensive observations and analysis. With a compilation of imagery from satellite and unmanned aircraft with RGB, LiDAR, and multispectral sensors, we classified habitat types in a ~350-acre intertidal mosaic in St Augustine, Florida along multiple time steps using machine learning image classification and object-based analysis. Comparison of the timesteps reveals significant spatial and temporal variation of habitat types, including salt marsh lateral erosion and interior drowning, spread of mangroves, and migration of shell rakes. Including ancillary data such as hydrological and biological parameters increase the understanding of the driving forces behind habitat dynamics. This research contributes to the knowledge of tidal wetland dynamics and the causes of their change, creating a tool that can inform coastal management decisions.

11. Green Solutions for Gray Spaces: A Case Study of the Tietê River in São Paulo City, Brazil Infrastructure Planning

Luciana Iannone Tarcha, University of Georgia

Floods have been part of São Paulo City dynamics since the early human interventions. The 1929 flood of the Tietê River is considered the greatest that has ever hit the city, and yet, 90 years later, São Paulo still suffers from significant floods and water contamination. These are consequences of intense and disordered urbanization, a phenomenon that took place in many other Latin American cities. Over the years, a variety of projects and initiatives were made to manage flood hazards and water quality issues of the Tietê. However, apart from gray infrastructure and superficial green approaches, the concept of Natural and Nature-Based Solutions (NNBS) as a potential solution has not yet been studied nor applied in this system. This study aims to determine how these features can be applied to densely urbanized river floodplains to develop efficient, sustainable, and resilient systems. First, a hydrodynamic model was developed for the study area that includes surface runoff, stream flow, and storm sewer. Then, the proposed infrastructure features were introduced into the model to assess their efficiency. A combination of multiple environmental forcings, such as precipitation, storm flow, and illegal sewer discharge, was considered. Finally, a multicriteria decision analysis determined the best combination of solutions. Latin American people face many challenges related to both past and recent political, economic, and social mismanagement. As the world is an extensive and complex system, it is time to share knowledge so that we can transform it into a resilient and sustainable one.

12. Jacobs Driving Impact: Optimizing Holistic NbS for Climate Resilience

Devyani Kar, Jacobs

The approach for Network for Engineering With Nature (N-EWN) is founded on the belief that infrastructure challenges are best met through rich and in-depth collaboration, transdisciplinary teamwork, real-world applications, and education & outreach. To align with these pillars and as a fundamental commitment to increasing climate resilience, Jacobs has applied the EWN framework to multiple projects at different scales in counties, municipalities, and cities, and on military installations.

As an example of real-world applications, Jacobs' team of biologists and ecologists designed and implemented several wildlife crossings. Such crossings are a proven and cost-effective approach to improving road safety and conserving species and ecosystems, and they are increasingly required aspects of infrastructure projects.

Jacobs understands that forming partnerships and effectively exchanging knowledge are vital to fostering innovation and progress. The transdisciplinary team at Jacobs is helping to advance and operationalize the EWN Program by working with the U.S. Army Corps of Engineers to publish a series of engineering guidance reports on designing and constructing nature-based solutions (NbS) for riverine and coastal systems.

One of Jacobs' core commitments is education and outreach to the many markets we serve globally. Through our partnership with the Urban Land Institute, we developed the "Nature Positive and Net Zero: The Ecology of Real Estate" report. It educates landowners and developers on best practices for implementing nature-positive solutions at multiple scales as part of their overall climate strategy.

Jacobs is proud to be a N-EWN member and looks forward to opportunities for collaboration with the Network to advance and accelerate uptake of NbS globally.

13. A Two-Phase Model Framework for Wave Attenuation by Submerged Flexible Vegetation

Hyun Dong Kim, University of Florida

A state-of-the-art model framework, designed for flow-multibody interactions, was implemented to investigate the wave attenuation by a finite patch of submerged aquatic flexible vegetation (SAV). The two-phase model waves2foam that captures the free-surface waves using volume-of-fluid method has been coupled with finite element ANCF beam model to resolve the flow-structure interaction. With softbody dynamics, interactions among vegetation blades are also considered. Validation was conducted using laboratory experiment data of oscillatory flow over vertically wall-mounted flexible flaps by Favier et al. (2017). The validated model was applied to study wave attenuation by submerged flexible vegetation canopy in 2D. Regular waves were implemented following the Stokes wave theory. By varying the wave properties (wave period and wave height) and water depth, wave transformation and attenuation over SAV canopy were investigated. Key parameters that control the dynamics are the Cauchy number (defined as the ratio of hydrodynamic to elastic restorative forces), Buoyancy number, Keulegan-Carpenter number (KC; the ratio of wave orbital excursion to the blade length), the dimensionless gap distance between adjacent vegetation blades (the ratio of distance between two adjacent vegetation blades to the blade length) and the submergence ratio (the ratio of blade length to the water depth). The relation of wave attenuation coefficient with the key dimensionless parameters was investigated using the novel numerical model framework.

14. Effects of Belowground Vegetation on Coastal Dune Erosion

Jorge Laurel-Castillo, University of Florida

Coastal dunes provide invaluable ecosystem services to coastal communities as well as protection from coastal storms. To assess potential storm damages to coastal foredunes, Sallenger (2000) proposed a conceptual model that included four coastal impact regimes depending on the height of the total water level relative to the dune crest and toe levels. In the collisional regime under Sallenger (2000), under which the total water levels exceed the dune toe but not the dune crest, it is generally expected that dune erosion will occur. This magnitude of volumetric dune erosion is also known to be modulated by the presence and properties of vegetation. Given the importance of accurately predicting the degree of retreat of coastal dunes for the purposes of quantifying present and future flooding risk, recent research efforts have been focused on evaluating and parameterizing the effects of vegetation on dune erosion processes. Most of these efforts have been directed towards the analysis of the effect of the above-ground vegetation. Above-ground vegetation modifies surf-zone hydrodynamics as it modifies the bed shear-stress and thus, the bed-load transport. How the dune erosion responds to below-ground vegetation is comparatively not as well understood and further research is needed in this area. In this poster, by means of simplified analytical/empirical models, we explore the effects of below-ground biomass on dune erosion at the storm time scale. First, we implemented the parameterization of Ajedegba et al. (2019) in the Dune Response Tool (Cohn., 2022), which uses the parameterization by Palmsten and Holman (2012) to account for dune volume losses and retreat. This approximation was then contrasted with experimental measured data, for both, a bare and a vegetated dune, where the same beach/dune profile was subject to the same forcing conditions (water level and wave height). Model simulations of these scenarios showed that the simplified approach reproduced reasonably well the final profile for both the vegetated and unvegetated dune scenarios. Furthermore, the results of additional exploratory simulations utilizing a larger range of biomass densities are shown to inform how belowground processes may influence the dune erosion rates during storms.

15. Basin-Scale Modeling of Collective Management Practices in Agriculture to Reduce Sediment and Nutrient Inputs Into Flood-control and Drinking Water Reservoirs

Ting Liu, Arizona State University

As basins in semi-arid and arid regions of the Western U.S. continue to face extreme water shortages due to prolonged droughts and threats from increasing hurricanes moving inland, reservoirs become an essential control on the hydrologic regime. However, management of agricultural lands upstream and downstream of reservoirs is often not aligned with reservoir management for water resources, let alone water quality considerations. Agricultural lands can be a source or sink for pollutants and may also be users, generators, or storage for large quantities of water. Similarly, reservoirs have controls but on a centralized system. While reservoirs are primarily managed from a water quantity standpoint, they inadvertently play a significant role in water quality, especially in agricultural-impacted systems.

In the presentation, we present a Soil & Water Assessment Tool (SWAT) watershed model developed for the Trinity River Basin in Texas to explore collective management of agroecological infrastructure and built infrastructure. The model is developed at a high resolution on agricultural lands to improve model fidelity and help identify priority areas for agricultural management of water quality. The mixed resolution allows the primary decision-making scale on agricultural lands while enabling a large-scale, highly managed basin simulation. As the existing 15 reservoirs and their operations are built into the model, we will present an exploratory analysis of how collective management of the agricultural lands and reservoirs in the watershed could advance water quantity and quality goals. The work will discuss implications for building watershed-scale engineering with a nature-based approach to collective agriculture-reservoir management.

16. Scaling Up Investment in Nature-based Solutions Using Green Banks

Sara Mason, Duke University

Recent government investment in nature-based solutions (NBS) through programs funded by the Inflation Reduction Act and Bipartisan Infrastructure Law is unprecedented, but there is still a need for scaled-up financing of NBS projects in the US. EPA's \$14 billion National Clean Investment Fund and \$6 billion Clean Communities Investment Accelerator allow investment in NBS that contribute to climate change mitigation, remediation of legacy pollution, and development of clean water infrastructure. These funds are meant to catalyze additional investments through financing mechanisms established by Green Banks and community lenders like Community Development Finance Institutions (CDFIs).

Green banks and community lenders are mission-driven financial institutions with mandates often related to decarbonization, climate, health, and equitable communities. NBS have the capacity to deliver on some, if not all of those goals. While green banks and community lenders have not traditionally focused on NBS, there is an opportunity to work with these financial institutions to more explicitly include restoration and NBS into their missions and charters to help enable scaled-up financing of these types of projects. A workshop held in summer 2023 gathered a group of academics, practitioners, financiers, and NBS investors to create resources that could help green banks and other similar financial institutions gain access to the information and resources they need to begin to scale-up these types of investments. This presentation will provide an overview of these resources and share the status of green bank investment in NBS.

17. Non-Profit/For-Profit Partnerships for Implementation of NBS at Scale

Mary-Margaret McKinney, Native Shorelines

Widespread private buy-in of nature-based solutions is still in its infancy. Programs that both increase education and incentivize installation can significantly move the needle on implementation. For-profit/non-profit collaboration can leverage the resources of both type of entities to promote nature-based solutions and implement their use at scale. A successful case study of how such partnerships have led to the implementation of miles of living shorelines in North Carolina will be presented.

18. Developing the Next Generation of Engineering With Nature Professionals: A Presidential Dream Course on Nature-Based Solutions

Robert Nairn, University of Oklahoma

The University of Oklahoma (OU) began the Presidential Dream Course program in 2004. The call for proposals asks “What sort of classes would OU faculty members devise if money were no object? Well, for one thing, they would bring in the best guest lecturers in their fields to stimulate interest and inspire students to delve more deeply.” Based on a regularly offered Ecological Engineering Science class, an undergraduate/graduate Dream Course entitled “Engineering the Nature of Change” was taught in spring 2023 at OU. The course was based on the premise that solving the environmental challenges facing the Earth requires a revolution in our thinking of the relationship between humanity and the planet and enrolled nearly 30 students from five academic majors. With funding provided by the Office of the Senior Vice President and Provost, five Distinguished Speakers were brought to campus. Each speaker met with the class and provided a short guest lecture leading to a conversation on a specific topic. Well-publicized and well-attended Public Lectures provided in the evenings were live-streamed and recorded for a broader audience. Speakers included representatives from the U.S. Army Corps of Engineers, White House Office of Science and Technology Policy, the private sector, and academia. Topics included Engineering With Nature and resilient infrastructure, the National Nature Assessment, passive treatment design and function, ecological engineering and the circular economy, and an historical accounting of ecological engineering over the past 50 years. Substantial community interest provided extraordinary experiences for both enrolled students and a broader audience.

19. A Spatial Conservation Prioritization of Coastal Freshwater Impoundments Based on Predicted Climate Impacts and Waterfowl Habitat Value

Alexa Ouellette, University of Georgia

Along the southeast Atlantic coast, impoundments have been created to enhance freshwater wetland habitat for migrating and wintering waterfowl. These freshwater impoundments were constructed by clearing all woody vegetation and constructing exterior and interior levees, or “dikes,” and controlling water and salinity levels using water control structures, or “trunks.” In recent years, these impoundments have begun to face issues relating to dike overtopping and salinization by outside water sources (e.g., tidal water and rivers), often due to tropical weather systems. Under current climate and sea-level rise projections, these sites will become increasingly vulnerable to these threats, subsequently increasing the frequency and cost of repairs. Without the conservation of these tidal freshwater systems, freshwater habitat for waterfowl and shorebirds in coastal areas could decline significantly in the future. With limited financial resources to support the increasing cost of maintenance and repair, identifying areas of greatest vulnerability relative to habitat value provided is critical. Omnidirectional connectivity models will be constructed to determine the relative value of waterfowl habitat for eight ecologically and recreationally significant waterfowl species across the landscape. The goal of this project is to create a conservation prioritization tool to better guide future management decisions that trade off vulnerability to damage/loss from sea level rise and storm surge with waterfowl habitat value across the landscape.

20. Integrating Landscape Architecture and Engineering Concepts to Foster Nature-Based Solutions

Mindy Strevig, AnchorQEA

The Natural and Nature-Based Features and Engineering With Nature (EWN) concepts provide the U.S. Army Corps of Engineers (USACE) valuable tools to develop sustainable approaches to coastal storm and flood risk management projects.

EWN uses natural processes for maximum engineering and operational benefit, increases diversity of infrastructure value, and uses science-based collaboration to organize and focus stakeholder and partner interests.

Collaboration of scientists and engineers with landscape architects yields innovative EWN strategies that are based in sound science, which are visualized for ease of understanding by stakeholders. EWN Proving Grounds provide USACE Districts with creative ideas that can further “move the needle” on Beneficial Use of dredged material.

The collaboration under this ERDC initiative will result in a suite of innovative strategies and solutions.

21. Evaluating the Equity of Greenspace Access for Infrastructure Planning

Caleb Sytsma, USACE ERDC, Environmental Laboratory

Greenspace access brings an array of wellbeing benefits to communities, but it is not equitably distributed across all communities in the United States. As the country looks to build natural infrastructure to mitigate climate hazards, it is important to consider the implications of project location on the distribution of benefits. Natural infrastructure can be deliberately sited and planned to generate wellbeing co-benefits for nearby communities including increasing access to greenspace. However, planners lack established metrics or methodologies for assessing the impact of project alternatives on the equity of access to greenspace. This presentation proposes a methodology to fill that gap. It uses the Gini index computed with a GIS-based workflow that utilizes publicly accessible data in R and Python to calculate greenspace access equity metrics for user-defined study areas and project alternatives. The methodology allows users to identify locations in their study area where additional greenspace would have the largest impact on greenspace access equity.

22. NBS in the Trinity River Floodway

Craig Taylor, LimnoTech

The Trinity Floodway is a quarter-mile dividing line between downtown Dallas and west Dallas. The proposed Harold Simmons Park is a gathering place where the two unique communities can come together and explore a park several times larger than New York's Central Park. Developing a park in a floodway provides both environmental uplift and vibrant space for the community poses many unique challenges. This poster will highlight NBS techniques used in the design and provide a review of how we communicated those design elements to the community stakeholders.

23. Re-Imagining Infrastructure for a Biodiverse Future

Charles van Rees and Seth Wenger, University of Georgia

Civil infrastructure will be essential to face the interlinked existential threats of climate change and rising resource demands while ensuring a livable Anthropocene for all. However, conventional infrastructure planning largely neglects the contributions and maintenance of Earth's ecological life support systems, which provide irreplaceable services supporting human well-being. Furthermore, infrastructure development and biodiversity conservation are often planned and executed in isolation, despite the interdependence of contributions to solving sustainability challenges. Here, we envision a new infrastructure paradigm wherein biodiversity and ecosystem services are a central objective of civil engineering. In particular, we reimagine infrastructure practice such that 1) ecosystem integrity and species conservation are explicit objectives from the outset of project planning; 2) infrastructure practices integrate biodiversity into diverse project portfolios along a spectrum from conventional to nature-based solutions and natural habitats; 3) ecosystem functions reinforce and enhance the performance and lifespan of infrastructure assets; and 4) civil engineering promotes environmental justice by counteracting legacies of social inequity in infrastructure development and nature conservation. This vision calls for a fundamental rethinking of the standards, practices, and mission of infrastructure development agencies and a broadening of scope for conservation science. We critically examine the legal and professional precedents for this paradigm shift, as well as the moral and economic imperatives for manifesting equitable infrastructure planning that mainstreams biodiversity and nature's benefits to people. Finally, we set an applied research agenda for supporting this vision and highlight financial, professional, and policy pathways for achieving it.

24. Assessing the Potential Role that Integrated Agricultural-Reservoir Systems Have on Water Quality

Danna Villareal, University of Arkansas

Water pollution is commonplace across watersheds in the U.S. and globally, driven primarily by anthropogenic influences. Understanding and managing water quality across diverse and complex systems can be daunting, given multiple drivers and interactions. For instance, thousands of dams and associated reservoirs were constructed in the U.S. to provide flood control, water supplies, and navigation, yet we know that they also impact water quality, whether or not operations consider this outcome. Many of these reservoirs are downstream of significant agricultural activity which also impacts quantity and quality outcomes. Despite their interconnectedness, agricultural systems and downstream or nearby water resources infrastructure are rarely managed cohesively. This misalignment of activities and goals could be leading to substantial inefficiencies in the investment of resources and management of water resources. In this work we developed a scoping study to understand the extent of these kinds of systems in the U.S. and to help prioritize future coordination efforts and studies. We retrieved data from the National Inventory of Dams and combined it with high-resolution national hydrological data (NHD+ HR) to generate upstream watershed delineation for all dams in the U.S. Technical validation was performed using other existing datasets. We then classified the extent of agricultural systems within the contributing areas of U.S. reservoirs. We then use additional data including size, reservoir purpose, and spatial relationships to help classify these complex systems, as our future goal is to understand how these different systems impact water quality parameters, such as nitrogen and phosphorus. The ultimate outcomes of this study will be to advance water resources management in these kinds of complex systems.

25. Comparative Analysis of Estimated Longshore Sediment Transport Rates with River and Dredging Fluxes in the Savannah Harbor

Oscar Villegas, University of Georgia

Understanding the relative contributions of inland and marine sediment sources in estuaries is crucial for predicting and managing sedimentation in harbors. Among various oceanographic factors such as winds, tides, and currents, near-shore waves play a significant role in coastal geomorphology, generating sediment transport along the surf zone through longshore current generated by breaking waves.

In the context of the Georgia Bight, net longshore sediment transport is pivotal for beach dynamics, with islands relying on transport from north to south. However, interpreting the predominant longshore sediment transport direction becomes challenging due to the coexistence of tidal processes, shaping the coast in conjunction with longshore processes. Prevailing southward sediment transport direction has been observed in generalized field studies, often interspersed with local reversals.

The US Army Corps of Engineers has persistently dredged the Savannah River since the 19th century to facilitate the passage of larger container ships. In 2020, annual dredging in Savannah Harbor reached 7.1 million cubic yards, with an estimated 4% of dredged material managed using Regional Sediment Management principles. A two-dimensional hydrodynamic model was employed to understand sediment dynamics in the Savannah Harbor Channel during typical conditions, emphasizing the interplay between hydrodynamics and sediment transport coupled with a wave model. Predominant currents and sediment transport were integrated to elucidate sediment dynamic patterns. The results were compared with estimated total sediment annual discharges and dredge records provided by the Savannah District. These offered valuable insight for effective sediment management and potential beneficial use project implementation.

26. Spatiotemporal Causal Learning for Streamflow Forecasting

Shu Wan, Arizona State University

Streamflow plays an essential role in the sustainable planning and management of water resources. Traditional hydrological modeling approaches simulate streamflow by establishing connections across multiple physical processes, such as rainfall and runoff. This data, inherently connected both spatially and temporally, possesses intrinsic causal relations that can be leveraged for robust and accurate forecasting. Recently, spatiotemporal graph neural networks (STGNNs) have been widely adopted, excelling in various domains such as urban traffic management, weather forecasting, and pandemic control. However, learning causal relationships directly from vast observational data is theoretically and computationally challenging. In this study, we employ a river flow graph as prior knowledge to facilitate the learning of the causal structure and then use the learned causal graph to predict streamflow at targeted sites. The proposed model is tested in a real-world study in the Brazos River basin in Texas. Our results demonstrate that our method outperforms regular spatiotemporal graph neural networks and achieves higher computational efficiency compared to traditional simulation methods. By effectively integrating river flow graphs with STGNNs, this research offers a novel approach to streamflow prediction, showcasing the potential of combining advanced neural techniques with domain-specific knowledge for enhanced performance in hydrological modeling.

27. Challenges and Solutions for Permitting Coastal Nature-based Solutions

Chloe Wetzler, Duke University

The environmental and social benefits of nature-based solutions have made them a subject of growing interest in the U.S. and these types of projects are more commonly being prioritized. Yet, despite their clear ecological and economic advantages, many challenges slow the implementation of nature-based solutions. One of the primary challenges is permitting. Permitting for nature-based solutions, specifically in coastal areas, becomes complicated due to the overlapping and fragmented jurisdiction and authority of federal, state, and local environmental statutes. Depending on the size of a proposed project, its purpose, and its expected impacts on surrounding habitats and species, different regulations and permits apply. Because of the varied nature of the regulations, the permit application process is unattractive to project managers who will have to apply for multiple permits from agencies at different levels of government and often do not have a simplified model they can replicate. Using both literature review and expert interviews we have summarized common permitting challenges and possible solutions for coastal nature-based solutions projects. Additionally, case studies are shared to highlight some successful solutions that have been making progress on the ground, which hopefully can be modeled to bring about increased efficiency in the permitting process.

28. Quantifying the Increasing Flood Risks Produced by Legacy Levee Systems

Elissa Yeates, University of Georgia

Legacy levee systems have associated residual flood risk, which grows over time through layered processes of development, changing climate, and infrastructure aging. Recent work to quantify the effect of levee systems on inducing development in protected floodplains has shown a 50-60% increase in exposure in the event of levee failure, compared with the pre-levee floodplain. Efforts to assess the distribution of this risk across vulnerable populations in the United States have found that non-white and low-income groups are disproportionately living in levee-protected floodplains which, as in the recent Pajaro flooding event, may be insufficiently maintained over time. As population pressures increase floodplain development and climate change increases the likelihood of flood events that exceed system design criteria, this residual risk profile grows.

Strategies to mitigate increasing risks of flooding include hardening built infrastructure systems (such as repairing, maintaining, and raising levees), which can have the effect of worsening downstream flooding potential by increasing riverine flow velocities and scour and inhibiting the function of natural floodplains to attenuate flow. Alternatively, levee systems can be set back, allowing for increased “room for the river” to restore natural floodplain function and increase capacity to attenuate higher flows. We develop a framework to integrate economic and engineering models of risk with SETS theory to determine the scale of the current risk produced by levee systems in the United States. This can guide decision-making on where and when to shift away from hardening traditional levee systems toward strategies of floodplain restoration and levee set-back, considering the hazard, exposure, and vulnerability framework of risk under a shifting climate. Questions considered include: What is the magnitude and distribution of the risk posed by flooding under legacy levee systems? Where and when does investment in system transformation become a favored strategy for mitigating this risk? How can concepts of risk hazard, exposure, and vulnerability be applied to decision-making about levee removal or setback at scale?

Track 1

Wednesday, 1:15 - 2:45

A: Nature-Based Solutions Policy and Planning

Ponce de Leon Room

Moderated by Matt Shudtz, University of Georgia

Legal and Social Components of Nature-Based Solutions: The Example of Levee Setbacks (*Yee Huang & Katie Foster, UGA*)

Planning and Designing With Nature Based Solutions (*Billy Johnson, LimnoTech*)

Opportunities to Protect People, Property, and Nature by Connecting Insurance, Risk Science, and Nature-Based Solutions (*Megan Kelso, UCSC*)

A Resilient Texas Coastline – Aligning Our Natural and Built Infrastructure for the Future (*Chris Levitz, AECOM*)

Nature-Based Solutions as a Pathway to Equitable Risk Reduction from Climate Hazards (*Victoria Salgado, AECOM*)

B: Wetlands

Anastasia Room

Moderated by Lee Marlowe, San Antonio River Authority

Sand Seepage Wetlands as a Way to Increase Our Wetland Inventory and Improve Our Surface Water Resources (*Joseph Berg, Biohabitats*)

Developing a Numerical Model to Predict the Nutrient Removal from Borrow Pits Wetlands in the Middle Missouri River Basin (*Mohamed Gaballah, CMU, UGA*)

Reinventing Nature-based Solutions for Treatment of Domestic Wastewater (*Amanda Ludlow, Stantec*)

Identifying Potential Sites for Wetlands via Causality-based Data Imputation and Knowledge Transfer (*Yoonhyuk Choi, ASU*)

Optimizing the Natural Infrastructure Benefits of Conservation and Restoration (*Elizabeth Guthrie, Ducks Unlimited*)

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Coquina Room

Moderated by Shaun Donovan, San Antonio River Authority

Bank Stabilization Using Natural Channel Design Along the San Antonio River (*Collen Brownlow, San Antonio River Authority*)

Hydrologic Controls on Phosphorus Dynamics Within Legacy Sediment Floodplains (*Cheyenne Morgan, OU*)

Short Bumps, Tall Trees: Trajectories of Landscape Carbon Balance After Dam Removal (*Laura Naslund, UGA*)

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Legal and Social Components of Nature-based Solutions: The Example of Levee Setbacks

Yee Huang & Katie Foster, University of Georgia

This talk will discuss the legal and regulatory considerations for implementing nature-based solutions through the federal civil works process, focusing specifically on the example of a levee setback. Repeated and catastrophic levee failures, evolving public values, and increasing frequency of extreme weather events have driven the search for better ways to manage flood risk, to repair flood-damaged levees, and to meet environmental and ecosystem needs.

A levee setback is a nature-based solution (NbS) that addresses these goals by improving flood protection and reestablishing historical floodplains. However, the legal and regulatory landscape to implement a setback is evolving and raises social and equity concerns that complicate the decision-making process in infrastructure investments. One particularly complex issue is how to, and with what funding, voluntarily acquire property in the historical floodplain.

For a community interested in implementing a setback, understanding and preparing in advance are critical. This talk will cover specific laws that allow or encourage levee setbacks, how the federal suite of environmental laws specifically apply to levee setbacks, what federal funding is available to support levee setbacks, and lessons learned from using federal funds to voluntarily acquire floodplain properties.

This talk is based on an IRIS in Focus primer written by UGA legal researchers Yee Huang and Matthew Shutz and subsequent investigations of the complex social issues related to voluntary purchases of floodplain property.

Planning and Designing Nature Based Solutions

Billy Johnson, LimnoTech

Nature Based Solution (NBS) Design offers a process for incorporating multiple components (hydrology, geology, ecology, human systems) in the development of environmental restoration projects. The incorporation of each component over the course of a project necessitates iteration, or the reexamination of the project as a whole, to determine if the project definition and formal design concept are still capable of delivering maximum benefit in balance. Iteration allows a project to be scrutinized at multiple levels, from the site extent project definition to the specific form/function of the project.

Facilitating a process of NBS design for clients necessitates a clearly laid out process and key tools that can facilitate iterative design. The process definition can help clients ask important questions about the extent and function of a site as well as the process for incorporating data and design decisions along a timeline. With every site being unique but with common core characteristics to the process, we can help avoid a single design fits all strategy. While process definition can inform an approach, we have identified key areas of technical methods which necessitate the development of tools to enable the process to achieve design excellence.

Planning Questions: 1) H&H – What scales and/or locations control H&H? What are approximate costs for earthwork and infrastructure? What are O&M costs?; 2) Geomorphology – Which forms are present in the system? How dynamic or these forms?; 3) Water Quality – Which factors and processes influence WQ? To what degree? Which processes can be influenced?; and 4) Biology/Ecology – What is the current state and direction of the ecosystem? In what way do we want to influence the ecosystem? How significant is the feedback from biology and ecology to the other tiers (i.e. H&H, Geomorphology, and WQ)?

This presentation will focus on the design process, tool development, and example projects.

Opportunities to Protect People, Property, and Nature by Connecting Insurance, Risk Science, and Nature-Based Solutions

Megan Kelso, University of California, Santa Cruz

Risks from natural hazards are growing due to climate change and habitat loss. There is an urgent need to ramp up risk mitigation efforts and growing interest in doing so with novel strategies that link insurance with nature-based risk mitigation projects with insurance. Here, we present work that USCS is conducting to advance practical science and action at the intersection of nature-based solutions (NBS) and insurance. We share key findings from a recent project and resulting report completed in collaboration with USACE EWN to assess the current state of science and practice on integrating nature into risk science and insurance, and the most promising opportunities to advance this space going forward. Our key recommendations fall into 4 main categories: risk modeling, insurance coverages, public-private partnerships, and financing opportunities. We will present some of our current and upcoming work in these areas, including efforts to better incorporate coastal habitats in private industry risk models, develop fragility curves for coastal ecosystems, model waves better to improve assessments of risks and coastal habitat benefits, support the development of nature-positive insurance products, build capacity in local communities and within the private risk industry, and collaboratively incorporate results into the models and products used by the private risk industry. Through this work, we aim to enhance protection of communities from growing coastal hazards and unlock substantial new funding for coastal NBS.

A Resilient Texas Coastline – Aligning Our Natural and Built Infrastructure for the Future

Chris Levitz, AECOM

Texas is taking steps to proactively plan for climate-related challenges along its coast, both for the immediate future and the long-term. The Texas General Land Office (GLO) has led the charge to assemble the Texas Coastal Resiliency Master Plan, releasing the third iteration of their Plan in early 2023. The Plan provides a framework towards the protection of coastal communities, ecosystems, and infrastructure. What coastal community infrastructure looks like in an evolving landscape is critical to identifying actionable and resilient projects that integrate both nature-based and traditional infrastructure working together as hybrid solutions to achieve the goals of diverse groups of stakeholders.

Understanding the latest science and dynamism of the coastal zone is paramount to the GLO's overall planning effort. Another critical development in the GLO's planning process has been to build consensus among stakeholders with considerably different priorities by promoting collaborative solutions through ten "actions" that propose a comprehensive view of coastal resilience spanning the state's natural, social, and economic systems. By looking at these triple bottom-line benefits through the lens of a single, unified coastal system, the 2023 Plan thus works (a) to make complex resilience concepts approachable for all stakeholders along the coast, and (b) to rally diverse groups of Texans to support key proposed projects by creating win-win scenarios.

This presentation will present coastal resilience through a system-based approach using hybrid solutions that result in actions with diverse benefits in the face of climatic pressures through the lens of the 2023 Texas Coastal Resiliency Master Plan.

Nature-based Solutions as a Pathway to Equitable Risk Reduction from Climate Hazards

Victoria Salgado, AECOM

Climate hazards are projected to increase in intensity and frequency over time, furthering the need to deploy a wide range of adaptation solutions. Utilization of nature-based solutions (NBS) to reduce drought, flood, wildfire, and coastal hazard risk will be vital to bolster resiliency and ecosystem services in the face of uncertainty, particularly for frontline communities disproportionately impacted by climate change and lacking equitable access to natural spaces and their benefits. AECOM is developing an approach to demonstrate the feasibility of a variety of NBS approaches in hazard risk reduction while providing co-benefits for communities throughout California. This work will evaluate and demonstrate eligibility of NBS under FEMA Hazard Mitigation Assistance (HMA) Programs, increase the visibility/usability of NBS in FEMA Benefit-Cost Analyses (BCAs), and highlight areas for improvement. Anticipated outcomes include resources for communities to conceptualize, develop, and implement NBS, including the daunting task of developing BCA evaluations and other barriers for NBS. In addition, this work addresses systemic and structural inequities exacerbated by projected climate hazards for communities throughout California. In particular, communities often excluded from the broader climate change conversation, such as disadvantaged and lower resourced communities, frequently bear the disproportionate burden of climate change impacts. By highlighting shortcomings in the planning and funding processes communities face, and providing that information to FEMA and other agencies, this work will be used to advocate for policy changes that further enable NBS implementation in California and beyond.

Track 1

Wednesday, 1:15 - 2:45

B: Wetlands

Anastasia Room

Moderated by Lee Marlowe, San Antonio River Authority

Sand Seepage Wetlands as a Way to Increase Our Wetland Inventory and Improve Our Surface Water Resources

Joseph Berg, Biohabitats

Developing a Numerical Model to Predict the Nutrient Removal from Borrow Pits Wetlands in the Middle Missouri River Basin

Mohamed Gaballah, Central Michigan University/University of Georgia

Reinventing Nature-based Solutions for Treatment of Domestic Wastewater

Amanda Ludlow, Stantec

Identifying Potential Sites for Wetlands via Causality-based Data Imputation and Knowledge Transfer

Yoonhyuk Choi, Arizona State University

Optimizing the Natural Infrastructure Benefits of Conservation and Restoration

Elizabeth Guthrie, Ducks Unlimited

Sand Seepage Wetlands as a Way to Increase Our Wetland Inventory and Improve Our Surface Water Resources

Joseph Berg, Biohabitats

Sand seepage wetlands are novel wetland systems that use pulsed stormwater flows to initiate and sustain wetland hydrology and providing surface water treatment, while also creating a diverse wetland habitat and supporting associated biotic communities. The design approach uses seepage pools/reservoirs to collect and store pulsed flows and riffle grade control structures to retain water at higher elevations and use this created to head to drive the surface water through a carbon-rich granular hyporheic bed that supports microbial processes. In addition to cooling and cleaning the water, supporting a variety of wetland habitats from submersed and emergent communities through wetland shrub and tree communities, this approach also attenuates peak discharge and extends time of concentration. In the presentation I will review two successfully implemented projects, one in an agricultural watershed troubled by poultry production in the vicinity of Ocean City, Maryland constructed ten years ago and one site historically used for rubble dumping in an urban watershed in the vicinity of Hackensack, New Jersey constructed last year. These systems can be a great alternative to regional stormwater detention ponds, delivering opportunities for engagement with nature through the incorporation of trails and overlooks, creating opportunities for immersive engagement in wetland habitat.

Developing a numerical model to predict the nutrient removal from borrow pits wetlands in the middle Missouri River Basin

Mohamed Gaballah, University of Georgia

The U.S. Army Corps of Engineers (USACE), in collaboration with local partners, constructs and maintains an extensive levee network along U.S. rivers, including the lower Missouri. During the repair, maintenance, or realignment of these levees, substantial amounts of fill material are sourced locally from "borrow pits". Some of these borrow pits have been transformed into wetlands to improve habitat conditions. Notably, certain agricultural drainage ditches have been redirected through these newly created wetlands to enhance water quality, primarily by removing nutrients, before discharge into the Missouri River. Presently, these wetlands are not specifically designed for nutrient retention, and the water quality benefits derived from this practice have not been quantified. The objective of this research is to assess the potential water quality improvements associated with rerouting agricultural drainage through the established constructed wetlands in the lower Missouri River basin. The aim is to contribute to the enhancement of the design of these nature-based solutions. Consequently, a monitoring program focusing on the hydrology and water quality of these borrow pits is being implemented. The intention is to develop and calibrate a numerical model that can assess various design alternatives, offering recommendations to optimize nutrient removal within these wetlands. Additionally, the feasibility of extending these wetlands along the river for the same purpose will be investigated. The outcomes of this study will assist USACE in prioritizing locations for constructed wetlands and refining their design to maximize water quality benefits.

Reinventing Nature-based Solutions for Treatment of Domestic Wastewater

Amanda Ludlow, Stantec

Across the United Kingdom, tightened permit limits are placing pressure on water companies to introduce new nutrient removal schemes. Traditional ways of treating stormwater and wastewater can be expensive and use a lot of energy especially under high flows conditions. Stantec is utilizing its expertise with treatment wetlands and other nature-based solutions to develop holistic catchment-based approaches to address degraded water quality and protect our clients assets.

While treatment wetlands have been around for decades, recent research has gained an appreciation and further understanding for the complexity of a wetland environment and the benefits brought about by its natural biodiversity and resiliency. Bringing nature back as an integral part of wastewater solutions can lead to a more sustainable and resilient future.

Stantec is working with various water utilities in the UK to design Treatment Wetlands for domestic wastewater treatment and combined sewer overflows to maximize the benefits of restoration ecology by incorporating enhanced biodiversity and habitat creation built into the topography of the landscape. Treatment wetlands are being designed to provide biological treatment to a secondary treatment requirement for all or parts of the flows and/or used as a tertiary treatment process to 'polish' flows.

This presentation will provide an overview of two case studies utilizing treatment wetlands for wastewater treatment: (1) Yorkshire Water Services (YWS) Clifton Wastewater Treatment Works and (2) United Utilities Southwaite Wastewater Treatment Works.

Identifying Potential Sites for Wetlands via Causality-based Data Imputation and Knowledge Transfer

Yoonhyuk Choi, Arizona State University

Wetlands (swamps, marshes, bogs, floodplains, and estuaries) are pivotal in shaping their surrounding ecosystems by providing a diverse spectrum of benefits, including floodwater storage and retention, protection against storms and hurricanes, stabilization of shorelines, water purification, and carbon fixation. Yet, how to detect potential sites for wetlands and utilize them is a challenging question. Wetland site detection involves a decision process assessing various parameters, including land use type, soil characteristics, water table depth, and potential evapotranspiration. Traditional techniques primarily depend on domain expertise, yet this expertise-driven decision process is especially difficult considering the heterogeneous nature of wetlands and their diverse use contexts. While model-driven approaches are promising, it is computationally expensive and data may be sparse. This comprises spatio-temporal and contextual sparsities, such that some locations have missing data for months or even years due to data collection issues. Moreover, a model learned in one context (one location, considering one particular end goal) may not be directly transferred to a different context. We therefore propose a novel approach towards the identification of potential sites for wetlands through causality-based data imputation and prediction with context-informed knowledge transfer. To address the data sparsity issue, we first discover underlying causal structures among the covariates and utilize them for data imputation through knowledge transfer from contexts with richer data to sparse ones. Finally, we build causally informed models for the identification of potential sites for wetlands, to enhance the explainability of our method.

Optimizing the Natural Infrastructure Benefits of Conservation and Restoration

Elizabeth Guthrie, Ducks Unlimited

Wetland conservation and restoration holds the potential to provide important sustainability benefits to both people and wildlife. Ducks Unlimited has partnered with the University of Georgia to develop science-based information to raise the profile of the role of wetland conservation and restoration as a means of increasing societal resilience to floods, droughts and storms. This partnership evolved to help answer the clear need for data and data-driven tools to enable coastal and riverine adaptation on the scale necessary to address the impacts of current and future natural hazards. There is a critical need to develop natural infrastructure design guidance and develop scalable, repeatable measures and models of natural infrastructure project performance in a way that pairs practitioners like Ducks Unlimited and our project partners, with academic partners.

We present here multiple case studies that illustrate how this partnership has been utilized to address these needs through existing and planned conservation and restoration projects. For many projects, monitoring performance and outcomes represents a significant unknown that is necessary to improve methods and standards and understand the costs and benefits for conservation and restoration activities that aim to optimize natural infrastructure benefits. Future research, partnership, and funding needs are discussed in the context of accelerating natural infrastructure implementation through this approach.

Track 1

Wednesday, 1:15 - 2:45

C: EWN and Rivers

Coquina Room

Moderated by Shaun Donovan, San Antonio River Authority

Bank Stabilization Using Natural Channel Design Along the San Antonio River

Collen Brownlow, San Antonio River Authority

Hydrologic Controls on Phosphorus Dynamics Within Legacy Sediment Floodplains

Cheyenne Morgan, University of Oklahoma

Short Burps, Tall Trees: Trajectories of Landscape Carbon Balance After Dam Removal

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Development of an Eco-Hydrology Design Tool

Lauren Melendez, USACE ERDC

Bank Stabilization Using Natural Channel Design Along the San Antonio River

Collen Brownlow, San Antonio River Authority

The San Antonio River Authority (River Authority), created in 1937, is one of many such active river authorities in the State of Texas. Its jurisdiction covers 3,658 square miles in Bexar, Wilson, Karnes and Goliad Counties. In San Antonio, Texas, the River Authority owns and operates the Mission Reach Park. The Mission Reach ecosystem restoration and recreation project has increased the quality, quantity and diversity of plants and animals (flora and fauna) along the eight miles of the San Antonio River Mission Reach area. The ecosystem restoration process will be accomplished over many years through several steps including construction on the river to reconfigure the channel and create improved aquatic habitat, reestablishing hundreds of acres of native grasses and wildflowers and finally the planting of over 20,000 native trees and shrubs. The culmination of these steps will result in the transformation of the river into a more natural state.

Following several major flashflood events from 2015-2018, sections of the Mission Reach bank along the San Antonio River were experiencing severe bank erosion and destabilization. Bank erosion repairs at two locations along the banks of the San Antonio River were implemented using natural channel design (NCD) principles. By using natural channel design, the River Authority intended to restore the stream channel and riparian areas to a more natural condition using native materials, minimizing structures to reduce maintenance costs while at the same time enhancing aquatic habitat.

Hydrologic Controls on Phosphorus Dynamics within Legacy Sediment Floodplains

Cheyenne Morgan, University of Oklahoma

Legacy sediments are deposits of historic sediment accumulations often due to current or historical anthropogenic activities. In the case of reservoir draining, volunteer riparian ecosystems may establish in legacy sediment deposits. Legacy sediment riparian ecosystems may include various floodplain ecosystems including deltas, marshes, backswamps, bottomland hardwood forests, and other riparian wetlands. It has been established that legacy sediments may contain elevated concentrations of accumulated pollutants which may negatively impact adjacent waterbodies. However, it is less clear if legacy sediment riparian ecosystems (i.e., floodplains) remain a source of pollution decades after reservoir drainage.

At Lake Frances, Oklahoma, a research project was initiated to better understand phosphorus (P) dynamics within soils of a developing bottomland hardwood forest legacy sediment floodplain (LSF). Since dam loss and reservoir drainage in 1990, the system has been allowed to naturally mature, providing a template for nature-based solution applications. Research objectives are to: 1) quantify hydrologic storage and subsurface flow within the LSF, 2) assess the role of hydrologic pathways in releasing and/or retaining P in LSF surficial soils, and 3) evaluate the role of alluvial groundwater in LSF P dynamics. The project is divided into three studies. The initial study will determine site-wide soil physical and hydrologic characteristics. The second study provides an estimate of soil P pools and fluxes. The third study focuses on P dynamics in alluvial groundwater beneath the LSF. This research will provide information to assist water resource managers, environmental scientists, and other stakeholders in developing legacy sediment best management practices.

Short burps, tall trees: Trajectories of landscape carbon balance after dam removal

Laura Naslund, University of Georgia

Dams can facilitate high emissions of carbon dioxide and methane from their reservoirs by flooding terrestrial soils and concentrating organic matter under hypoxic conditions. Dam removal has been proposed as a strategy to reduce emissions while restoring aquatic ecosystems; however, the carbon balance of formerly impounded landscapes depends on multiple pathways of gas exchange. For example, buried organic matter can be rapidly mineralized when exposed to air after reservoir drawdown (resulting in ‘burps’ of carbon emissions), but newly forming terrestrial vegetation and soils in the reservoir footprint can store carbon. The relative contribution of these and other pathways of carbon emissions and storage following dam removal, and thus, the viability of dam removal as a natural climate solution, is unknown. We combine empirical models of surface gas exchange, reservoir sedimentation, and forest regeneration to estimate and characterize the uncertainty in relevant carbon fluxes before, during, and after dam removal. We apply this model to completed dam removals on the Elwha River, WA and the Penobscot River, ME. We find that the fate of previously inundated reservoir sediments is a major determinant of the magnitude and dominant pathways of carbon emissions during dam removal. Regrowing vegetation can eventually offset carbon emissions during dam removal and compensate for lost carbon storage with reduced sediment burial; however, the time to reach this compensation point after dam removal depends greatly on reservoir, dam, and basin characteristics, suggesting that removal of some, but not all, dams may be a beneficial climate solution.

Modeling *Arundinaria gigantea* (Giant Rivercane) as a Culturally Important Nature-Based Solution for Riparian Area Restoration

Hailey Seago, University of Oklahoma

Native vegetation on river and stream banks and associated riparian zones is beneficial for erosion and pollution control and habitat provision. *Arundinaria gigantea*, or rivercane (a native grass), is considered a culturally important species to Native American communities who use it for sacred ceremonies, tool making, and hunting and gathering purposes. Established rivercane stands can grow into a dense configuration called a canebrake, an important riparian ecosystem in the southeast and southcentral United States, which has an interlocking rhizomic root structure with excellent soil stabilization potential. Less than 2% of original rivercane ecosystems still exist in the U.S. Taking into consideration known cultural and ecological uses, rivercane restoration may serve as a nature-based solution (NBS) for several environmental challenges associated with urbanization and climate variability. An evaluation of rivercane as an NBS is being conducted with the watershed-based model, Gridded Surface/Subsurface Hydrologic Analysis (GSSHA). GSSHA is a multi-dimensional physics-based hydrologic simulation of physical processes, impacts of restoration alternatives, and methods for reducing or preventing pollution to surface water, developed by the USACE. The GSSHA model is being used to analyze how rivercane restoration and other NBS, like wetland creation, can influence water quality and quantity in riparian settings on the Illinois River watershed located on the Oklahoma-Arkansas border. The objectives for the GSSHA model are to create a calibrated and validated hydrologic model representative of the study site and to evaluate rivercane as a riparian area NBS.

Development of an Eco-Hydrology Design Tool

Lauren Melendez, USACE ERDC

The U.S. Army Corps of Engineers (USACE) has a major responsibility for the regulation of the Nation's streams, rivers, and waterways. This often requires developing water quality models to resolve issues and concerns with regard to the environment and ecosystems. U.S. Army Engineer Research and Development Center (ERDC) and LimnoTech Inc. are currently developing an Eco-Hydrology Design Tool supported by years of research and development in the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model and a suite of Water Quality and Ecosystem Models (Clearwater Water Quality Modules). GSSHA is a physics-based, distributed, hydrologic, sediment and constituent fate and transport model. Features include two dimensional (2-D) overland flow, 1-D stream flow, 1-D infiltration and unsaturated flow, 2-D saturated groundwater flow, with full coupling between the groundwater, shallow soils, streams, and overland flow. Sediment and constituent fate and transport are simulated in the shallow soils, overland flow plane, and in streams and channels. GSSHA can be used as an episodic or continuous model where soil surface moisture, groundwater levels, stream interactions, and constituent fate are continuously simulated. The fully coupled groundwater to surface-water interaction allows GSSHA to model basins in both arid and humid environments. Clearwater (Corps Library for Environmental Analysis and Restoration of Watersheds), developed by the ERDC, offers a library of environmental simulation software that leverages capabilities of existing water resource simulation models to assess environmental impacts and design solutions to manage and restore aquatic ecosystems. The following Water quality modules are included: NSMs (Nutrient Simulation Modules, I and II), TSM (Temperature Simulation Module), MSM (Mercury Simulation Module), CSM (Contaminant Simulation Module), GCSM (General Constituent Simulation Module), SSM (Solids Simulation Module), and RVSM (Riparian Vegetation Simulation Module). This presentation will discuss current development efforts and future directions in support of a design tool for Nature Based Solutions (NBS).

Track 2

Wednesday, 3:15 - 4:45

A: Panel and Lightning Talks - Biodiversity

Ponce de Leon Room

Moderated by Seth Wenger and Kyle McKay

Panel - Opportunities for Biodiversity Conservation in Mainstreaming Natural Infrastructure and Nature-based Solutions

Kyle McKay, USACE ERDC

Matt Shudtz, UGA

Katie Foster, UGA

Tim Dekker, LimnoTech

Shaun Donovan, San Antonio River Authority

Lightning Talks:

Reefense - Realizing the Potential of Hybrid Reefs (*Laura Cherney, AECOM*)

Quantifying the Impacts of Future Shorelines Modification on Biodiversity (*Daniel Coleman, UGA*)

A Holistic Modeling Approach to Decode Hydrology and Ecology in Urban Watersheds (*Abel Porras, City of Austin*)

Inspiring Biodiversity Conservation and Stewardship Using Simple Techniques to Monitor Outcomes of Urban Nature-based Infrastructure Projects (*Lee Marlowe, San Antonio River Authority*)

Engineering Hybrid Reef Structures for Coastal Protection: Reefense X-REEFS (*Mike Beck, UCSC*)

Promoting Coastal Bird Biodiversity in Coastal Louisiana Using Dredged Sediments from Baptiste Collette Bayou (*Burton Suedel, USACE*)

Track 2

Wednesday, 3:15 - 4:45

B: Marshes, Living Shorelines, and Sediments

Anastasia Room

Moderated by Jan Mackinnon, GADNR

Smoothing the Path to Resilience Through Georgia's Living Shorelines (*Meghan Angelina, GADNR*)

Predicting the Outcomes of Sediment Addition in Florida's Changing Coastal Landscape (*Britney Hay, UF*)

Sediment Budgeting to Support Beneficial Use Planning and Sustainability Assessment (*C. Rhett Jackson, UGA*)

Accrediting Evidence: How a Natural Sediment Event and a Thin Layer Placement (TLP) Study Led to Similar Conclusions in Two New England Salt Marshes (*Gregg Moore, UNH*)

Process-Based Model of Salt Marsh Coupled Dynamics Highlighting the Physical Drivers of Vulnerability (*Kiran Adhithya Ramakrishnan, UF*)

C: BCA and Economics

Coquina Room

Moderated by Matt Chambers, University of Georgia

Economic Value of Green Infrastructure Investments on the Georgia Coast (*Craig Landry, UGA*)

A Place for Structural Causal Modeling in Quantifying the Ecological Costs and Benefits of Nature-Based Solutions in Aquatic Systems (*Bertrand Lemasson, USACE ERDC*)

An Applied Evaluation of Ecosystem Services Decision-Support Tools (*Ali Meek, OU*)

Port of San Diego: An Example Cost Benefit Analysis for Nature Inclusive Design Approaches within Port Infrastructure (*Maor Bezner, EConcrete*)

Nature-based Solutions for CCR Closure (*Josh Running, Stantec*)

Track 2

Wednesday, 3:15 - 4:45

A: Panel and Lightning Talks – Biodiversity

Ponce de Leon Room

Panel – Opportunities for Biodiversity Conservation in Mainstreaming Natural Infrastructure and Nature-based Solutions

Leads: Seth Wenger, University of Georgia and S. Kyle McKay, USACE ERDC

Matt Shudtz, University of Georgia

Katie Foster, University of Georgia

Tim Dekker, LimnoTech

Shaun Donovan, San Antonio River Authority

As Nature-based Solutions and Natural Infrastructure (hereafter NbS) are increasingly recognized and prioritized as strategies to mitigate and adapt to the impacts of climate change on human societies, many scholars and policymakers cite their potential environmental benefits as a key advantage. The notion that NbS are a “win-win” for both humans and the environment remains insufficiently explored and merits strategic research and planning to increase the likelihood that ecological gains are part of their mainstream implementation. This panel convenes experts working on biodiversity conservation and NbS implementation across different systems and sectors to discuss and highlight opportunities for leveraging NbS development for ecological restoration and achieving biodiversity conservation goals. Panelists will present on topics like benefit quantification for strategic infrastructure planning and corporate sustainability, ecological restoration and monitoring within NbS projects, promoting social justice via nature positive NbS, and legal mechanisms for enhancing biodiversity through NbS development.

Biodiversity Lightning Talks

Reefense - Realizing the Potential of Hybrid Reefs

Laura Cherney, AECOM

AECOM is supporting the University of Miami (UM) as part of the US Department of Defense (DoD) Defense Advanced Research Projects Agency's (DARPA) program, which aims to address coastal threats that are targeting DoD and civilian infrastructure and personnel. DARPA is looking to implement natural solutions in the form of hybrid (biological and engineered) reefs. These reefs will be designed to attenuate waves and dissipate their energy before reaching shore to lessen coastal erosion, flooding, and storm damage. Research is also focused on interventions to improve the resilience of corals and reef ecosystems in a changing climate. Due to this combination of biological interventions and engineered systems, the hybrid reef will support a variety of fish, corals, and crustaceans, strengthening the local ecosystem and allowing the reef structure to be self-healing while promoting natural coral growth. This provides a more resilient shoreline protection solution, as the structure can respond and adapt to changing environmental conditions, including warming ocean temperatures and sea level rise.

The UM project, known as X-REEFS, is expected to see initial deployment at Elliott Key, Florida with AECOM as the program manager. The X-REEFS team is comprised of research and industry experts to perform other tasks, such as Penn State University (structural design and fabrication), Florida International University (adaptive biology), University of California at Santa Cruz (hydrodynamic modeling), SECORE (reef engineering), and others. This presentation will discuss the research and design process thus far, exploring the unique challenges and opportunities the program presents for Engineering With Nature.

Quantifying the impacts of future shoreline modification on biodiversity

Daniel Coleman, University of Georgia

People often modify the shoreline to mitigate erosion and protect property from storm impacts. The two main approaches to modification are gray infrastructure (e.g. bulkheads and seawalls) and natural or green infrastructure (NI; e.g., living shorelines). Gray infrastructure is still more often employed for coastal protection than NI, despite having more detrimental effects on ecosystem parameters, such as biodiversity. Here we assess the impact of gray infrastructure and whether or not the adoption of NI can mitigate losses in biodiversity. We first analyze existing literature to quantify the relationship of both gray infrastructure and NI to biodiversity. We then developed a model using temporal geospatial data on ecosystem distribution and shoreline modification to project future shoreline modification for our study location, coastal Georgia, USA. Finally, we applied the literature-derived empirical relationships of infrastructure effects on biodiversity to the shoreline modification projections to predict change in biodiversity under different NI vs gray infrastructure scenarios. We found that if approximately 40% of all new coastal infrastructure were to be NI, previous losses of biodiversity from gray infrastructure could be mitigated by 2100. As biodiversity continues to decline from human impacts, it is increasingly imperative to minimize negative impacts when possible. We therefore suggest changes to policy and the permitting process to promote the adoption of NI.

A Holistic Modeling Approach to Decode Hydrology and Ecology in Urban Watersheds

Abel Porras, City of Austin

The City of Austin Watershed Protection Department (WPD) has built thirteen watershed models covering about twenty square miles within and around the Full Purposed Jurisdiction of the City of Austin (COA). These models were constructed to simulate the hydrology of the watersheds under current land uses, impervious cover conditions, and soil types. The Watershed Modeling System software with the Gridded Surface Subsurface Hydrologic Analysis (WMS/GSSHA) was used to build the watershed models. The models contained a surface water component paired with a groundwater component to simulate stream baseflow and infiltration and were run over a simulation period of eight years (2011 to 2018). The resulting models outputted hydrographs at points along the stream coincident with points at which ecological data was collected. A side benefit of these watershed models is that they could be used to create infiltration maps of the City as well as estimate the baseflow in the streams. The ecological data was used to create pollution tolerance metrics. The coincident hydrologic and ecological data were then used to train a Deep Learning (DL) model. This model allows watershed managers to estimate ecological metrics at stream locations that have not been observed and then identify ecological problems at a small scale.

Inspiring Biodiversity Conservation and Stewardship Using Simple Techniques to Monitor Outcomes of Urban Nature-based Infrastructure Projects

Lee Marlowe, San Antonio River Authority

Simple monitoring techniques can be used to document the benefits of urban nature-based infrastructure projects incorporating local native plants such as the provision of habitat for resident and migratory wildlife including species of international significance and unexpected species outside of their typical range. Simple, low-cost methods that incorporate the use of iNaturalist, a free online biodiversity mapping tool and database, can be used to demonstrate the ecological benefits of projects and specific native plants through time. These methods can provide additional beneficial outcomes through education and outreach that inspires community-based biodiversity conservation and resource stewardship. Examples of applying simple techniques to gather data along site and landscape scale urban nature-based infrastructure projects that demonstrate value and inspire action will be presented.

Engineering Hybrid Reef Structures for Coastal Protection: Reefense X-REEFS

Mike Beck, University of California, Santa Cruz

Coastal flooding and erosion from extreme weather events affect thousands of vulnerable coastal communities globally. Nature-based solutions are gaining increasing traction as a strategy to mitigate risk and cost of coastal flooding. In tropical coral-lined coasts globally, among the areas globally most susceptible and vulnerable to extreme weather events and climate change, and in the US specifically, the use of coral reef restoration as a form of nature-based coastal protection is receiving increasing attention given their high value as a natural infrastructure system. However, reef-engineered examples specifically designed for coastal protection remain very limited. This is partly because reef engineering involves the interaction of complex hydrodynamic, ecological and engineering processes at multiple spatial scales.

Here, we present the design and development of hybrid engineered and biological coral reef-mimicking structures that are designed to be fast-growing and resilient, while still providing immediate protection from waves. The Reef Engineering to Enhance Future Structures (X-REEFS) is one of the selected projects in the Reefense Program by the Defense Advanced Research Projects Agency (DARPA). The X-REEFS Project aims to develop a hybrid biological and engineered reef system to mitigate coastal flooding and erosion. By combining physical testing with computational fluid dynamics models, we assess the performance of different hybrid reef structure designs in the laboratory and in the field, to meet target metrics of over 70% wave energy dissipation. Designs were tested in the laboratory and with wave models (OpenFOAM and with nearshore phase-averaged models XBeach Non-Hydrostatic and FUNWAVE-TVD) to optimize the design, performance and costs, while factoring in effects on reef induced circulation and ecological outputs, to prepare its deployment in Florida.

The project has led to a new hybrid reef design that uses innovative multi-layer structures, materials, 2D/3D hydrodynamic modeling, and flume tests to deliver a durable and flexible system that maximizes wave attenuation and biological enhancement benefits. Novel aspects of the design include the combination of different sub elements to enhance wave breaking and boundary layer friction, optimized porosity while reducing wave transmission, and a modular design to create different reef sections and layouts. The primary function of the base structure is to dissipate wave energy through both wave breaking atop, turbulence through the porous reef structure, and lattice subunits that direct the flow in a helical pattern through the structure to further enhance the physical and biological performance of the structure. The design is combined with other ecological and biological components. Ultimately, X-REEFS aims to develop a next-generation hybrid, offshore, submerged structures with optimized engineering and ecological performance.

Promoting Coastal Bird Biodiversity in Coastal Louisiana Using Dredged Sediments from Baptiste Collette Bayou

Burton Suedel, USACE

In 1978 the New Orleans District (CEMVN) began to regularly maintain the Baptiste Collette navigation channel with the objective to create island features that could serve as nesting habitat for shorebirds. Unconfined placement of dredged sediment is designed to create wetland habitat and islands that are suitable for colonial nesting seabirds. To attract seabirds to established islands, CEMVN intentionally covers plant overgrowth with sand dredged from the channel to keep the island relatively vegetation free and create large areas of bare ground necessary for seabirds to nest. Allowing the dredged sediments to flow outward unconfined from the wetlands and islands creates broad intertidal flats that serve as foraging areas for a variety of coastal birds. Both the intentional smothering of plant overgrowth and creation of tidal flats represent current state-of-the-practice and are adaptations made over the Baptiste Collette's lengthy beneficial use history. Avian surveys conducted on Baptiste Collette's beneficial use sites have documented that the island and wetland features are utilized by seabirds for nesting and other purposes. In August 2020, the Louisiana Department of Wildlife and Fisheries observed over 50,000 seabirds on Gunn Island. As part of the Baptiste Collette bird island chain, Gunn Island's seabird colony was composed of approximately 45% Royal Terns, 21% Black Skimmers, 14% Sandwich Terns, 8% Gull-billed Terns, 5% Caspian Terns, 5% Laughing Gulls, and the remaining 1% were comprised of 19 other species. In 2020, Gunn Island hosted the state of Louisiana's largest nesting tern colony with an estimated 10,000 breeding individuals. Since the initial construction of the Baptiste Collette navigation channel, over 1,000 acres (405 ha) of coastal habitat have been created by placement of sediment during routine maintenance dredging events. The bird nesting islands have been identified as a U.S. Important Bird Area because of the essential habitat they provide to significant numbers of breeding Caspian and gull-billed terns and black skimmers, as well as roosting habitat for pelicans. In this presentation we will discuss how we are developing an improved understanding of shorebird and seabird response to placement activities in Baptiste Collette Bayou that promotes biodiversity of coastal bird species.

Track 2

Wednesday, 3:15 - 4:45

B: Marshes, Living Shorelines, and Sediments

Anastasia Room

Moderated by Jan Mackinnon, GADNR

Smoothing the Path to Resilience Through Georgia's Living Shorelines

Meghan Angelina, GADNR

Predicting the Outcomes of Sediment Addition in Florida's Changing Coastal Landscape

Britney Hay, University of Florida

Sediment Budgeting to Support Beneficial Use Planning and Sustainability Assessment

C. Rhett Jackson, University of Georgia

Accrediting Evidence: How a Natural Sediment Event and a Thin Layer Placement (TLP) Study Led to Similar Conclusions in Two New England Marshes

Gregg Moore, University of New Hampshire

Process-Based Model of Salt Marsh Coupled Dynamics Highlighting the Physical Drivers of Vulnerability

Kiran Adhithya Ramakrishnan, University of Florida

Smoothing the Path to Resilience through Georgia's Living Shorelines

Meghan Angelina, GADNR

Living shorelines (LS) are a priority adaptive management strategy of coastwide resilience planning in Georgia. The goal of implementing LS is to provide alternatives to traditional stabilization techniques that increase habitat value and resiliency to rising sea levels while stabilizing the shoreline to erosion in this unique, high tidal environment. The Georgia Coastal Management Program (GCMP) and its partners are leading the way to guide planning, design, implementation, and monitoring. There are twelve LS that have been constructed in Georgia since GCMP began exploring their use in 2006. Despite the low number of constructed sites, inquiries for LS have been great, suggesting public interest in utilizing these techniques. Several uncertainties are the likely cause of low construction numbers, including future storm surge attenuation, lack of regulatory incentives, lack of information showing that LS are stable structures that abate erosion, access to native materials, and no known private funding opportunities. CRD's Shoreline Policy and Resilience Review Team has been established to identify the regulatory framework of nature-based projects, and staff are working with the only known, Georgia-based engineer and contractor with LS experience to develop site suitability criteria, standards, and BMPs. This information will be used in a Community Resilience Reference Guide. With the help of the Georgia Living Shorelines Workgroup, GCMP recently started managing a photo catalog of LS for monitoring purposes. The GCMP has organized workshops for local governments, engineers, and contractors and has provided resources such as funding for a children's book and the development of a StoryMap.

Predicting the Outcomes of Sediment Addition in Florida's Changing Coastal Landscape

Britney Hay, University of Florida

Thin-layer sediment placement provides a solution for restoring elevational losses from sea level rise in saltmarshes by applying a layer of dredged material to the marsh surface. While this technique has been successful in temperate saltmarshes suffering from sediment loss and/or sea level rise, its outcomes in subtropical environments facing similar challenges are largely unknown. Specifically, in the state of Florida elevational losses in coastal saltmarshes are becoming more pronounced with sea level rise. At the same time, Florida's northern Atlantic and Gulf coasts are transforming as less intense annual freeze events allow mangroves to establish and persist beyond their historic northern boundary. How marsh-mangrove ecotones transforming due to climate change will respond to sediment amendments is largely unknown. Additionally, thin layer placement studies in mangrove wetlands or marshes where mangrove encroachment is occurring are lacking. We address these knowledge gaps with a pilot-scale study in a degrading saltmarsh on Florida's north-eastern coast with an expanding mangrove presence. In July 2022, we manipulated sediment quantity and composition in experimental plots dominated by Black mangroves (*Avicennia germinans*) or Smooth cordgrass (*Spartina alterniflora*) to understand how ecological responses to sediment addition vary based on the type of coastal wetland vegetation. The outcomes of sediment addition to plots in this system during the first year of the experiment are highlighted here, covering what appears to be two distinct moments in recovery time: an initial phase of decline, and subsequent phase of regrowth and colonization.

Sediment Budgeting to Support Beneficial Use Planning and Sustainability Assessment

C. Rhett Jackson, University of Georgia

Sediment has been called the currency of coastal resilience. Material that is dredged to maintain the navigability of ports and waterways can be strategically placed to create natural infrastructure, such as beaches, dunes, habitat islands, and marshes. However, efficient use of sediment at a regional scale requires data on the volume, grain size, and contamination status of sediment sources in addition to the volume and grain size needs of potential natural infrastructure projects. Using the Savannah District of the United States Army Corps of Engineers as a case study for matching sediment supplies and demands, we are developing a sediment budget that includes river loads, annual dredging quantities, sediment stored in containment facilities, offshore sand deposits, and tidal, wave, and current transport. We have also estimated and compiled expected regional sediment volume needs for beneficial use projects. We will review the uncertainties in the budget and evaluate the long-term sustainability of coastal natural infrastructure enhancement with respect to sediment needs and availability.

Accrediting Evidence: How a Natural Sediment Event and a Thin Layer Placement (TLP) Study Led to Similar Conclusions in Two New England Salt Marshes

Gregg Moore, University of New Hampshire

Significant regulatory hurdles in New England discourage scalable application of a type of beneficial reuse of dredge materials known as thin layer placement (TLP), despite evidence of the utility of this technique elsewhere in the US. The approach harnesses natural materials to potentially help salt marshes keep pace with sea level rise. As our research group sought ways to permit large scale TLP projects in MA and NH, a natural weather event resulted in a large-scale natural sediment deposition event that provided an unprecedented opportunity to explore the effects of sediment placement in the Great Marsh (MA). Meanwhile an ongoing small scale TLP pilot field manipulation looked at the same metrics in Great Bay (NH). Despite different scales, both studies found 1) sediment did not significantly migrate after placement; 2) pore water chemistry did not differ for parameters including pH, redox, salinity or sulfide concentration; 3) vegetation composition and percent cover reflected reference conditions within two growing seasons for additions through 7cm depths; 4) infaunal invertebrates were not affected for additions ≤ 14 cm; and 5) belowground biomass rapidly exploited new sediment regardless of sediment deposition thickness. Our evidence suggests that whether natural or manually placed, ≤ 7 cm sediment doesn't significantly impact vegetation or invertebrates and appears to build marsh capital. These results suggest TLP may be a viable option to increase marsh capital for salt marsh facing severe threats of subsidence and/or elevated seas level pressure.

Process-based model of salt marsh coupled dynamics highlighting the physical drivers of vulnerability

Kiran Adhithya Ramakrishnan, University of Florida

The salt marsh is an invaluable ecosystem that provides services such as coastal protection, habitat for multi-species, etc. The state of a marsh is determined by a complex interplay of flow, sediment, and vegetation. Several models to analyze these dynamics across different temporal and spatial scales have been developed in the literature. Here a process-based model is constituted to represent the dynamics across an idealized marsh domain. The effect of vegetation on sediment transport is considered at the tidal scale. The vegetation is modeled following an elevation controlled logistic growth with flooding resistance dictating its mortality. The surface elevation is obtained from the Exner's equation. The coupled non-linear model elucidates the drowning pattern formation akin to a real scenario of fragmented marshes with ponds. The evolution of the marsh in a tidal-dominant environment is used to obtain the marsh's steady state under different conditions. The transition from a fully vegetated marsh to a drowning marsh is found to be driven by the competing rates of sediment deposition and the relative sea level rise. The state transition is sensitive to the key control parameters, namely the sediment settling velocity, tidal influx suspended sediment concentration and the marsh surface elevation relative to the tidal range. These highlight the necessity of accurate field measurements for more accurate prediction and evaluation of the marsh state. The process-based model could aid in planning restoration activities to preserve the ecosystem, such as informing Thin Layer Placement (TLP) of the required increase in surface elevation to recover the marsh state.

Track 2

Wednesday, 3:15 - 4:45

C: BCA and Economics

Coquina Room

Moderated by Matt Chambers, University of Georgia

Economic Value of Green Infrastructure Investments on the Georgia Coast

Craig Landry, University of Georgia

A place for structural causal modeling in quantifying the ecological costs and benefits of nature-based solutions in aquatic systems

Bertrand Lemasson, USACE ERDC

An Applied Evaluation of Ecosystem Services Decision-Support Tools

Ali Meek, University of Oklahoma

Port of San Diego: An example cost benefit analysis for nature inclusive design approaches within port infrastructure

Maor Bezner, ECOConcrete

Nature-Based Solutions for CCR Closure

Josh Running, Stantec

Economic Value of Green Infrastructure Investments on the Georgia Coast

Craig Landry, University of Georgia

Using survey data from the Coastal Empire region of Georgia (Chatham, Bryan, and Liberty Counties, including the city of Savannah), we assess respondents' perceptions of climate change, sea level rise, and flood & erosion risk, and estimate support and willingness to pay (WTP) for coastal infrastructure approaches to manage climate risk, as well as the value of ecological services provided by infrastructure. A choice experiment is used to assess preferences for green, grey, and hybrid infrastructure investments along water ways in Coastal Empire. An existing policy tool, Special Purpose Local Options Sales Tax (SPLOST), is used as the payment/provision vehicle to enhance realism of the valuation exercise, and the choice experiment is designed to incorporate differential levels of service provision across infrastructure types (e.g., grey exhibits better performance levels for flood protection, while green is superior for habitat provision). We estimate Conditional Logit and Equality-Constrained Latent Class choice models; information criteria support the latter, which controls for attribute non-attendance. Results indicate that green options are the most preferred, followed by hybrid, and grey designs. Economic value estimates indicate MWTP of \$17 per household for a one percentage point decrease in the likelihood of severe flooding in low-lying areas over the next 30 years, and MWTP of \$6 for a one-day decrease in nuisance flooding. Total household WTP measures for coastal infrastructure projects that deliver the greatest level of environmental services are \$154 for grey infrastructure (10% chance of flooding in low-lying areas; 10 days of nuisance flooding per year; and good wildlife habitat), \$293 for green infrastructure (30% chance of flooding in low-lying areas; 30 days of nuisance flooding per year; and the best level of wildlife habitat), and \$324 for hybrid infrastructure (10% chance of flooding in low-lying areas; 10 days of nuisance flooding per year; and the best level of wildlife habitat).

A place for structural causal modeling in quantifying the ecological costs and benefits of nature-based solutions in aquatic systems

Bertrand Lemasson, USACE ERDC

There is growing interest to advance the use of nature-based solutions (NBS) in our engineering designs, but adopting such solutions remains limited in practice. A common challenge stems from the uncertainty in the ecological observables selected, which can be non-linear, spatially and/or temporally dynamic, and likely to covary with a suite of other metrics. Effectively, it's a mess. Aquatic restoration efforts have used a variety of metrics to quantify non-monetary ecological benefits, from targeting species listed under the Endangered Species Act (ESA) to environmental, socio-economic, or cultural metrics falling under the umbrella of ecosystem goods and services. Yet, after decades, many projects have either been unsuccessful in demonstrating any net ecological benefits or inconclusive. Here, we briefly review the merits of adopting a structural causal modeling (SCM) framework to evaluate the ecological benefits of NBS. Starting with promoting consensus and fostering engagement with stakeholders, the SCM framework can also guide model development and refine monitoring protocols across scales of ecological complexity. The SCM framework is flexible, being agnostic to the stochastic nature of the process of interest and enabling researchers to adopt linear or non-linear approaches. The workhorse of the SCM framework is the Directed Acyclic Graph (DAG), which not only facilitates communications of our assumptions, but can reduce confounding, bias, and aid in model selection. We demonstrate various stages of the SCM approach using examples from efforts to evaluate the potential costs and benefits of dredging activities within San Francisco Bay (vis-à-vis fish entrainment) and the Lower Columbia River (island creation).

An Applied Evaluation of Ecosystem Services Decision-Support Tools

Ali Meek, University of Oklahoma

Nature's value as an asset is unmistakable, evident through the tangible benefits it provides, such as agricultural yields and tourist attractions. These amenities, known as ecosystem services (ES), are easy to appreciate due to their direct market connections. However, implicit ES, like climate regulation and flood control, are often overlooked until their absence becomes painfully evident. Although wetlands are recognized to contribute to ecological integrity, human well-being, and national resilience, population growth and economic development have historically led to the transformation of these critical habitats. A gap exists between wetland conservation policies and site-level decision-making, often stemming from inadequate documentation of wetland ES costs and benefits at the local and regional levels. This study tested the hypothesis that ES Decision Support Tools (ES-DSTs) effectively quantify site-specific wetland ES, providing valuable insights into environmental and social variables for more comprehensive ES reporting. To deepen understanding of how ES-DSTs bridge the gap between wetland conservation policies and practical implementation, a select number of representative ES-DSTs were applied to three different wetland sites including two treatment wetland systems in Ottawa County, Oklahoma and one volunteer bottomland hardwood forest wetland in Adair County, Oklahoma. The effectiveness of ES-DSTs in measuring wetland ES was underscored, offering a pathway to comprehensive documentation of wetland ES in landscape-scale benefit-cost analyses (BCAs) and overall strengthening of their utility in local and regional decision-making.

Port of San Diego: An example cost benefit analysis for nature inclusive design approaches within port infrastructure

Maor Bezner, EConcrete

Ports are at the forefront of environmental challenges associated with climate change and coastal development and are uniquely positioned to implement innovative approaches to build resilient infrastructure and transform how waterfronts look and function. In recent years, EConcrete has partnered with several ports to demonstrate ecological alternatives to traditional coastal infrastructure, including the Port of San Diego in California.

In 2019, the Port of San Diego partnered with EConcrete to demonstrate an ecologically designed coastal armor unit element, the CoastaLock. The project was launched in 2021, and the results from the multi-year biological monitoring show development towards a richer, more diverse community compared to adjacent control rocks. Furthermore, the results from the monitoring efforts have been applied as part of a cost benefit analysis to demonstrate the monetary value of the habitat created and associated ecosystem services, the results of which are being used by the port to communicate the value of integrating nature-based approaches into future port projects. The presentation being offered here will showcase the process and methodology for generating the cost benefit analysis.

These projects provide examples of nature-inclusive solutions designed to address not only the structural and coastal engineering requirements for coastal protection, but also the need to promote native marine habitats, increase biodiversity, and restore local coastal ecosystems. EConcrete aims to catalyze a fundamental change in best practices for the design and construction of ports by shifting from 'grey' infrastructure towards nature-inclusive 'blue' infrastructure with structural, environmental, and socioeconomic benefits.

Nature-based Solutions for CCR Closure

Josh Running, Stantec

Employing nature-based solutions in Coal Combustible Residuals (CCR) Unit closure can reduce construction costs by millions of dollars while supporting water treatment and management goals, and investing in natural capital improvements that grow with time. This presentation will review real-world scenarios of natural capital development opportunities that can support attaining a property owner's carbon, biodiversity, and other environmental, social, and governance (ESG) goals.

Enforcement of the CCR rule has created conditions where Closure-by-Removal (CbR) remains an extremely expensive endeavor when compared to Closure-in-Place (CiP). The costs for closing CCR units by CbR are commonly projected to be greater than 4-10 times CiP costs, which is substantial when CiP costs can regularly range between \$20-100 million.

A significant part of CbR costs is attributed to the fill material needed to replace the excavated CCR for future use. Not only are the costs of buying, transporting, and placing the fill material significant, so too is the cost of borrow material land necessary to provide the millions of yards of soil to be harvested.

Even though the CCR is removed, regulatory closure is not achieved until the associated groundwater meets appropriate site criteria. Therefore, engineered wetlands can provide polishing and water treatment to support the site's larger closure goals.

By employing NbS in CCR CbR projects, pollinator grasslands, low-lying wetlands and water features are developed and the need for fill material is reduced, providing the capital to invest in replanting native communities. The co-benefits can also be quantified and attributed to a company's corporate climate and community goals.

Track 3

Thursday, 8:00 – 8:55

A: Panel – Progress Report: Multi-jurisdictional Research on Regulatory Best Practices to Promote Engineering With Nature

Ponce de Leon Room

Matthew Shudtz, Michelle Covi, Yee Huang, Daniel Shtob, Kyle McKay

B: Panel – Integrating Agriculture to Advance the Next Frontier of Engineering With Nature

Anastasia Room

Rebecca Muenich, Todd Bridges, Brian Bledsoe, John Sabo, Robert Nairn

C: Panel – Building Tomorrow’s Resilience: AECOM’s Pathway to Climate Adaptation and Natural Infrastructure Integration

Coquina Room

Chris Levitz, Marisa Escobar Arias, Shane Parson, Lauren Swan

Track 3

Thursday, 8:00 – 8:55

A: Panel – Progress Report: Multi-jurisdictional Research on Regulatory Best Practices to Promote Engineering With Nature

Anastasia Room

Lead: Matthew Shudtz, University of Georgia

Michelle Covi, University of Georgia

Yee Huang, University of Georgia

Daniel Shtob, CUNY Brooklyn

Kyle McKay, USACE ERDC

CZMA and EFH and 404, oh my! Environmental laws that were designed decades ago to avoid or minimize the adverse impacts of commercial development can create challenges to efficient implementation of EWN projects. As interest in- and funding for- EWN-type projects grows, both project development teams and regulatory agencies are looking for ways to improve the way projects are reviewed and permitted under a variety of federal and state laws. N-EWN partners have been conducting desktop research and interviewing practitioners and government officials to identify the best practices for moving projects through the regulatory and permitting process.

In this session, researchers will share insights from their ongoing research and discuss the opportunities for streamlining regulatory and permitting processes.

Key topics include: the utility (and limits) of Clean Water Act § 404 general permits; the impact of protected species and habitats on project design and implementation; comparative analysis of state laws/regulations; comparative analysis of federal agencies' regional/district-level approaches; discussion of NBS-specific challenges.

Track 3

Thursday, 8:00 – 8:55

B: Panel – Integrating Agriculture to Advance the Next Frontier of Engineering With Nature

Ponce de Leon Room

Lead: Rebecca Muenich, University of Arkansas

Todd Bridges, University of Georgia

Brian Bledsoe, University of Georgia

Ting Liu, Arizona State University

John Sabo, Tulane University

Robert Nairn, University of Oklahoma

The proposed panel will be a discussion on how to advance engineering with nature through integrations with agricultural ecosystems. In practice, this is already being done, but more coordinated efforts and guidance are needed to scale up engineering with nature in agricultural ecosystems. Question and answer discussion will be focused on existing EWN projects integrated with agriculture, as well as forward-thinking needs for the community.

Track 3

Thursday, 8:00 – 8:55

C: Panel – Building Tomorrow’s Resilience: AECOM’s Pathway to Climate Adaptation and Natural Infrastructure Integration

Coquina Room

Lead: Chris Levitz, AECOM

Marisa Escobar Arias, AECOM

Shane Parson, AECOM

Lauren Swan, AECOM

In this panel we propose to discuss how AECOM’s trajectory in resilience and climate adaptation can be used to envision a robust natural infrastructure for resiliency practice. Our panel, consisting of experts from AECOM, will delve into the evolution of our approaches, focusing on the integration of natural infrastructure to solve the most pressing environmental challenges of our time.

We will discuss the constraints and opportunities to navigate the complex landscape of natural and hybrid infrastructure. Drawing examples from our work in diverse geographies, with a focus on river, coast, estuary, urban, and mountain ecosystems, we will review our approaches to integrate social equity, flood resilience, habitat health, and ecosystem restoration. We will also use this discussion to identify gaps and innovative solutions to continue advancing climate adaptation and resilience through natural infrastructure integration.

The panel aims to provide insights into AECOM's vision for the future, emphasizing the intersection with N-EWN's mission. Through this dialogue, we hope to contribute to the collective understanding of large- scale, sustainable, and research-informed natural infrastructure implementation. The panel will delve into questions such as:

- How does AECOM envision its role in climate resilience and adaptation through natural infrastructure solutions?
- What challenges and opportunities does AECOM foresee in scaling up NBS across diverse landscapes?
- How does AECOM's evolving approach intersect with the goals of the N-EWN, specifically in integrating people and policy?
- How do we all effectively collaborate across industries, agencies, non-profits, and academia?

Track 4

Thursday, 9:05 – 10:00

A: Panel – Identifying and Overcoming Obstacles to the Implementation of Natural Infrastructure for Shoreline Modification

Ponce de Leon Room

Daniel Coleman, Craig Landry, C. Brock Woodson, Matthew Shudtz, Savanna Barry

B: Panel – EWN/NBS Educator Panel: Lessons Learned and Future Directions

Anastasia Room

Lori Han, Robert Nairn, Kyle McKay, Jane Smith, Candice Piercy

C: Panel – N-EWN's Newest

Coquina Room

Todd Bridges, Mary-Margaret McKinney, Chris Allen, Chris Mack, Walter Dinicola, Matthew Berg, Matthew Campbell, Maor Bezner

Track 4

Thursday, 9:05 – 10:00

A: Panel – Identifying and Overcoming Obstacles to the Implementation of Natural Infrastructure for Shoreline Modification

Ponce de Leon Room

Lead: Daniel Coleman, University of Georgia

Craig Landry, University of Georgia

Scott Pippin, University of Georgia

C. Brock Woodson, University of Georgia

Shoreline modification, the practice of altering natural coastlines to protect against erosion and other hazards, is expected to become more prevalent with climate change. Shoreline modification is often achieved via living shorelines (a type of Natural Infrastructure; NI) or armoring (gray infrastructure). Living shorelines have been shown to be far less detrimental to natural ecosystems when compared to traditional gray infrastructure (Gittman et al. 2016; Coleman et al. abstract submitted to symposium). This more environmentally friendly approach has piqued the interest of many coastal communities, as well. Despite scientific evidence and growing community support, the adoption of NI for coastal protection is still limited in the United States and other parts of the world. For example, in Georgia, less than 1% of shoreline modification is living shorelines (Georgia Department of Natural Resources 2013). For many, it remains unclear what factors are responsible for the scarcity of NI along the coastline.

This panel aims to address the existing difficulties with implementing NI for coastal protection and how these difficulties can be overcome. We will address this issue from legal, economic, engineering, and manager perspectives. While research continues into the feasibility, design, and performance of NI (Bliss, et al. 2014; Bugbee 2020), many regulators and property owners have been concerned about unknown or unproven effects (Smith, et al. 2020). Engineers and practitioners

lack the clear design standards and specifications for NI that are readily available for gray infrastructure. In many US states, including GA, it is more difficult to obtain a permit for NI relative to conventional hard armoring (Jones and Pippin 2022). The panel members will discuss the intricacies of these factors, as well as other complicating factors. We will conclude the panel with a Q+A and/or Open Discussion about the next steps that can be taken to address the discussed issues.

The goals of the panel are:

Elucidate to researchers why application appears to be lagging behind the state of the science.

Promote the development of design standards by connecting researchers and engineers.

Offer tips and guidance for people proposing coastal NI and those responsible for reviewing and permitting such proposals.

Facilitate transdisciplinary collaborations for the further adoption of coastal NI.

Inspire experts to make advancements in their respective specialties.

Track 4

Thursday, 9:05 – 10:00

B: Panel – EWN/NBS Educator Panel: Lessons Learned and Future Directions

Anastasia Room

Lead: Lori Han, University of Georgia

Robert Nairn, University of Oklahoma

Kyle McKay, USACE ERDC

Jane Smith, University of Florida

Candice Piercy, USACE ERDC

John Aliu, University of Georgia

The proposed panel will be a guidance discussion on education in the EWN/NBS space. The panel will consist of 4 to 5 members who currently teach EWN/NBS courses in higher education from across the country and within a variety of contexts (engineering, ecosystem restoration, social science, etc.). Question- answer discussion will be centered on coursework and programmatic development and teaching such content in the classroom and field.

Track 4

Thursday, 9:05 – 10:00

C: N-EWN's Newest – Meet Some of Our New Partners!

Coquina Room

Moderated by Todd Bridges, University of Georgia

Learn what our newest members are doing and how their work intersects with N-EWN's mission. This panel will provide an opportunity for some of our newest partners to introduce themselves.

Speakers:

Mary-Margaret McKinney, Native Shorelines

Chris Allen, Jacobs

Chris Mack, Moffat & Nichol

Walter Dinicola, AnchorQEA

Matthew Berg, Simfero

Matthew Campbell, Natrx

Maor Bezner, EConcrete

Track 5

Thursday, 10:30 – 11:45

A: NBS Policy and Scaling

Ponce de Leon Room

Moderated by Sara Mason, Duke University

Taking Nature-Based Solutions to Scale: What's Next?
(*Michael Beck, UCSC*)

Advancing Science to Enable Nature-Based Solutions That Move Past Short-Term Considerations, Small Scales, and Holding the Line (*Trevor Meckley, NCCOS*)

Federal Process on Accelerating Deployment of Nature-Based Solutions (*Lydia Olander, Duke*)

Accelerating Nature-Based Solutions Implementation: A Roadmap for the Department of the Interior (*Katie Warnell, Duke*)

B: Coastal Dune Communities

Anastasia Room

Moderated by Amanda Tritinger, USACE ERDC

Temporal and Spatial Variability of Cross-shore Fetch and the Potential for Aeolian Dune Recovery at Anastasia Island, FL (*Pete Adams, UF*)

Leveraging Natural Succession to Improve Sand Dune Restoration (*Hallie Fischman, UF*)

Strategic Planting and Nutrient Amendments to Accelerate the Revegetation of Rapidly Retreating Coastal Dunes (*Joseph Morton, UF*)

Coastal Dune Processes and Management (*Amanda Tritinger, USACE ERDC*)

Track 5

Thursday, 10:30 – 11:45

C: Flood Modeling

Coquina Room

Moderated by Anouk Savineau, LimnoTech

Compound Flood Modeling for Coastal Military Defense Communities (*Lina Cardenas Caro, UGA*)

Modeling the Service Potential of Green Stormwater Infrastructure in Urban Coastal Communities (*Matt Chambers, UGA*)

Combining Riverine and Coastal Natural Infrastructure for Reducing Compound Flood in Estuary Systems (*Felix Santiago-Collazo, UGA*)

Design Principles for Engineering Wetlands to Improve Resilience of Coupled Built and Natural Water Infrastructure (*John Sabo, Tulane*)

Track 5

Thursday, 10:30 – 11:45

A: NBS Policy and Scaling

Ponce de Leon Room

Moderated by Sara Mason, Duke University

Taking Nature-Based Solutions to Scale: What's Next?

Michael Beck, UC Santa Cruz

Advancing Science to Enable Nature-Based Solutions That Move Past Short-Term Considerations, Small Scales, and Holding the Line

Trevor Meckley, National Centers for Coastal and Ocean Science

Federal Process on Accelerating Deployment of Nature-Based Solutions

Lydia Olander, Duke University

Accelerating Nature-Based Solutions Implementation: A Roadmap for the Department of the Interior

Katie Warnell, Duke University

Taking Nature-Based Solutions to Scale: What's Next?

Michael Beck, University of California, Santa Cruz

In the past decade, there has been significant progress in the science and demonstration of coastal nature-based solutions (NBS). We will briefly review advances in the ecology, engineering, economics, and business of NBS. We will then focus on what has been impeding further progress including environmentalism and what will be needed to spur a wider reliance on nature-based solutions as part of national infrastructure for disaster risk reduction and climate adaptation. Current hazard mitigation and climate adaptation responses still focus predominantly on artificial infrastructure that further degrades nature. We will explore what it will take to get to large scale use of nature-based solutions from science to policy, practice and finance.

Advancing Science to Enable Nature-Based Solutions That Move Past Short-Term Considerations, Small Scales, and Holding the Line

Trevor Meckley, NOAA National Centers for Coastal Ocean Science (NCCOS)

Coastal projects and plans are often under pressure to be inexpensive. This leads to a cycle of investment in short-term and local projects that reduce short term risks for a site, while inadvertently increasing long term coastal vulnerability across the region. Without information to inform holistic corridor level planning that considers phased actions over short and long-time scales as well as both the built and natural environment, this cycle is difficult to break. We will discuss the primary science advancements targeted by NOAA's Effects of Sea Level Rise Program (ESLR) to inform the effective use of nature-based solutions and offer case studies. ESLR is a national multidisciplinary research program that supports teams of engineers, biologists, ecologists, transportation professionals, economists, and social scientists working collaboratively with coastal stakeholders. A current portfolio of 20 research projects around the country focus on science to advance the use of nature-based solutions in ways that range from small scale living shorelines to large scale dune and marsh nourishment projects, to projects that re-envision the coastal corridor. Corridor level planning allows for rethinking how we access and interact with our coastlines in a holistic way now and in the future.

Federal Progress on Accelerating Deployment of Nature-based Solutions

Lydia Olander, Duke University

The Biden Harris Administration has made nature a central pillar in achieving its climate, equity, and economic prosperity goals. One element of that has been working to accelerate deployment of nature-based solutions through federal action and partnering with states, Territories, local governments, Tribes and non-federal partners. In Nov of 2022 a Federal Roadmap to Accelerating Deployment of Nature-based Solutions was released recommending five areas of strategic action: (1) Policy, (2) Funding, (3) Federal Assets, (4) Workforce, and (5) Research & Evidence. Significant progress has been made and is ongoing in all of these areas. For example, Federal regulations, funding programs, and large projects (e.g., Army Corps projects) are required to do a cost-benefit analysis as a way to ensure the government is making wise decisions. Recently the administration updated these guidances (Circular A4 and A94) and for the first time released a related guidance on ecosystem services that provides direction for how agencies can incorporate ecosystem services into their decision-making processes. Better accounting for nature could increase federal support for nature-based solutions including restoration. This presentation, by the former White House Director of Nature-based Resilience, will provide an overview and suggest ideas for how members of N-EWN can help to accelerate progress.

Accelerating Nature-based Solutions Implementation: A Roadmap for the Department of the Interior

Katie Warnell, Duke University

Funding for and recognition of nature-based solutions (NBS) – actions that incorporate natural features and processes to protect, conserve, restore, sustainably use, and manage natural or modified ecosystems to benefit both people and nature – is accelerating in the U.S. The Biden-Harris administration is encouraging federal agencies to fully consider nature-based solutions when planning projects and implement them when practicable. As a manager of more than 420 million acres of land in the U.S., plus Tribal lands, marine national monuments, and the Outer Continental Shelf, the Department of the Interior is well positioned to use NBS to ensure its management approaches provide the most value to people while also improving ecosystem health. The Nicholas Institute for Energy, Environment & Sustainability at Duke University worked closely with DOI to develop a DOI Nature-based Solutions Roadmap, which provides consistent and credible information about NBS through a DOI lens – for example, what NBS strategies match certain conditions and goals, what cobenefits they are likely to provide, example projects, and additional resources for project planning, construction, and monitoring. This presentation will introduce the first iteration of this living document, review what we have learned from DOI personnel about its usefulness and their information needs, and discuss plans for updates and expansion of the Roadmap. We welcome input on how to make a new web version of the Roadmap most useful and ideas for case studies and other resources to include in the next iteration of the Roadmap.

Track 5

Thursday, 10:30 – 11:45

B: Coastal Dune Communities

Anastasia Room

Moderated by Amanda Tritinger, USACE ERDC

Temporal and Spatial Variability of Cross-shore Fetch and the Potential for Aeolian Dune Recovery at Anastasia Island, FL

Pete Adams, University of Florida

Leveraging Natural Succession to Improve Sand Dune Restoration

Hallie Fischman, University of Florida

Strategic Planting and Nutrient Amendments to Accelerate the Revegetation of Rapidly Retreating Coastal Dunes

Joseph Morton, University of Florida

Coastal Dune Processes and Management

Amanda Tritinger, USACE ERDC

Temporal and Spatial Variability of Cross-shore Fetch and the Potential for Aeolian Dune Recovery at Anastasia Island, FL

Pete Adams, University of Florida

Coastal dune fields are prominent along sandy coastlines and provide critical storm buffering and flood protection services for coastal communities and infrastructure. While these aeolian features are important for providing coastal resilience, they are highly dynamic and respond to numerous processes over a range of temporal and spatial scales. To evaluate the temporal and spatial variability of the potential for dune recovery and retreat at Anastasia Island, FL, we use a 10-year record of U.S. Army Corps of Engineers' (USACE) National Coastal Mapping Program topobathymetric LiDAR data extending ~30km alongshore. We conduct a morphological feature extraction using the USACE's Joint Airborne Lidar Bathymetry Technical Center of Expertise Dune Feature Extraction ArcGIS Pro toolbox to determine the beach width, dune toe position, and mean high water line for each lidar dataset. Extracted features are coupled with a 10-year ERA5 wind hindcast to determine effective cross-shore fetch at 100m intervals alongshore. Our preliminary results indicate that temporal patterns exist where onshore winds capable of driving aeolian dune recovery are largely limited to the Winter and Spring seasons. Further, our results imply significant alongshore variability in effective cross-shore fetch (length of sandy beach exposed to wind) over the 10-year study period which appears to be dependent on beach width and shoreline orientation. Next steps for this work include determining alongshore patterns of dune recovery and retreat and comparing these observations to alongshore variability in cross-shore fetch.

Leveraging Natural Succession to Improve Sand Dune Restoration

Hallie Fischman, University of Florida

Coastal ecosystems provide critical storm and flood protection services, making their restoration imperative. Here, we evaluate if facilitated succession, whereby pioneers facilitate climax species, can be leveraged to accelerate coastal dune revegetation. In a survey spanning 270km of the Southeast US, we discovered that *Panicum amarum* (bitter panicum) supports higher plant richness than *Uniola paniculata* (sea oats), and that sea oat cover is 230% greater on mature than disturbed dunes, suggesting bitter panicum functions as pioneer and sea oats a climax species. A reciprocal transplant experiment confirmed this inference: bitter panicum stem production and height fell by 37% and >20cm, respectively, when planted proximate to sea oats versus in isolation, while sea oats produced 38% more and >12cm taller stems when planted proximate to bitter panicum than in isolation. A second experiment evaluating the density-dependence of this facilitation revealed that sea oats transplanted into low densities of bitter panicum grew >15% taller relative to isolated and high-density treatments. However, within seven months, wave-induced erosion eliminated >60% transplants in both experiments. To explore the frequency of foredune inundation and the implications for dune recovery via successional revegetation, we applied empirical wave runup models at 101 locations throughout Volusia County, Florida. While disturbance frequency varied seasonally and annually, sites with low profiles and steep beach slopes experienced particularly frequent inundation. We synthesize our results in a decision matrix to guide where planting via facilitative succession is a viable solution or where geomorphology-modifying nourishment activities are necessary to establish resilient, vegetated dunes.

Strategic Planting and Nutrient Amendments to Accelerate the Revegetation of Rapidly Retreating Coastal Dunes

Joseph Morton, University of Florida

The increasing frequency and severity of disturbances to coastal dune ecosystems necessitates the development and implementation of restoration strategies that rapidly accelerate reestablishment of vegetation, enhance dune accretion, and ultimately preserve dune ecosystem services. To assess how to rapidly re-establish vegetation to counter ecosystem losses, we conducted a manipulative field experiment on a created dune in Northeast Florida, USA to determine what combinations of planting density, outplant species composition, and nutrient addition maximize dune revegetation rate. After three months, we found that increased planting densities combined with nutrient addition elevated aboveground plant biomass by 868-2,961%, while growth in sparsely planted and unfertilized treatments was negligible or negative. These thickly revegetated, high density + nutrient addition plots accreted 1-5 cm more sediment, demonstrating that this planting method can rapidly kickstart dune-building processes. Additionally, densely planted, fertilized plots containing bitter panicum (*Panicum amarum*) produced 1.7 times more biomass and accreted 1.5 times more sediment than plots containing sea oats (*Uniola paniculata*), suggesting that this species and planting scheme may be most effective for rapid dune building. These findings reveal that coupling nutrient addition with dense planting can trigger self-sustaining, reinforcing plant growth and dune building feedbacks within months, likely warranting the cost of additional transplants by enhancing the long-term success of dune restoration investments.

Coastal Dune Processes and Management

Amanda Tritinger, USACE ERDC

Coastal dunes and coastal dune ecosystems are critically important for shoreline protection and significant resources have been allocated to their conservation, restoration and understanding of their physical processes for flood protection ability. Dune vegetation is known to modify dune ecosystem response to wind, waves, and storms, but little focus has been given to understanding how vegetation, specifically belowground structures and associated microbial symbionts, can enhance dune stability. Further, coastal dune communities often support diverse vegetation assemblages and may have similarly diverse restoration histories. Little is known about how different species and previous management activities alter sediment strength, stability, and overall dune morphology. To address these knowledge gaps, interagency collaboration, and communication has been ongoing across coastlines to better develop and understand coastal dune processes and management strategies. This dedicated session is aimed at encouraging communication between the coastal dune community of practice, to better link scientific and engineering advancements in understanding dune systems between scientists and engineers, but also encourage the collaboration and communication between coastal planners and practitioners to improve coastal management strategies for maintaining both coastal resiliency and ecosystem health.

Track 5

Thursday, 10:30 – 11:45

C: Flood Modeling

Coquina Room

Moderated by Anouk Savineau, LimnoTech

Compound Flood Modeling for Coastal Military Defense Communities

Lina Cardenas Caro, University of Georgia

Modeling the Service Potential of Green Stormwater Infrastructure in Urban Coastal Communities

Matt Chambers, University of Georgia

Combining Riverine and Coastal Natural Infrastructure for Reducing Compound Flood in Estuary Systems

Felix Santiago-Collazo, University of Georgia

Design Principles for Engineering Wetlands to Improve Resilience of Coupled Built and Natural Water Infrastructure

John Sabo, Tulane University

Compound Flood Modeling for Coastal Military Defense Communities

Lina Cardenas Caro, University of Georgia

Coastal flood hazards have become a topic of concern due to their increasing occurrence worldwide. Assessing coastal hazards for present and future scenarios under climate change and land use is a foundational step for flood risk. This research aims to develop a compound flood risk assessment focused on military installations and their surrounding communities. The methodology is being developed and tested for the Fort Stewart military installation and adjacent communities, which includes Savannah, GA. The first stage of this research developed a rapid flood risk assessment methodology using a GIS approach, which considered social vulnerability, flood exposure, and critical infrastructure data from open data sources. Results from the rapid flood risk assessment showed the sensitivity of the flood hazard since there was a notorious change in flood risk between the assessments using FEMA flood zones and SACS (South Atlantic Coastal Study) data. For example, the study area's 2,600 miles of road network changed from low to high flood risk using the FEMA and the SACS data, respectively. This shows the relevance of improving flood hazard data for more accurate flood risk results. Despite the current availability of flood hazard data (e.g., FEMA 100-yr floodplain), data accounting for compound flooding still needs to be provided. Therefore, our ongoing research is focused on developing a framework for the simulation of compound floods, studying the hydrodynamics in the transition zone, and how this will lead to more accurate flood risk assessments.

Modeling the Service Potential of Green Stormwater Infrastructure in Urban Coastal Communities

Matt Chambers, University of Georgia

Urban green stormwater infrastructure (GSI) has become popular for its ability to provide a wide range of ecosystem services in addition to flood risk management. However, recent literature has questioned the efficacy of GSI in coastal communities exposed to rising groundwater tables from sea-level rise and overloading by compound flooding from multiple flood hazards. In this work, we use a numerical hydrodynamic model to quantify the service of individual GSI (and their combination as systems) under multiple compounding flood hazards, as well as their sensitivity to fluctuations in groundwater levels. Our two-dimensional numerical model (ICPR platform) is capable of propagating coastal processes (e.g., storm surge and astronomical tides), and estimating hydrologic processes (e.g., infiltration, rainfall-runoff, and initial abstractions) simultaneously with dynamic surface to groundwater interchange, thus, allowing us to model the efficacy of GSI under the kinds of hazards coastal communities may face with climate change. Our modeling framework was tested with a barrier island community in Georgia, which enables us to explore the dynamics of interfacing GSI with conventional stormwater infrastructure and practical constraints, such as, where GSI can be placed spatially and underground storage capacity. Furthermore, groundwater and climatologic data are being collected throughout the island and are being used to update and refined the accuracy of our modeling. The utility of this research is advances in numerical modeling techniques for quantifying the service potential of GSI in the face of non-stationary and uncertain future flood hazards driven by anthropogenic climate change.

Combining Riverine and Coastal Natural Infrastructure for Reducing Compound Flood in Estuary Systems

Felix Santiago-Collazo, University of Georgia

As the world moves towards resilient and safe solutions against natural disasters and climate change, numerical modeling of Natural and Nature-based Features (NNBF)—or even hybrid systems—has been a beneficial approach in recent years. It is vital to analyze these features holistically for estuarine regions to understand and predict their behavior under compound flood events comprising coastal and riverine interactions. However, modeling these features can be challenging, especially if complex numerical models and large amounts of detailed data are required to achieve accurate results. Thus, this project aims to determine the optimum combination of riverine and coastal NNBFs to reduce compound flood impacts from tropical cyclones (TC) in estuarine communities. First, a land-to-ocean characterization will be made for several estuarine systems within the Gulf of Mexico and US Southeast coastline. This will allow us to understand the coastal watershed characteristics within the different regions to create idealized two-dimensional coastal watershed domains that will be used as a testbed for a robust compound flood model. The compound model consists of the ADCIRC model as the main modeling framework, and it will be coupled with a hydrologic model that will quantify the riverine flow conditions. This framework will be subject to several synthetic TC producing extreme wind and rainfall events in close succession. As the world is increasingly concerned about the accuracy of natural hazard predictions and preparedness, it is essential to have less demanding compound models that can be applied to several situations without losing their accuracy and reliability.

Design Principles for Engineering Wetlands to Improve Resilience of Coupled Built and Natural Water Infrastructure

John Sabo, Tulane University

Intensifying climate extremes and ageing-built infrastructure has prompted the idea to replace aged built infrastructure with natural infrastructure. In this paper we ask: How does a distributed portfolio of smaller wetlands perform compared to a flood control reservoir in terms of flood mitigation? Using a framework of a loosely coupled land surface model with a hydrodynamic model, in the Brazos basin (Texas), we found that: i) two smaller wetlands have more impact on flood mitigation than one double sized wetland, and ii) creating multiple wetlands (prioritized based on storage) increases flood mitigation. Further, we found that a portfolio of wetlands equivalent to the size of submergence area of the biggest flood control reservoir (Whitney) in the basin, can create additional flood control storage, equivalent to ~10% of the total storage of Lake Whitney. Creating a portfolio of wetlands can increase the overall resiliency of the basin.

Track 6

Thursday, 12:50 – 2:05

A: Flood Planning

Ponce de Leon Room

Moderated by Anouk Savineau, LimnoTech

Toward Mainstreaming Nature-based Solutions in Federal Flood Management Infrastructure By Improving the Accounting of Benefits in Investment Decision-making Tools (*Matt Chambers, UGA*)

Accelerating Use of Hybrid Infrastructure Systems in Water Resources (*Kyle McKay, USACE ERDC*)

A CONUS-Wide Assessment of the Best Locations for Manages Aquifer Recharge Using Floodwater (FloodMAR) (*Daniel Siegel, Earth Genome*)

B: Engagement for Engineering With Nature

Anastasia Room

Moderated by Ben Carswell, UGA

Assessing the Social Suitability of Managed Aquifer Recharge (*Laura Castro-Diaz, ASU*)

Branching Out: NNBS Accessibility for All Stakeholders (*Isabella Gandara, AECOM*)

Working Together: The Crucial Role of Partnerships in Implementing Successful Nature-Based Solutions (*Robert Nairn, OU*)

Including Tribal Perspectives, Treaty Rights, and Knowledge in Restoration (*Brian Zettle, USACE TNTCX*)

C: Panel – Hydrodynamic Modeling to Support Nature-based Solutions in the Coastal Zone

Coquina Room

Moderated by Matthew Bilskie, UGA

Aditya Gupta, Xiao Yu, Amanda Tritinger, Trevor Meckley, Soupy Dalyander, C. Brock Woodson

Track 6

Thursday, 12:50 – 2:05

A: Flood Planning

Ponce de Leon Room

Moderated by Anouk Savineau, Limnotech

Toward Mainstreaming Nature-based Solutions in Federal Flood Management Infrastructure By Improving the Accounting of Benefits in Investment Decision-making Tools

Matt Chambers, University of Georgia

Accelerating Use of Hybrid Infrastructure Systems in Water Resources

Kyle McKay, USACE ERDC

A CONUS-Wide Assessment of the Best Locations for Managed Aquifer Recharge Using Floodwater (FloodMAR)

Daniel Siegel, Earth Genome

Toward Mainstreaming Nature-based Solutions in Federal Flood Management Infrastructure by Improving the Accounting of Benefits in Investment Decision-making Tools

Matt Chambers, University of Georgia

A critical barrier to mainstreaming nature-based solutions (NbS) in the United States are the institutional practices by which the US Army Corps of Engineers (USACE) manages decision-making in infrastructure investments. USACE's primary quantitative tool is a simple form of benefit-cost analysis (BCA), that at present, has limited accounting for ecosystem services – both market and non-market – and does not accurately account for the spatial and temporal scales over which services may be realized. Recent literature has explored the ecosystem service potential of NbS and developed numerous turn-key tools to catalog and value hypothetical services. However, such approaches are data intensive, while site-specific data is often limited, and many hypothetical services (e.g., carbon sequestration and storage) may have low monetary values relative to core services in infrastructure systems designed to, for example, mitigate flooding or support a water supply. In this work, we use the example of a large-scale levee setback on the Missouri River to contextualize ecosystem service valuation and identify the most salient services capable of “moving the needle” in BCA. We then demonstrate simple and repeatable methods for quantifying benefits transfer while defining the spatial and temporal scales practitioners at agencies like USACE will need to accurately account for services in BCA. The utility of this work is the translation of NbS research to practice through refinement of the existing institutional tools USACE uses to plan and justify infrastructure investments.

Accelerating Use of Hybrid Infrastructure Systems in Water Resources

Kyle McKay, USACE ERDC Environmental Laboratory

The long-term sustainability and resilience of infrastructure systems depends on our ability to maximize benefits, while reducing monetary and non-monetary costs and creating co-benefits. Design of these systems will require multiple actions that are spatially distributed across a landscape utilizing a range of natural, built, and hybrid features. However, infrastructure design guidance often focuses on single features in isolation and pits “green” and “grey” features against one another as competing alternatives (e.g., a coastal wetland or a seawall). The reality, of course, is that natural and built features function together at systems scales (e.g., a wetland buffering wave action in front of a seawall). As such, practitioners need additional techniques and guidance for designs that blend natural and built features into hybrid infrastructure systems. Here, we articulate a vision for how to execute hybrid infrastructure planning in the context of water resources problems. We offer seven pragmatic opportunities for accelerating the use of hybrid infrastructure solutions, specifically: (1) expand the scope of design benefits, (2) consider performance over a range of conditions, (3) understand the relative risks of performance, (4) design systems with complementing forms of resilience, (5) capture synergy in grey-green function, (6) design in both directions, and (7) concede that infrastructure systems cannot solve all problems. Ultimately, we hope these ideas provide interdisciplinary professionals working on water infrastructure with a functional understanding of how to strategically blend green and grey infrastructure in their local context.

A CONUS-Wide Assessment of the Best Locations for Managed Aquifer Recharge Using Floodwater (FloodMAR)

Daniel Siegel, Earth Genome

In response to the deepening groundwater crisis, there has been increased interest in capturing floodwater for use in Managed Aquifer Recharge (Flood-MAR). However, no national study has yet been done to assess the best locations for this practice. Here we create a GIS screening tool that compares the relative feasibility of FloodMAR in different river basins. A successful FloodMAR site requires three things: available surface water, a depleted aquifer, and flat land with permeable soils. We calculate indicators that reflect the presence of these three characteristics for all HUC8 subwatersheds in the Continental United States. Water available for recharge (WAFR) is estimated from the National Water Model reanalysis simulation, geophysical feasibility from the National Elevation Dataset and SSURGO, and available aquifer storage from a novel machine-learning based groundwater model created especially for this project. We determine an overall FloodMAR feasibility score for each HUC8 and evaluate the sensitivity of this score to variations in indicator weight. We also investigate financial aspects such as the cost of expanding abstraction capacity, and undertake a survey to better understand social and governance issues that can affect project feasibility. This research can help highlight the best subwatersheds for FloodMAR in any given region of interest in order to guide investment and planning in FloodMAR schemes.

Track 6

Thursday, 12:50 – 2:05

B: Engagement for Engineering With Nature

Anastasia Room

Moderated by Ben Carswell, University of Georgia

Assessing the Social Suitability of Managed Aquifer Recharge

Laura Castro-Diaz, Arizona State University

Branching Out: NNBS Accessibility for All Stakeholders

Isabella Gandara, AECOM

Working Together: The Crucial Role of Partnerships in Implementing Successful Nature-Based Solutions

Robert Nairn, University of Oklahoma

Including Tribal Perspectives, Treaty Rights, and Knowledge in Restoration

Brian Zettle, USACE TNTCX

Assessing the Social Suitability of Managed Aquifer Recharge

Laura Castro-Diaz, Arizona State University

Managed Aquifer Recharge (MAR) is a method of taking excess available water to recharge declining aquifers. In addition to benefitting aquifer stability and long-term water storage, MAR is also proposed as an option for managing drought and floods, particularly in the high and low water years enabled by climate change. While MAR is well-understood in this capacity, what remains to be determined is the degree to which MAR will be accepted by and benefit or impact local stakeholders. This project is a collaborative effort between Earth Genome, the U.S. Army Corps, and researchers from Arizona State University.

Our goal is to develop a tool for assessing the social suitability of MAR sites by surveying MAR's acceptability, perceptions, and knowledge among members of the Army Corps who work on water-related matters and are trained in water resources management. Furthermore, we will also survey stakeholders across the United States who could be impacted by and benefit from MAR (government/state officials, agriculture stakeholders, conservation groups, and community groups). Here, we present early findings from the survey. This method could readily be adapted for a particular community in the U.S. or could be adapted and used cross-culturally to achieve a better understanding of perceptions and knowledge of MAR. Our results will be used to a) further social science knowledge of MAT and b) contribute to developing a tool that combines the physical and social suitability of MAR to help decision-makers find and develop MAR sites. In piloting this tool, we will communicate with a range of restoration managers, practitioners, and policymakers to better understand how the tool can help them in their decision-making.

Branching Out: NNBS Accessibility for All Stakeholders

Isabella Gandara, AECOM

In FEMA's 2022-2026 Strategic Plan, Natural and Nature-Based Solutions (NNBS) emerge as a preferred hazard mitigation approach. However, the adoption of NNBS faces a common hurdle—limited technical expertise among stakeholders. This presentation delves into the pivotal role of bridging state and federal resources to empower local stakeholders in NNBS for flood mitigation, using ongoing initiatives in Puerto Rico as a compelling case study.

This presentation will explore how the Puerto Rico Joint Recovery Office (JRO) is addressing this need by developing technical tools or “Job Aids” focused on NNBS for: (1) stormwater management, (2) streambank stabilization, and (3) shoreline stabilization tailored to the general geographic and climate conditions of the Island. The Puerto Rico JRO has committed to promoting and prioritizing NNBS to address water resource management challenges as part of the ongoing recovery effort on the Island. Each Job Aid includes NNBS conceptual designs and methodologies for the three areas of focus, and a worksheet geared toward the standardization of cost estimates to educate and empower JRO staff, local stakeholders, and grant applicants on how to apply these concepts to the Island. Ultimately, this is an exercise in empowering local communities to act and regularly implement NNBS for flood mitigation.

The presentation will provide the audience with actionable recommendations for advancing NNBS through effective resource coordination. This includes understanding where there are frequently gaps in knowledge and understanding with NNBS, and how resources such as the Puerto Rico Job Aids can help with real-world progress in their implementation.

Working Together: The Crucial Role of Local Partnerships in Implementing Successful Nature-Based Solutions

Robert Nairn, University of Oklahoma

Interest in and support for Engineering With Nature has grown dramatically in recent years. Successful on-the-ground implementation of practical nature-based solutions inherently requires development and maintenance of mutually beneficial partnerships with varied stakeholders. Several case studies, focused on applied research and undergraduate/graduate education, illustrate the crucial role of creating and nurturing long-term, trustworthy relationships with a variety of local tribal, private, public, and non-profit partners. In the Southern Great Plains, water supply and availability (both quantity and quality) are critical drivers of environmental, social, and economic sustainability, increasingly rendered ever more vital in the context of climate change and weather extremes. Although water is considered crucially important by all stakeholders, successful implementation of novel nature-based solutions to water challenges requires consideration and understanding of sometimes competing perspectives. Research applications include evaluation of co-benefits provided by ecologically engineered passive treatment systems in drastically disturbed watersheds, natural restoration of riparian wetlands and floodplains, and the challenges and opportunities of innovative water reuse applications. In a like manner, exposure of undergraduate and graduate students to the non-technical necessities of successful project implementation is too often neglected in traditional academic training. Several senior capstone projects focused on nature-based solution design demonstrate the need for multidisciplinary approaches and local buy-in. In all cases, prior to design and implementation, a considerable foundation of trust, based on mutual respect and understanding, was essential. These efforts provide a roadmap for successful and sustainable nature-based solutions in concert with local partners.

Including Tribal Perspectives, Treaty Rights, and Knowledge in Restoration

Brian Zettle, USACE Tribal Nations Technical Center of Expertise

Ecosystem restoration practitioners are accustomed to reviewing for Section 106 National Historic Preservation Act (NHPA) impacts when designing projects. The Section 106 process is a required review component to complete in identification of potential impacts to historic properties and cultural resources and avoiding or mitigating those impacts. Section 106 is important and it's the law, but it represents the minimum Tribal engagement that should occur when designing a project.

Tribal communities have much more to offer restoration practitioners than just an accounting of what might be impacted by the project. Environmental engineers typically neglect other equally important aspects of Tribal consultation – indigenous perspectives, knowledge, and Tribal Treaty Trust rights (rights to hunt, fish, and gather on ceded lands). Ample anecdotal evidence supports ecosystem restoration projects designed and implemented collaboratively with Tribal communities and integrating traditional ecological knowledge perform substantially better than those without this insight. Furthermore, early collaboration with Tribes allows for the inclusion of cultural keystone species, gathering spaces, and hunting/harvesting access into the design.

The purpose of this presentation is to discuss the benefits of Tribal collaboration in ecosystem restoration projects, how to integrate cultural knowledge and values into the design, and how to approach a Tribal engagement. The presentation may be of interest to Environmental Engineers, Biologists, Planners, Tribal Historic Preservation Officers, and other State or Federal scientists seeking a proactive rather than reactive relationship with Tribal Nations.

Track 6

Thursday, 12:50 – 2:05

C: Panel – Hydrodynamic Modeling to Support Nature-based Solutions in the Coastal Zone

Coquina Room

Lead: Matthew Bilskie, University of Georgia

Aditya Gupta, University of Georgia

Xiao Yu, University of Florida

Amanda Tritinger, USACE ERDC

Trevor Meckley, NOAA NCCOS

Soupy Dalyander, The Water Institute

C. Brock Woodson, University of Georgia

This session will highlight activities on using coastal numerical and sediment transport models to aid in the feasibility, design, implementation, and performance assessment of NbS. The session will discuss modeling improvements necessary for NbS design and implementation across large scales for wave and water level attenuation.

Session Topics:

- Inclusion of nature-based solutions within numerical models (spatial discretization, vegetation characteristics, etc.)
- Numerical model outputs to inform of NbS strategies, types, and scales for wave and water level attenuation
- Numerical model outputs for project prioritization
- Numerical model outputs to inform engineering design guidance
- Modeling improvements and future needs for NbS

