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Abstract Compilation

(in alphabetical order by presenter last name)

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How the G20 Global Land Initiative is Addressing the Challenges of the Southwest at the Global Scale

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Land degradation of Earth's land surface due to human activities is already causing adverse effects on over 3.2 billion people worldwide, and this situation is expected to worsen as the impacts of climate change intensify. Land degradation is a widespread and systemic issue that affects all regions of the world and can manifest in various detrimental forms, such as chemical contamination, pollution, salinity, soil erosion, nutrient depletion, overgrazing, deforestation, and desertification. Desertification, a specific type of land degradation occurring in arid areas, currently affects more than 2.7 billion people.
The rapid decline in land quality often results from a flawed economic system characterized by an inefficient food production system. This is compounded by other practices that pollute and degrade the land, yielding short-term economic gains that primarily benefit a few individuals at the expense of the broader population.

In an international domain, various commitments such as the Bonn Challenge; The African Forest Landscape Restoration Initiative (AFR100); UNCCD's Land Degradation Neutrality; UN Convention on Biological Diversity's National Biodiversity Strategy and Action Plan, and the Kunming-Montréal Global Biodiversity Framework; as well as the Nationally Determined Contributions of the UN Framework Convention on Climate have been established by countries committing to restore land.

As a significant development in the domain, the leaders of the G20 Member Countries, under the Saudi Presidency, in November 2020 launched the Global Initiative on Reducing Land Degradation and Enhancing Conservation of Terrestrial Habitats to prevent, halt, and reverse land degradation (Global Land Initiative or GLI). They declared: "Building on existing initiatives, we share the ambition to achieve a 50 percent reduction of degraded land by 2040, voluntarily." The Riyadh Leaders' declaration is the boldest articulation for land restoration yet. A 50 percent reduction in land degradation translates to about 1 billion hectares of land to be restored by 2040.

This session will highlight the objective and work of GLI, the theory of change. Furthermore, the discussion will underscore the significance of fostering technical partnerships across various sectors, including international organizations, the private sector, civil society, and academic institutions, all working together towards a shared objective. Finally, GLI welcomes the opportunity to explore synergies and engage in discussions about potential collaborative endeavors.

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Supporting Geomorphic Processes across the Riverscape in Stream Restoration Design –The Use of Wood in Rural and Urban Stream Restoration Projects

Michael Adams[1] *and George Athanasakes*[2]

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Best practices in stream restoration call for the practitioner to work with natural geomorphic processes to design channels that maximize function and support ecological services across the riverscape. Armed with guidance from multiple restoration schools of thought, the designer has several options at their disposal to craft designs that satisfy the goals and objectives of the project. Among the decisions the designer must consider is the application and extent of use of wood throughout the project. In the early 2000s when stream restoration was still in its infancy as a practice, many designers shied away from using wood in favor of rock due to the perceived lack of stability associated with wood as a structural element; fortunately, the paradigm of stream restoration is shifting from stability as a singular goal to an approach that incorporates riverine processes and recognizes the import role wood plays across the riverscape for improving and/or restoring in- and near-channel ecological services. This presentation discusses uncertainties, real or perceived, associated with using wood in stream restoration in both rural and urban projects; the benefits of using wood in stream restoration projects; guidance for design of several applications of wood; and examples of several types of wood-centric stream restoration projects. Our expectation is attendees will appreciate the importance of using wood in stream restoration projects focused on working with natural geomorphic processes across a wide range and size of ecosystem types.

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A Novel Approach to Monitoring Northern Leopard Frogs (*Lithobates pipiens*)

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Northern leopard frogs (*Lithobates pipiens*) are experiencing significant population declines within the Southwestern United States. On the Navajo Nation, they are listed as "Imperiled" and are considered a species of special conservation concern. Northern leopard frogs are vulnerable to habitat change because they require a permanent source of water to reach reproductive maturity. A significant threat to this species is loss of habitat due to grazing and climate change. Our goal is to provide a current species occurrence list of northern leopard frogs to the Navajo Nation Department of Fish and Wildlife using environmental DNA (eDNA) sampling coupled with conventional survey methods (i.e., visual encounter surveys, audio loggers, and camera traps). Environmental DNA is a non-invasive technique used for wildlife monitoring. Water samples will be collected from waterbodies that have known northern leopard frog observations within the last 20 years. Using quantitative polymerase chain reaction (qPCR) analysis of filtered water samples, we will determine presence or absence of our target species. We expect that eDNA sampling will be a good complement to conventional survey methods. eDNA sampling has been successfully used in aquatic species and we expect to yield accurate species occurrence data for our target species. We expect that there have been changes in their habitat over the last 20 years and expect to determine if suitable habitat still persists. Monitoring northern leopard frogs is critical to understanding if habitat restoration and/or reintroduction campaigns should be priorities for ensuring species persistence on the Navajo Nation.

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Dam Removal & the Klamath Basin Integrated Fisheries Restoration and Monitoring Plan

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Now underway, dam removal is the most consequential response to Klamath Basin fish population declines and when completed will allow native species to access an additional 420 miles of historical habitat including cool-water refugia. However, many uncertainties confront what other habitat restoration activities should be paired with dam removal to maximize the benefit of restoring fish passage. Recognizing the need to move beyond "bits and pieces" restoration and a more unified approach, the U.S. Fish and Wildlife Service and Pacific States Marine Fisheries' Commission partnered with ESSA between 2016-2023 to lead the development of an Integrated Fisheries Restoration and Monitoring Plan (IFRMP) for the Klamath Basin in close collaboration with local restoration practitioners. Incredibly, the IFRMP successfully completed the collaborative identification and costing of 146 priority fish habitat restoration and monitoring actions for the entire basin. The cost of implementing all IFRMP recommended activities exceeds $500 Million USD. The data and mechanics behind the IFRMP's prioritization process are unified in the web-based Klamath IFRMP Restoration Prioritization Tool that allows users to browse project details, view the individual criteria scores and underlying data that contribute to overall rankings, and explore how rankings change when criteria weights are adjusted to reflect changing restoration priorities. The IFRMP also identifies a workflow for updating every 1-2 years a companion Restoration Action Agenda (RAA) to help guide future restoration related Federal solicitations and related funding. This presentation will showcase a successful example of fisheries restoration at the science-knowledge-policy interface and highlight some of the key factors that enable and hinder large scale restoration implementation.

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Capitalizing on the Mycorrhizal Relationships of Tree Seedlings to Enhance Restoration Success in Changing Climates

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Ambitious reforestation targets to combat climate change will require expansion and optimization of the reforestation pipeline. Successful transplantation of nursery grown seedlings is a key bottleneck in this pipeline. While the impact of seed sourcing is well documented, less is known about how the nursery environment itself can prepare seedlings for success or failure in particular conditions after transplanting. Nursery conditions may increase transplanted success by recruitment of locally adapted microbial associations, especially root symbiotic fungi. Mycorrhizal fungi are key mediators of tree tolerance to abiotic conditions, such as nutrient or drought stress. Mycorrhizal associations developed during nursery production may have unintentional effects on restoration success. While underexplored, nursery seedlings are known to develop diverse fungal associations, which can have consequences for out planting success. Here we assess the effect of nursery management and location on rhizosphere microbial communities on bare-root seedling stock for a diversity of species. To assess whether bare-root seedlings bring different fungal communities to planting sites, we obtained seedlings from four public bare root nurseries (one each in IA, MO, IL, and WI), as well as a private nursery in northern IL. We obtained 2-5 species from each nursery, including a mix of softwood and hardwood species, and species that associate with both arbuscular and ectomycorrhizal fungi. We characterized the fungal communities on seedling roots using the ITS2 gene. The sequences were clustered into exact sequence variations and identified to species level. We used the FungalTraits database to assign fungal species to ecological guilds (Arbuscular Mycorrhiza and Ectomycorrhiza). A permutation MANOVA tested whether fungal community composition differed by nursery, while controlling for seedling genus. Soil fungal communities differed strongly between softwood (conifers) versus hardwoods (Angiosperms), but within these tree groups nursery location had the strongest control over fungal communities. There were fungal differences at ecological guilds within nurseries. We are currently assessing survival and growth of transplanted seedlings in ambient and droughted conditions in a central Illinois old growth forest. Documenting fungal associates of bare root seedlings of nurseries across the Midwest leads to assessment of tree-fungal interactions in nursery management practices that may lead to improved transplant success in restoration practices.

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A Naturalistic Approach to Watershed Restoration and Water Resources Development

*J Michael Chavarria, **Garret Altmann**, and Daniel Denipah*
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Santa Clara Creek consists of a 23-mile, west-to-east trending stream that flows from the Jemez mountains, down into the Rio Grande in northern New Mexico. Since 1998, three devastating wildfires have impacted the 32,000-acre Santa Clara Creek Watershed, which serves as a primary source of water, cultural identity, and spiritual sanctuary to the Santa Clara Native American Tribe. The most devastating of these events was the 2011 Las Conchas Fire which burned 60% of the watershed and resulted in widespread flooding and devastating debris flows which resulted in 100% fish kill within the watershed. Santa Clara Pueblo has since coordinated a collaborative effort to mitigate fire and flood damages by leveraging federal, state, and non-governmental resources. Starting at the watershed boundary, the Tribe implemented a 'top-down approach' to treating the watershed after it became apparent that mitigating erosion at the source was needed before restoration efforts could be sustained along the creek. After 12-years and over 5,000 hand-built erosion structures, creek restoration efforts have commenced since 2018. This presentation will review these restoration efforts by highlighting best practices, fish passage, water security, and how the Tribe is developing a ‘naturalistic approach for water resources development’ with the goal of restoring native Rio Grande Cutthroat Trout and long-term climate resilience to this watershed.

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Synergistic D/B/M Team, the Foundation to Transformative Restoration

Donna An
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Construction of ecological restoration projects rely on the work of multiple practitioners that often precede the engagement of the contractor. However, the degree of success in maximizing restoration potential, serving multiple stakeholders, accurately estimating schedule and budget, minimizing disturbance, and identifying and managing risks, to name a few, greatly depends on the level of collaboration consistently practiced by the team. As prime contractor, Actaeon forged a small and mighty group of practitioners to design, permit, construct and maintain a severely degraded, ultra-urban stream with 43-acre drainage area and 35% impervious surface in Southeast Washington, DC. Following the presentations by District Department of Environment and Energy (DOEE) on behind-the-scenes effort leading up to the contract award and Straughan Environmental on collaborative design and permitting process, Actaeon will discuss the tenet of our restoration team that facilitated synergy and guided the expert execution of the Branch Ave Park Stream Restoration in minimizing tree removal and constructing grade control structures on 12-25% slopes to achieve stability, improve water quality and increase habitat.

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Modeling the Effects of Natural Infrastructure in Dryland Streams in Baja California Sur, Mexico

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The Los Planes coastal watershed (961 km2) in Baja California Sur, Mexico has an arid climate whose water supply challenges are related to agricultural activity, increasing water demand, and threats of saltwater intrusion. Since the early 2010s partners at Rancho Ancón, a working ranch within the Los Planes watershed, have implemented sustainable management practices including the installation of natural infrastructure in dryland streams (NIDS). NIDS are natural or anthropogenic made structures that use earth, wood, debris, or rock, to promote restoration of degraded landscapes by slowing water flow and creating soil-water-carbon sinks that support vegetation and other life-forms. The U.S. Geological Survey (USGS) has extensive experience documenting and studying the impact of NIDS in the Southwestern United States and Northern Mexico. In 2022, the USGS was hired to provide technical assistance in understanding the hydrogeological cycle in Rancho Ancón in response to NIDS. This presentation describes the application of a watershed model (Soil & Water Assessment Tool, SWAT) to estimate model parameters before and after NIDS were installed. A first model iteration utilized currently available data, but the larger project involves field instrumentation and monitoring using remotely sensed data to develop high resolution land cover, vegetation, and hydroclimate datasets that will assist in the refinement and validation of subsequent model iterations. Preliminary results of the baseline SWAT model portray areas in the Los Planes watershed that have high water yield, infiltration, and evapotranspiration. Using locations of the NIDS installations, a "treated scenario" will be developed to quantify how these restorative structures will impact the water budget. Results will be disseminated with local partners in Science, Technology, Engineering, Arts, and Mathematics (STEAM) to assist in creating community-relevant curricula for local families that highlight the link between best management practices and watershed management in the North American Southwest.

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Wind Erosion and Dryland Restoration on the Navajo Nation

***Amber Renee Archie**, Audrey Harvey, Karen Anne Haubensak*
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Arizona's enduring drought, spanning nearly three decades, presents a formidable challenge to sustainability, especially in its desert ecosystems. These arid landscapes inhabit around one-third of Arizona's territory, distributed across four unique desert regions. Historically, these resilient desert biomes have adapted to their harsh environment over millennia, but the persistent drought, coupled with desertification, poses a grave threat. Desertification, the degradation of arid and semi-arid land due to climate variations and human activities, carries severe socio-economic and environmental repercussions. Prolonged droughts, soil erosion, and human interventions are driving forces behind this phenomenon. A concerning consequence is the migration of sand dunes, which results from wind-driven soil erosion. To address desertification, particularly the issue of migrating sand dunes, I've initiated an experimental project. The project's primary goal is to restore drylands using native vegetation, combating soil erosion by creating a stable soil structure. We are cultivating a variety of native grasses and forbs found in northern Arizona, with a focus on lands belonging to the Navajo Nation. This approach not only preserves traditional ethnobotanical resources but also diversifies land coverage in these areas. Over the next year, we will collect seeds from various northern Arizona locations and plant them on the project site, located on the Navajo reservation. This initiative aims to observe the growth of native plants and evaluate their effectiveness in preventing wind erosion by compacting the soil.In battling Arizona's persistent drought and desertification, this project holds promise as a sustainable solution to safeguard the state's fragile desert ecosystems while promoting resource diversity and resilience.

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Designing for Functional Uplift in Degraded Urban Streams

Joe Arrowsmith
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Urban headwater systems represent an underappreciated opportunity for resource recovery. Stormwater outfalls and gullies represent the link between our uplands and our lowland rivers. Although these systems are highly degraded, we offer a template for rehabilitation and meaningful restoration. Successful projects in this setting are truly transformational. We can create conditions for rare and valuable aquatic life in locations that presently do not support it.

In this session, I will provide an overview of the history of degradation to urban headwaters, including presentation of my research on the history and burial of headwater streams in Washington, DC. I will then introduce and discuss the components of a successful urban stream restoration, with focus on maximizing aquatic habitat in highly constrained, low-flow systems. I will share lessons learned through the lens of a specific project example, including pre-project functional assessment, discussion of design and construction process, and an evaluation of post-project performance. While the location, geology, and techniques are specific to one project, the constraints, goals, and success criteria are broadly applicable and scalable to urban systems and stormwater outfalls nationwide.

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Meta-Analysis of Riparian Zone Width Effects on Instream Processes and Taxa Richness

***Rosamar Ayala-Torres*[1]*; Dietterich, Lee*[2]*; Wiest, Samantha*[3]*; McKay, Kyle*[4]

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Riparian ecosystems have been studied globally to determine the effects of buffer width on instream and ecological functions. This study conducts a meta-analysis of buffer width efficacy to resolve competing width recommendations for the protection and restoration of riparian areas. We compiled original scientific research that observed the effect of varying riparian buffer widths on instream outcomes (i.e., removal efficacy of various constituents) and taxonomic outcomes (i.e., species richness). More than 450 worldwide studies were identified that quantify the relationships between the width and these response variables. Preliminary results indicate that a 30-m width corridor is sufficient to retain more than 90% of sediment and nutrient inputs (n = 27), also riparian areas with grass as vegetation and slope less than 15% present a better retention. However, a 100-m width corridor is required to reach 60% of taxonomic outcomes (n = 29 with mixed vegetation surroundings. Few studies were available for emergent contaminants and habitat outcomes, indicating a potential area for future research. Meta-analysis results revealed a positive correlation between widths and the instream/ecological process observed, suggesting that riparian protection and restoration is crucial to improving biological processes and diminishing instream impacts.

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Landscape Scale Restoration through Local Implementation

Lewis Bair
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One driver for regulatory actions in California is declining salmon populations. While governmental agencies respond to their own mandates in efforts toward salmon recovery, local water users have been coalescing around the idea that they are uniquely suited to be stewards of their own watersheds and the species that inhabit them. Recovery of salmon populations in California has long been focused on flow: increased flow should result in increased population. This assumes that the additional water will overcome the infrastructure that prevents system habitat services. The opportunity is really to create that habitat functionality while maximizing the broad benefits needed from every drop of water.
In the Sacramento Valley, there is a commitment to "The Fix not the Fight" that provides a platform for groups to engage in dynamic complex solution-oriented collaboration. More than two decades of partnerships and stewardship in the Sacramento River watershed have set the stage for a bottom up locally driven process to address landscape scale improvements for the betterment and health of species recovery. And the most foundational, exciting, and unique result of this path: empowering landowners to engage in restoration across a watershed.

Lewis Bair, general manager of Reclamation District 108, one of the oldest reclamation districts in the state with flood protection and irrigation supply responsibilities, will highlight local engagement with State and Federal entities to develop an on the ground approach to species recovery. RD 108 is a signatory to the Agreements for Healthy Rivers and Landscapes and the fiscal agent for programs that empower landowners to engage in landscape scale solutions. Mr. Bair will highlight unique aspects of these program, including providing technical assistance to landowners to better understand possibilities of habitat improvement as integrated with existing land uses and operations.
Panel: California's Agreements for Healthy Rivers and Landscapes: A Historic Approach to Integrating Flows and Habitat

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An Empirical Analysis of Freshwater Mussel Abundance and Pollutant Abatement in Minnesota Rivers

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Freshwater mussels are a sentinel species for ecosystem function and contribute towards many ecosystem services, such as water filtration, nutrient cycling, and aquatic habitat, while having an important role in food webs. Ecosystem services being essential for human well-being, there is a need to protect freshwater mussels both for conserving the species and for sustaining the flow of ecosystem services. As mussels require clean water to survive, and since conserving ecosystem services is implicit in the federal Clean Water Act, incorporating mussel conservation into clean water goals could serve multiple conservation goals, including ecosystem restoration for major river systems such as the Mississippi, Minnesota, St Croix, Red, and Rainy River basins in Minnesota. However, freshwater mussels are also one of the most sensitive and imperiled aquatic taxa, and are threatened by water pollution, habitat loss, and altered hydrology. Regulating pollution through National Pollutant Discharge Elimination System (NPDES) permits has a variety of benefits but also entail costs in terms of wastewater treatment technology as well as resources and time needed to implement water quality standards. To understand better the association between regulation, improvements in water quality, and mussel conservation, we link data on mussel abundance and extirpation rates to the temporal change in key pollutants such as sediment, nutrients, and chloride, as well as other factors including flow alteration, habitat features, and fish diversity. These data will be analyzed using a generalized mixed effects regression model to generate findings on the relationship of mussel health with improvements in water quality. We will look at these relationships for different freshwater mussel life history strategies, such as equilibrium, periodic, and opportunistic to gain more insight into their effective conservation. Our results will inform more effective strategies for ecosystem protection through mussel conservation, thereby improving cost-effectiveness in meeting multiple Clean Water Act goals.

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Natural Capital Valuation to Optimize Value on Private Lands

*Michael Rockel[1], Mark Rockel[2], **Andrew Bechard**[3], and Viktoria Grossman[4]*

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Private landowners have multiple options for generating value on their land such as mining, which is rivalrous and excludable to carbon sequestration which is non-rivalrous and non-excludable as well as all of those options in between. We use a Natural Capital Valuation framework and methods to identify which options can potentially generate the most value and which may be more compatible with each other in terms of preserving the overall value of the land parcel. Accordingly, this talk discusses market valuation methods to measure rivalrous and excludable options and willingness-to-pay studies using benefit transfer to measure the non-rivalrous and non-excludable options allowing landowners to optimize among different options and to better understand the ensuing tradeoffs among options.

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Pinyon Trees Response to Wildfires and Tree Thinning Treatments in Northern Arizona

Jared Litson Begay[1]*, Amy V. Whipple*[2]*, Donald Busse*[3] *,Peter Z. Fulé*[4]

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The pinyon-juniper woodlands occupy a wide range in Northern Arizona, and the region has been experiencing many ecological disturbances such as lethal wildfires and extreme drought conditions. These pinyon pine (*Pinus edulis*) and juniper spp. ecosystems provide many ecosystem services to the Diné people, such as the production of pinyon nuts, which provide a food source for humans and wildlife through thousands of masting events. There is growing concern of rising pinyon mortality and decrease in pinyon pine nut production due to climate change. We are studying the comparison in cone production among two different sites, post-wildfire and a recently thinned site, coupled with a control site to compare the cone production. The methods also involve using the cone-abscission-scar methods developed by M. Redmond to estimate the dates of previous masting events. We are comparing the current cone production to past masting events to determine the effects of wildfire and tree thinning practices. We hypothesize that the areas with the implementation of tree thinning treatments and have experienced wildfire will increase the pinyon cone production in the treated plots compared to control plots due to the release from competition. Our research will help inform how forest management treatments could preserve this important traditional food source and ecosystem health for future generations.

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Flow Monitoring and Tidal Exchange Ratio Estimation for the Bahia Grande Bay and Coastal Wetland System Post-Tidal Connection Channel Widening

Jude Benavides[1]*and* ***Sabas Lopez***[2]

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The Bahia Grande (BG) is a 9,000-acre set of coastal bays and wetlands located near Port Isabel, Tx near the Gulf of Mexico (GOM) coastline. In 2005, the Carl Joe Gayman Pilot Channel was constructed to somewhat address hypersalinity concerns resulting from anthropogenically caused tidal isolation. The Texas General Land Office (GLO) increased the channel width in 2022 with the hopes of increasing tidal exchange ratios by a factor of two to three. After channel widening was complete, two SL-1500 side-looking ADCPs were periodically deployed under a channel bridge crossing (Texas Highway 48) over a 6-month period and various tidal conditions, further supplemented by periodic deployment of an S5 River Surveyor. Data from these sensors, along with a new depth-to-volume relationship for the bay system, confirmed that tidal exchange ratios increased from a previous range of 5-10% to a range of 20-25% after channel widening. Data from the deployed sensors provided the first continuous flow monitoring into and out of the BG system post-widening as well as within the last several years. Additional synoptic (point-in-time) measurements of peak ebb and flood tidal flows will be measured for the next year to confirm tidal exchange ratios are within this increased, and more beneficial range.

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The Problem and Consequences of Conowingo Reservoir Infill on the Chesapeake Bay Water Quality

***Gopal Bhatt*[1], *Lewis Linker*[2], *Gary Shenk*[3], *Qian Zhang*[4], *Richard Tian*[4]**

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The Susquehanna River is the largest tributary to the Chesapeake Bay that contributes approximately 41% of nitrogen, 25% of phosphorus, and 27% of sediment to the tidal Bay. Recent studies have documented how, over time, sedimentation has filled in the three Lower Susquehanna reservoirs, altering their behavior. The upper two reservoirs, Lake Clarke and Lake Aldred, reached full infill capacity, also called dynamic equilibrium, prior to the beginning of the Chesapeake Bay Program (CBP) Partnership's Phase 6 Watershed Model simulation period of 1985 to 2014, and recent research has indicated that the most downstream reservoir, the Conowingo, is at or approaching dynamic equilibrium (Cerco, 2016, doi:10.2134/jeq2015.05.0230; Linker et al., 2016, doi:10.2134/jeq2014.11.0461; Zhang et al. 2016, doi:10.1021/acs.est.5b04073). Hirsch (2012, URL: https://pubs.usgs.gov/sir/2012/5185/) found that scouring of sediment may be increasing over time in the Conowingo based on an analysis of monitoring data. Langland (2015, doi:10.3133/ofr20141235) used monitoring and bathymetric surveys to show that sedimentation had altered all three reservoirs. Model refinements were made to the CBP Partnership's Phase 6 Watershed Model using multiple lines of evidence in the estimation of how the deposition and scour rates have changed as well as variability in the bioavailability of nutrients. The model was applied to estimate changes in sediment and nutrients delivery under different watershed management, climate, and reservoir infill states. Under the 1995 management, additional delivery of about 20 Mlb/yr of nitrogen, 3.5 Mlb/yr of phosphorus, and 1.3 Mton/yr of sediment was estimated between 1995 Infill and the current state of dynamic equilibrium, and an additional delivery of 12 Mlb/yr of nitrogen, 1.8 Mlb/yr of phosphorus, and 0.7 Mton/yr of sediment under the Phase 2 Watershed Implementation Plan. The model was used by the CBP partnership to support decision-making and estimating additional management actions that will be needed for mitigating these additional loads.

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The Value of Preserving and Restoring Migratory Bird Habitat to Residents of the Pacific Flyway

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Deterioration of habitat along the flyways has been a major contributor to migratory bird loss. A number of agencies, including the U.S. Forest Service, are working to increase the quantity and quality of migratory bird habitat to address this problem.

The Pacific Flyway includes vast amounts of public lands, within which are numerous habitat obligates (migratory bird species which depend upon adequate quality and quantity of specific habitat types). To provide information about the value of different types of migratory bird habitat, this stated preference survey elicits willingness to pay from the general public to purchase habitat along the Pacific Flyway. The survey design provides a framework which can be applied to flyways across North and South America. The results of this survey will provide values which resource managers and policy makers can utilize in decision making across ecosystem types and project scales.

This survey instrument is inclusive of the wide range of ecosystem service values which habitats provide. We elicit information on use and knowledge of bird habitat, and preference for the environmental good: Habitat type and quality. Respondents will be shown examples of six habitat types at different quality levels. For each habitat type respondents will be shown a representative sample of habitat obligates.

2,000 Pacific Flyway residents (California, Oregon, Washington, and Alaska) will be surveyed via Qualtrics in the Fall of 2023 and the data will be analyzed using standard discrete choice logit models. Focus groups with households in the targeted region will be undertaken before launching the survey.
Values from this study will be used to inform local and regional management decisions related to habitat preservation and restoration, wildlife management, and responses to environmental threats from climate change.

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Quantifying Ecosystem Health and Carbon Capture of Coastal Restoration Using Drones and Machine Learning

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Assessing the progression and success of coastal restoration in the face of climate change and sea level rise is vitally important. This can include estimating carbon capture, monitoring site erosion, and evaluating the effects of sea level change on vegetation. Drones and machine learning are revolutionary technologies that allow us to answer questions at resolutions not possible using satellite data and scales not feasible using field data. Drone-derived data can be collected more cost effectively than traditional approaches, with the added benefit of limiting disturbance to sensitive ecosystems.

CDM Smith used drone-mounted optical and 5-band multispectral cameras to collect multiple data sets at a tidal salt marsh restoration site and an adjacent reference marsh in Savannah, Georgia. These data sets were used to assess site topography, erosion, vegetative health, and biomass. The team combined drone-derived surface elevations and multispectral data with traditional field sampling techniques into a machine learning model to quantify site-wide above ground biomass of saltmarsh cordgrass (*Spartina alterniflora*) at a quarter meter resolution. The machine learning model results (R^2 = 0.78) were more accurate than biomass estimates using simple linear regressions of multispectral drone data.

The high resolution and spatially explicit estimates of above ground biomass in relation to elevation can provide land managers with valuable site-specific data on the potential effects of sea level change and coastal erosion on restoration sites. The combination drone-derived 3D structural data and multispectral data to estimate biomass could be applied to non-wetland restoration sites as well to track biomass in native versus invasive species. Additionally, this approach can be scaled to a range of restoration sizes (1 to >1,000 acres). This information helps land managers improve restoration efforts and is a key component to quantifying carbon capture and providing a more detailed picture of site-wide sequestration.

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Examining Collaborative Governance for the Bahia Grande in Cameron County, Texas

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The Bahia Grande, a 6,500-acre tidal basin in southeastern Cameron County, Texas, is a historically significant wetland that once provided habitat for a diverse array of species. Construction projects, such as the construction of a railroad trestle bridge, an adjacent highway, and the Brownsville Ship Channel, altered ecosystem functions and separated it from its water source, reducing it to a dusty dry lakebed. In 2000, U.S. Fish and Wildlife Services (USFWS) acquired this area and began restoration initiatives. USFWS reconnected Bahia Grande to the Lower Laguna Madre in 2005 with the construction of a restoration channel. Further restoration efforts, including a recent widening of the channel, continue. Despite this progress, this area had notable deficiencies in management efforts due to resource scarcity, limited research, and insufficient public awareness.

This research investigates the effects of management strategies on the antecedents and barriers to collaboration for ecosystem restoration. It operationalizes a typology of management strategies and other concepts and uses them in semi-structured interviews with key stakeholders in the restoration of the Bahia Grande and surrounding floodplain. It seeks to understand what is done, how the network of stakeholders involved interacts, what barriers to a collaborative and co-productive process remain, and how the actions taken by network leaders affect the process. This study not only informs Bahia Grande's recovery efforts but also contributes to the broader scholarly literature on stakeholder collaboration in preserving and revitalizing ecosystems facing similar challenges.

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Automated Monitoring to Support Adaptive Management of Actively Managed Riparian Restoration Areas

*Monisha J. Banerjee[1], **Lindsey Bunting[1]**, James Knowles[2], Mike Milczarek[1]*
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Through implementation of the Lower Colorado River Multi-Species Conservation Program (MSCP), the United States Bureau of Reclamation is tasked with creating nearly 6,000 acres of cottonwood-willow land cover to create and maintain habitat for threatened and endangered species. Successful restoration of these obligate phreatophytes requires maintenance of shallow groundwater and low soil and groundwater salinity. Additionally, creating successful avian nesting habitat for target species such as the Southwestern Willow Flycatcher (SWFL) also requires maintenance of saturated and/or moist surface soils. As part of the adaptive management phase of MSCP restoration activities, 55 groundwater and 90 soil monitoring stations were installed within eight restoration areas to monitor groundwater depth, soil moisture, and groundwater and soil salinity in real time. These data are used to optimize irrigation schedules, determine if irrigation schedules are being followed by irrigators, and for identifying inefficiencies.

Data from the first five years of monitoring were analyzed to determine whether groundwater depth and salinity were maintained within plant tolerance thresholds during the period of peak evapotranspirative demand, and whether moist surface soils were maintained during the avian nesting season. Vegetation health was assessed using publicly available remote sensing vegetation indices for the region, which allow for rapid and inexpensive analysis of seasonal and annual changes in vegetation greenness at restoration sites. Results indicated that careful irrigation management was an essential predictor of relative interannual changes in vegetation health, particularly in areas where groundwater was deep or salinity was high. Maintenance of moist surface soils was highly dependent on soil type and irrigation frequency. At most sites, soil and groundwater conditions were maintained within vegetation tolerance thresholds. Vegetation greenness declined annually at many sites during the five-year monitoring period and may indicate declining vegetation health or changes in species composition over time.

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Small Stream, Big Challenges

Josh Burch

District Department of Energy and Environment, Washington, DC, USA

The District Department of Energy & Environment executed an award-winning design-build stream restoration in SE Washington, DC that involved community planning, conflict, compromise, and collaboration. This 500ft stream restoration project transformed the stream and surrounding park to a vibrant urban space that was previously unused and unknown to much of the surrounding neighborhood. This presentation will examine the outreach and engagement work during the pre-bid, design, construction, and maintenance phases of the project. Despite being a small restoration project, the community engagement components of the projects had as many points of success and agreement as it did points of disagreement and acrimony.

The presentation will examine DOEE's historical relationship in the community, its work to reach out to every neighbor, and how early community engagement efforts exposed signs of dissension. Once the construction vehicles arrived at the site feelings of antipathy from a small group of passionate neighbors came to the forefront. DOEE will examine multiple points of conflict and discuss where DOEE could make compromises and where it could not. DOEE will provide key community engagement lessons learned from the project and offer a set of strategies for managing community expectations throughout the design, build, and maintenance process.

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Building Bridges for Beavers - A Continental Coexistence Collaboration

Adam Burnett
Executive Director, Beaver Institute, Salem, NY, USA

We're no longer facing an urgent climate crisis, we are living it. In the midst of environmental emergencies, communities are urgently adapting out of necessity, with uncertainty often as the only known. Corporate and political institutions often seem incapable of addressing the crisis. In this quagmire, hope can slip past despair and into apathy. Where do we go from here? How can one single person's action matter within such complex systems?

From these questions Beaver Institute (BI) was founded to nurture climate-resilient communities by equipping individuals with the education, tools, and resources to repair and restore nature by partnering with the North American beaver (*Castor canadensis*). Through a multiplex of exchanges and partnerships, BI has created a large, inclusive tent of individuals and communities with the shared goal of beaver-human coexistence for the benefit of all living things Through intentional bridge-building, BI facilitates disparate ideas, unexpected partnerships, and collaborations with a reach for plurality and innovation.

Drawing from a career in multi-generational, community-invested, maximally inclusive, internationally constellatory, experimental theatre-making, I will share strategies and actions in the national movement for beaver currently implemented through Beaver Institute's programs, activities, and channelized networks. Weaving the science and technicalities of beaver-related restoration with the wisdom of the humanities, I will breathlessly and joyfully expound upon the inherent contradictions nestled in the loci of humans existing with one another, as much as coexisting with the natural world.

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Monitoring and Adaptive Management Saves Money and Extends Functional Life of Middle Rio Grande Habitat Restoration Projects

Todd Caplan[1]*, Grace Haggerty*[2]*, and Chad McKenna*[1]

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This presentation provides a case study demonstrating that maintaining ecological functions of Middle Rio Grande habitat restoration projects through a coordinated monitoring and adaptive management strategy is an essential step towards achieving recovery goals for the federally endangered Rio Grande silvery minnow. Eleven restoration projects were constructed between 2016 and 2019 along a 30-mile river reach between Sevilleta National Wildlife Refuge and Socorro, NM. All projects involved mechanically lowering elevated floodplain terraces to promote overbank inundation at discharges between 800cfs and 2000cfs. The chief objective was to create favorable habitat conditions for spawning and rearing silvery minnow along river segments with inherently low channel habitat complexity. While all eleven projects were designed to provide off-channel habitat at low to moderate discharges, the construction period coincided with above average and prolonged snowmelt runoff. A comprehensive effectiveness monitoring program documented that biological and physical success criteria were achieved at the design discharge, but that sediment plugs deposited along backwater channel inlets would prevent all project sites from functioning at the design discharge without adaptive management intervention. Nonetheless, topographic surveys revealed that the volume of deposited sediment was relatively small compared to amount removed during construction. These data demonstrate that modest funding is required to remove these sediment plugs and extend the functional life of these projects.

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One of The Largest Coastal Wetland Restoration Projects in The United States: The Bahia Grande Hydrologic Restoration Project

Tessa Syvertsen[1], Derek Salazar[2], Luis M. Maristany[2],Aaron Horine[1] , Joelynn Barclay[3], and Allison Fischer[3]
Presented by: ***Josh Carter***[3]

[1]fmr. Mott MacDonald
[2]Stantec Consulting Services Inc. (fmr. Mott MacDonald)
[3]Texas General Land Office

The Bahia Grande was historically a tidally influenced coastal wetland connected to the Lower Laguna Madre Bay System. Starting in the 1930's construction including a railroad, the Brownsville Ship Channel, and later Highway, connecting the city of Brownsville to Port Isabel, TX, which cut off all tidal flow into the Bahia. The ecosystem dried up, resulting in massive "dead zones", and the bay became the source of dust storms and fish kills. In 2000, the Laguna Atascosa National Wildlife Refuge acquired the 22,000-acre Bahia Grande Unit and in 2005, a pilot channel was constructed to connect the Brownsville Ship Channel to the Bahia Grande to reflood the basin and reduce the probability of dust storms. That project successfully mitigated the dust storms but did not provide enough circulation to the system and salinities stayed high.

Mott MacDonald, with the Texas General Land Office and The Port of Brownsville, designed and constructed channel improvements to lower salinity levels and restore wildlife and habitat within the 22,000-acre sanctuary. The objectives were to maximize natural tidal circulation, while providing protection to the Highway 48 bridge. Numerical models were used for the salinity/hydrodynamic modeling to test a variety of deepening and widening alternatives against existing conditions. The analysis of preferred alternative resulted in a reduction of salinity levels within the Bahia by approximately 11-13%, which would result in the restoration of approximately 10,000 acres of wetland and shallow water habitat for local wildlife and fisheries. This is one of the largest coastal wetland restoration projects in Texas history. The design was kept flexible, providing many opportunities during construction to analyze collected data and adjust where necessary, to not limit the construction methodology. The project involved widening the pilot channel from 50' to 100' and cutting to a depth of -8 ft.

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Evaluation of Sediment Augmentation in the Central Platte River, NE, USA

*Sarah Fancher[1,2], Jason Farnsworth[1,2], **Libby Casavant**[1,2] and Ed Weschler[1,2]*

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The Platte River near Lexington, Nebraska incised due to lack of sediment downstream of an irrigation return that releases sediment-free water into the river channel. Since the start of operations at the J2 Hydropower Return in the 1940s, the river channel downstream of the Return transformed from a braided river planform to a wandering planform. Starting in 2017, the Platte River Recovery Implementation Program, a large-scale endangered species recovery and adaptive management program, implemented sediment augmentation as a management strategy to address the possibility of incision and planform change affecting downstream habitat for target species, including the endangered whooping crane (*Grus americana*). Sediment augmentation included mechanical transfer of terrace sediments into the active channel for immediate mobilization by the river. The cost of this project ranged from $60,000–$260,000 each year. In this study, we evaluate changes during the first five years of sediment augmentation and one year prior to augmentation (2016–2021) to help decisionmakers assess whether to continue sediment augmentation efforts. We evaluate the efficacy with analyses of longitudinal change in sediment volume, river channel elevation, and channel geometry (slope, width, and sinuosity). Aggradational response from augmentation is present immediately downstream of the augmentation area (average 5 in of elevation gain over 1.3 mi), and bed erosion throughout the upper half of the study area decreased by 45–60%. Downstream, the channel remains degradational (average 16 in and 7 in of elevation loss over 1.0 mi and 1.7 mi, respectively) until it rejoins the main channel of the Platte. Within the habitat areas beyond the confluence, we observed relative stability despite the continued sediment deficit. Sediment augmentation is considered successful in this context for a defined distance, but uncertainties remain regarding the persistent sediment imbalance and threat of river incision to downstream habitat areas.

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Building Rock Gabions and Check Dams Supports Sustainable Ecotourism in the Cacachilas Mountain Range, B.C.S., Mexico

***Florence Cassassuce**, Gabriel Patron, Carlos Lim, and Florent Gomis*
Rancho Cacachilas, La Paz, BCS, México

Rancho Cacachilas is a land restoration and ecotourism project in the Sierra Cacachilas mountain range, 30km east of the city of La Paz, Baja California Sur, Mexico. The 14,000 ha of the ranch are located in the upper mountain range of the Los Planes watershed, which has historically been impacted by overgrazing of goats and cattle as well as deforestation from cutting down of hardwood trees for fence posts, leather tanning, and mining operations. This ecosystem degradation started back in the Jesuit era at the turn of the 18th Century when mining began. This degradation worsened in the 20th century, with government subsidies for ranchero families to expand their herds and get free animal feed during summer months. To revert the desertification and land erosion trend, Rancho Cacachilas embarked in 2013 in an intense project of gabion and check dam construction in the canyons of the ranch and installing these and our unique, gabioncitos, along the road network. Fencing of the entire ranch began in 2020 and continues to this day to exclude free roaming cattle. Our rock detention structures have had a direct impact on the vegetation, biodiversity, and water flows along our canyons. Most thrilling is the return of oasis-type ecosystem with palm groves, water-loving plants and semi-perennial water flows in arroyos that started as bare rock channels and were converted into sand and organic matter sponges by constructing ¨gabion stairways¨ along mile long stretches. This water replenishment work is now supporting a diversity of activities at Rancho Cacachilas, ecotourism around hiking and biking in our regreened canyons, cheese making and sustainable meat production from holistically managed cattle and organic agriculture to produce fruits and vegetables that our chef prepares for our ranch guests, a virtuous cycle of ecological, social and economic abundance.

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Barriers to Understanding Sea-Level Rise Impacts on Everglades Restoration

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Florida's Everglades restoration partners have long recognized the need to consider the impacts of sea-level rise on restoration efforts. However, many partners are not formally incorporating sea-level scenarios into restoration planning. There are high levels of uncertainty around how sea-level rise will affect the Everglades ecosystem, and what it means for restoration goals and outcomes. To help reduce this uncertainty, partners require tools and methods to confidently include sea-level rise scenarios into restoration plans. We are working with Everglades restoration partners to understand how they each think sea-level rise will impact their restoration efforts, how it may alter their goals and priorities and which resources will be most helpful for evaluating the impacts of sea-level rise on Everglades restoration. We have conducted focus groups and semi-structured interviews with members of RECOVER (REstoration COordination & VERification), a multi-agency scientific group of government, non-profit, and Tribal organizations that provide input on the implementation of the Comprehensive Everglades Restoration Plan (CERP). The results reveal the potential sea-level rise impacts that partners are most concerned about, gaps in data and model limitations that restrict their ability to plan for those impacts, assumptions and uncertainties embedded in restoration planning, and tools that partners would find most helpful for decision-making. These insights are informing the design of data visualization tools that can help partners choose sea-level rise scenarios most relevant to their unique projects, incorporate those scenarios into current planning processes, and decide between competing restoration plans as CERP projects continue to be implemented across the landscape.

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Partnerships and Nature-based Restoration in Mitigation Banking Projects

Amy Chadwick *and David Patrick*
Eco-Asset Holdings, Helena, MT, USA

The purpose of mitigation banking is to provide a means of replacing wetland or stream habitat that has been degraded or destroyed by development, infrastructure projects, or other permanent impacts. Such offsets are provided in advance and per high standards. Mitigation banking projects provide benefits at multiple levels by working in partnerships with landowners, engineering and other contractors, agencies, funding entities, and the ecosystem itself. For mitigation to provide an environmental benefit, impacted wetland and stream habitat must be replaced with habitat of equal or higher ecological function, yet for mitigation to be cost-effective, restoration costs must be considered. Adoption of nature-based restoration has allowed mitigation projects in Montana to restore systems to higher ecological function and to provide greater habitat complexity for aquatic and terrestrial species by keeping design and materials costs lower and by focusing on restoring natural processes rather than imposing a static design to the system. To sustain the mitigation banking business model, projects should aim for multiple bottom-line gains, with financial benefit to the banking entities and the landowner host, but also providing a real and significant benefit to degraded stream and wetland ecosystems and providing environmental outreach and education opportunities.

This presentation focuses on two stream and wetland mitigation banking projects, one on a prairie slope wetland system with ephemeral runoff within the Crow Reservation in eastern Montana, and one on a large perennial montane stream subject to ice scour in west-central Montana. Both projects utilize new designs to adapt to site-specific landscape, soil, and hydrologic profiles. The important role of partnerships to develop and monitor projects is also discussed.

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Bridging the Estuary: The history, current status, and future of restoration planning, policy, and implementation in the Sacramento-San Joaquin Delta and San Francisco Bay

Dylan Chapple
Delta Stewardship Council, Sacramento, CA

This talk will compare restoration progress and monitoring in the San Francisco Bay (SF Bay), Sacramento-San Joaquin Delta (Delta) Estuary System. While the Bay and Delta are part of the same estuary, the combination of different land-use histories, salinity regimes, policy approaches, and species' needs all led to distinct trajectories for restoration across the two regions. Restoration in the saline, urbanized SF Bay began in the 1970's, has proceeded relatively steadily since then, and is largely not the result of mitigation requirements. In contrast, restoration in the fresher, largely agricultural Delta is more recent, with Federal Endangered Species Act-required mitigation for fish species including Delta smelt and Chinook salmon as a central motivation. To improve understanding of how context impacts restoration implementation, this talk will provide a high-level history comparing the two regions of the estuary focused on the range of restoration projects and programs in each system, their motivations, relevant funding structures, and progress made towards restoration implementation in the system to date. It will employ a series of case studies focusing on how institutions, ecology, policy, and geography impact how, when, and where restoration projects and related activities are implemented. These case studies will explore how uncertainty is addressed through monitoring and adaptive management programs, invasive species control, restoration design and construction, and public access. In each of these cases, regional difference play major roles in how programs are implemented. By addressing the role that the broader context plays in restoration implementation, this talk will help restoration practitioners and planners better understand how to navigate challenges across scales.

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Restoration Benefits Observed from The Biscayne Bay Coastal Wetlands Project

Bahram Charkhian
South Florida Water Management District, West Palm Beach, FL, USA

The Biscayne Bay Coastal Wetlands Phase 1 (BBCW) project is focused on restoring Biscayne Bay and adjacent coastal wetlands as part of the Comprehensive Everglades Restoration Plan (CERP). Objectives include redistribution of freshwater from existing point source canal discharges to coastal wetlands providing for more natural and historic overland flow to remnant tidal creeks. The project will also improve ecological function of saltwater wetlands and the nearshore bay environment by improving salinity conditions and increasing habitat for estuarine organisms.

Phase 1 of the BBCW project is composed of three components: Deering Estate, Cutler Wetlands and L-31E Flow-way. Pump station and culvert construction at each of these sites will allow delivery of freshwater as sheet flow to the coastal wetlands and Biscayne Bay. The South Florida Water Management District (SFWMD) has implemented adaptive management processes to enhance and improve restoration benefits including modified operation of the Deering Estate pump station to create more natural wetland hydroperiods. Another example involves a collaboration with Miami-Dade County to eliminate runoff of polluted surface water from land fill facilities by constructing an earthen plug within the eastern end of Goulds Canal.

Comparison of baseline and ecological monitoring data from the last ten years indicates there has been substantial progress towards achieving project goals. Nearshore water quality and salinity levels have improved as more freshwater is redirected from canals to wetlands and the bay. Vegetation in the vicinity of the Deering Estate is responding to improved hydrology as demonstrated by replacement of upland vegetation with wetland species, and surface and groundwater salinities in the historic remnant wetlands have decreased in response to increased pumping of freshwater from the newly constructed pump station. SFWMD initiated construction of the Cutler Wetlands Flow way in Spring 2023 and is currently collecting baseline data for this component of the project.

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Ch'osh doo Yit'íinii Dlǽádí dóó ábishjaa' Łeezh bii' Silá: The Bioremediation of Degraded Soil Through Biocrust Inoculation

Seth Charley, *Madeline Mayorga, Anita Antoninka, Nelly McCuistion, Lydia Bailey, Matthew Bowker*
School of Forestry and Center for Adaptable Western Landscapes, University of Northern Arizona, Flagstaff, AZ, USA

Over the past century, post-colonization activity has had a profound impact on Navajo Nation soil and environmental health. Today, the effects of overgrazing and heavy metal/coal mining are felt at every socioeconomic level among the Dine, and the health of fertile soil is crucial for the sovereignty of the Navajo Nation. These issues are further complicated by climate change and increasing anthropogenic presence characteristic of dryland environments. The bioremediation of soil through biocrust treatment could dramatically reduce the effects of soil degradation. Biocrusts are small, but incredibly complex, ecosystems of microbes among fungi, cyanobacteria, and mosses that are major players of their environments, particularly within desert ecosystems. Occupying the top few millimeters of soil, biocrusts are vital for soil aggregation, nitrogen fixation, nutrient storage/availability, water retention, and plant growth. They can take years, sometimes centuries, to recover after a disturbance without active restoration. At the Center for Adaptable Western Landscapes at Northern Arizona University, we are researching efficient, cost-effective, large-scale solutions to the degradation of soil from biocrust disturbance. Some of our methods include the dispersal of pellets with cultivated biocrust and anti-herbivory agents. With the inoculation of damaged soils with biocrust inoculate, we aim to speed up the establishment of healthy biocrust through active restoration.

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Using Hydraulic Modeling and Particle Tracking to Assess Restoration Impact on Egg and Larval Refuge

Mark Horner, ***Breana Chavez***[2]
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Recent geomorphic changes observed along the Pecos River in east-central New Mexico have prompted concern that quality egg and larval fish retention habitat for the federally listed Pecos bluntnose shiner (Notropis simus pecocensis, hereafter shiner) is declining. As part of a three-phase project, the U.S. Fish and Wildlife Service and Tetra Tech conducted cross-section surveys, evaluated current habitat conditions, and conducted a comprehensive hydrologic and fluvial geomorphic study of the Pecos River between Santa Rosa Dam and Dexter, NM. Through these investigations, several disconnected meander bends were identified as potential restoration sites.

To evaluate the potential of meander bend reconnection to act as a refuge for shiner eggs and larvae during block flows and summer monsoons, a two-dimensional (2D) HEC-RAS model was developed. A particle tracking method that simulates movement of semi-buoyant objects was applied to track the paths an egg would take. Travel paths and times for existing and restored conditions were compared to evaluate if restoration led to increased egg retention and if eggs would exit the meander as flows receded. Additionally, large woody debris were simulated in the main channel to evaluate their potential for creating refugia. Results showed there is potential to retain eggs and larvae during block flows without trapping eggs/larvae. During monsoons, the meander was not an effective means of improving egg/larvae retention. Modeling showed localized slower velocities at large woody debris, which indicated some potential for creating refugia during block flows and monsoon flows.

While this specific meander bend may not have the desired potential for improved habitat if reconnected, the study provides insight to identify characteristics of meanders that have higher potential for reconnection. Additionally, this approach, which combines 2D hydraulic modeling with semi-buoyant particle tracking, can be used to explore similar riparian habitat changes in almost any river system.

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Re-Watering The Ground

Valer Clark
Cuenca los Ojos

We have experienced the placement of rocks on hillsides in eroded areas. The rock dams capture silt and water. A great many dams placed close together in all drainages capture so much water that the hills become sponges. On a larger scale we have built many substantial structures with wire baskets filled with rocks and placed them strategically in large washes wherever flooding was destroying riparian areas.

Both methods imitate what Nature does in areas that have not been disturbed. Both change over time with storm events. Rocks move, trees are downed, but wherever the structures are the water slows down which allows sediment to redistribute to where it is needed. In all cases vegetation increases and the water near structures goes into the ground lasting longer and building up an underground flow which increases year after year. We measured an increase in the size of a wetland where we put the structures.

Ten years after installing structures we witnessed the largest flood in recorded history “Odile” Odile completely rearranged the river breaking apart some structures redepositing soils that had accumulated behind the structures Many trees were downed but the overall effect was positive. New growth came out of the downed trees, and the river reset itself carving deep and shallow basins in the riverbed. The uplands profited from the overflow of the floods and new growth appeared there as well.

Structures can be effective in arid regions throughout the world by increasing the amount of water that goes into the ground. In areas where flooding is a danger the structures can modify the potential damage and, depending upon the terrain, direct the flow as well.

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Hydrological Restoration of Degraded Grasslands in Arid and Semi-Arid Communities

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We live in the Anthropocene. The entire surface of the earth has been impacted by human activity and our land management decisions. In this context, most of the grasslands in arid and semiarid regions are experiencing severe and continuing degradation. This work describes the changes European culture has made to the landscape of northern Mexico and the Southwest United States and how this has drastically altered the hydrologic response to rainfall intensities typical of this region. It explains the prime causes of the deterioration of grasslands in semi-arid zones, identifies systemic strategies to address these causes, and presents several basic landscape intervention techniques that can help restore hydraulic function to these ecosystems. These include the restoration of historic flow paths, road drainage with rolling dips, Induced Meandering using post vanes to restore eroded stream banks, and one-rock-dams to arrest downcutting in small, incised tributaries.

Restoration is difficult; therefore, it is imperative for a project to identify and remove the root cause of degradation so that we don't waste time. The effects of these techniques are documented photographically. The interventions and management guidelines presented in this paper can improve grassland hydrology, conserve soil resources, and have a large potential to reduce the vulnerability of ecological communities to droughts and floods.

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The Everglades Vulnerability Analysis: Integrating Ecological Indicator Responses to Inform Restoration

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The Comprehensive Everglades Restoration Plan (CERP) aims to restore natural hydrologic processes throughout the Florida Everglades by changing the quantity, quality, timing, and distribution of water. An interdisciplinary, interagency scientific and technical team, REstoration COordination and VERification (RECOVER), conducts systemwide analyses to inform CERP and track progress toward a restored ecosystem. RECOVER uses models to evaluate how ecological indicators will respond to hydrologic changes resulting from CERP projects. However, the current set of models generate outputs at different spatial and temporal scales, and uncertainty associated with model outputs is not available or considered. RECOVER identified the need for the development and application of an ecosystem vulnerability model that would enable integrative analysis of ecological indicator responses to multiple stressors and restoration actions that operate on a wide range of scales.

In collaboration with the U.S. Geological Survey and the National Park Service, the Everglades Vulnerability Analysis (EVA) was developed using Bayesian networks (BNs), which connect several disparate models to provide an integrated system-wide understanding and predictive ability for the Everglades ecosystem. The EVA currently consists of four BN modules: vegetation type, American alligator nesting potential, wading bird colony size, and sawgrass peat accumulation. Each BN module within the EVA predicts indicator responses on a unified spatial and temporal scale to facilitate comparison between indicators and incorporates uncertainty within module outputs to calculate vulnerability scores based on user-defined ideal states. By quantifying the level of uncertainty inherent to indicator responses, the EVA can help RECOVER understand what uncertainty exists for each indicator across the ecosystem and where to direct future monitoring to reduce uncertainty to an acceptable level. The EVA will enable RECOVER to inform CERP with an integrated, systemwide evaluation of indicator responses to CERP implementation and will provide insight on responses and relative vulnerability of areas, species, or systems to climate-related long-term changes such as sea-level rise.

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Hinge-Felling, Best & Cheapest

A. Thomas Cole
Ranch co-owner, Silver City, NM, USA

Lucinda Cole and I retired to the Pitchfork Ranch in southwest New Mexico two decades ago. We've overseen 17 government grants to install grade-control structures in 31 side-drainages and the ranches' 9-mile reach of the 48-mile-long Burro Ciénaga riparian watercourse, 1.5-miles perennial ciénaga. We've propagated over 1,000 trees, installed more than 1,000 grade-control structures of various types, including Hinge-Felling addressed here. Our ranch restoration goal is to shallow the land, provide wildlife habitat and capture atmospheric carbon.

The goal of my conference remarks will explain wetland Hinge-Felling grade-control structures.

Wetland restoration is an important climate crisis tool because restoration is one of 21 recognized natural climate solutions capable of capturing up to 37% of excess atmospheric carbon. Wetlands like ciénagas, bogs, marshland, swampland and other wetted sweet spots capture five-times more carbon than forests and 500 times more carbon than oceans.

My remarks will power-point a single-page set of four pairs of then-and-now same-location photographs to illustrate restoration-based change on the Pitchfork Ranch followed by three pages of 20 images demonstrating Hinge-Felling:
(1) how-to construct them, (2) how they slow water flow and capture sediment
(3) how they evolve or grow, (4) why they persist, and (5) their low cost. Finally, a diagram, with Trifecta Crisis & Natural Climate Solutions source data

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Maximizing Habitat Diversity under Widely Varying Hydrologic Conditions

Steven Collins

Johnson, Mirmiran & Thompson, Lake Mary, FL, USA

How do you establish and maximize survivorship of native plantings in a system intended to have wide water level fluctuations, and when future conditions are predicted to differ from current conditions? Diversity and flexibility are key. The primary objectives of the John Paul Landing project were to provide regional water quality and flood detention (650 ac-ft) in northwestern Harris County, TX. In our design, we took the opportunity to maximize ecological lift and restore lost regional function and values by adding wildlife habitat islands, both forested and unforested with prairie plantings, and submerged aquatic vegetation shelves of varying depths. Located within a public park, the design also includes recreation and educational opportunities for the community, including a kayak trail, walking trail, floating boardwalk, outdoor classroom, and an imported sand beach. Scheduling construction and removal of berms to manage water levels was challenging. However, the critical challenge was establishing wetland plants under both flood and drought conditions.

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Influence of Management Practices on Plant Diversity in Conservation Reserve Program Grasslands

***Jaron Cook**, Chelsey Blanke**,** Daniel Larkin*
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The Conservation Reserve Program (CRP) is the largest land restoration program in the United States, with over 23 million acres enrolled across the contiguous 48 states as of 2022. However, ecological studies of CRP lands have shown that the program does not provision biodiversity, acre-to-acre, as well as other restored grasslands and remnant prairies.

This study aims to identify the effects of restoration practices and site characteristics on biodiversity-related outcomes. The ultimate goal is to identify practicable opportunities for the Farm Service Agency and participating landowners to improve biodiversity outcomes on CRP-enrolled lands.

We sampled plant species composition and richness on 10 CRP-enrolled sites and 5 reference sites across western Minnesota and eastern North Dakota to characterize plant communities established by high- vs. low-diversity CRP practices (seed mixes) and compare these outcomes to nearby reference prairies. We worked with county Farm Service Agency offices to compile seed mixes and management history for each participating site and conducted interviews with landowners to tabulate year-to-year land management activities that were not officially reported. We applied statistical models to explain trends in biodiversity outcomes based on seed-mix diversity and management practices, while accounting for topographic heterogeneity and hydric soils as key underlying environmental factors.

We found that frequency of active management (including mowing, grazing, and fire) was positively correlated with multiple metrics of biodiversity, highlighting the importance of regular disturbance for maintaining plant diversity in grasslands. We also found that sites seeded with higher forb:grass mixes tended to have higher native forb: grass composition in the established vegetation. However, sites seeded with higher forb:grass mixes also tended to have higher relative abundance of non-native grasses , suggesting a tradeoff between establishment of native forbs vs. suppression of non-native grasses.

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Wetland Restoration in the Great Black Swamp

Melanie Coulter *and Rob Krain*
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Wetland restoration is a key strategy for reducing nutrient loading and improving water quality in the Western Lake Erie Basin. Historically, most wetland restoration in northwest Ohio was focused on Lake Erie coastal areas. In recent years, the Black Swamp Conservancy has been at the forefront of demonstrating the importance and benefits of wetland restoration in the upper watersheds of the Western Lake Erie Basin. Our process involves strategic land acquisition and focused wetland restoration of marginal agricultural fields in key locations in the watershed. This talk will highlight our experience and lessons learned from implementing wetland restoration projects as part of the H2Ohio Initiative. We will discuss how we use the historical and hydrological context of the historic Great Black Swamp to guide our project selection to ensure habitat benefits as well as water quality benefits. We will also describe how our design process aims to maximize the nutrient capture and retention functions of wetlands and highlight how we are collaborating with scientists to monitor and evaluate the outcomes of our restoration efforts. With examples of both successful and challenging projects, we hope our talk will inspire and inform other practitioners interested in wetland restoration in a large-scale watershed context.

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Incentivizing Private landowners to Invest in Ecosystem Restoration

Bea Covington
Sustainability and ESG Director, Greene Economics, Seattle, WA, USA

Implementing conservation practices that enhance and support ecosystem restoration on private lands is a critical aspect of achieving restoration goals and meeting carbon sequestration and other climate mitigation and resilience planning targets. It is important to understand the opportunities, barriers and constraints associated with private landowner participation in and implementation of these types of projects in order to plan for success. Using Washington State as a case study, this presentation will provide an overview of the current state of existing programs (RCPP, WHIP, CREP, CSP, etc.) and support mechanisms that support private landowner participation as well as an overview of the emerging landscape of other market-based incentives and market opportunities that, in principle, should motivate private landowner participation in restoration activities. The presentation will focus on exploring barriers and constraints to landowner utilization of these various mechanisms and their effectiveness at incentivizing private landowner participation in ecosystem restoration efforts.

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Comprehensive Everglades Restoration Plan Adaptive Management: Integrating Science across Projects to Increase Restoration Success

Michael Simmons[1], Gina Paduano Ralph[1], Phyllis Klarmann[2], Andrea Atkinson[3], Laura Brandt[4], Jenna May[1], Fred Sklar[2], Danette Goss[1] and Amanda Kahn[2] *Presented by:* ***Lisa Cowart Baron***[1]

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The Comprehensive Everglades Restoration Plan (CERP) was approved by Congress in 2000 to restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region, including water supply and flood risk management by improving the quantity, quality, timing, and distribution of water throughout the system. The Everglades is an extensive mosaic of natural communities with complex interactions. This complexity produces a considerable amount of uncertainty related to ecological responses to hydrologic restoration. Recognizing significant uncertainties exist within the Everglades, CERP was designed to be implemented iteratively within an adaptive management framework.

Within the context of CERP, adaptive management is a structured management approach to address restoration uncertainties by testing hypotheses, linking scientific results to decision making, and adjusting design and implementation, as necessary, to improve the probability of restoration success. The development and coordination of CERP adaptive management was tasked to the REstoration, COordination and VERification (RECOVER) Program, an interagency and interdisciplinary scientific and technical team seeking continuous improvement in CERP by using and building upon existing science and technology. RECOVER instituted a monitoring and assessment plan to address key uncertainties and to provide an assessment of baseline conditions for future comparison as CERP is implemented. With the incremental execution of CERP, RECOVER established interim goals and targets to ensure restoration progress remains aligned with CERP goals and objectives.

Understanding communication and collaboration are fundamental keys to restoration success. RECOVER developed the CERP Adaptive Management Strategy, CERP Adaptive Management Integration Guide, and CERP Programmatic Adaptive Management Plan, to facilitate the integration of new science and information between restoration project delivery teams to improve the implementation of CERP. Together these documents: (1) identify the process for integrating adaptive management, (2) outline adaptive management strategies including monitoring and management options to reduce uncertainty, and (3) provide a communication framework for sharing knowledge on both system-wide and project-level scales.

In recent years, improved scientific understanding has resulted in adaptive management refinements to several CERP projects through collaborative sharing of scientific knowledge and data to improve restoration success. Examples of successful adaptive management adjustments to design or operations will be highlighted to showcase the application of the CERP adaptive management framework.

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An Endangered Grass "Falls" for a Complex Hydrologic Regime in Everglades National Park

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Hydrologic regimes strongly influence plant population dynamics over time in seasonally flooded environments. Aspects of the hydrologic regime, such as the seasonal timing, magnitude, and frequency of flooding, should be considered when managing populations of endangered plant species in seasonally wet places. We tested the response of *Digitaria pauciflora*, a federally endangered grass, to different flooding regimes of Everglades National Park, where the extent and duration of flooding is generally greater during the wet season but varies spatially along topographic gradients. We established demography plots at both ends of *D. pauciflora*'s elevation range. We measured vital rates, including growth, survival, and reproduction, annually for four years (2020-2023). Results showed that *D. pauciflora* has a patchy distribution across the landscape, likely because it reproduces seasonally through vegetative reproduction via plantlets. Mature plants produce plantlets that remain on the plant until they become heavy and fall, placing plantlets in direct contact with the ground. The plantlets can then begin rooting, provided they land in suitable microsites that are not flooded. We found that *D. pauciflora* had increasing population growth in lower elevation areas, but only when seasonal flooding ended before plantlets fell to the ground. In these instances, *D. pauciflora* had both higher establishment and survival. During extended flooding events, the establishment of new plants was rare, causing a net decrease in population size (i.e., greater mortality than establishment). We suggest that *D. pauciflora* has a "boom or bust" population demography. Over the long term, this cycle should maintain populations of *D. pauciflora* provided bust years do not outnumber boom years during which the population can recover. *Digitaria pauciflora* and other plant species might be considered indicator species and should be recurrently monitored to guide the restoration of hydrologic regimes in Everglades National Park and elsewhere.

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Improving Science Communication: Developing a Communication Plan for Everglades Restoration Progress

Jessica Dell
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The Comprehensive Everglades Restoration Plan (CERP) is the largest aquatic ecosystem restoration effort in the nation. Spanning over 18,000 square miles, CERP includes a series of restoration projects to alter the quantity, quality, timing, and distribution of water throughout south Florida with the goal of improving the health of more than 2.4 million acres of the Everglades while also providing for the region's water supply needs and flood protection. Restoration projects of all sizes depend on clear and open communication among scientists, land managers, and stakeholders; however, scientific reports often fall short in bridging the gap between restoration science and restoration practices. Communication plans can be used by restoration teams to identify their target audiences and tailor scientific reports to the needs and expertise of their audience.

RECOVER (REstoration, COordination & VERification) is a multi-agency team of scientists, modelers, planners, and resource specialists who provide essential support to the CERP effort. RECOVER applies a system-wide perspective to the planning and implementation of CERP and communicates and coordinates the results of scientific and technical evaluations and assessments to managers, decision makers, and the public. To promote effective communication, RECOVER developed a communication plan for the System Status Report which is a technical document that assesses whether the CERP goals and purposes are being achieved. CERP project managers, agency leadership, and Congress will use this information to make decisions on the planning and implementation of CERP and Everglades restoration.

RECOVER developed the communication plan by identifying the target audience and their needs, determining the communication goals and objectives, and selecting the best communication strategies to support the purpose of the report. Following the release of the report in 2024, RECOVER will survey target audience members to evaluate how well the communication goals and objectives of the report were achieved. This effort highlights the importance of developing communication plans to support restoration projects and inform stakeholders and decision makers on the status of restoration.

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Integrating Information from the Past into Oyster Restoration

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In the United States, the eastern oyster (*Crassostrea virginica*) is an economically, culturally, and ecologically important oyster species that ranges from Maine to Texas. Eastern oyster populations are managed by a variety of federal, state, and local governments as well as non-governmental organizations. In addition, the long history of oyster harvesting and coastal land-use change in the United States, and asynchronous fluctuations in abundance across the species range due to diverse pressures (e.g., hydrological changes, pollution, disease, overharvesting), combined with often scarce historical monitoring records documenting the timing and magnitude of the changes, have challenged the management of oyster resources for well over a century. To explore ways to help overcome this challenge, the Oysters Past Working Group (OPWG) brings together academic researchers who specialize in collecting and interpreting information from the past (paleoecologists, archaeologists, and historical ecologists) and practitioners and resource managers who work on oyster conservation, management, and/or restoration for government agencies or non-governmental organizations. More specifically, the primary goals of the OPWG are to: 1) identify oyster management needs that require information from the past; and 2) create a guidance document on best practices for applying information from the past to oyster management. Here, we report on the results of a survey that the OPWG circulated to the broader oyster resource management and policy community to gather perspectives about currently used oyster population and habitat management indicators, the timescales on which these data are typically available, and how longer-term records may be helpful for practitioners and resource managers.

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Responses of Molluscan Communities to Improved Water Quality in Long Island Sound

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Water quality in Long Island Sound (LIS) has improved since the adoption of a nitrogen Total Maximum Daily Load (TMDL) management strategy in 2000. However, no long-term monitoring data of benthic macroinvertebrate communities are available for evaluating the success of the management intervention. Time-averaged molluscan death assemblages (DAs) that readily preserve and accumulate in the sediment provide a unique opportunity to reconstruct past habitat conditions. Here we use the remains of dead mollusk shells retained in 10 benthic grab samples collected from LIS as part of the Environmental Protection Agency-led 2020 National Coastal Conditions Assessment (NCCA) to evaluate the response of benthic communities to the TMDL intervention. We hypothesized that habitat condition—measured using the NCCA-adopted Multivariate AZTI Marine Biotic Index—changed since the introduction of the TMDL, with the direction of change related to the direction of change in water quality (indexed as the frequency of summer hypoxic events at each sampling location). Radiocarbon dating results confirm that the molluscan DAs reflect pre-TMDL conditions. Overall, post-TMDL improvements in water quality led to increases in pollution-sensitive species relative to pollution-tolerant species from the DA to the living molluscan assemblage, although habitat conditions today remain moderately disturbed at some sites, potentially due to the persistence of high levels of heavy metals and other pollutants in the sediment. Our results illustrate how molluscan DAs that are collected using standard sampling protocols for the living benthic macroinvertebrate community can be used to provide a cost-effective and efficient means of retroactively acquiring data to assess the success of restoration actions in other estuarine and coastal waters lacking long-term monitoring data.

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What is Conservation Paleobiology? Tracking 20 Years of Research and Development

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Conservation paleobiology has coalesced over the last two decades since its formal coining, united by the goal of applying geohistorical records to inform the conservation, management, and restoration of biodiversity and ecosystem services. Yet, the field is still attempting to expand its identity beyond its academic roots. Here, we ask a deceptively simple question: What is conservation paleobiology? To track its development as a field, we synthesize complementary perspectives from a survey of scientific community members familiar with conservation paleobiology and a systematic literature review of publications that used the term. We present an overview of conservation paleobiology's research scope and compare survey participants' perceptions of what it is and what it should be as a field. We find that conservation paleobiologists use a variety of geohistorical data in their work, although research is typified by near-time records of marine mollusks and terrestrial mammals collected over local to regional spatial scales. Our results also confirm the field's broad disciplinary basis: survey participants indicated that conservation paleobiology can incorporate information from a wide range of disciplines spanning conservation biology, ecology, historical ecology, paleontology, and archaeology. Finally, we show that conservation paleobiologists have yet to reach a consensus on how applied the field should be in practice. The survey revealed that many participants thought the field should be more applied but that most do not currently engage with conservation practice. Reflecting on how conservation paleobiology has developed over the last two decades, we discuss opportunities to promote community cohesion, strengthen collaborations within conservation science, and align training priorities with the field's identity as it continues to crystallize.

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Bringing Back Beaver in California: Lessons Learned from Changing Perceptions, Practices and Policies

Brock T. Dolman
Occidental Arts & Ecology Center, Occidental, CA USA

A vital part of aquatic ecosystems across the continent, the North American beaver (*Castor canadensis*) came close to extinction in California by the early 1900s. Thanks to the good work of many diverse advocates, this ecosystem engineer is making a comeback. Urban and rural communities are learning to partner with beaver to revive watershed health, recover endangered species and increase resiliency to drought, floods and wildfire. In this presentation wildlife biologist and beaver restoration specialist Brock Dolman, from the Occidental Arts & Ecology Center (OAEC), will share entertaining stories about how this "keystone" species went from most reviled rodent to celebrated resiliency partner in California.

Over the past quarter century, OAEC has actively campaigned to change the way California understands beaver as both a native and beneficial species. Brock will share some of OAEC's Bring Back the Beaver Campaign strategies and tactics that have worked over all these years to achieve this historic and positive statewide pivot in California's perceptions, practices, and policies towards beaver restoration. This presentation will provide a broader description of OAEC's overarching strategic approach with examples of actionable items others can adopt to enhance their own process-based beaver restoration efforts. He will illustrate that change is possible. Audience members will leave with a better understanding of the lessons learned and strategic elements of OAEC's successful Bring Back the Beaver Campaign. This story of how we won will enhance the capacity of others to adapt and integrate relevant strategies into their own efforts to change beaver restoration policy and practices.

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Process-Based Stream Restoration Effectively Alters Riparian Plant Functional Composition and Diversity

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Process-based stream restoration aims to reestablish natural rates and magnitudes of hydrogeomorphic processes. Successful treatments alter the dominant environmental filters through which riparian plant communities assemble water availability and fluvial disturbance. Life history strategies and functional traits of streamside vegetation can be used to gauge treatment efficacy. We used plant functional traits, shifts in vegetative reproductive strategies, before-after-control-impact monitoring, and Bayesian statistical analysis to determine whether process-based treatments, including beaver dam analogs and plug and ponds, effectively altered environmental conditions and achieved restoration targets. Changes in community-level functional traits and vegetative reproductive strategies provided information on whether process-based stream restoration successfully raised water tables or increased overbank flooding, and how riparian plant communities responded to ecosystem alterations. Shifts in functional traits and reproductive strategies have implications for ecosystem services including nutrient cycling, carbon storage, wetland habitat quality. They also guide whether seeding or sodding is optimal in restoring riparian zones. Bayesian analysis of BACI functional composition data provides an estimate of the probability of achieving a specific desired effect size (e.g., ≥20% in cover of obligate wetland plants). As process-based treatments become more common, our approach helps evaluate their effectiveness, aiding decision-makers and managers in balancing costs and conservation of riparian ecosystems.

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Lessons Learned from 23 Years Restoring a 55,000 Acre Residential Development in Southwest Florida

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The goal of the Picayune Strand Restoration Project is to restore sheetflow across a 55,000-acre failed residential development and adjacent public conservation lands. Restoration involves filling 41 miles of large canals to force water out onto the land surface, degrading 265 miles of roads and 65 miles of logging trams, and leveling spoil associated with these features to remove impediments to sheetflow. Construction activities are designed to restore natural hydrologic and fire regimes in Picayune to support long-term redevelopment of native plant and animal communities appropriate for existing conditions. The single most important lesson learned was that when the goal is to restore a naturally functioning ecosystem, the regular onsite personal involvement of highly qualified field ecologists who are very familiar with the ecosystem, and who have authority to make decisions about when construction criteria are being met, is required. This understanding of the site has been crucial to limiting major omissions and flaws in project design as well as facilitating innumerable smaller decisions on an almost daily basis over the course of 15 years as restoration activities proceeded across the Picayune landscape. It also allowed extrapolation of lessons learned in Picayune to a smaller but functionally similar southwest Florida project where there were serious unnecessary impacts occurring and contributed to the initial design of the even larger Western Everglades Restoration Project. Information on ecosystem conditions in hydrologically restored portions of Picayune and adjacent lands has been reducing uncertainties associated with protecting populations of endangered manatees and red cockaded woodpeckers. It is also reducing uncertainties about plant community recovery on 9,000 acres of construction footprints and the degree and extent of hydrologic impacts of major canals and what is required to reduce those impacts.

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Land Tender: A collaborative, cloud-based decision support platform for resource management and wildfire risk mitigation

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Interactions between climate warming and human impacts to landscapes and ecological processes are leading to increasing scales and velocities of ecosystem degradation. The scale and complexity of the problem are challenges to rapid, concerted management response. Key components of responding to complex, multijurisdictional management problems include (1) efficiently incorporating stakeholder input; (2) generating data/analytics that can be understood and manipulated by users; and (3) prioritizing potential investments and actions. *Land Tender*^{TM} (LT) is a cloud based, scenario-building and decision support application built to resolve these and other management issues at local, statewide, or national scales. LT incorporates high-resolution data, disturbance simulations, and optimization routines to develop a management scenario "atlas" for a given planning unit. Climate change effects can be incorporated by changing fire and drought occurrence and intensity, and by modifying site potentials. The optimization function schedules treatments based on user-generated prioritizations of "resilience" categories linked to strategic assets and resources, including water, biodiversity, carbon, economic outputs, forest resilience, and fire safety. Stakeholder participation occurs throughout the workflow; users can visualize scenario treatment tradeoffs, treatment prioritizations, and treatment sequencing. LT outputs include spatial and tabular comparisons of final management alternatives that can be exported to environmental assessments that precede implementation.

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Using Death Assemblages to Fill Historical Data Gaps and Estimate Long-Term Trends in Oyster Size

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Long-term data are critical to habitat management and restoration because they allow directional trajectories in a habitat's condition to be distinguished from natural variation (which often operates on multiple timescales simultaneously). In practice, however, most long-term datasets are too geographically or methodologically limited to fully address the information needs of resource managers, who are often responsible for monitoring multiple indicators across large geographic areas. Sedimentary records, such as death assemblages (DAs; the accumulated, identifiable remains of organisms that lived in or near the habitat in the past), are an increasingly common, but still underutilized, resource for generating location-specific historical data retrospectively and "on demand". We used DA samples from 31 oyster reefs in Florida, USA to add historical context for existing measurements of live oyster size. Despite its importance as an indicator of oyster population condition, monitoring records of live oyster size in Florida are generally short-term (~5-10 years) and recent (many post-2010). In contrast, most of the DA oyster samples pre-dated the monitoring records from the same reef by at least ~20 years, represented an averaged condition over years or decades, and were collected in a single season. We describe how trend assessments using the live-oyster monitoring data alone can differ after incorporating the historical information from the DA samples and how the study results are refining our understanding of the long-term condition of intertidal oyster reefs in several of Florida's Aquatic Preserves and National Estuarine Research Reserves. Given the ubiquity of DAs in marine sediments and the paucity of long-term information on many submerged habitats worldwide, the utility of DA data for supplementing real-time monitoring data demonstrated by our case study is an encouraging sign for the more general applicability of DA records to management and restoration of other submerged habitats in the future.

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Integrating Flood Risk Management and South Florida Everglades Ecosystem Restoration

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The Civil Works program in the U.S. Army Corps of Engineers Jacksonville District (Corps) includes water resource development activities including flood risk management, navigation, coastal storm risk management, and ecosystem restoration. In the past, these projects have been planned individually, but our current goal is to understand how these projects work together to improve the overall regional resiliency and how we can tie them together through integration. As part of the Federal resiliency effort, the Corps planning approach supports an integrated strategy for reducing coastal risks and increasing human and ecosystem community resilience through a combination of the full array of measures: natural, nature-based, nonstructural, and structural. This approach considers engineering attributes of the component features and the dependencies and interactions among these features over both the short and long term. It also considers the full range of environmental and social benefits produced by the component features. In southeast Florida, the Corps has several projects in the planning phase under ecosystem restoration (Biscayne Bay and Southeastern Everglades Ecosystem Restoration, Broward County Water Preserve Area, and Biscayne Bay Coastal Wetlands), flood risk management (Central & South Florida Flood Resiliency), coastal storm risk management (Miami-Dade Back Bay, Key Biscayne, and Dade County), and navigation (Port Everglades Deepening and Miami Harbor Navigation Improvements). All of these projects are addressing many of the same issues such as drainage and land use changes, exposure to sea level rise, flat topography, porous substrate, flood protection level of service requirements, water level requirements for different habitats, and vulnerable infrastructure. Projects across multiple mission areas can be implemented and work in coordination to achieve each project's objectives and improve the resiliency of southeast Florida. The Corps is using an integrated approach to plan and implement these projects across multiple mission areas to ensure functionality of all projects.

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Restoring and Protecting Wildlife Corridors in Urban Development: Two Front Range Colorado Case Studies

Joseph Ehrenberger *and Joshua Eldridge*
Matrix Design Group, Denver, CO, USA

Restoration of wildlife corridors often evoke an image of big game species crossings and expensive bridge projects. But what about corridors through urban and developing environments? Development should not equate to a total loss of diversity or connectivity, nor should wildlife managers be resigned to losing common species, but rather find ways to create more opportunities for human-wildlife benefits. We share case studies of conservation-minded planning and adaptive management strategies for a new community in Douglas County, Colorado, USA and a master plan for an established 90-acre park and open space surrounded by existing homes in Denver, Colorado USA. We discuss early successes and challenges we faced during ecosystem recalibration, the successional evolution of plant and wildlife communities resulting from development, and how to mindfully provide wildlife habitat in urban settings. Development that considers restoring corridors from larger game species to pollinators as well as common nuisance wildlife issues, protects developers and homeowner investments through landscape design that enhances lifestyles and allows opportunities for beneficial coexistence with wildlife. These case studies offer models for consideration when communities consider growing responsibly, and we provide additional considerations and opportunities to reduce human-wildlife conflicts.

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Innovation and Resilience in Stormwater Management and Urban Stream Restoration in the Dever Metropolitan Area

Joshua D. Eldridge
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Sanderson Gulch drains an approximately 10 mi^2 watershed from the west side of Denver to the confluence with the South Platte River (SPR). Just prior to the confluence with SPR, the gulch is constricted by road and railroad crossings that caused regular overtopping, flooding more than 100 homes and businesses. Additionally, the site is adjacent to a former radium processing facility that resulted in radioactive soil contamination. The design solution for the flooding was to split the storm flows with baseflows up to the 10-year storm event staying on the surface and replacing the concrete lined channel originally in place with a higher functioning stream system that includes meanders and an active floodplain. Anything over the 10-year event was diverted into a series of box culverts that go below the road and railroad crossings allowing increased conveyance and removing the homes and businesses from the floodplain. The contaminated soils needed to be removed from the site, but one of the unique things about this project is that it contains a series of test plots comparing the use of wood chips as a soil amendment to benefit native species by modifying the soil carbon to nitrogen ratio. This approach uses a byproduct of urban forestry operations and utilizes the wood chips to improve soil health and native plant revegetation. This presentation will present data from four years of monitoring and share lessons learned.

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Community-based Conservation: Making a Community's Vision of a Refuge a Reality

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We have all heard that engaging the communities we serve leads to greater buy in, increased support and overall greater success in our conservation efforts, but how does that work in the real world? How do you engage community members when all the decisions are already made? How do you build trust with communities to start with? How do you keep community members engaged throughout the lifespan of a project?

In this presentation, Cameron Weber, Habitat Conservation Director and Jacob White, Habitat Field Technician and Community Justice & Resilience Specialist, of Rio Grande Return, and Ariel Elliott, former Wildlife Biologist and current Deputy Refuge Manager will share the story of Valle de Oro National Wildlife Refuge in Albuquerque, New Mexico, and its mission to be built "by the community, for the community". After completing community-based site planning for the refuge, staff and partners have the difficult task of bringing the shared vision to life. Learn how the refuge continues to engage community members and how those relationships have shaped the refuge's programs, partnerships, and workforce.

Ariel Elliott is the Deputy Refuge Manager at Valle de Oro National Wildlife Refuge and works to provide support for all programs, staff, partners, visitors, and community members as the day-to-day supervisor of the refuge. Formerly, Ariel was the Wildlife Biologist for Valle de Oro NWR, working together with others to create a mosaic of natural Middle Rio Grande Valley habitats back onto the refuge. Ariel has a B.S. in Wildlife and Fisheries Science, concentration in wildlife and fisheries management, and a minor in Forestry from the University of Tennessee – Knoxville.

Cameron Weber serves as Habitat Conservation Program Director for Rio Grande Return, a non-profit devoted to the unique waters, wetlands, and wildlife of the Southwest. Cameron's projects are primarily focused on rewilding agricultural landscapes and ecological systems dependent on human participation. Cameron holds a master's of Community and Regional Planning from the University of New Mexico and has worked for over 15 years on community-oriented nature care, native plant materials development, and conservation planning.

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Merging Lessons-Learned on System Resilience and Applying Those to a New Generation of Water Resources Projects

Jason A. Engle
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The U.S. Army Corps of Engineers (USACE) Jacksonville District (SAJ) has a decades-long history engaging in large-scale Ecosystem Restoration projects. Throughout this process it has been recognized that healthy ecosystems are more resilient to extreme events (storms, drought, etc.) than unhealthy ecosystems. We are now progressing to include assessments of how these restored ecosystems will respond to climate change and evaluating different climate change scenarios as part of our project formulation process to determine tipping points and adaptation strategies accordingly.

SAJ also has a decades-long history of large-scale coastal storm risk management (CSRM) projects--primarily in the form of beach and dune restoration. The use of nature-based renourishment of shorelines with native/compatible sand has resulted in CSRM projects that look and function as if they were intended to be Ecosystem Restoration projects. Resilience from events (storms) is the primary goal of CSRM and the projects have proven highly effective in this regard with very little economic damage from flooding at our projects across almost 50 years of storm exposure. However, owing to the fact that the economic benefits are achieved through restoration of natural beach and dune systems, these projects also greatly enhance the resilience of their coastal ecosystems.

Jacksonville District is now taking these decades of experience and success and bringing that to bear on the places that lie between the Ecosystem projects and the CSRM beach projects--urban bay and estuarine communities where climate changes are significantly increasing flood risk. SAJ has formed multidisciplinary teams, comprised of experts from our Ecosystem and CSRM programs, to study and develop solutions for these areas that connect our existing programs. This presentation will discuss examples of resilience from the Ecosystem and CSRM programs and how those are being used on this new generation of studies and projects.

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Metrics for Success – Pre-& Post-Restoration Monitoring for Urban Streams

Matthew English and Josh Burch
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Pre and post-restoration monitoring data are essential for showing that environmental projects achieve project goals. Many stream restoration practitioners struggle to capture the necessary data to show environmental uplift because monitoring may be limited by project budgets or simply designed to meet regulatory requirements rather than intentionally planned to detect targeted improvements. The Department of Energy and Environment (DOEE) reviewed the pre and post-restoration monitoring data for over 10 stream restoration projects in the District of Columbia to evaluate the effectiveness of stream monitoring in demonstrating environmental uplift and to provide guidance on monitoring program improvements. This presentation provides an analysis of biological, physical, and chemical parameters collected for constructed stream restoration projects and provides a discussion of how sampling plan frequency, timing, and duration impact the ability to display environmental improvement. This presentation also investigates the role of monitoring in long-term project site maintenance and adaptive management. In addition, examples are provided to show how technology is being used to enhance stream monitoring programs in Washington, DC. Lastly, suggestions are provided to help practitioners re-think monitoring plans and to encourage a holistic view of monitoring that will be effective for meeting the needs of a variety of stakeholders.

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Monitoring the Picayune Strand Restoration Project: Macroinvertebrate, Anuran, and Fish Communities

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The Picayune Strand Restoration Project (PSRP), part of the Comprehensive Everglades Restoration Project (CERP), is intended to restore hydrology and habitat to the former Southern Golden Gate Estates (SGGE), Collier County, Florida. The SGGE was a residential development, which began by digging canals, establishing a network of roads, and selling lots for homes. The PSRP is now an on-going 55,000-acre restoration project initiated in 2004. It includes the removal of the roads, plugging of the four large canals, and construction of three pumping stations to prevent inland flooding to the Golden Gate Estates community. Baseline bioindicator surveys were conducted between 2005 and 2007 at impacted (drained) wetlands in PSRP and reference wetlands in Fakahatchee Strand Preserve State Park and Florida Panther National Wildlife Refuge. The monitoring program has evolved to include unrestored/drained, hydrologically restored, and reference sites for comparison. Monitored habitats include graminoid (wet prairie), cypress-graminoid, and cypress. We report on the results of the on-going monitoring program that includes aquatic macroinvertebrates, anurans, and fish. Compared with baseline surveys, subsequent monitoring events indicate change in community structure of the restored sites toward reference conditions but significant differences between restored and reference wetlands remain. The invasion of exotic Cuban treefrogs (*Osteopilus septentrionalis*) and exotic fish, particularly the African jewelfish (*Hemichromis letourneuxi*), has limited the ability to use methods employed during baseline sampling events to evaluate restoration success for anurans and fish. It is not yet clear if this is an artifact of sampling method bias or species competition/displacement. Macroinvertebrate communities remain reliable indicators of restoration success using the same sampling methods. The monitoring program is a creative collaboration among a non-profit organization, private industry, a public university, and graduate student research projects to efficiently explore the restoration progress.

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Smokey the Beaver: How Beavers Build Fire-Resistant Riverscapes

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Beaver dams and beaver mimicry (e.g. Beaver Dam Analogs) are gaining popularity as a low-cost, nature-based strategy to build climate resiliency at the landscape scale. Though once abundant on this continent, beavers were pushed to near extinction during the Fur Trade. With the loss of beavers came vast losses in beaver-engineered wetlands. Beavers slow and store water in their ponds, canals, and the surrounding soil during wet periods which can then be accessed by riparian vegetation during droughts. As a result, the well-watered vegetation in beaver-dammed riparian corridors is less flammable. Recent research has shown that these beaver-influenced patches of the landscape stay green and can serve as fire refugia, preserving intact, mature riparian habitat, even during megafires. Modern riverscape restoration has increasingly looked toward beavers as inspiration, or even partners, in ecological restoration. And now our data suggests that we could benefit from partnering with beaver's ecosystem engineering to achieve many of our wildfire and climate resilience-related restoration goals as well.

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Identifying Important Considerations for Successful Bunchgrass Restoration from Seed

Jennifer M. Fill*, Debriana Love, April Zee, Sarah Tevlin, Hector Perez, and Raelene M. Crandall*
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The first few years of ecosystem restoration are undoubtedly the most challenging and uncertain. Restoration practitioners benefit enormously from information on methods that could circumvent limitations or improve progress toward objectives. We started a field restoration project to examine how using different seeding rates and managing competition with regrowing vegetation affected restoration of wiregrass (*Aristida beyrichiana*) in a degraded pine savanna in Florida. Wiregrass is a native bunchgrass typically included in restoration projects because its flammability promotes the spread of fires that are important for maintaining pine savannas. We set up plots with different seeding rates (10 lbs/acre, 15 lbs/acre, 25 lbs/acre) and levels of competition (weeded or not weeded). Given evidence for wiregrass ecotypes, practitioners advise that seeds be obtained from local areas, and to source and plant seeds into similar soils. We, therefore, replicated the Latin square design using wiregrass seeds from locations with dry and wet soils sown into dry and wet plots in our study site. We tested whether the seed source, soil type, seeding rate, and competition with regrowing vegetation affected wiregrass density, growth, and reproduction in the field. We found that competition removal resulted in significantly larger plants and a greater proportion of reproductive plants with more culms. Seeds sourced from the wet site resulted in more plants per plot than seeds from the dry site, likely because of differences in initial seed viability. None of the wiregrass variables we measured differed between seeding rates. Although manually weeding restoration plots might prove impractical on a large scale, competition removal could be feasible on smaller-scale restoration projects if the goal is to increase the density of germinating and surviving plants. Most importantly, however, our findings add to a predominance of evidence that seed viability is a critical consideration for wiregrass restoration projects.

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The Binational Effort to Restore the Colorado River Delta

Karl W. Flessa*[1], *Martha Gómez-Sapiens*[1], *Roberto Real Rangel*[2] *and the Binational Science Team

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Treaty agreements between Mexico and the United States allocate water and funding for the restoration of riparian habitat along the 136 km course of the Colorado River from the border to the Gulf of California. A binational team of scientists from government agencies, universities and non-government organizations monitors restoration progress.

Efforts began in 2014 with a two-month long "pulse flow" that briefly re-connected the river to the sea. Active restoration followed: removing invasive saltcedar, grading and contouring sites, planting native vegetation, post-planting care and irrigation. Pronatura Noroeste, Restauremos el Colorado and the Sonoran Institute each manage a restoration area. Each group now builds community support through outreach programs. Raise the River/Alianza Revive el Río Colorado, a consortium of six environmental groups, provides funding for purchase or lease of water rights held by local farmers. Water is delivered to sites through the regional system of irrigation canals. Efforts have resulted in a total of 572 hectares of marsh, cottonwood-willow, mesquite bosque and adjacent upland vegetation. The restored habitat has increased the abundance and diversity of priority bird species and attracts other wildlife – including beavers.

The U.S. and Mexico each provide water equal to the amount arranged by the environmental consortium. To date, half of this "federal water" has been delivered as two five-month, in-channel flows delivered just upstream of two of the restoration areas. In-channel flows recharged local groundwater, reduced salinity in the upper estuary and provided recreational benefits to local communities. Benefits to vegetation and birds from the in-channel flows have been relatively modest.

Ten years of efforts have been successful. The current treaty agreement extends through 2026. Continuation and expansion of restoration efforts depend on funding, the availability of water and a new binational agreement.

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Marsh Lake – Project History, Vegetative Response, Monitoring and Observations of Shorebirds and Muskrats.

Walt Gessler

Minnesota DNR, Division of Fish and Wildlife, Watson, MN USA.

Marsh Lake, located in west-central Minnesota, is entirely within the Lac qui Parle Wildlife Management Area. This presentation will review the history of this project and document important steps starting in the 1930's until project completion and final implementation. Changes in aquatic vegetation over several decades and response of vegetation to the initial drawdown will be discussed. As part of our monitoring of environmental changes, observations and monitoring of shorebird and muskrat (*Ondotra zibethicus*) response to habitat changes will be discussed.

The Marsh Lake Dam was originally established as a water conservation and flood control project in the late1930's by establishing a fixed crest dam and re-routing the Pomme de Terre river. Over several decades, it became apparent that the original project was not meeting objectives and producing negative environment affects. Over the course of several decades, beginning in 1985, discussions began to modify the dam and facilitate the ability to alter water levels on Marsh Lake. Over the course of the next 34 years through multiagency planning and coordination a final ecosystem restoration project was brought to completion and implementation.

One of several aspects of our monitoring of this project was to document shorebird use of the lake during the drawdown. Citizen observers were recruited to make observations of species use and numbers. The drawdown attracted large numbers of shorebirds. 25 different shorebird species were identified totaling over 28,000 individuals.

A two-year drawdown of Marsh Lake produced a dramatic change in vegetation conditions. A nearly 5500-acre lake that was nearly devoid of vegetation, saw a significant increase in emergent vegetation present on the lake along with some increases in submerged aquatic vegetation. Emergent vegetation coverage increases from approximately 1000 acres to over 4000 acres occurred after the drawdown. Submergent vegetation also increased, although increases have not been as significant.

One aspect of monitoring that was added later was changes in muskrat use of the lake. Muskrats can be viewed as a keystone species or ecosystem engineer in prairie wetlands by changes they produce in habitat conditions through their grazing and house building. We used November satellite images to document changes in muskrat house numbers post project completion.

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Enhanced Natural Areas: Impacts on Chatfield Farms

Erik Geyer
Denver Botanic Gardens Chatfield Farms, Littleton, CO, USA

Denver Botanic Gardens Chatfield Farms is working to create replicable approaches to converting non-native areas into diverse native plant communities. The long-term stability of our plantings is directly related to site preparation, minimizing soil disturbance, seed treatment, and variable introduced disturbance. Our goal is to promote a biologically active environment to maximize seed germination and early establishment. Recruiting a diverse set of perennial roots will jumpstart the soil building process and increase the potential of our soils overtime. Management of above ground biomass plays a key role in how we maintain species diversity. Our methods for reconnecting the sun to the soil can be adapted and applied to a variety of plant material and ecosystems.

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An Analogy to the Natural Flow Regime: Quantification of River Drying with Satellite Imagery

Eliza I. Gilber

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Most rivers around the world are regulated making downstream ecosystems reliant on human management and the natural flow regime paradigm was developed to support regulated river management for ecosystem function. The paradigm suggests hydrograph components (e.g., magnitude, duration, frequency, etc.) drive fish-flow relationships. However, our ability to mimic the natural flow regime is diminishing as human demands and climate driven aridification causes perennial river drying and increased intermittency in naturally intermittent rivers. Here we use a rare dataset from the Rio Grande to assess fish-drying relationships with the idea that drying components, analogous to hydrograph components, can be used to understand how resilient different fish species are to drying. We then assess the feasibility of using satellite imagery of two southwestern rivers to develop a similar river drying dataset. Our results suggest drying components predict the decline or persistence of Rio Grande fishes. Use of satellite imagery to detect and quantify river drying is feasible but some aspects of southwestern rivers such as narrow their widths, riparian species composition, and sediment laden monsoonal water can confuse common algorithms used to remotely detect water.

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Puget Sound Recovery: Partnering with Federal, State, and Tribal Governments on Fish Passage and Nearshore Restoration on Multiple-Benefit Projects

Nancy Gleason *and Jessie Winkler*
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The Seattle District USACE is effective in coalition building to support large-scale ecosystem restoration projects with multiple benefits in Puget Sound. Many of these projects focus on restoring habitats for ESA-listed salmon species, which thereby benefits the ESA-listed Southern Resident killer whales that prey on salmon. Challenges include working in the transportation arena, which is not a USACE mission, and developing unique engineering solutions that are still in research and design. Two case studies for projects with multiple benefits and challenges are the Duckabush Estuary causeway replacement and the Howard Hanson Dam downstream juvenile fish passage facility.

The Duckabush Estuary aquatic ecosystem restoration project involves removing two bridges and substantial fill across the mouth of the river and replacing a segment of State Route 101 with an elevated bridge. This ecosystem restoration project will open a free-flowing river outlet and tidal channels, restoring tidal wetlands and estuarine mixing habitats for greater biological diversity including ESA-listed salmon. The project benefits transportation by replacing nearly 100-year-old bridges. Partners include WDFW and WSDOT, and coordination with the Skokomish Indian Tribe due to interests in shellfish harvesting at this location.

Howard Hanson Dam provides flood risk management to Seattle and King County, Washington and provides additional municipal and industrial water supply for Tacoma. The USACE will construct a downstream fish passage facility at this high head dam in partnership with Tacoma Public Utilities who has already constructed the upstream adult fish passage facility. Coordination includes working with the Muckleshoot Indian Tribe to support salmon resources in their Usual & Accustomed fishing areas and to ensure maintenance of Tribal Treaty Rights. The USACE is also collaborating with a technical working group to include biologists and engineers within NOAA Fisheries, WDFW, and King County.

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Genetic Variation & Local Climate Adaptation in Grassland Species: Implications for seed sourcing

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Planting native species is a proactive approach that can be effective in restoring biodiversity and ecological function following ecosystem degradation. Semi-arid grasslands, a dominant biome in the western United States, are becoming increasingly degraded by human impacts and the effects of climate change. Following grassland disturbance, a primary aim of active restoration is rapid establishment in current conditions as well as long-term persistence in a changing environment. Wild-collected seed may have advantages in addressing this aim due to the presence of genetic diversity that has evolved as species have adapted to a range of natural habitats. In turn, this genetic diversity can be crucial for restored populations to adapt to the myriad of selective pressures that may be encountered following planting. However, determining where to source genetically appropriate seed for a given restoration project is challenging. To better understand and address this challenge, we are conducting a multi-year field-based common garden experiment at Denver Botanic Gardens Chatfield Farms in Colorado. Common garden experiments can be used to quantify levels of genetic variation (both within and between populations), and to assess local adaptation to key ecological drivers, such as climate. We are using seed collected by the Bureau of Land Management's Seeds of Success (SOS) program for four focal species: one grass (*Boutelua gracilis*), one shrub (*Ericameria nauseosa*), one sub-shrub (*Artemisia frigida*), and one forb (Penstemon virens). In this highly replicated study, we are growing individuals from multiple (6 to 21) populations, sourced from a range of habitats in the western U.S. This experiment was initiated in 2022; data collection includes plant growth rate, size, leaf characteristics, flowering phenology, and reproductive output. Results show considerable variation in traits between populations and differing levels of intra-population variation. We identify climate variables with strong correlations to several traits in each species.

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Colorado River Basin Aridification and Resource Management in Grand Canyon, Arizona (USA)

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The Colorado River is both an essential source of water for agriculture, cities, and industry in the western US and the focal point of the landscape of the Colorado Plateau, including several of the nation's most unique and valued National Parks and Recreation Areas. Although water needs of these landscapes was not considered at the time water allocations were first negotiated, these needs were recognized in subsequent legislation and policy. Management goals span a range of aquatic and riparian resources, including fine sediment (sand, silt, and clay) which, in Grand Canyon, is important for ecological, cultural, and recreational resources. Over ~30 years, stakeholders, resource managers, and scientists collectively developed operational strategies for sediment management to meet goals outlined by an adaptive management program. However, prolonged drought, or "aridification," resulting in declining runoff and the lowest reservoir storage levels in decades has challenged those strategies. The paradigm for sustainable sediment management relies on (1) sand accumulation on the bed of the Colorado River during periods of sediment-rich floods from tributaries in the summer/fall monsoon season, and (2) dam-released high-flow experiments (HFEs) to redistribute the accumulated sand to rejuvenate bar and floodplain deposits. Lower dam releases associated with drought have changed the pattern of sand accumulation and low reservoir levels have prevented the implementation of high flows following the existing management protocols. We present preliminary findings from a test of an alternative strategy for HFE planning and implementation which indicate that management goals for sediment under conditions of prolonged drought may be achievable but will likely require substantial changes in dam management strategies.

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Lessons Learned Using Stream Morphology and Simple Erosion Control Structures from the Past Decade that Improve Longevity and Project Performance

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The use of simple erosion control structures, one-rock-dams, rock sills, trincheras, etc have gained great popularity in recent years. Ease of construction, relative cost and effectiveness are driving increased and widespread use. While generally effective, failure rates can be high if hydrology, hydraulics and basic channel morphology are not incorporated into the design of the structures. The type of practice and design should be appropriate for the goals of the project rather than using a one size fits all approach. The shape, dimensions and spacing of the structures should be adapted to provide for simple grade control, management of channel aggradation, or complete obliteration of the channel as appropriate to the project goals. Even when channels are relatively small, attention to appropriate channel dimensions, planimetrics, riffle and pool spacing can greatly enhance the longevity and success of the structures. Additionally, a simple method for estimating hydraulic forces and appropriate rock size is provided using stream competency techniques.

These methods are offered as a relatively simple and accessible field techniques that can enhance the success of erosion control projects without the need for full scale engineering analysis. They are not meant to replace engineering analysis in areas where the consequences of structure failure can lead to the loss of infrastructure or the compromise of human safety.

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River Restoration Opportunities in the Middle Rio Grande even in a Water Uncertain Future

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The Rio Grande has changed rapidly in the past century primarily due to human intervention, from historically highly variable spring and monsoonal flows accompanied with widespread flooding and massive sediment movement along with extensive periods of drought and river drying into segmented river sections of controlled flows between dams to supply water for agriculture and reduce flooding to allow for development. Surface water was apportioned on the Rio Grande in the early 1900's between the states of Colorado, New Mexico, and Texas without attention to the ecological impacts on the river with the result that many native fishes were extirpated or became extinct and riparian habitats and wetlands were lost. With changing regulatory and societal values, restoring wildlife habitats particularly for federally listed threatened and endangered species, such as the Rio Grande Silvery Minnow and Southwestern Willow Flycatcher, within the remaining floodplain of the Middle Rio Grande has become a critical part of many federal, state, and local water manager's objectives while continuing to achieve their core missions. The New Mexico Interstate Stream Commission and the Middle Rio Grande Conservancy District have worked closely with other stakeholders to address multiple challenges in the Middle Rio Grande that affect the ability to deliver irrigation water, ensure interstate stream compact obligations to downstream water users are met, and manage and restore native plant communities and processes in rapidly changing climate, ecosystem, and water resource conditions. Examples of work include removing lateral constraints in the river, manual redistribution of sediment and vegetation, creating pulse flows for spawning fish, native vegetation planting, creation of habitat features, strategically providing water at irrigation outfalls, managing for fire, rehabilitating fire-scarred lands, and participating in water conservation and adaptive management.

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The Bois d'Arc Lake Mitigation Project: A Watershed Scale Ecological Restoration

Matt Stahman *Presented by **Brandon Hall***
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In 2022, the North Texas Municipal Water District completed the construction of a new surface water reservoir in Fannin County, Texas, to supply a growing regional population; the first reservoir in Texas in approximately 30 years. Environmental impacts from the resulting Bois d'Arc Lake are being mitigated by restoring, enhancing, and preserving ~15,000 acres of wetland and upland habitats and 69 miles of ephemeral, intermittent, and perennial streams within the same watershed on three Permittee Responsible Mitigation (PRM) sites. Much of this restoration takes place on Riverby Ranch, formerly used for agriculture and livestock production for over 100 years. The project includes ~8,500 acres of forested, emergent, and scrub-shrub wetlands, ~2,600 acres of upland forest and riparian woodlands, and ~3,300 acres of native grassland restoration and enhancement, as well as ~24 miles of Priority 1 stream restoration and ~45 miles of stream enhancement. Restoration and perpetual protection of these habitats will decrease erosion, sedimentation, and nutrient loads in a significant portion of the Bois d'Arc Creek watershed that drains into the Red River between Texas and Oklahoma. This presentation will provide background on the development of the Bois d'Arc Lake Mitigation Project as well as the status of construction, monitoring, and maintenance, including a discussion of the project's cornerstone Willow Branch stream and floodplain restoration, which resurrected over two miles of abandoned stream channel and adjacent wetlands. We will discuss the variety of habitats on-site, restoration techniques employed, and lessons learned to date on ecological restoration at this scale.

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Vital Signs and Vibrant Lives: Ecosystem Restoration and Wellbeing in Puget Sound

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Ecosystem recovery is intricately linked to human wellbeing. Human wellbeing in this context is an interdisciplinary perspective on what allows humans to thrive in relation to the natural environment and entails values, physical and psychological health, governance, and social, cultural, and economic wellbeing. In the Puget Sound region, ecosystem health and recovery include both biophysical and human wellbeing goals. The "Puget Sound Vital Signs "measure progress toward these goals. To monitor Vital Sign indicators of human wellbeing, we conducted three mail surveys of the general population between 2018 and 2022. These surveys tell us about Puget Sound residents' personal feelings and experiences with the environment. However, the survey may not adequately capture the perspectives and experiences of minoritized and overburdened populations. Through community-based participatory research approaches and additional optional surveys with Latinx, Asian American and Pacific Islander and Black and African American residents, we established new community partnerships while also gaining insight into how well the Vital Signs resonated with different communities. This raised essential questions about equity in environmental experiences, benefits, and barriers. To navigate these questions, the *Puget Sound Equity Guidebook* provides a comprehensive framework for ensuring that ecosystem monitoring is inclusive and addresses challenges impacting diverse communities. Our goal with this presentation is to help inspire more dialogue about the importance of considering human wellbeing as part of ecosystem restoration and how to embed an equity lens within monitoring and reporting.

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How Connected Are Your Food Webs? How to include hydrogen stable isotopes in stream restoration monitoring

Gregor L. Hamilton*, Thomas F. Turner*
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A key goal of many stream restoration projects is to reconnect the severed ties between aquatic and riparian food webs. There are several ways to understand food web processes, each with their pros and cons. Stable isotopes analysis of carbon and nitrogen is traditionally used to define food web structure by tracing primary production resource use and estimating trophic positions, but these have limited applicability to understanding connectivity between adjacent food webs. Doucett et al. (2007) showed the potential for discriminating between aquatic and terrestrial primary production resource use using hydrogen stable isotopes. Here we compiled the most comprehensive hydrogen stable isotope dataset, to our knowledge, of aquatic and riparian producers and consumers. We were able to discriminate aquatic and terrestrially derived resource use among consumers along a clear gradient. There is clear potential for hydrogen stable isotope analysis to be a tool for monitoring stream restoration success.

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Tasking High-Resolution Satellite Imagery for Monitoring Ecosystem Projects

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The Corps of Engineers St. Paul District's GIS team is a part of an adaptive management team tasked with monitoring the Marsh Lake Habitat Enhancement Project. This ecosystem project is located on the Minnesota River in West-Central Minnesota and is a multi-agency 15-year effort to return Marsh Lake to a less degraded and higher functioning condition. One of the key project objectives is to restore aquatic and emergent vegetation to the lake which had almost disappeared by the 1990s. The GIS team's role is to collect new imagery that would assist in determining how the vegetation in Marsh Lake responded after the construction of project features in 2020. High-resolution air photo and satellite imagery (<1m) can help visualize, monitor, and analyze an active or completed ecosystem project. However, finding imagery with site level detail during a specific time of year is challenging and costly. Publicly available air photo imagery from the Farm Service Agency provides high-resolution imagery but is generally flown every two years and only during the summer months. Publicly available satellite imagery from the Sentinel-2 satellite can provide imagery for most clear days but is lower resolution (10-20 meters) making it difficult to see site details. Contracting a plane or drone crew will provide high-resolution detail and timely collects but can come with significant costs. Today it is possible to task a high-resolution satellite to capture imagery over large expanses of land during a specific time frame with less costs than ever before.

The GIS team was given an area of interest which covered approximately 5,665 hectares. The anticipated image collection needed to have significant detail (less than 1m cells) and be collected once per month during the growing season. Given these requirements, the GIS Team worked with the Army Geospatial Center's Aerial Imagery Office to task a satellite for this data collection effort starting in 2022.

Between May 2022 and November 2022, six high-resolution (50 cm) true color and color infrared satellite (Pleiades) images were collected. The images were shared with the adaptive management team and published to a public ArcGIS StoryMap. The images have shown an increase of emergent and submersed aquatic vegetation which can damper wave action and filter nutrients, thus improving water clarity. The collection effort has continued into 2023 with six more expected images for viewing and analysis. To better determine specifics, an ongoing GIS imagery comparison analysis is being run by the GIS team to determine the approximate acreage change of open water and emergent vegetation from 2015 to 2023 using pre-project and post-project aerial imagery during the month of August. The imagery analysis results will be shared at the end of 2023 with project sponsors and the public.

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Assessing the Social Suitability of Managed Aquifer Recharge Sites

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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 uncertain 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 the acceptability, perceptions, and knowledge of MAR among members of the Army Corps and stakeholders across the United States who could be impacted by and benefit from MAR. Here we present early findings from the Army Corps sample, as well as anticipated results from the stakeholders' sample. This method could be readily 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 MAR, 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 policy makers to better understand how the tool can help them in their decision-making.

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The Habitat Suitability Index: Strengths, Weaknesses, and Emerging Opportunities via Model Validation

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Habitat Suitability Indices (HSI) are a means to characterize the quality of habitat available for a particular taxa on a 0 to 1 scale from hostile to ideal environmental conditions. The index transforms qualitative concepts about a species niche into a quantitative metric that can be measured over space and time. The method is flexible to many applications, including modularity to focus on different species, regional locations, life stages, or habitat function (e.g., foraging, breeding). HSI is also intuitive and easy to set up in numerical models or spatial analysis. Finally, the parameters selected for HSI (e.g., depths, velocities) can be directly connected to design criteria.

Despite its popularity, HSI has shortcomings. An HSI may not perform well because of errors during habitat conceptualization, including underestimating the importance of temporal variability, species competition, or even environmental parameter selection. Additionally, there are pragmatic challenges related to the availability of observational data, how these data were collected or summarized, and the algebraic computation of the HSI. However, there are several techniques that can improve the effectiveness of HSI in field application, including desktop validation, probability analysis, and re-parameterization through monitoring in adaptive management. Furthermore, coupling habitat models with physical models, such as hydrologic and hydraulic engineering models, allows for inference to be made at a wider range of environmental conditions, improving scenario analysis, and model prediction capabilities.

The purpose of this presentation is to discuss the opportunities and pitfalls in HSI development and demonstrate how to improve the implementation of HSI for ecosystem management. Examples are focused on riverine habitats and leverage environmental flows analysis and hydraulic models. Methodologies to validate HSI at various temporal and spatial scales will be discussed. The nexus of river engineering, planning, and ecological expertise is emphasized as necessary interdisciplinary collaboration for effective HSI development and application.

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Scaling up Native Seed Production to Improve Plant Restoration Material on the Colorado Plateau

***Audrey Harvey**, Dr. Amy Whipple , Dr. Liza Holeski, and Dr. Karen Haubensak*
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The Southwest is experiencing unprecedented severe to extreme drought which will have lasting effects on plant germination, production, and regeneration. Wild seed stock limitations are known to occur in the Western U.S., where drought conditions are prolonged and severe and have led to extensive lack of wild native seed for restoration projects. Under these conditions, we also aim to understand how plant traits evolve and are expressed over time. One avenue that traits are passed on is through maternal effects, in which the offspring expresses a phenotypic response driven by its development in its maternal environmental conditions. Over generations, the selecting for certain adaptive traits leads to that maternal effect that persists in the population, such as traits that determine drought resistance. This research examines the utility of maternal effects for the purpose of improving restoration material on a large-scale.

Studying the extent of maternal effects and phenotypic plasticity in multi-generational species like perennial forbs poses challenges in field and greenhouse settings. Consequently, the dynamic expression of adaptive traits within each generation necessitates further research on the persistence and extent of such traits in perennial offspring species. A common garden experiment was conducted in summer 2021 and 2022 to compare traits (i.e., plant height, survivorship, peak flowering, and seed set) of maternal plants that grew in varying arrangements of fertilizer and irrigation treatments to create a manipulated environment the plants experience. In summer 2023, greenhouse experiments will assess offspring traits with those of their maternal lineages. We will assess the degree of maternal effects and their potential heritability to better understand underlying mechanisms of heritability as it relates to provenance. This research aims to enhance restoration materials by providing insights into strategies that can be employed to optimize sourcing plant material for habitat improvement. Large-scale restoration projects often require the propagation and establishment of numerous plant species, and incorporating maternal effects into the selection and cultivation process could improve the performance and resilience of restored ecosystems.

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Managing Wetlands for Fish and Fowl

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Understanding the role of the Sacramento-San Joaquin Delta as rearing habitat for juvenile salmon has been identified as a critical scientific gap for stock-specific life cycle models guiding salmon management and the development of novel actions to improve this habitat (Lindley NOAA and J. Peterson USGS, pers. comm.). To test the current assumptions of these models, a previous Proposition 1-funded study quantified how habitat attributes and the network location of marsh habitat in the Delta influenced the observed use and growth of juvenile salmon. This study confirmed that salmon fry rear in Suisun Marsh, with smaller fish encountered more frequently around waterfowl ponds and larger fish in closer proximity to the migration corridor. Although results are still preliminary, the study also found that juvenile salmon in enclosures grew faster and larger in cages placed in channels connected to large off-channel water bodies. The purpose of this study is to determine to what extent management of water exchange between off-channel waterfowl ponds and marsh channels can improve trophic subsidies and growth rates of fish using these nursery habitats, employing juvenile salmon as a model species.

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Modeling the Effects of Climate Change and Potential Management Interventions on Pinyon Juniper Woodland Distribution Using Aerial Imagery

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The piñon-juniper woodlands of the semiarid southwest have been in a rapid decline in mortality due to droughts intensified by climate change. These woodlands have historically been identified as being a drought hardy ecosystem. Under climate change, they have approached a threshold where drought induced mortality is occurring. The loss of these ecosystems can be an area of concern for many Native American tribes within the Southwest as the pinyon pine is a cultural keystone species. Specifically, it is of great importance to the identity of the Diné and for the advancement of biocultural conservation efforts within their communities. A way to help mitigate and monitor the change of these woodlands is by analyzing aerial imagery provided by the National Agricultural Imagery Program, the Federal Inventory Analysis National Program, and other data sets. This data will be used to develop large scale maps displaying the species distribution of areas where stands of pinyon juniper woodlands have recently died back by combining remote sensing data calibrated with FIA overflight data to estimate pinyon mortality using ArcGIS Pro software. The data will be analyzed to potentially gain more detailed information to provide a 'why' for trees that are dying in specific geographic ranges that can involve soil types and bedrock or identify why they are thriving. This project has the potential to be used to develop models and maps depicting areas of potential future mortality and/or recruitment for conservation, restoration, and general forest management purposes.

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Post-Channel Widening Water Quality Monitoring at Bahia Grande, Cameron County, Texas

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Passive restoration of the Bahia Grande estuary was initiated in 2005 through construction of a narrow pilot channel, 4.5 m wide, 685.5 m long, connecting it to the Brownsville Ship Channel and filling the >25 sq km basin for the first time in over 70 years. A monitoring program (2005 – present) identified the occurrence of extreme hypersalinity events (>70 psu) over large portions of the basin that interrupted and redirected benthic and nekton community succession. These extreme hypersalinity events resulted in shifts away from the desired outcomes of restoring associated ecosystem services for ecologically and economically important fauna and wildlife. In July 2022, the pilot channel was widened to 45.7 m. The anticipated result was an estimated 4-fold increase in tidal exchange from ~7% to ~30% of the total water volume exchanged per tidal cycle and a more moderate basin-wide salinity regime. Post-channel water quality monitoring employed continued use of three permanent water quality monitoring stations established in 2005 for comparison with historic data. In addition, a 71 point-station grid was sampled in 2019 (pre-widening) and in 2023 (post-widening). Data collections included measurements of dissolved oxygen, pH, salinity, conductivity, water depth, and water temperature. Post-widening water quality monitoring indicates extreme hypersalinity and hypoxic conditions continue to persist in the largely hydrologically isolated northern compartment (~2/3rds the total basin area) and relieved temporarily by episodic rainfall. An abandoned railroad causeway (~4.5 km) bisecting the basin is a known barrier to tidal exchange. A system-wide hydraulic circulation model is recommended to inform natural resource management decisions for modifying the railroad causeway to improve tidal circulation to the northern compartment and passive restoration of an additional ~770 hectares of habitat.

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Overview of US Army Corps of Engineers Tribal Partnership Program and Working with Tribal Nations

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The U.S. Army Corps of Engineers (USACE), the Nation's environmental engineers, play a pivotal role in water resources development projects, including ecosystem restoration. In recent years, USACE has been developing strong partnerships with Tribal Nations under the Tribal Partnership Program. These collaborations incorporate indigenous knowledge into USACE planning processes to better align with the diverse ecosystem needs of Tribal communities. These projects serve as a beacon of cooperation and respect for Tribal heritage while advancing the common goal of ecological and community resilience.

USACE's engagement with Tribal Nations is deeply rooted in our Tribal Policy Principles: 1) Recognition of Tribal Sovereignty; 2) Honoring the Trust Responsibility; 3) Engaging in Government-to-Government relationships; 4) Engaging in Pre-Decisional Consultation: 5) Promoting Self Reliance, Capacity Building, and Growth; and 6) Protecting Natural and Cultural Resources. The Tribal Partnership Program was first authorized in the Water Resources Development Act (WRDA) of 2000 and has been amended in each subsequent WRDA bills. The most significant amendments were authorized in WRDA 2016 when the study only authority was expanded to include design and construction up to a specific dollar amount authorized by Congress.

Through the Tribal Partnership Program and the integration of indigenous knowledge, restoration efforts will draw upon the wisdom passed down through generations. This approach not only enhances the effectiveness of ecosystem restoration but respects and preserves the unique cultural heritage of Tribes. Furthermore, these collaborative efforts strengthen the connection between Tribes and their natural and cultural resources. This holistic approach contributes to the overall well-being and self-determination of Tribal Nations.

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Great Lakes Pollinator Task Force: Collaboration to Overcome Conservation Challenges

Meredith Holm
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Native insect pollinators are important components of ecosystems, acting as keystone species, providing ecosystem resilience and economically important ecosystem services. Several pollinator species have demonstrated significant population and distribution declines across the U.S., including within the Great Lakes Basin. Critically, some species are now facing extinction, such as Poweshiek skipperling, Mitchell's satyr butterfly, and rusty-patched bumble bee. Other once-common species are now being considered for protection under the Endangered Species Act, such as monarch butterfly and American bumble bee, species that could be representative of declines in other pollinators in the region.

The Great Lakes Restoration Initiative (GLRI) Pollinator Task Force, funded through the Environmental Protection Agency, is a collaborative, multi-agency team whose mission is to increase pollinator community resiliency, reduce or eliminate the future need to list native insect pollinator species under the Endangered Species Act, restore diverse interconnected pollinator habitat, and increase awareness and knowledge of Great Lakes native pollinator conservation issues and collaborative efforts. The Task Force hopes to initiate a paradigm shift in the way restoration work is carried out by pulling together a diverse stakeholder group, incorporating innovative science that directly informs on the groundwork and prompting land managers to be more mindful of impacts on and benefits to pollinators in habitat restoration or management efforts.

With a focus on native bees, the Task Force is working with partners, across multiple scales to identify, prioritize and refine activities and focus areas for habitat restoration within the Great Lakes Basin in the face of many threats, how to communicate the importance of these conservation efforts to multiple audiences and how to work more effectively as a team. This presentation will review challenges faced and lessons learned by the Task Force that can aid conservation efforts far beyond the boundaries of the Great Lakes Basin.

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National Park Service DEWA Watergate Wetlands Restoration Project: Restoration for Today and the Future

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As a result of climate change effects causing changes more rapidly, wetland managers have to embrace a new approach when designing wetland restorations by no longer designing just to predisturbance conditions, but designing restorations that will also facilitate adaptation and long term resiliencey. The National Park Service proposed to restore wetlands associated with Van Campens Brook at the Watergate Recreation Site by removing artificial dams and ponds, thereby reestablishing its floodplain connection. Restoration efforts were conducted as compensatory mitigation for unavoidable impacts on wetlands associated with a transmission line project. WSP USA, Inc. provided full design, permitting and construction services to achieve a high-functioning wetland and riparian floodplain system with more natural fluvial dynamics.

The Watergate site is a critical host to multiple special status species documented within the New Jersey Categorial 1 waterway of Van Campens Brook, in which its watershed and resource value is solely contained within NPS property. To develop the overall restoration approach, multiple design studies were conducted, including Hydrologic and Hydraulic modeling, climate resiliency adaptation, geomorphology and reference site surveys, topographic survey, soil investigations and beneficial reuse classification, cultural resource investigations, T&E surveys (flora and fauna) and mitigation plans, and invasive treatment management. Key to the design and sustainability of the site was the evaluation of impacts to designed habitats as a result of climate change. Utilizing over 20 climate models to develop a regionalized temporal model, daily precipitation, evapotranspiration and storm frequency rainfall depths were projected to 2100. The impact of these projected future climate conditions were used to evaluate the adaptability of the design. Adjustments were then incorporated into the restoration design to allow for the natural lateral migration of wetland habitats predicted within Van Campens Brook floodplain.

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Enabling the Study of Multi-trophic Responses in Restoration

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A main goal of restoration is to sustain biodiversity at multiple trophic levels while improving resiliency and ecosystem function. Monitoring is a key component of successful restoration to evaluate and quantify success and adjust management as needed. However, it is often challenging to determine what the appropriate benchmarks for success should be with ever-changing environments and multi-trophic systems that might have opposing responses. In an effort to restore lands managed by Denver Botanic Gardens and establish projects that can be used to demonstrate and study successful riparian and prairie restoration, we endeavor to establish standardized long-term monitoring efforts, but also evaluate projects across multiple trophic levels to understand how the ecosystem is connected and how restoration techniques might differentially impact riparian and upland communities. For a riparian project initiated in 2015, we installed in-stream structures to reconnect the floodplain and long-term monitoring plots with extensive plant, water, and aquatic macroinvertebrate sampling. We will present the first four years of this work. In 2018, we started a prairie restoration experiment to examine the impacts of different seeding and herbicide treatments to remove a dominant non-native and increase plant diversity. In addition to measuring the impact on the plant community, we have invited colleagues to investigate the impact of these restoration treatments on the soil microbial and pollinator communities. Not only is this important for restoration in general but is especially important to the local land managers as the restoration site is also on a working farm that aims to implement sustainable agriculture practices.

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Two Decades of Restoration in the Middle Rio Grande

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Like many arid southwestern riverine systems, the Rio Grande in New Mexico has had many anthropogenic influences over the past 100 years that have changed both the physical form as well as the related function of the system.

Within the central portion of the Rio Grande in New Mexico (call the Middle Rio Grande) various agencies, partners, stakeholders and other interested parties have worked individually and together to implement restoration and enhancement projects with the goal of sustaining existing quality habitat and increasing a 'mosaic' of habitat types similar to those that historically occurred.

The presentation will review a number of restoration efforts implemented throughout the Albuquerque Reach of the Middle Rio Grande and beyond, as well as discuss lessons learned.

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Vegetation Establishment to Promote Dust Control Using Natural Physical Barriers and Surface Hydrology at the Salton Sea, CA

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The Salton Sea is a hypersaline inland lake situated in the Imperial Valley of Southern California. Over the past 20 years the lake surface elevation has decreased by approximately 12 ft, exposing the dry lakebed (playa) and accumulated lakebed sediments containing metals, salts and likely a suite of degradation products resulting from chemicals used in production agriculture. The lake surface elevation is expected to drop another 18 feet over the next 20 years (CH2M Hill, 2018), thus exposing an additional 80,000 acres of lakebed. If no action is taken, the increase in exposed lakebed is anticipated to exacerbate the regional air quality problem.

A multi-disciplinary team led by the California Department of Water Resources, along with Tetra Tech, is designing a landscape-scale dust suppression and vegetation enhancement project over 2,500 acres. The primary aim of this plan is to prevent dust emissions. This initial planning effort has consisted of a review of plant establishment challenges on the playa, climatic and hydrologic factors, and edaphic and vegetative parameters associated with plant establishment. Roughness-based dust control methods consist of the construction of natural physical structures and establishment of *Allenrolfea occidentalis*, a keystone species in hyper-xeric halophytic settings. Ephemeral surface water inputs from surrounding watersheds are proposed to be utilized with surface contouring built in key landscape positions in order to retain stormwater flows on site and promote vegetation germination and establishment. The selection and rationale for structures and placement will be presented along with the modeling efforts and field data collection activities.

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Not Too Big to Fail – The Missouri River Recovery Program

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Efforts to rehabilitate the Lower Missouri River illustrate the acute challenges of ecosystem recovery in large, complex, and highly altered ecosystems. Rehabilitation on the Missouri River began with the Water Resources Development Act (WRDA) of 1986, which authorized the Missouri River Bank Stabilization and Navigation Fish and Wildlife Mitigation Program (Mitigation Program). The Missouri River Recovery Program is presently the U.S. Army Corps of Engineers' umbrella for implementation of the Mitigation Program, Endangered Species Act (ESA) compliance, and collaborative adaptive management. Through time, conservation objectives have evolved in response to ESA listings, critical scientific reviews, litigation, and practice of collaborative adaptive management. Initial objectives were defined by reference to habitat area that was lost due to channelization; the initial goal was to recover about one third of 522,000 acres of lost aquatic, sandbar, and connected floodplain habitat. Biological opinions in 2000, 2003, and 2018 progressively focused on more-specific ecological needs of three listed species (interior least tern, piping plover, pallid sturgeon). For pallid sturgeon, the objectives evolved from holistic to reductionist: Initial efforts were to increase shallow (2-5 ft depth) and slow (< 2 ft/s) water, which was more abundant in the historical river. Historically informed objectives were succeeded by objectives of providing habitat conditions specific to critical life stages, including spawning habitats hypothesized to increase production of viable gametes and interception-rearing complexes hypothesized to increase growth and survival during the first few weeks of larval dispersal. It was hoped that application of increasingly precise scientific understanding of reproductive needs of the species would minimize conflicts with socio-economic uses of the river. Instead, investment in robust science has been inadequate to counter perceptions held by influential stakeholders that Missouri River management is a zero-sum game: that conservation efforts to support the species necessarily detract from socio-economic objectives.

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Restoring Ecological Functions From Landscape-Scale to Site-Scale in the Embudo Valley, New Mexico

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In the last decade, multi-party teams developed plans aimed at ecological health of the 200,000-acre Embudo watershed and its forests and wetlands. The landscape-sale plans direct actions across multiple jurisdictions to ensure steady future supplies of water suitable for irrigation. Therefore, forests must become more fire-adapted, watershed soils healthy and less erodible, and streams and wetlands ecologically functional and resilient. This will benefit the local, traditional and Native American communities, many of whom practice agriculture with gravity-fed irrigation systems and still use wood for heating and cooking.

In past decades, local livelihoods have suffered from drought and soil loss due to excessive erosion, sedimentation, water pollution, and severe wildfires. To reverse these trends, the landscape-scale plans now guide multiple partners in implementing site-specific restoration plans ranging from forest thinning, local wood harvesting cooperatives, woodland restoration, erosion control, and wetland stabilization. Commonly, woody byproducts and local rock are utilized in mulching the soil and building gully stabilization and sediment retention structures to spread, infiltrate, and store water in the soil. Soil health is gradually restored, and flash flooding, sedimentation, and wildfire risk reduced. The work generates jobs, on-the-job training, new income streams, and regional collaboration among public and private entities.

Word is spreading in electronic mail, newspapers, and hands-on workshops, and the approach, blended with success stories from elsewhere, is gradually being emulated in regional ecosystems ranging from high elevation forests to lower elevation drylands and riparian areas. The techniques applied are simple, mostly using local materials and basic natural principles, and adaptive to people's skills and creativity to ensure that the effects are appropriate for a diversity of site conditions. Strategically locating work sites in the landscape ensures effective upscaling with landscape-wide effects. Workshops with pocket-sized field guides in Spanish and English ensure inclusivity and ongoing replication and training.

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Accessible Adaptive Management: An Introduction to the Land Treatment Exploration Tool

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Each year, public land managers make decisions regarding reclamation, rehabilitation, and restoration actions that influence landscapes and ecosystems. Many of these decisions involve soil and vegetation manipulations, often known as land treatments. These treatments were historically planned on a case by case basis with decisions about implementation, methods, and operations derived from personal experience of past successes or failures. Modern adaptive management strategies strive to capture this local knowledge through time, to create a comprehensive picture of effective treatment strategies both locally and regionally. In 2017, the U.S. Geological Survey partnered with the Bureau of Land Management (BLM) to create the Land Treatment Exploration Tool to facilitate adaptive management of land treatments. The Exploration Tool taps into a wealth of information about past treatments in the Land Treatment Digital Library (LTDL), a catalog of information about all known treatments on public lands administered by the BLM in the Western United States. The Exploration Tool is designed for resource managers to use when planning land treatments. The tool provides useful summaries of environmental characteristics of planned treatment areas and facilitates adaptive management practices by comparing those characteristics to other similar treatments within a specified distance or area of interest. The tool also integrates long-lead, multi-month weather forecasts, ecosystem water balance models, and information about environmental requirements for plant establishment to produce forecasts for recruitment and establishment that inform restoration seeding decisions. This presentation will provide an overview of the functionality of the tool, highlight newly released features, and run through real world examples of how the tool is currently being utilized.

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Using Long-term Community Science Monitoring to Inform Middle Rio Grande Bosque Restoration

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Bosque restoration faces numerous challenges including anthropogenic alteration, climate stressors, and changing conditions in areas that need restoration work. The Albuquerque District U.S. Army Corps of Engineers (USACE) designed and constructed the Middle Rio Grande Bosque habitat restoration project at 17 sites along a 22-mile reach of the Middle Rio Grande in the Albuquerque area from 2011 to 2016. Restoration work focused on restoring river function and included removing non-native vegetation, planting native vegetation, and excavating floodplain terraces to create seasonally inundated riparian wetlands. Following construction, USACE worked with various entities, including the Bosque Ecosystem Monitoring Program (BEMP, a community engaged research program) to monitor the outcomes of these projects.

BEMP collects monthly data with students (primarily from Title I schools) including depth to groundwater, precipitation, litterfall, and site observations. Other core data sets collected by BEMP include surface-active arthropods, vegetation surveys, water chemistry, tamarisk leaf beetle presence/density, temperature data, phenology, and fuel load. GeoSystems Analysis, Inc and Tetra Tech, Inc conducted additional vegetation and soils monitoring. Results of monitoring have not only provided insight into effectiveness of restoration methods, but allowed lessons learned from monitoring at early sites to inform design at sites constructed later. The long-term data collected is also being used to inform management in the face of climate change.

We focus on lessons learned and highlight several USACE project sites. We demonstrate data-driven take-home points including the need to connect to groundwater to support native riparian vegetation, the significance of soil type in restoration design and success of willow planting, how on-site wood chipping without flooding supports exotic species, and the importance of fire intensity and groundwater availability as drivers of post-fire recovery.

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Urban Planning With Integrated Natural Systems (UPWINS)

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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.

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Partnering with the Lower Brule Sioux Tribe for Ecosystem Restoration and Natural Resources Preservation near Lower Brule, South Dakota

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The construction of Big Bend Dam (1964) and Fort Randall Dam (1953) irreversibly altered the thousands of acres of native riparian forests, plant communities, and natural landscapes that were vital to the everyday lives and traditions of the Lower Brule Sioux Tribe. For centuries the landscape and native trees, plants, and animals along the river provided shelter, food, medicine, and many other uses. The dams inundated all of the historic islands and landscape features significant to the Tribe, and destroyed approximately 95 percent of the native cottonwood forests (Federally significant resource and dominant floodplain community pre-dam) on the Reservation. Continual erosion has destroyed another 2,000 acres of Tribal reservation lands and remnant natural landscape features and habitats, and is threatening critical Tribal infrastructure.

Omaha District has partnered with the Lower Brule Sioux Tribe to construct one project and complete an approved feasibility report for a second project to address the degraded habitats. These were developed in close coordination with Tribal Elders and staff to integrate Tribal indigenous knowledge and perspectives on lost and degraded resources and goals for each project. When completed, the two projects will restore a sustainable ecosystem corridor along almost five miles of shoreline including a total of 102 acres of riparian cottonwood forest and 49 acres of wetlands (both scarce along this reach of the Missouri River). The first project also incorporated recreational features including a boat ramp, swim beach, and other amenities to reestablish safe access for Tribal members to interact with the river. The second project will incorporate focused reestablishment of native and heirloom plants that are used by Tribal members as food and medicine and in ceremonies. This restoration will serve as a natural "classroom" enabling Tribal Elders to pass on traditional cultural knowledge to future generations regarding uses for these native plants.

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Cultivating Science-Policy-Practitioner Partnerships in Wetland Restoration

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Understanding water-quality related functions of restored wetlands is challenging due to scientific uncertainty in ecosystem processes and variation in management actions. The H2Ohio Wetland Monitoring Program mobilizes university researchers across Ohio to investigate the effectiveness of state agency-funded wetland projects. This presentation will describe how sustained working relationships with wetland practitioners help capture relevant metrics to assess the impact of wetland design and management decisions. Simply putting scientists and stakeholders in the same room (or same wetland) is a key step in the process of understanding restoration intentions, actions, and outcomes. The Program's annual workshop connects >30 academic scientists and technical staff, along with dozens of agency and management partners for a series of structured activities and informal networking. Likewise, researchers exchange knowledge with land managers through a combination of standardized prompts and unstructured field visits, the latter of which catch insights not always detected in written form. Dialogue in each space grounds the Program's purpose in acquiring actionable data, without sacrificing independent scientific research. The Program maintains workflows and tools for inter-institution communication across the life cycle of a wetland project (i.e., design, construction, present use) and integrates management-related metrics into monitoring design (i.e., sampling locations near water level control structures, avoiding sensitive features upon land manager request). Program documentation provides example aquatic monitoring protocols and practical guidance, which restoration scientists and professionals can draw upon and adapt to other geographies or ecosystems. The first two years of the Program offer emergent themes to frame next steps in the broader space of "science-informed management"; considering how to balance expectations of urgently requested information with the scientific reality of monitoring ecological change. Ultimately, investment in wetland practitioner partnerships can strengthen understanding of wetland nutrient services in human-altered landscapes and human-managed ecosystems.

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Bridging the Gap: Adaptive Management Returns Wild Razorback Sucker to the Upper Colorado River Basin

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The Upper Colorado River Endangered Fish Recovery Program makes recommendations for river flows and manages wetland habitats in the Green and upper Colorado rivers to increase recruitment of wild-spawned Razorback Sucker, *Xyrauchen texanus*. Since 2012, experimental spring peak releases from Flaming Gorge Dam have been timed to coincide with the presence of drifting river-produced Razorback Sucker larvae that are subsequently entrained into warm, food-rich floodplain wetlands. These experiments are based on previous data on the timing of larval drift, dam release operations, and habitat availability and fish use, which led to the development of the "Larval Trigger Study Plan." Initially, biologists inundated a single wetland, Stewart Lake, which was managed as a native fish nursery habitat. In the last 10 years, the Program has constructed four additional managed wetlands and re-operated a fifth to improve Razorback Sucker growth and recruitment. These sites share common features designed to facilitate juvenile survival including: 1) a water control structure that regulates filling and draining of the habitat; 2) screens to reduce wetland colonization by adult nonnative fishes during filling; and 3) a mechanism to add water during hot summer months to improve water quality. The resulting wetland operations have increased our knowledge of the species' life history while producing over 9,000 wild, juvenile Razorback Sucker. In addition, forty-eight presumptive wild Bonytail, Gila elegans, have been produced in two of these managed wetlands. In 2020, wetland-reared Razorback Sucker larvae were first observed as age-6 adults at known spawning locations. Additional wild Razorback Sucker are needed to maintain riverine populations, therefore wetland managers continue to refine their operations, address challenges, and improve facilities in the face of increased conservation challenges from drought, climate change, and invasive species.

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A Human Wellbeing Evaluation Framework for Ecosystem Restoration

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Ecosystem restoration–meant to remove pollution or improve conditions for wildlife–typically only measures for water quality, wildlife population, or plant cover to determine success. However, with growing interest in how restoration efforts affect people and communities, researchers have documented positive connections between restoration and property value, reduced flood risk, outdoor recreation, and happiness. Further, researchers demonstrate that these benefits for people are much more likely to lead to public support for restoration efforts. Nonetheless, many restoration funding programs still do not prioritize people and the adoption of new paradigms has been slow.

To promote socio-ecological systems thinking in restoration–we set out to explore how many projects are designed to directly benefit people, as opposed to solely the environment. Therefore, to document current levels of interest and to encourage more considerations for people and communities, we developed a socio-ecological framework for evaluating restoration projects. Then, we surveyed over 400 project managers who do actual restoration work by drawing from the Great Lakes Restoration Initiative (GLRI) as a case study. The federally funded GLRI has provided over $3.5 billion to more than 5,300 projects in the midwestern United States since 2010.

Through the application of our framework, we found that almost half of the project managers set goals to improve the lives of people and communities, and more than 70% of those who did believe they achieved it. In comparison, 90% of project managers believed they met their environmental goals. These results indicate that restoration efforts already have positive impacts for both people and nature, and the level of human wellbeing considerations are higher than expected given that they are not required. To build on these findings, our framework can be applied or adapted to other restoration contexts across the globe.

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Restoring Aquatic Connectivity to a Historic Reach of the Pomme de Terre River and the Rapid Colonization of Freshwater Mussels and Fish

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One of the goals of the Marsh Lake Ecosystem Restoration Project was to restore the historic lower Pomme de Terre River reach to a similar dimension, planform and profile of an upstream reference reach and likely to its previous condition. Stream restoration in various forms is an important way to improve ecosystem function and biological diversity. A potential benefit of restoration is the capacity for freshwater mussels to colonize formerly degraded or unavailable habitats via dispersal by their obligate host fish. The composition of colonizing mussel assemblages depends, in part, on the composition, proximity, and connectivity of source populations. Colonization rates in these habitats are poorly known. We studied mussel colonization rates, community structure, and fish use of the restored reach of the Pomme de Terre River, a tributary of the Minnesota River in west central Minnesota.

The Pomme de Terre was diverted to a constructed adjacent channel in 1939, abandoning 2.2 km of the lowermost channel to stagnate and fill with sediment. Mainstem flow was reconnected to the abandoned channel in October 2018, 79 years later, restoring aquatic connectively to the Minnesota River. Fish surveys were conducted during 2021, 3 years after flow was reconnected to the channel. We surveyed the restored channel for mussels in August 2022 during a 19-hour timed search. General observations suggest that up to 6 vertical feet of accumulated sediment was flushed from the channel with portions of the historic riverbed exposed revealing consolidated sand substrate with a small number of relic mussel shells present. We collected mussels at multiple sites totaling 163 individuals of 9 species, representing 60% of potential species from the source assemblages downstream in the Minnesota River and upstream in the Pomme de Terre River. Age estimates from external annuli counts averaged 1.9 years and included all age classes 0 to 5 years. Species with opportunistic and periodic life history strategies made up 98% of colonists, whereas equilibrium and periodic species were most abundant (70%) in the potential source assemblages. Our results showed that colonization by mussels occurred soon after flow was restored, likely by host fish, thus providing measurable benefits in a short time.

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Beaver Coexistence: A Lesson in Innovation, Adaptation, and Compromise

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In urban and rural environs, beavers working to engineer ecosystems often encounter pushback from humans. Homes, roads, and other infrastructure that occupy historic floodplains and wetlands are particularly susceptible to impacts when beavers work on stream restoration of their own. While it is widely accepted that beaver ponds benefit native fish species, water quality, and water quantity, our human-modified stream systems and declining salmon runs raise a growing number of questions about how humans can best coexist with aquatic habitats. Beaver coexistence flow devices have been a happy compromise to balance the needs of people, beavers, and the other animals that call beaver ponds home. In order to retain more beavers on the landscape and support ecosystem resilience, Beavers Northwest has implemented flow devices and other coexistence practices across a wide geographic region in Washington State. Beavers Northwest has worked closely with regulators and other organizations to develop best management practices for maintaining natural processes that occur at beaver dams including fish passage.

In this talk, we will dive into the best practices and innovations for flow devices to meet the varied needs of people, beavers, and fish. These adaptive management strategies support beaver powered restoration, serving as vital tools for any practitioners that have encountered wanted or unwanted beaver impacts. These examples will be widely transferrable to other regions working to address the balance between beaver and human modified systems with strategies to plan for, adapt to, and coexist with beavers.

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Mapping Juniper Mortality on the Navajo Nation

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There has been a notable increase in severe droughts and heat waves worldwide, exemplified by the prolonged megadrought that has affected the western United States since the year 2000. In recent years, severe and extreme drought conditions were witnessed across the southwestern US. In particular, 2021 saw 75% of the region experiencing severe and extreme drought levels, often exhibiting a correlation with extensive tree mortality and canopy dieback, as seen in a 2000 drought that resulted in over a million ha of Pinus edulis mortality in the US southwest. The regional extent of the mortality remains unknown. Still, it is expected to increase due to the multi-year persistence of the regional drought and because regional droughts are expected to become hotter, drier, more frequent, and more severe. Quantifying the cumulative impacts of persistent droughts or frequent regional drought events is crucial for preparing for future droughts because they significantly affect ecosystem services and functions, including water budgets, carbon budgets, and land-atmosphere interactions. Here, we hope to estimate a regional drought-induced tree mortality event in 2021 across the Colorado Plateau spanning Arizona, southern Utah, and eastern New Mexico, focusing on the Navajo Nation. Through ground-truthing, we can determine if reported tree mortality is accurate or true through satellite estimates (?) compared to direct observation. Estimating and mapping regional tree mortality can improve climate models and projections and offer valuable insights into the complex interplay between megadrought, ecosystem management, and the resilience of pinyon-juniper woodlands in the face of evolving climatic challenges.

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Evaluating Nutrient Function Across Diverse Wetland Restoration, Construction, and Enhancement Projects: The H2Ohio Wetland Monitoring Program, Ohio, USA

***Lauren Kinsman-Costello*[1]*, Ricky Becker*[2]*, Thomas Bridgeman*[2]*, Kennedy Doro*[2]*, Stephen Jacquemin*[3]*, Laura Johnson*[4]*, Ganming Liu*[5]*, Kevin McCluney*[5]*, Helen Michaels*[5]*, G. Robert Midden*[5]*, Silvia Newell*[6]*, Justin Chaffin*[7]*, Kristen Fussel*[7]*, Christopher Winslow*[7]*, Olivia Johnson*[1]*, Raissa Mendonca*[1]*, and Janice Kerns*[8]

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To assess the nutrient removal function of wetland restoration, enhancement, and creation projects being implemented as part of the H2Ohio Initiative, the Ohio Department of Natural Resources has established an independent monitoring program implemented by teams from six Ohio universities. The H2Ohio Wetland Monitoring Program takes advantage of a unique opportunity to investigate nutrient cycling in diverse wetland projects under a unified framework. We are developing tools for nutrient budgeting and indicators of wetland nutrient function using a tiered sampling approach. Indices of soil and water nutrient status and wetland hydrology are measured in all monitored wetland projects, while we collect more intensive, high-resolution data for comprehensive nutrient budgeting in selected, representative "Focal Projects." This tiered approach balances evaluation of broad, state-wide restoration program trends and robust, mechanistic understanding to inform management. The H2Ohio Wetland Monitoring Program has now produced baseline data from monitoring surface water nutrient concentrations, soil nutrient status, and basic hydrology in approximately 30 projects. In 2022, the H2Ohio Wetland Monitoring Program's first year of routine monitoring data collection, teams of scientists visited at least 45 distinct wetland projects, collected over 1700 water samples and over 600 soil samples. In select Focal Projects, we have mapped soil characteristics using geophysical tools, surveyed vegetative communities, deployed integrated sensor networks, tested rates of nutrient exchange betweed sediments and surface waters, and built 3D hydrodynamic models for more detailed understanding. A centralized data management and quality control system ensures data quality, long term storage, accessibility, and shareability in accordance with open science best practices. Surface water nutrient concentrations and soil nutrient status reflect the heterogenous hydrologic regimes, landscape connectivity, and land use histories of the diverse wetland restoration projects. Coordinating and leveraged research projects expand the scope of this monitoring program to meet broader goals throughout the Great Lakes.

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Lower Colorado River Multi-Species Conservation Program

Terry Murphy *Presented by:* ***Jimmy Knowles***
US Bureau of Reclamation, Lower Colorado Basin Region, Boulder City, NV, USA

The Lower Colorado River Multi-Species Conservation Program (LCRMSCP) is a multi-stakeholder federal and non-federal partnership responding to the need to balance the use of lower Colorado River water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act. The LCRMSCP is a 50-year program to conserve at least twenty-seven covered species along the lower Colorado River, from Lake Mead to the Southerly International Boundary with Mexico, through the implementation of a Habitat Conservation Plan (HCP).

The Bureau of Reclamation began implementation of the HCP in October 2005. Initial efforts concentrated on continuing ongoing research and monitoring programs for covered fish, wildlife, and habitat; developing new research and monitoring programs; planning and initiating several large-scale habitat creation projects; and establishing procedures necessary for implementation of the LCRMSCP, including the development of a science strategy to ensure that implementation of the conservation measures outlined in the HCP is based on scientific information, methods, principles, and standards in a transparent manner.

Species research, system monitoring, and post-development monitoring are being conducted on covered and evaluation species and their habitats. Single and multi-species monitoring protocols have been established. Species and vegetation monitoring is conducted on habitat creation sites to determine if goals and objectives are being met for each habitat creation site. Traditional restoration methods and approaches have been modified to function in a highly managed riverine system. Pilot scale restoration projects have led to full scale implementation. Results are presented in annual accomplishment reports and posted on the LCR MSCP Website at www.lcrmscp.gov.

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Monitors with Memories: Death Assemblages Record a Century of Wastewater Pollution and Remediation

Broc S. Kokesh
University of Chicago, Chicago, IL, USA

Long-term sediment monitoring programs are invaluable for detecting biological responses to changing environmental conditions under anthropogenic stressors. However, monitoring is rarely launched before the onset of human stressors, even where watershed industrialization and urbanization are quire recent. Integrating recent fossil records – e.g., time-averaged dead-shell assemblages – with ecological time series is a promising method to (1) characterize conditions prior to the onset of monitoring, and (2) detect otherwise unappreciated decline in condition. Here, I use the durable skeletal remains of bivalves to assess live-dead discordance in three types of ecological metrics: traditional univariate measures (e.g., richness, evenness, dominance), multivariate measures (e.g., dispersion), and abundance-weighted indices of ecological condition (e.g., Benthic Response Index; Infaunal Trophic Index; ATZI's Marine Benthic Index).

My test material includes (a) a 50-year-long dataset of living bivalve assemblages from the Palos Verdes shelf in Southern California, sampled annually at 44 sites to monitor the effects of treated wastewater effluent, and (b) dead bivalve shells sampled from the post-processed residue of the 2008 survey. The time series was parsed into temporal bins based on phases of wastewater treatment.

All metrics demonstrated that benthic conditions improved with remediation, and the greatest changes were close to the outfall source. Bivalve death assemblages – which include shells >100s years old on this shelf – indicated better conditions than was observed in early communities (1970s-80s) and either agreed with or underestimated the strain in more recent communities (2000s-10s). This live-dead discordance suggests that time-averaging causes death assemblages to retain a signal from pre-pollution benthic conditions that the shelf benthos is now re-attaining. Recent fossil assemblages, combined with long-term biological time series data, can reveal both the existence and direction of changing environmental conditions. Because skeletal remains are often sampled alongside living communities, live-dead discordance is an inexpensive procedure to add to biomonitoring protocols.

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Remote Sensing and Machine Learning for Invasive Species Identification

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Collecting environmental data using traditional field methods can be challenging and time consuming due to site size, safety hazards, and access limitations. Improvements in the affordability of drones and recent advances in drone-mounted sensors have made it possible to mitigate some of these challenges while offering additional data collection and analysis capabilities. Sensors such as multispectral or hyperspectral can detect what the human eye cannot and provide meaningful data on environmental conditions at spatial resolutions as high as square inches. By leveraging automation and machine learning, we can unlock these large, high-resolution environmental datasets. In this presentation, we will provide a brief background on methods for collecting, processing, and analyzing digital data, focusing on multispectral sensors and data; discuss a multiyear case study that applies these methods; and provide recommendations on how similar methods can be applied to other ecosystems or scaled to larger sites using satellite data.

The case study focuses on identifying and mapping invasive and native species at a 100-acre mixed upland and wetland restoration site in Florida. A 10-band multispectral sensor was used to collect 100 acres of data in 2021 and 2023. Field sampling was performed to produce training and validation data for different machine learning models. Our final model included 14 species and achieved an overall species-level accuracy above 80%. By comparing our model results from 2021 to 2023, we identified changes over time and provided stakeholders with detailed, quantifiable information that they can use to improve land management decisions in the future.

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What Does the Quaternary Fossil Record Tell Us about Marine Extinctions Threats?

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The emerging field of Conservation Paleobiology demonstrates that the Quaternary fossil and archaeological records can document ecological transitions from the pre-human biosphere into its current state. The conservation paleobiology studies demonstrate that geohistorical approaches are applicable to many groups of organisms, including mollusks, corals, ostracods, foraminifera, fish, and marine mammals. Many of these taxa have an excellent fossil record and may help elucidate biodiversity dynamics in marine ecosystems during and before the early modern times. Moreover, rapid advances in dating techniques, other advanced instrumentation, and numerical methods enable conservation paleobiology to contribute powerful insights into the most recent history of marine ecosystems. For example, age-dating of shells or bones continues to uncover extinctions and extirpations in the recent past and help us to assess if humans played a significant role in those events. The age distributions of dated specimens can also estimate the timing of extinctions and extirpation events and provide numerical assessments of decimations, which can help identify extinction threats. In short, geohistorical archives are a great resource for understanding the recent past and identifying human-driven changes that already took place. Geohistorical studies also indicate that many marine ecosystems have deteriorated in terms of taxonomic and functional diversity – marine ecosystems have been accumulating a human-driven extinction debt for centuries or even millennia. Despite limitations and assumptions that underlie geohistorical archives, they represent a key source of data that complement conservation efforts and play an important role in assessing extinctions, extirpations, extinction debts and extinction threats. Geohistorical approaches document biodiversity losses and threats that would not and could not have been discovered otherwise and provide direct insights into the transition of the pre-human biosphere into its current state.

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The Urgency of Urban Ecosystem Restoration - Evolving Strategies and Motivations on the East Coast

Marit Larson[1]*, Terry Doss*[2]*, Sarah Charlop-Powers*[3]*, James Duncan*[4]*, and Pippa Brashear*[5]

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In our rapidly urbanizing world, cities are faced with numerous challenges to balance preservation of natural spaces with development for housing, commerce, and infrastructure. Natural areas within the urban landscape provide critical benefits to city dwellers, and the need for urban ecosystem restoration has become more pressing than ever due to the increased impacts of climate change on urban centers along the east coast where the majority of Americans live. Assessing and tracking ecosystem services provided by urban natural areas is required to inform protection, management, and restoration efforts across a wide variety of habitats. Restoration and management of urban natural areas is complex because ecological networks involve humans as well as their built infrastructure. Understanding on-going stressors exacerbated by physical space constraints as well as human actions and climate change is critical to establish achievable restoration goals.

This panel discussion will take a broad look at urban restoration planning and design strategies and actions, with a focus on how they have changed over the last ten years. Panelists will provide unique perspectives on how restoration approaches transcend habitats at the landscape scale (e.g. from upland forest to coastal wetlands) while also interacting with dense urban development. Our panelists are experts on public-private partnerships, research to inform planning and design, ecological design and construction, assessment and long-term monitoring, vegetation management, public engagement and stewardship, and public access to amenities offered by natural systems. They will offer case studies about unique projects in New York City, Miami and other urban areas and interactive discussions to provide participants with actionable insights and tools to consider for their own cities.

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Strategies for Collaborative Conservation in North American Grasslands

Ariel Léger[1]*, Scott Feldhausen*[2]*, Julia Guglielmo*[3]*, and* [4] *Robert Perez*

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Erosion, drought, invasive species, woody plant encroachment, and land use conversion that affect grassland ecosystems, grassland dependent species, and the people who depend on them, occur on a landscape scale. Erosion issues that start in the headwaters or uplands need to be addressed at a watershed scale. Migratory species of birds, mammals, and insects depend on connected grassland habitat. Unfortunately, management of grassland ecosystems is fragmented by administrative and geographical regions, impeding the coordination that is needed, both within and across regions, to effectively address landscape scale issues affecting North American grasslands. This lack of coordination reduces the effectiveness of on-the-ground grassland restoration when managers and restoration practitioners within and among regions are not learning from each other.

In this session, participants will hear from presenters who are taking diverse approaches to grassland restoration and leading efforts to coordinate landscape scale grassland restoration efforts in the central and western United States. Presenters will focus on the strategies they are using to increase coordination and address priority issues in their respective regions, and lessons learned from coordination within their region and between grassland biomes. By sharing successful strategies for landscape scale coordination, participants will learn about strategies that they can implement to improve coordination and the outcomes of on-the-ground restoration and management activities in their regions of interest.

Furthermore, this session will generate dialogue about **how to move forward from this foundation of regional coordination, towards a more unified approach to grassland management on the North American continent.** One that is aligned with the needs of migratory species and recognizes the flow of species and impacts of climate change on grassland ecosystems on a continental scale.

Panelist Biographies:

Ariel Léger is a Research Scientist at the University of Arizona where they are a Program Coordinator at CART, the Conservation and Adaptation Resources Toolbox, and lead a Grassland Community of Practice.

Scott Feldhausen, is the Bureau of Land Management's Gila District Manager. He has a wealth of knowledge on grassland restoration and working cooperatively with partners.

Julia Guglielmo is the Conservation and Science Director of the Altar Valley Conservation Alliance (AVCA). The AVCA conserves healthy and productive working landscapes, promotes a thriving agricultural economy, and sustains cultural and historical traditions of the Altar Valley. Julia designs, manages, and monitors restoration projects by building on expertise and resources from local landowners as well as researchers and practitioners in Southeast AZ.

Robert Perez is the Oaks and Prairies Joint Venture (OPJV) Coordinator where he works on bird conservation in parts of Texas and Oklahoma (BCRs 20 and 21) through a self-directed partnership guided by the OPJV Management Board.

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How Much Room Does a River Need? Approaches From Floodplain Restoration in the Pacific Northwest

***Nick Legg**, Nora Boylan, and Luke Russell*
Wolf Water Resources, Portland, OR, USA

Over the past decade, stream restoration practitioners have increasingly emphasized floodplain reconnection to address the encroachment and disruption of natural floodplain processes by historic development. By giving the river space, floodplain restoration creates room for the river to move and build habitat through time. More space also brings forth benefits to people experiencing increasing flood risk, especially as levees age and climate change impacts compound. These restoration and management efforts beg the question: how much room (floodplain) does a river need? The answer(s) to this question are multi-faceted, just like the benefits from connected floodplains and the dependencies of people on rivers. This presentation will review existing tools and emerging methods we have developed to evaluate this question of space, while considering both floodplain habitats and reduced hazards to people and infrastructure from stream dynamics. We present on our reach-scale evaluation methods that consider habitat area, flood potential, erosion potential, and lateral migration of dynamic streams within the Pacific Northwest. Our approaches emphasize relative (incremental) benefits of floodplain expansion, to address complex decisions needed for restoration in and around built floodplain environments. We intend to generate discussion about how stream restoration and floodplain management communities can develop more comprehensive planning approaches that apply to broad geographies and river systems, thereby achieving greater balance for people and ecosystems.

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Build It and They Will Come, if It's Built Correctly: Quality Control During Construction of Restoration Projects

Timothy Lewis[1]*, Craig Palmer*[1]*, Molly Middlebrook*[1]*, and Louis Blume*[2]

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In order to determine whether a particular ecological restoration treatment is effective, one must first know whether the treatment was implemented according to engineering design specifications. Quality assurance (QA) and quality control (QC) oversight during all phases of project implementation and construction are critical to determining the level of adherence to the engineering design. The U.S. Environmental Protection Agency Great Lakes National Program Office (GLNPO) spearheaded an effort to develop a guidance document (EPA-905-K19-001, April 2019) focused on the principal components of quality documentation fundamental to planning effective quality oversight during the construction, installation, or implementation phases of an ecological restoration project. Such projects may involve creating certain ecological features (e.g., riparian corridor stabilization for erosion control) or modifying existing habitat (e.g., optimal ratio of pool/riffle/run). Quality control includes calibrating all measurement and testing equipment, confirming the quality and quantity of all construction material used in the project, verifying appropriate seed/plant species are used for the habitat and geographic area, and more. The guidance addresses the value of documenting continuous assessment of the construction processes, materials, and techniques being used to ensure the quality of workmanship and the effective use of resources. This guidance provides a comprehensive approach to QA/QC oversight in ecological restoration construction projects through integration of new and existing concepts from reputable and published sources. This presentation summarizes the key components of this guidance document and is funded under an EPA contract in support of the Great Lakes Restoration Initiative.

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Assessment of Chesapeake Climate Change Using A Suite of Airshed, Watershed, and Estuary Models

Lewis C. Linker[1]*, Gopal Bhatt*[2]*, Richard Tian*[3]*, Carl F. Cerco*[4]*, and Isabella Bertani*[3]

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A comprehensive analysis of Chesapeake climate change was done in order quantify impairments to water quality and subsequently implement needed nutrient reductions in Watershed Implementation Plans (WIPs) to remove the impairments. The assessment used integrated models of the Chesapeake watershed, airshed, and estuary with scenarios run for the years 2025, 2035, 2045, and 2055. The intent of this presentation is to examine the Chesapeake climate change analysis as a case study to provide a guide to modeling practitioners and resource managers in the assessment of climate change impacts in eutrophic coastal watersheds.

The climate change analysis looked at 22 different influences on Chesapeake water quality standards, principally on the living resource-based oxygen concentration criteria in the deep waters of the Chesapeake. The major and minor influences of climate change were identified and quantified allowing decision makers to choose appropriate levers of watershed or estuarine management to respond to its challenge. In the Chesapeake watershed, the major influences are greater precipitation volumes and to a lesser extent intensities, which increase flows and consequently nitrogen, phosphorus, and sediment loads. In tidal waters the estimated key impacts on water quality standards were higher water temperatures, which decrease DO saturation rates and increase stratification, and deep-water respiration causing an amplification of hypoxia in the Chesapeake.

Climate change is a multi-generational challenge for Chesapeake Bay restoration. Flow, nutrient, and sediment loads from the watershed and tidal Bay hypoxia are estimated to continue to increase from 1995 to 2055 from climate change. In response, the Chesapeake Bay Program is developing better management tools combined with an ongoing multi-decadal plan of adaptation to climate change to maintain the Chesapeake TMDL restoration objectives. The assessment of climate change impacts on the Chesapeake TMDL is an iterative process and reassessments each decade are currently planned.

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EcoRestore: Coordinating large-scale ecosystem restoration in the Sacramento-San Joaquin Delta

Erik Loboschefsky *and Charlotte Bigg*
California Department of Water Resources, Sacramento, CA USA

EcoRestore is a multi-agency initiative launched in 2015 to restore and enhance at least 30,000 acres of critical habitat in California's Central Valley, including the Sacramento-San Joaquin Delta, Suisun Marsh, and Yolo Bypass. The Delta is a crucial water and ecological resource for California. As the largest estuary on the West Coast, the Delta is historically home to thousands of native fish and wildlife. The Delta's rivers provide drinking water for nearly 27 million Californians, as well as water to millions of acres of farmland.

Efforts to restore nature habitat bring together federal, state, and local agencies, water contractors, NGOs, landowners, and others with a stake in the Delta's health. Led by the California Department of Water Resources (DWR), EcoRestore pursues complex multi-benefit habitat restoration to support native fish and wildlife, and natural processes. In less than 10 years, restoration efforts have doubled protected Delta habitat lands. DWR and its partners have restored 28,000-acres to date, with an additional 10,000-acres in planning. This includes several target habitats including tidal wetlands, floodplains, and riparian.

DWR's restoration projects represent over $500 million investment and have encouraged new partnerships and project delivery models to accelerate progress. Projects include multi-benefit features such as flood protection, public access, climate change resiliency and buffers, and groundwater recharge. Ensuring long-term functionality and adaptive management are central to DWR's efforts. DWR has embraced partnerships with local agencies and resource conservation districts to carry out a robust land stewardship, vegetation management and monitoring on restoration sites including quantifying carbon sequestration.

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Historic Agreements for New Instream Flows & Habitat Restoration in California's Bay-Delta Watershed

Erik Loboschefsky *and Louise Conrad*
California Department of Water Resources, Sacramento, CA USA

Environmental improvements are greatly needed for the Sacramento and San Joaquin Rivers, its major tributaries, and the Bay-Delta, collectively known as the Bay-Delta Watershed, to reverse long-term declines in native fish populations. The State of California's natural resources agencies, local water districts, and several federal natural resources agencies are working to advance a transformational, watershed-wide approach to increase river flows, restore ecosystems and strengthen water supply reliability across California.

The proposed approach -- sometimes referred to as "Voluntary Agreements" because parties came together to propose it, is a comprehensive, multi-year solution that brings together dozens of water agencies with the state and federal governments to pool resources and take concrete actions to provide targeted increases in river flows and expand habitat enhancements in the Bay-Delta Watershed. These environmental improvements are guided by collaborative decision-making, scientific monitoring, and a comprehensive science program. This new approach will also allow water managers to adapt operations based on real-time conditions and enable broad coordination across watersheds to manage flows for maximal benefits. Such adaptive management is critical as climate change increases uncertainty and drives extreme conditions.

Once finalized, the agreements would dedicate a large quantity of new water to the environment, up-to 825 thousand acre-feet (TAF), and restore over 30,000 acres of aquatic habitat for native fish species and other animals. This approach provides a promising pathway to protect and restore our environment, enable California's economy to thrive, and establish a foundation for a more resilient future.

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More Nature, Less Paperwork: Insights from Research on Streamlining Permits for Restoration Projects

Becca Madsen
Environmental Policy Innovation Center, Denton, TX, USA

Restoration projects are burdened with delays and permitting costs that can burn through up to a third of a project's budget. This presentation will review research results from the Environmental Policy Innovation Center's (EPIC) quantitative analysis of US Army Corps of Engineers data on timelines of mitigation bank approvals. Using a live survey tool, we will find out what the audience thinks are the top opportunities to speed restoration projects and compare that to a synthesis of recommendations from interviews with 30 restoration project developers across the US. Examples of implementing those recommendations will be highlighted from EPIC's database of permit streamlining policies and programs.

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Assessment of Biodiversity and Ecological Uplift Potential to Leverage Natural Capital

Randy Mandel[1] *and Galen Peracca*[2]

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An essential factor to determine a property's ecological status is the comparison of its current condition versus its potential by examination of reference areas of similar physiography and habitat type. Such comparison can be used to determine uplift potential through quantification of its ecological services such as biodiversity, habitat value, overall condition, and connectivity. As such, this presentation focuses on coupling on-site assessment with remote analysis to inform decision-making.

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Assessing mycorrhizal community differences within pinyon pines in the Four Corners region

***Melissa Marquez Vargas*[1,2]*,Catherine Gehring*[2,3]*, and Maria Theresa Hernandez*[2,3]**

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Climate change has created drought conditions across the Four Corners region which has increased mortality rates in pinyon pine (*Pinus edulis*). Pinyon pine is a culturally significant species to the Navajo Nation along with representing a critical resource for the pinyon jay, which is under review to be added to the endangered species list. Below-ground microbes can help mitigate the hotter, drier conditions created by climate change, however, these species composition and function of these microbes are poorly understood in pinyon pines within the Navajo Nation as research has not been geographically extensive. We propose to examine how ectomycorrhizal fungal (EMF) communities differ among soil types across the Navajo Nation to determine if there is a linkage between EMF communities and cone production in pinyon pines. We expect to find a positive correlation between *Geopora*, a fungus that promotes drought tolerance, abundance and pinyon cone production. Soil samples of approximately 250 milliliters will be collected from pinyon pines and a small amount will be reserved for DNA sequencing to determine all of the microbes present in the soil. Pinyon seedlings will be grown in the soil and their roots will be harvested and analyzed for ectomycorrhizal fungi that will be molecularly identified and examined to see how they differ across the range and among soil types that will be assessed using texture, bulk density and other variables. Understanding the importance of soil microbial communities to pinyon cone production could be important to restoration following climate related disturbances such as drought and stand-replacing fire.

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Implications of *Sackett vs. EPA* for Ecosystem Restoration: Lanes of Response to Protect Our Waters and Wetlands

Jessie Ritter *Presented by:* ***Alicia Marrs***
National Wildlife Federation, Washington, DC

Clean and healthy waters and wetlands are at the foundation of ecosystem restoration efforts around the nation, supporting thriving populations of fish and wildlife as well as drinking water, climate resilience, and public health for communities around the nation. Unfortunately, after attacks in the Courts and Congress, the Clean Water Act has now been undermined to the point where it no longer offers the protections science tells we need to provide safe drinking water, safeguard communities from harms like flooding, and ensure wildlife have adequate habitat. In particular, on May 25, 2023, the United States Supreme Court decided *Sackett v. EPA,* which effectively eliminates federal protections for over half of the Nation's wetlands and likely removes protections for many streams.

This represents the largest clean water crisis in over half a century. Even before Court rollbacks, insufficient enforcement of the law itself, poor river and floodplain management decisions, outdated and inequitable water infrastructure, and an overreliance on grey infrastructure for flood protection—combined to exacerbate the pollution and development plaguing our waters today.

Nearly a year after the Sackett v. EPA decision, this presentation will provide the history of this issue and examine the understood impacts and implications of the court decision, including for iconic ecosystems around the nation and for restoration practitioners. We will also discuss available lanes of response at the federal, state, and grassroots levels, to work to close the gap in protections and ultimately restore clean water protections nationwide. This will include a careful look at other federal authorities and funding streams that can be deployed to protect clean water and wetlands.

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Scaling Up Investment in Restoration and Other Nature-based Solutions Using Green Banks

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Nature-based solutions (NBS) are actions to protect, manage, or restore natural or modified ecosystems that address societal challenges, simultaneously benefiting people and nature. Many important NBS involve ecosystem restoration. Recent government investment in 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 allows 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 Development Finance Institutions (CDFIs).

Green banks and CDFIs are mission-driven financial institutions with mandates often related to decarbonization, climate, health, and equitable communities. Restoration-focused NBS have the capacity to deliver on some, if not all of those goals. While green banks and CDFIs 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 poster will provide an overview of these resources and an update on the status of green bank investment in restoration and NBS.

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Progress and Recovery in the San Juan River Basin

Melissa Mata

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The San Juan River Basin Recovery Implementation Program (SJRIP) is a collaboration among Federal, State, and Tribal partners with the goal of recovering Colorado pikeminnow and razorback sucker in the San Juan River basin while providing Endangered Species Act compliance for existing and new water development projects. When the SJRIP began in 1992 a small remnant population of Colorado pikeminnow was present but razorback sucker was functionally extirpated from the system. Adult populations of both species that regularly reproduce have been established via a successful hatchery augmentation program but recruitment of wild-spawned individuals to subsequent life stages remains rare. Habitat degradation and nonnative species competition and predation are thought to be major threats limiting recovery. However, spring releases from Navajo Reservoir are not of sufficient magnitude and frequency to create and maintain habitats needed to sustain all life stages and nonnative fish management efforts have not resulted in anticipated species responses. Because of these ongoing recovery challenges, the SJRIP must continue to innovate and implement on-the-ground management actions that resolve recruitment bottlenecks that lead to self-sustaining populations of Colorado pikeminnow and razorback sucker in the San Juan River basin.

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Updating a System-wide Monitoring and Assessment Plan for a Large-scale Ecosystem Restoration Project

Jenna C. May *and Gina P. Ralph*
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Authorized by Congress in 2000, the Comprehensive Everglades Restoration Plan (CERP) aims to find the correct balance among flow characteristics throughout the Florida Everglades by changing the quantity, quality, timing, and distribution of water, leading to improved ecosystem health and ensuring quality of life in south Florida. RECOVER (REstoration COordination & VERification) is a multi-agency and multi-disciplinary team that organizes and applies scientific and technical information to support the goals and objectives of the CERP. RECOVER applies a system-wide perspective to the planning and implementation of CERP and communicates and coordinates the results of evaluations and assessments to managers, decision-makers, and the public.

The CERP is the largest environmental restoration effort ever pursued and documenting its success relies on a system-wide monitoring plan as the basis for assessing system-wide performance. The CERP monitoring plan was conceived as the primary tool by which RECOVER will assess the performance of the south Florida ecosystem as it responds to CERP implementation. The purposes of the monitoring plan are to: (a) provide a framework that supports measurement of system-wide responses to determine how well CERP is achieving its goals and objectives; and (b) support and enable adaptive management for updating and improving the CERP, when needed. From the inception of the CERP monitoring plan in 2000, it was recognized that refinement of the document would be a continuous and iterative process. As CERP implementation has proceeded, new information, lessons learned, and changing priorities have been the impetus for updating the monitoring plan. These factors include recommendations from the National Research Council, information gained from the completion of technical evaluations and reports, the issue of climate change (specifically sea-level rise), and the need to incorporate CERP project-level monitoring into the CERP monitoring plan.

The last update to the CERP monitoring plan occurred in 2009. RECOVER will undertake an update to the monitoring plan that will consider new information pertinent to conceptual ecological models, restoration hypotheses, uncertainties, and individual monitoring components. Examples of methods employed to synthesize new information and to evaluate the current monitoring plan will be provided. Promoting a more insightful and focused monitoring plan enhances the CERP adaptive management program and will provide managers with the capacity to act in an accelerated manner, even in the face of risk, with the knowledge that they have the best information and scientific support available.

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Biocrust Capsules: New Medicine for Soil Restoration

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Biological soil crust (biocrust) is a community of organisms, composed of mosses, lichen, and cyanobacteria, that form a living crust in and bind the top millimeters of mineral soils in dry and/ or cold ecosystems. This diverse community of organisms is essential in dryland ecosystems because they stabilize the soil through aggregation, promote soil fertility, and interact with vascular plants.

Biocrust faces many threats from climate change and land use and is predicted to decrease by 17%-30%. Land managers need restoration techniques to inoculate biocrust that are cost-effective, can be used on a large scale, and do not require maintenance. To meet management needs, we are testing biocrust capsules that can be dispersed widely and survive drought. We are exploring capsules which break down quickly or more slowly and are filled with biocrust collected from the field or grown in the greenhouse, with and without native seeds in a fully factorial greenhouse experiment with daily watering. We will monitor capsule breakdown and biocrust establishment daily for the first week, then biweekly for the remaining weeks. The biocrust establishment will be monitored using a pulse amplitude modulator, which will indicate photosynthesis. We hypothesize that biocrust capsules will promote establishment of biocrust and seeds, and we expect that greenhouse cultivated biocrust will do as well as field collected. If successful, this technique can be broadly used across degraded landscapes.

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Can Restored Urban Wetlands Avoid Recontamination? An Overview of Biota/Sediment Monitoring in NYC

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New York City (NYC) is facilitating the restoration of critical coastal resources by establishing the Saw Mill Creek Wetland Mitigation Bank. This publicly operated wetland bank in Staten Island is near industrially developed land. Extensive dumping of trash and historic fill had occurred throughout the Site for decades. Sediment samples indicated that prior to restoration, the Site posed an ecological risk to wildlife due to metals, pesticides, and PCBs. Restoration actions removed over 40,000 cubic yards of contaminated soils and 40 truckloads of tires and debris from the 54-acre site to create tidal creeks and marshes planted with native vegetation.

The restored wetland is meeting success criteria developed in collaboration with state and federal agencies, including permit-required sediment and biota baseline sampling (conducted immediately after construction/planting of the restored wetland) and post-construction annual monitoring. The requirement for post-construction sediment and biota sampling is based on agency concerns that wildlife are attracted to the newly established marsh and could be exposed to contaminants that may accumulate at the site from other sources within the Hudson Raritan estuary – an estuary that includes multiple Superfund sites.

The baseline and post-construction sediment monitoring program was designed using incremental sampling methodology to collect spatially representative sediment samples across the wetland. Baseline and post-construction biota tissue sampling include ribbed mussels, mummichog, fiddler crab, amphipods, wolf spiders, and long-jaw spiders as key receptors in the wetlands.

The four years of post-construction sediment and biota tissue results are comparable to baseline restoration conditions, suggesting that the wetland has not been re-contaminated. The monitoring indicates that contaminants from off-site sources within the urban estuary are not accumulating within the restored wetland. The information from this monitoring program may be transferred for use in habitat restoration in other urban areas by eliminating uncertainty regarding recontamination in restoration implementation.

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Applying Ecosystem Goods and Services to Plan Army Corps Aquatic Ecosystem Restoration Projects

Kat McCain
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The U.S. Army Corps of Engineers Civil Works uses a structured 6-step planning process to develop, evaluate, and compare alternatives, and ultimately select a recommended plan to address a specific water resources problem, including aquatic ecosystem restoration projects. Ecosystem goods and services may be influenced by different alternatives, and these effects and trade-offs, in qualitative and quantitative terms, are integral to any planning effort. Considering ecosystem goods and services may inform decision-making and tell a more robust story of the comprehensive benefits for the project beyond the ecological outputs typically reported (e.g., acres restored). This presentation explores how Corps of Engineers study teams have applied ecosystem goods and services during the planning process from various aquatic ecosystem restoration projects.

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New Mexico's Rapid Assessment of Lowland Riverine Wetland Ecosystems: Understanding Condition to Carry Out Comprehensive Restoration

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Given the predominantly arid environment of New Mexico, water is not only more limited but is highly variable across the landscape and through seasons and years. New Mexico's lowland riverine corridors are highly dynamic and complex fluvial environments supporting biologically complex ecological communities. The complexity of lowland riverine corridors guided the development of New Mexico's Rapid Assessment Method (NMRAM) for lowland riverine wetlands tailored to represent the ecological integrity of a relatively large low-gradient river system flowing through a broad river valley and structured to recognize the evolution of fluvial surfaces in response to flooding and channel migration. The NMRAM for lowland riverine wetlands uses a set of 14 observable and relatively easy to measure landscape, biotic and abiotic map-based and field-based indicators to express the condition against a reference disturbance gradient. It was originally developed in the context of a relatively intact reference set (the Gila River in NM), and scores may be significantly lower in controlled river systems such as some reaches of the Rio Grande. The premise is that the current condition score applies to the entire sample area which represents the Wetland of Interest and considers the restoration in the context of the entire complex. However, the scores for individual metrics or attribute category can be used to target restoration measures that improve ecological integrity and may increase overall scores. A checklist of stressors that are potential drivers of declining ecological condition helps identify what might be affecting condition primarily at a landscape scale.

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Ecosystem Restoration along the Rio Grande and Tributaries, Espanola, NM

Governor Larry Phillips[1], Governor Michael Chavarria[2], and ***Stephanie McKenna[3]***

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The Rio Grande and Rio Chama have been affected by severe channel degradation resulting in loss of riparian "bosque" habitat. Both features have profound importance to indigenous people's way of life, considered integral to cultural identity, with their health fundamentally intertwined in significant cultural practices. For most indigenous people, the landscape is an essential part of constructing social identity and the transmission and survival of historical and cultural knowledge and practice. People define themselves in relation to the landscape, and the landscape is an interface where the past gives meaning and context to the present. Loss of the bosque is more than simply loss of plants and animals; it presents a real threat to customs, beliefs, and practices essential to the cultural identity and continuity of the Tribes in the United States.

About 70 percent of bird species in the arid Southwest are riparian-dependent during some part of their life cycles. The riparian habitat along the Rio Grande Flyway is a critical corridor between wild and scenic river areas, multiple state and national wildlife refuges, and links Central and South America to North America. The project will directly improve and restore ecological function to nearly 1,000 acres of critical wildlife habitat. The project will indirectly benefit the entire Espanola Valley, the Middle Rio Grande region, and Flyway providing benefits on an international scale.

This project represents strengthening restoration through collaboration in partnerships the United States Army Corps of Engineers has developed with local Tribes, how we incorporate indigenous knowledge that our tribal partners offer, in respect we show for tribal sovereignty, and in thoughtful planning, design, and construction of projects aimed at reducing uncertainty in the restoration process so that our tribal partners are able to realize high survival rates in plantings and maintain them for years to come.

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Understanding Botanical Traits of Rancho La Brea Fossils for Conservation Purposes

Steven Mendoza
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The La Brea Tar Pits and Museum in Los Angeles has over 4 million Pleistocene fossils that help us better understand California during the last Ice Age. While the focus of Rancho La Brea research has often been on understanding the site's megafauna, the plant fossils of this site hold a wealth of untapped information. Seeds, nuts, pods, leaves, and entire trees have been preserved in the asphalt to such a degree that researchers have identified over 150 different species of plants. These plants document the environmental changes Southern California has experienced from before the Last Glacial Maximum until today, proving their resilience during extreme climatic changes.

This project aims to create a landscape restoration plan that demonstrates different time periods and plant assemblages as they changed over time. La Brea Tar Pits is a unique site where a dialogue between paleontological researchers and environmental practitioners (habitat restorationists, city planners, conservation specialists, etc.) can be facilitated. For this conceptual Pleistocene Park, paleontological data will be utilized to inform and create plant recommendations for ecological practitioners to restore certain parts of Hancock Park to different temporal ranged iterations of Pleistocene LA. This will create a "living laboratory" that researchers from the Museum and elsewhere can utilize to survey, observe, and explore how novel ecosystems respond to plant assemblages of the past. This information is imperative to understanding how paleontological data can better inform conservation decisions in different regions and ecosystems.

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Upper Mississippi River Navigation and Ecosystem Sustainability Program

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The Navigation and Ecosystem Sustainability Program (NESP) is a long-term program of navigation improvements and ecosystem restoration for the Upper Mississippi River System (UMRS).

The primary goals of the program are to increase the capacity and improve the reliability of the inland navigation system while restoring, protecting, and enhancing the environment through implementation of an integrated, dual-purpose plan to ensure the economic and environmental sustainability of the Upper Mississippi River System.

Transportation, boating, fishing, and myriad other business and recreational uses of the Upper Mississippi River and Illinois Waterway (UMR-IWW) provide approximately $1 billion dollars annually in net benefits to the nation's economy. Equally important is the high environmental value these rivers provide the nation. Balancing these combined, and sometimes conflicting, factors make managing the river system challenging, with many individuals and organizations championing great and varying interests.

In view of these considerations, the U.S. Army Corps of Engineers conducted the Upper Mississippi River - Illinois Waterway System Navigation Feasibility Study to determine the best way to manage the UMRS in a manner which balances economic, environmental, social, and political needs. This study took a systems approach since changes in one part of the system may have an impact elsewhere in the system.

Under the study, the Rock Island District, St. Louis District and St. Paul District of the U.S. Army Corps of Engineers investigated the feasibility of navigation improvements to eight locks and 348 miles of the Illinois Waterway and 29 locks and 854 miles of the Upper Mississippi River. The feasibility of ecosystem enhancement and restoration on both rivers was also investigated.

The study determined the location and appropriate sequencing of any needed navigation improvements and ecosystem projects on the two rivers and prioritized these capital investments for the first half of the next century. The study also included a system-wide environmental assessment leading to the completion of a system Environmental Impact Statement.

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Interagency Ecological Restoration Quality Committee (IERQC) – Advancing Applications of Quality Assurance in Ecological Restoration Across the Laurentian Great Lakes

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The Interagency Ecological Restoration Quality Committee (IERQC) was formed in 2012 to support the U.S. Great Lakes Restoration Initiative (GLRI). The central role of the committee is to serve as a 'think-tank' focused on advancing applications of quality assurance (QA) and quality control (QC) practices in ecological restoration. The IERQC is chaired by the U.S. Environmental Protection Agency's Great Lakes National Program Office (GLNPO) and is composed of representatives from federal, tribal, state, and non-governmental organizations. The committee provides a collaborative environment for developing and advancing quality best practices and includes developing guidance publications and factsheets, virtual- and in-class workshops, a monthly webinar series, and contributing symposia and presentations at scientific meetings. The committee invites speakers to present on topics addressing quality best practices used in planning, implementation, and monitoring in ecological restoration across the Laurentian Great Lakes region. Published in 2019, "Application of Quality Assurance and Quality Control Principles to Ecological Restoration Project Monitoring," EPA-905-K-19-001 (https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100XC2E.txt) represents the committee's flagship publication. This publication is a comprehensive treatise on QA/QC best practices fundamental to planning, implementing, and assessing ecological restoration projects. Other resources developed by the committee include a set of tools to support developing data management plans, an annotated bibliography on quality concepts applied to adaptive management (AM), an online Zotero Group® reference database on AM, and a synopsis publication describing a variety of online AM tools and resources. In addition, the committee recently developed guidance on quality oversight specific to ecological restoration projects that involve a construction phase (e.g., installation of engineered solutions, grade and elevational contouring, capping, wetland reconstruction, among others). This presentation is funded under an EPA contract in support of the GLRI and the concepts described have wide application to large and small ecological restoration programs and projects.

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Beaver Restoration in Bandelier National Monument

Sarah Milligan
Bandelier National Monument, Los Alamos, NM, USA

Following the Las Conchas Fire in 2011, which burned over 65% of the park, and subsequent flooding, restoration projects were discussed to determine how best to manage the damage done to the riparian areas of Bandelier National Monument (BAND). One of the primary methods discussed was beaver reintroduction. As a National Park unit, management staff wanted to avoid using unnatural, "heavy-handed" restoration methods. Beavers were extirpated from the area in the 1960's and had not been seen in Bandelier since then, though the evidence of their existence remained through old dams and lodges.

In 2018, the New Mexico Department of Game and Fish assisted BAND staff with an analysis of Frijoles Canyon to determine if the area could support a beaver population, how many it could support, and where the best reintroduction location was. Once that was determined, the Resource staff, with a team of volunteers, created three introduction ponds. In 2019, six beavers were reintroduced to Frijoles Canyon for the first time in almost 80 years. Since then, a total of 27 beavers have been translocated into BAND. Many have not survived over the years, but there is currently one very active family of four that has built over ten different dams in Frijoles Canyon and likely 2-3 more beavers in the upper areas of the Canyon.

In addition to the beaver reintroductions, park staff has been planting native trees along the stream and reintroducing native fish back into the system. The Southern Colorado Plateau Network has been monitoring the macroinvertebrate populations and water quality since before the fire. Discussions are underway to create a more robust restoration plan to increase planting efforts to include more shade plants and to purchase specific water monitoring equipment to monitor turbidity, pH, temperature, and dissolved oxygen.

As Ecosystem Engineers, beavers have provided other species a place for consistent water and food as well as a nice area to be in. The wildlife cameras set up on the beaver ponds have taken photos of most mammals and many birds that are seen at BAND. Long-term, they appear to be the best solution for the damaged riparian system at BAND.

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Reducing Uncertainty in the CERP C-111 Spreader Canal Western Project

Brenda Mills
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Decreasing uncertainty within Comprehensive Everglades Restoration Plan (CERP) starts during planning with application of the Applied Science Strategy. For the C-111 Spreader Canal Western project it was incorporated into the project development process during planning, design, construction, monitoring, and operation when initiated around 2004 and continued when project refinements started post-construction in 2012. Incorporation of science gained from implementation, testing, and monitoring were continuously applied to reduce uncertainties and improve project performance. This Applied Science Strategy can be adapted to other restoration projects and has been applied to other CERP projects. Planning depended on the collective efforts of multi-disciplinary, interagency teams applying real world knowledge to develop performance metrics and targets for project specific hydrologic models. These models simulated intended benefits of the CERP Project expected in the Everglades National Park. Design benefited from a value engineering evaluation that recommended additional pump house bays in case future capacity increases were warranted. While construction methods gained advantages learned from the adjacent federal C-111 South Dade Project to increase water conveyance efficiency across the highly transmissive Biscayne aquifer. RECOVER's regional monitoring combined with the project's plan monitor two scales of changes – near field and far field as well as hydrologic focused and salinity coupled with biotic responses. However, it has been difficult to assign improved performance to regional changes or to the project benefits to the Everglades, in general, and to Taylor Slough specifically. Eventually enough data over the past 10 years have been collected by scientists within SFWMD's Applied Science Bureau to confirm project benefits have been achieved consistent with the project's objectives. It supported the decision to modify the project features and operations to increase flows to Taylor Slough and elsewhere including physical and operational adjustments to enhance performance and increase project benefits. The C-111 Spreader Canal Western Project has successfully been implemented and modified to achieve its intended benefits, but changes in regional conditions whether from other restoration projects or sea level rise will dictate future performance of the project.

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Leveraging Hydrologic Models to Compare Ecosystem Restoration Measures in a Bar-Built Estuary

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Prior and current land uses often stress marshes in complex ways, making it difficult to predict the most efficient path for restoration. This is particularly true in bar-built estuaries, where natural lagoon closures are important drivers in the hydrology of perched marshes. Lower Watsonville Slough has been subject to 1) historic clearing that removed natural side channels and microtopographic relief, 2) reduction of marsh extent by agriculture and development, 3) hydrologic constrictions including berms between the slough and marsh plain and levees on the main stem of the Pajaro River, to which Watsonville Slough is a tributary, and 4) manual breaching of the lagoon during natural closures that would otherwise inundate the marsh.

Dominance of non-native xeric species and stunted growth of native species in portions of the marsh plain indicate truncated hydrology. To ascertain which restoration measures would maximally reestablish appropriate marsh hydrology, numerous hydrologic and geographic information system (GIS) models were leveraged and combined. Representative Hydrologic Engineering Center's River Analysis System (HEC-RAS) model scenarios were run for four distinct lagoon mouth (open and closed) and hydrologic (wet and dry) states through a year. Inundation heat maps were generated for each run, and then combined into an annual inundation heatmap using weightings derived from the Lagoon Quantitative Conceptual Model (QCM), a parametric mass-balance model used to predict lagoon closures and natural openings.

Ranges of modeled inundation that support robust marsh, upland or stunted marsh, and open water were determined by comparing the existing conditions annual inundation heat map with a vegetation map. Modeling was completed for the future without project and three alternatives to determine the most effective restoration of marsh hydrology. While intensive, this robust and thoroughly reviewed analysis led to a different selected plan than a simpler marsh condition index model might have supported.

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Restoration Trajectories in Created Tidal Marsh Habitat – A Case Study from Poplar Island, MD USA

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Tidal marsh loss in coastal areas of the U. S. has inspired a variety of approaches to restore habitat and associated ecosystem services, such as protection from flooding and shoreline erosion, nutrient cycling and carbon sequestration. Increasingly, material dredged during navigation channel maintenance is beneficially used to supplement declining marshes or create new marshes. We present results from a large-scale marsh creation project where fine-grained dredged material is used to create 314 hectares of tidal marsh habitat in mid-Chesapeake Bay, MD, USA. In contrast to marsh projects where sand is the substrate, the Poplar Island marshes are nutrient rich, leading to the hypothesis that vegetation development trajectories could also be quite different. We analyzed vegetation development in eight created marshes ranging in age from 3-16 years, seven with the high-nutrient substrate and one with low-nutrient sand, with the goal of characterizing trajectories to help inform future, similar projects. Additionally, trajectories using different vegetation monitoring methodologies were compared to offer insights for future marsh monitoring designs and suggest where cost savings might be possible.

We found that fine-grained dredged material enhances vegetation development, as reflected in aboveground biomass production, percent cover and canopy height, exceeding biomass and canopy height reported for many natural marshes for the first few years after establishment. There is, however, high variability, driven in part by *Spartina alterniflora* dieback, which frequently occurs within the first five years post-planting. Long-term monitoring shows that the marshes, including those recovering from dieback, trend toward biomass production levels more similar to natural marshes. Declining nitrogen availability is likely at least partially responsible for the observed trend in biomass production. In contrast, the low nutrient marsh shows a more gradual increase in aboveground biomass production and appears less subject to dieback. Similar trends were observed in canopy height and percent cover.

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Think Like a Watershed, Act like a River: The Culture of Community Based River Restoration in the Arizona-Sonora, MX Binational Watersheds

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After around 150 years of Powell's watershed map, we are getting there….. Think like watershed with interdependence and connectivity of the uplands-middle lands and lowlands and act like a river being the connector of these interactions from the top to the bottom and vice versa. In this presentation we are going to explore some lessons learned of three bi-national watershed shared between Mexico and USA. With the Kwapa Community in the Colorado River Delta, we developed community mapping strategies to elevate the role of the Kwapa in river restoration-cultural knowledge, management, and policy, thanks to this process the Kwapa continue to be an important presence in restoration initiative of the Colorado River Delta. By finding common ground with the ranching community of the Santa Cruz and San Pedro Rivers we are expanding best management practices for river restoration and range management with community benefits as well as binational watershed health. In Tucson, AZ within the Santa Cruz River basin with Watershed Management Group team, we are developing and implementing a 50 year vision for the restoration of the urban Santa Cruz with a multiple collaboration of a variety of stakeholders. These three cases provide insights of the importance of community based river restoration for rural and urban environments.

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Beaver Dams & their Analogs are Natural Infrastructure in Dryland Streams (NIDS) – a Synthesis

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In this presentation, we describe the benefit of Natural Infrastructure in Dryland Streams (NIDS) in dryland fluvial ecosystems. These ecosystems are comprised of natural hydrogeomorphological and biogeochemical cycles that make them unique, yet vulnerable to land use activities and climate change. NIDS, which are structures naturally or anthropogenically created from earth, wood, debris, or rock, can restore implicit function of these systems. This talk further discusses the capability of and functional similarities between beaver dams and anthropogenic NIDS, documented by decades of scientific study. In addition, we present the evidence-based finding that NIDS can create wetlands in water-scarce riparian zones, with soil organic carbon stock as much as 200 to 1400 Mg C/ha in the top meter of soil. We identify the key restorative action of NIDS, which is to slow the drainage of water from the landscape such that more of it can infiltrate, be used to support wetland and riparian vegetation, and improve water quality by reducing sedimentation. Specifically, we assert that the rapid drainage of water from such environments can be reversed through the restoration of natural infrastructure that once existed. We then explore how NIDS can be used to restore the natural biogeochemical feedback loops in these systems and provide examples of such loops, lessons learned from installation of NIDS in the southwestern United States, how such efforts might be scaled up, and what the implications are for mitigating climate change effects. Our synthesis portrays how restoration using NIDS can support adaptation to and protection from climate-related disturbances and stressors such as drought, water shortages, flooding, heatwaves, dust storms, wildfire, biodiversity losses, and food insecurity.

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How Advances in Federal Benefit Cost Analysis and Natural Capital Accounting Will Impact Restoration

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The Biden Harris Administration has put forward some important advancements on federal policy and statistics that can better account for nature in federal decisions and statistics. 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. On August 1 2023, the draft guidance was released for public comments. Better accounting for nature could increase federal support for nature-based solutions including restoration. The administration also released a National Strategy to Develop Statistics for Environmental Economic Decisions to build a US system for natural capital accounting. It creates a system to account for natural assets in the U.S.—from the minerals that power our tech economy and are driving the electric-vehicle revolution, to the ocean and rivers that support our fishing industry, to the forests that clean our air—and quantify the immense value this natural capital provides. The system, once in place, will help us understand and consistently track changes in the condition and economic value of land, water, air, and other natural assets and their impact on our economy. It will provide data to guide the federal government and the economy toward sustainable development. This presentation will provide an overview and some insights into these two new important advancements and how they could impact our understanding of and the opportunities for restoration.

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Restoring Bright Angel Creek: Saving Colorado River Native Fish One Tributary at a Time

Emily Omana, *Sarah Haas, Kurtis Shollenberger[3], Laura Tennant[4], Susan Wood[5], Ryan Green[6], and Rebecca Koller[7]*
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Predation and competition by invasive species present threats to native fish conservation, particularly in arid-land rivers where extensive damming have homogenized flows. Native river fishes of arid regions are particularly vulnerable to the impacts of invasive species and habitat alteration, as many evolved specialized life history strategies for highly dynamic ecosystems. Once established, invasive fishes are difficult and costly to remove and can displace native species. Five native fish species currently persist with invasive brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) in the tributaries and mainstem Colorado River in Grand Canyon National Park. Additionally, new warm water invasives including smallmouth bass (*Micropterus dolomieui*) are being detected below the Glen Canyon Dam and represent new threats to native fish conservation in Grand Canyon.

We report on a multi-year trout suppression program in Bright Angel Creek, a tributary to the Colorado River in Grand Canyon. Across eight seasons, mechanical suppression resulted in an 89% decline in the abundance of brown trout and rainbow trout, and concurrent increases in native fishes of 480%. Our results suggest rapid recovery of native fishes can be achieved through suppression efforts of non-natives, but additional effort may be necessary where stream temperatures are cooler and where environmental barriers exist to mechanical removal. Additional restoration of Bright Angel Creek via chemical treatment is in the planning stages, including analysis of environmental impacts to non-target species and consultation with tribal partners on effects to traditional properties. A wholistic approach to watershed restoration, including clear management objectives and ecosystem resilience potential, can lead to improved native fish habitat, and reduction in costs related to mechanical removal efforts. Protecting native fish habitat in tributary streams may become critical to protecting Colorado River native fish diversity and providing a sanctuary to invading non-natives.

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Henry Ford Estate Dam Fishway: Challenges Overcome to Provide Ecosystem Restoration

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The Henry Ford Estate dam, part of a National Historic Landmark, was built in the early 1900's by Henry Ford for the purpose of generating electricity for his home, located on the Rouge River, in Dearborn, Michigan. The construction of the dam impeded fish passage, cutting off over 160 miles the Rouge River and it tributaries from the Great Lakes system. In the early 2000's both the Rouge River Project and the USACE at different times explored dam removal, modification, and channel bypass were explored as ways to open up the river system to fish passage. Due to the historical significance of the dam, removal and modification were not feasible. Therefore, a channel bypass "fishway" was developed.

The Alliance of Rouge Communities (ARC) was awarded funding in 2015 from the GLRI, through NOAA, to develop the design for an 800 lft Fishway. Wayne County partnered with the ARC in 2017 under EPA GLRI funding to implement construction of the Henry Ford Estate Dam Fishway (a Rouge River Area of Concern (AOC) habitat restoration project). Detail of the design, which incorporated many parameters including maintaining a base level of flow over the dam to allow for hydroelectricity capabilities for the home used for historical demonstrations, while providing effective fish passage function, hydraulic function, and habitat value will be discussed. However, this project had many unique hurdles faced from the National Historic Site registration in design to construction suffering through and recovering from, two 100-year flood events and one 500-year flood event, experiencing historically high river levels, high levels of pedestrian use during the Covid-19 pandemic, and significant site access challenges. The strategies used to overcome these hurdles will be presented resulting in the successful outcome of this unique restoration project in the Great Lakes.

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Weedy Plant Species Response to Variable Precipitation Following Restoration Seeding in Drylands

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Restoration outcomes in semiarid and arid regions are often unpredictable, as precipitation is a major driver of success. This unpredictability will only increase with the growing effects of climate change, which are projected to increase precipitation variability and occurrence of extreme events in the American Southwest. Seeding is a commonly employed restoration tool, but can fail 17% of the time, resulting in no seeded species growth. Hence, due to its high-risk nature, more research is needed to better optimize seeding mixes, timing, and rates. While seeding of native species is often used to suppress weedy or invasive species, this strategy is successful only if seeded native species can outcompete weedy ones. Seedling establishment and growth during initial years is critical in determining if desirable versus weedy species will dominate a site. Previous research has shown that timing of precipitation in relation to seeding has a larger influence on native seedling emergence, growth, and survival than site-specific characteristics. Studies have also shown that non-native invasive species tend to recover from drought quicker than native species, but results can be site-specific and not necessarily predictive. As precipitation becomes more erratic in this region, understanding how invasive versus native seedlings respond to drought will become even more critical for restoration success.

Here, we examine the effects of back-to-back years of unusually high and low precipitation on native versus invasive plant growth following seeding across an aridity gradient. Our study is part of the Restoration Assessment & Monitoring Program for the Southwest (RAMPS), a USGS program designed to foster collaboration and knowledge sharing across land managers and scientists. Our project, RestoreNet, is a network of dryland restoration plots located at 21 sites that span across the southwestern United States. The same treatments were employed across all sites to determine how restoration techniques varied across an environmental gradient. We tested two types of site-specific seed mixes: one that was optimized for current local conditions, and one that consisted of species from warmer and drier conditions, guided by climate change adaptation. Sites were monitored for 2-4 years, where we measured vegetation cover and seedling density of native and invasive species. Preliminary results revealed that the climate change-adapted seed mix did not perform as well as the local optimized seed mix, and that invasive seedlings outcompeted native seedlings following drought, but that seeded native plants outcompeted invasive ones under wetter conditions. Our work provides valuable insights into what to expect in the future under more variable inter- and intra-year precipitation in drylands, and how to harness this knowledge to deliver better restoration outcomes.

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Comprehensive Everglades Restoration Plan: Framework to Restore, Protect, and Preserve America's Everglades

Gina Paduano Ralph *and Jenna May*
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The Everglades ecosystem has been altered from over 130 years of highly effective efforts to drain water from the land. As a result, the remaining Everglades ecosystem no longer exhibits the structure, function, or diversity that historically defined the pre-drainage system. The Comprehensive Everglades Restoration Plan (CERP), authorized by Congress in 2000, restores, preserves, and protects the south Florida ecosystem while providing for other water-related needs including water supply and flood protection. CERP focuses on quantity, quality, timing, and distribution of water flow, given modern constraints, to recover critical ecological functions that characterized the historical Everglades and other portions of the south Florida landscape. Through construction and operation of 68 interdependent components, CERP aims to restore natural hydrology through removal of more than 240 miles of internal levees and canals, improving the health of over 2.4 million acres by allowing water to flow nearly unobstructed throughout the south Florida ecosystem.

Due to its size and complexity, many uncertainties are associated with CERP planning and implementation. Uncertainty exists when there is (1) a lack of knowledge about the ecosystem to be restored; and (2) the restoration design and its associated targets. As a result, uncertainties can impede planning, design, and operation, and pose a risk to successful restoration. To reduce these uncertainties, CERP employs an Applied Science Strategy implemented by REstoration, COordination and VERification (RECOVER), an interagency and interdisciplinary scientific and technical team created to ensure that system-wide science guides CERP implementation. The major components of the strategy include conceptual ecological models, performance measures and restoration targets, a system-wide monitoring plan, and a performance assessment protocol. Conceptual ecological models identify major drivers and stressors on the environment, how these stressors affect the environment, and which biological indicators are best to measure ecological responses. Performance measures determine the degree to which proposed project plans are likely to meet, or whether implemented plans have met, restoration targets. Data collected through the system-wide monitoring plan inform development of these predictive tools and are used to assess whether ecosystem performance is moving towards CERP restoration goals. If CERP projects are not moving towards defined goals, an adaptive management strategy is undertaken to adjust implementation to improve the probability of achieving success. Extensive planning and scientific investigations conducted by RECOVER, along with formulation and evaluation of CERP projects, have greatly increased scientific knowledge and understanding of the current and historic system, and reduced uncertainty surrounding the actions needed to achieve restoration goals.

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Fact Sheets Providing Guidance for Quality Assurance in Ecological Restoration Project Monitoring

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Ecological restoration in all regions requires collecting reliable data for determining the appropriateness of restoration techniques, evaluating project method effectiveness against restoration objectives, and building the necessary evidence to support management decisions. Often these data are collected as observations or estimates based on best professional judgment. Unlike accredited laboratory settings where rigorous quality assurance and quality control (QA/QC) procedures have been in place for decades, practitioners for ecological restoration projects do not have comprehensive guidance on how to ensure the reliability of data. To address this need, U.S. EPA's Great Lakes National Program Office (GLNPO) with the assistance of representatives from several federal agencies prepared a guidance document entitled *Application of Quality Assurance and Quality Control Principles to Ecological Restoration Project Monitoring* (EPA-905-K19-001, April 2019). A series of short fact sheets have been developed to cover each chapter of the document to acquaint restoration practitioners with the key concepts presented in greater detail in the guidance document. Topics addressed by this fact sheet series include a description of the benefits and principles of QA/QC (Chapters 1 & 2); defining the level of data quality to meet the intended data uses (Chapter 3); preparing for field data collection (Chapter 4); defining and establishing QC field checks (Chapter 5); data review (Chapter 6); and data quality assessment (Chapter 7). These factsheets are a convenient resource for practitioners who are preparing quality assurance project plans (QAPPs), need to disseminate information, or provide training to collaborators and contractors on a particular QA topic. This effort is funded under an EPA contract in support of the Great Lakes Restoration Initiative.

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Innovative On-Site and Remote Modeling Techniques to Quantify Biodiversity and Pollinator Habitat Potential

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Private landowners have multiple options for generating value on their land such as mining, which is rivalrous and excludable to carbon sequestration which is non-rivalrous and non-excludable as well as all of those options in between. We use a Natural Capital Valuation framework and methods to identify which options can potentially generate the most value and which may be more compatible with each other in terms of preserving the overall value of the land parcel. Accordingly, this talk discusses market valuation methods to measure rivalrous and excludable options and willingness-to-pay studies using benefit transfer to measure the non-rivalrous and non-excludable options allowing landowners to optimize among different options and to better understand the ensuing tradeoffs among options.

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Reimagining the San Joaquin River Using the EcoFIP Framework to Reconnect Floodplains

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Presented by: ***Noelle Patterson***

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Anthropogenic modifications to riverine systems intended to provide flood control and reliable water supply have altered flow regimes and river connectivity leading to heavily degraded freshwater systems. Restoring these systems to meet challenges of flood risk reduction, water scarcity, and changing climates requires an approach that integrates physical alterations to channels and floodplains while accounting for hydrologic changes that systems are experiencing (e.g., reservoir management or changing flow regime). Ecological Floodplain Inundation Potential (EcoFIP) is a methodology and toolbox that facilitates multiple levels of identification, screening, and design of multi-objective floodplain rehabilitation projects. EcoFIP leverages topographic data, hydrology, hydraulic modeling, soil characteristics, and groundwater data to estimate changes in ecosystem benefits resulting from physical alterations to river corridors (e.g., floodplain lowering, levee setbacks, revegetation) and changes in flow conditions (e.g., climate change, reservoir reoperation). EcoFIP can estimate these benefits at macro (river reach) and micro (site-level) scales, enabling evaluation of the ecological characteristics of any boundary of interest for various historical or potential flow regimes. These gains can be reported in metrics such as acre-days of inundated floodplain area, acre-days of suitable floodplain habitat (for salmonids or other species), and groundwater recharge volumes summarized over a range of water years.

A case study applies EcoFIP to assess over 100 miles of the Upper San Joaquin River and flood bypasses between Friant Dam and the confluence with the Merced River, in support of the California Department of Water Resources' Central Valley Flood Protection Plan and Conservation Strategy. The analysis is evaluating current and future flow regimes with the goal of identifying and designing potential multi-objective floodplain rehabilitation sites, that provide high-quality salmonid habitat, and maximize groundwater recharge from floodplain inundation.

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Remote Sensing of Evapotranspiration to Assess Water Budget Response Across a Restoration Landscape

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Estimates of evapotranspiration (ET) are valuable for effective monitoring and management of water resources, as they represent the largest component of the water budget. In areas that lack a ground-based monitoring network, remote sensing allows for accurate and consistent estimates of ET across a broad scale. Several global-scale remote sensing ET products exist, though each single product has limitations (i.e., consistency, resolution, availability). We developed an Ensemble Mean product to incorporate advancements, reduce uncertainty, and extend our period of study. The Ensemble Mean ET product is applied to estimate vegetative water use and variations in response to restoration using natural infrastructure in dryland streams (i.e., check dams, leaky weirs) and management interventions (i.e., fencing pastures) on a private ranch in Baja California Sur, Mexico. We initiated a paired watershed study to compare a watershed being restored with a series of adjacent control watersheds. Specifically, we identify and develop a consistent monthly Ensemble Mean product using this suite of ET products, assess changes in ET using this product over time across multiple Land Use/Land Cover types, and evaluate differences in vegetation and ET response between treated and control watersheds. We found the Ensemble Mean ET product is more reliable than using a single ET data product and can augment the efficacy of ET-based studies, particularly in areas without a ground-based monitoring network. We observe that ET across grasslands/shrublands depends more on precipitation, while forest vegetation appears to be less responsive. When expanding these results across the restoration landscape, increasing vegetation greenness and ET occurs within the restored watershed when compared to control sites (ET Slope*1000: Restoration = 0.3; Control = 0.24), indicating that restoration was effective at increasing vegetation health and greenness. We attribute this to greater water available to plants r and a reduction in grazing in the restored watershed.

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Fish Habitat Modeling on the Sacramento River

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The Fish Habitat Assessment and Simulation Tool (FHAST) is an open-source program was developed by the University of California, Santa Cruz and NOAA Fisheries for evaluating pre- and post-habitat alteration actions for anadromous fish on the Sacramento and American Rivers in the Central Valley of California, USA. Specifically, the model estimates the with and without project effects for levee protection construction and associated habitat mitigation for Chinook Salmon, Steelhead, and Green Sturgeon. FHAST uses hydraulic, vegetative and substrate information in combination with fish physiology and behavior to estimate fish habitat and population metrics. The model is written using an agent-based modeling framework (NetLogo) with R software for implementing analyses. FHAST is designed to estimate shaded riverine aquatic and inundated riparian habitat used by anadromous species at scales ranging from individual sites to river reaches.

The Fish Habitat Assessment and Simulation Tool framework is robust for transfer to other river systems with the Salmon and Sturgeon and adaptable for adding fish species of interest for evaluation. Expansion to other river systems requires hydraulic modeling and vegetation map layers for those systems. Common 2D riverine hydraulic models provide depth and velocity data for describing river flow as fish habitat parameters. Vegetation derived from existing geospatial data sources is the basis for the canopy and vegetative cover layers to estimate inundated riparian and shaded riverine habitat. The model has the potential to estimate habitat for other life stages like spawning redds and rearing habitat for Chinook Salmon, Steelhead, and Green Sturgeon.

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Creating Resiliency at Marsh Lake: Reverting a Shallow Freshwater Lake from a Turbid to Clear Water State

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Marsh Lake is located on the Minnesota River, near its headwaters and about 300 river miles upstream of its confluence with the Mississippi River. Originally this was a river floodplain lake created by a delta at the terminus of the Pomme de Terre River. The river was dammed in the 1930s as a project under the Federal Works Progress Commission, creating a shallow 2,000-hectare pool with submersed and emergent vegetation important for migrating waterfowl. Initial conditions after impoundment were indicative of a clear-water state, generally supportive of wildlife and fish. However, the environment degraded over some 80 years driven by, among other things, elevated wind and wave action, sediment loading, infestation by common carp and static water levels. By the early 1990s, the system transitioned to a turbid water state, resulting in a near complete loss of aquatic and emergent vegetation. The Marsh Lake Dam embankment also moved the mouth of the Pomme de Terre River upstream and into the pool, resulting in the loss of over 2 kilometers of the river and blocking seasonal fish passage.

After a lengthy planning process, the Corps of Engineers, in cooperation with the Minnesota Department of Natural Resources and the Upper Minnesota River Watershed District, designed modifications to the dam intended to restore ecosystem processes that included a water control structure, rock arch rapids fishway, embankment breach, re-route of the Pomme de Terre River channel, and shoreline stabilization. Despite challenges with record high flows, construction of the $13 million project occurred between 2017 and 2020. This was followed by two consecutive years of an intentional pool-wide drawdown under drought conditions. This resulted in drying most of the lakebed, thus compacting sediment and exposing important seed beds. In 2022, the water surface elevation was restored, and the pool became dominated by emergent and submersed aquatic vegetation that act to damper wave action and filter nutrients, thus improving water clarity. In the two years post-drawdown, aquatic vegetation continues to dominate and a clear water state persists. In addition, fish passage through the dam has been greatly enhanced, and flow through the historic Pomme de Terre River channel has resulted in colonization by mussels.

These features and the future management thereof, will simulate a more natural hydrologic regime to sustain aquatic vegetation critical as a food source and cover for migrating waterfowl, colonial waterbird, and shorebird populations. Over the long term, improvements in water clarity and fish passage will benefit native fish populations in the pool to the detriment of invasive carp. The project was recently handed over to the local sponsor with the responsibility of implementing an operational plan. An adaptive management team has been assembled to monitor performance and make recommendations for maintaining the system's resiliency and maximize project success.

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Research Initiatives for Restoration and Regulation

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Ecological restoration offers unique opportunities for large-scale experiments grounded in fundamental ecological theory. However, there exists a notable gap between restoration of habitats and ecosystems from the practical application of restoration ecology to the conceptual underpinnings of ecological science. Efforts to bridge this divide have been underway since as early as 1987, with scientists recognizing the mutual benefits of integrating restoration ecology and academic-based conceptual knowledge. The declaration of a "decade of ecosystem restoration" by the UN in 2019 has propelled a surge in restoration science across diverse sectors, fostering numerous potential connections with previously isolated scientific theories.

As global interest and investment in restoration and ecosystem improvement continue to grow, there is a critical opportunity for experts and policymakers to leverage this momentum to enhance the scientific understanding of ecological restoration. Practitioners in various fields, such as carbon markets, regenerative agriculture, forest revegetation, wildlife biology, and waterway protection, can derive substantial benefits from a more seamless integration of practical application with conceptual theories. While emerging environmental markets can benefit, focusing on established markets, such as the 1972 Clean Water Act and the 2008 Federal Compensatory Mitigation Rule, may prove to be easier to integrate ecological theory into acceptable and widely adopted restoration ecology practices. In light of recent shifts in waterway protection policies at the Federal level, there is perhaps a more urgent need to increase the science and knowledge-base surrounding current restoration projects of our streams and wetlands.

While the stream compensatory mitigation field has high regulatory oversight, with both federal and state policies, there exists room for refinement in the scientific approach. Stream design engineers and ecologists alike can benefit from integrating ecological theory into restoration practices, including initial design of stream and riparian habitat restoration, as well as elevated sophistication in the types of data collected throughout required monitoring periods. Given the increased demand for comprehensive data to demonstrate the determined performance standards of waterway restoration projects, this field of restoration ecology is well-positioned to benefit significantly from the integration of ecological theory.

This presentation delves into the potential mechanisms for integrating ecological theory into the application of restoration ecology. Key topics include proposed research programs for inclusion in stream compensatory mitigation projects, including various data collection methods and hypotheses outlined in detailed flow charts. Additionally, considerations are given to potential coalitions capable of spearheading such initiatives, and the exploration of viable funding mechanisms.

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Middle Rio Grande Bosque Habitat Restoration Holds Promise for Threatened and Endangered Songbirds

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The Albuquerque District US Army Corps of Engineers designed and constructed the Middle Rio Grande Bosque habitat restoration project at 17 sites along a 22-mile reach of the Rio Grande from 2011 to 2016. Since construction, restoration area habitat has matured, especially where shrub plantings are connected to groundwater. We will discuss habitat development at these sites and progress toward the goal of improving habitat for birds, including threatened and endangered songbirds.

Hawks Aloft, Inc. conducted Willow Flycatcher (*Empidonax traillii*) surveys at 16 restoration sites in 2004-2015, 2022, and 2023. Tetra Tech conducted surveys in 2016-2019. Cumulatively, Willow Flycatchers were detected at 12 of the 16 sites. Until 2019, most detections were in May, indicating migrating birds. Since 2020, surveys have included detections during the third survey period (July 31- August 15) at four sites, when only territorial and potentially breeding individuals of the federally endangered southwestern subspecies (*E. t. extimus*) would be expected. Nesting was confirmed at one site in 2020 and a possible family group was observed in 2023. These detections illustrate that habitat characteristics at most of the restoration sites are suitable for migrating Willow Flycatchers and that in some cases are suitable for territorial and potentially breeding individuals of the endangered southwestern subspecies.

Only a few Yellow-billed Cuckoo (*Coccyzus americanus*) surveys have been conducted since restoration activities were completed. In 2023, Hawks Aloft, Inc. conducted cuckoo surveys at 13 restoration sites and documented cuckoos at five sites. At four of those sites, cuckoos were documented during the second survey period (July 1 - 31) when birds would be expected to be territorial and potentially breeding. Although we could not confirm any breeding attempts, the 2023 detections illustrate that some restoration areas provide habitat that is potentially suitable for both migrant and territorial cuckoos.

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Developing a Molluscan Biotic Index for Establishing Geohistorical Baselines of Benthic Conditions

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An essential prerequisite to the use of biotic indices for assessing the condition of estuarine benthic macroinvertebrate communities is the establishment of relevant, location-specific baseline conditions that correspond with the restoration or remediation objectives, and that accounts for natural temporal and spatial variability. Unfortunately, without long-term monitoring records, it can be difficult to establish sound baseline conditions and therefore assess where the ecosystem is along the path towards recovery. A solution could be the use of the molluscan geohistorical record, which comprises dead shell remains preserved in the sediment that are time-averaged on the scale of decades to centuries, thereby providing a location-specific, long-term record of benthic conditions. However, the formation of the molluscan geohistorical record introduces potential biases that need to be accounted for before using the records to establish baseline conditions for biotic indices, including the preservation of species abundance, increased richness, and increased evenness. Here we outline the development of a molluscan biotic index that can account for the effects of time-averaging and preservational bias. We modified the nationally adopted Multivariate-AZTI Marine Biotic Index by substituting metrics known to provide greater concordance between the live, real-time monitoring and geohistorical records, such as fractional Hill numbers and abundance transformations. Using coastal condition survey data from the Atlantic and Gulf Coasts of the United States, sample sites were grouped by salinity and sediment type, and metrics were selected based on the effectiveness of the metric to distinguish degraded and minimally impacted sites, which were designated a priori based on sediment contamination, eutrophication, and hypoxia. The development of a molluscan biotic index geared towards application to the geohistorical record would facilitate the establishment of relevant, location-specific baseline conditions, especially in areas without prior monitoring records.

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Going to Extremes: The Role of Adaptive Management in Moving from Risk to Resilience

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There is growing acknowledgement, if not always meaningful action, among governments, businesses, international organizations, and the general public, of the compounding and cascading impacts arising from a changing world. Traditional risk assessment and management strategies are challenged by these systemic and evolving impacts of extremes, variability and change. We however also live in a creative world, where the opportunities for innovation abound as the COVID experience itself showed. Both prospective and adaptive management are needed on an unprecedented scale and at an unprecedented rate.

Decades of research and applications elucidate the cumulative and interconnected nature of risk. Developed by ecologists, disaster researchers, and policy scientists these concepts have become embedded in the IPCC and elsewhere. The IPBES (2019), the Sustainable Development Goals (SDGs) 2019 Reports and the UNDRR Sendai Mid-Term Review (2023) note that transitions to generate transformations required are not advancing at the speed or scale required. To paraphrase the late geographer Gilbert White (2004, pers. comm.) “if we know so much, why aren’t we doing better?” The challenges expose the need for scientifically and socially robust knowledge prospectively “for” change, and to proactively inform navigation “through” rapidly changing environments.

Over at least the past five decades we have learned that risk governance can only be effective within vertical and horizontal collaborative networks, reconciling problem-definitions, value conflicts, and shared visions over time. Five action categories of research the help to “ adapt” adaptive management entail (1) improved characterizations of extreme event dynamics and impacts forensics, (2) collaborative learning and storylines from focusing events highlighting risk creation and opportunities for risk reduction, (3) modernizing information systems to increase agility during windows of opportunity, (4) taking the governance and alignment of risk-based knowledge beyond issue attention cycles, and (5) evolving transdisciplinary professionals to move beyond translation and boundary-spanning.

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Wetland Restoration as an Act of Stewardship - A Seminole Perspective

***J. Redwine**. and **A. Nocentini** .*

Monitoring the effects of incremental restorative actions can help make restoration successful, especially when supported by a strong sense of stewardship. Rehydration of the Native area in the Seminole Tribe's Big Cypress Reservation, located within Southwestern Florida is currently being planned, along with a supporting monitoring effort. Establishment of the regional canal system created under the Central and Southern Florida Project (C&SF) has dried the area and isolated wetland systems, causing transitions in vegetated habitats from cypress (-17 %) and marsh (-85 %) communities to pine (+192 %) or to oaks and other hardwood tree (+397 %) communities. Preliminary data collected over the last decade show mean total phosphorus and total Kjeldahl nitrogen concentrations of 0.035 ± 0.029 and 1.17 ± 0.38 mg L^{-1}, indicating partially intact water quality conditions. Regional ecological monitoring efforts, such as the rehydration of Northeast Shark River Slough in Everglades National Park serves as an example of an ecological monitoring plan that documents hydrologic restoration success. In Northeast Shark River Slough, between 2015 and 2021, hydroperiod and mean water depth increased to 344 ± 6 days (+ 18%) and 55 ± 13 cm (+293%), and four prescribed fires affected 51% of the monitoring locations. Biogeochemical changes and vegetation community transitions in the wetland landscape were driven by both hydrology and prescribed fires. Total phosphorus concentrations in the soil decreased, while soil carbon:phosphorus and nitrogen:phosphorus ratios increased at sites further away from water management infrastructure, possibly indicating re-initiation of peat accretion. Abundance of dominant long-hydroperiod species increased. Restoring the Kissimmee Billie Slough in the Native Area of the Big Cypress Seminole Reservation is an important piece of a vision for restoring the regional system. The vision that we wish to nurture and promote includes pinpointing and bringing to a halt pollution sources, balancing the proportionality of land uses, and increasing the amount of land that accumulates peat soils and stores nutrients by increasing the amount of overland sheet flow compared to canal flow. These actions will incrementally restore the native ecosystem and should enhance water quality while simultaneously reducing future management burdens.

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Combining Remotely Sensed Data and Machine Learning for Rapid and Repeatable Wetland Mapping and Assessment

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Understanding baseline conditions prior to design and monitoring post-construction success accurately and cost-efficiently are crucial components of ecosystem restoration. Quality data and assessment methods help guide adaptive management and provide quick feedback to guide restoration approaches for future projects. Current non-machine learning methods to evaluate the extent and type of wetlands rely on extensive field efforts or desktop analysis often based on outdated and low spatial resolution data, which can be a subjective and laborious process. Existing wetland machine learning models identify and map wetlands at regional scales, but their accuracy might be less effective for smaller restoration projects.

CDM Smith created a machine learning model to delineate wetland boundaries using high-resolution LiDAR and publicly available multispectral NAIP imagery for projects across multiple geographies. CDM Smith utilized several approaches to train the model on site-specific data to save time while increasing accuracy and developed multiple model iterations with different sites and combinations of data. Combing high-resolution spatial datasets and leveraging machine learning allows for rapid wetland identification and quantification in a repeatable manner, which allows for the tracking of changes over time. Overall, the machine learning model accuracy was high, ranging from 70 to 90 percent.

A machine learning model based on quality digital data provides a variety of benefits to restoration monitoring. The high volume of quality data can help reduce and eliminate the uncertainty of baseline conditions at a restoration site. The digital data utilized for the wetland machine learning model can be leveraged to aid in H&H design, mapping vegetative communities, and identifying sensitive habitats. This machine learning model can be applied to site-specific regions and ecosystem types and optimized using additional site-specific data. The model can then be reapplied over time and eliminates the subjectivity that can come from variable human-based assessments.

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Agreements to Support Healthy Rivers and Landscapes – An Environmental NGO Perspective

Julie Rentner
River Partners, Chico, CA, USA

The Central Valley of California once supported millions of acres of wetlands and riverine habitats with a diversity of wildlife populations including the largest inland run of anadromous salmon in North America, bears, mountain lions, condor, elk and global migrations of arctic and Neo-tropical bird assemblages. The Central Valley also supported populations of Native Americans exceeding hundreds of thousands who managed the landscape with fire and water diversions to provide a rich and abundant lifestyle reliant upon the valley's functional ecology. We have lost 95% of this native ecology since 1850. The rapid and dramatic conversion of this landscape to the world's most productive agricultural economy has resulted in many layers of government commitments and agency oversight in the recovery of endangered species and promotion of cultural preservation that must be balanced with the needs of our existing and dynamic communities, farms and industries. Today, more than 27 million Californians rely on this watershed. Climate projections show increasing intensity of water scarcity. All investments in ecosystem recovery and river flow management require deep and respectful consideration of many interests, often with limited data and great uncertainty.

River Partners' habitat restoration work has demonstrated the value of large-scale nature-based solutions for river management and built cross-sector partnerships for healthy rivers and landscapes and communities in the Central Valley. This talk will share perspectives and lessons learned in navigating the translation of habitat and environmental targets from academic and public sectors into on-the-ground habitat restoration and river management changes that provide multiple benefits to communities such as reduced flood risk, improved water supply management, and increased access to the outdoors – all critical components of recovery of the ecology of the Sacramento and San Joaquin Rivers. Historic agreements in negotiation today will build on this foundation of adaptation, inclusion, and bold action.

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Juniper Tank, Pasture Rehab

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This project is located in the Juniper Tank Pasture on the Ash Creek Livestock Association.

The objective of this project is to decrease topsoil erosion coupled with decreasing excess sedimentation into the San Carlos River, the primary waterbody into which the project watershed drains. Historically gullies have formed along the hillsides causing deep soil loss. The implementation of check dams within the gullies will provide improved soil stability by eliminating further down cutting caused by concentrated water flow. The check dams will slow the surface water flow and capture sediment which will also provide for soil surface stabilization for native plants through root growth and water capture.

Soil stability will alleviate sedimentation within the projects sub-watershed, therefore reducing sedimentation of water within the watershed and sub-basin as well. Through the installation of check dam's sediment will be captured on site and allow water to infiltrate into the soil profile. Newly planted grass will utilize the additional water to develop root systems to further control the loss of soil from runoff and further minimize sedimentation within the sub-watershed.

The check dams, new grasses, and the infiltrated water will aid in the recontouring of the hillslope, reduce erosion, and provide increased native vegetation health for livestock and wildlife.

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Everglades Ecosystem Restoration and Management Under Climate Change

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Predictive modeling has been used for decades to help inform planning for natural resources management. With climate change set to impact species and ecosystems in novel ways, incorporating climate forecasts into predictive models can help managers understand potential future impacts to natural resources. Ecological models can focus on the temporal and spatial scales needed by decision makers, including forecasts at near-term, decadal, project, and landscape scales.

The Greater Everglades wetland ecosystem is already experiencing impacts from climate change and sea level rise by virtue of its low elevation and being bounded by three coasts in peninsular Florida. The Everglades is a formerly vast, free flowing wetland (47,000 km^2) but after the construction of canals and levees to drain the wetland for European settlement, the ecosystem is now intensively managed to maintain the wetland. Water managers and restoration planners continuously make decisions on how and where to move water through control structures to achieve desired water depths and flows.

Predictive modeling can help planners determine which water management actions and restoration projects are most likely to result in the desired hydrologic and ecological outcomes. The Joint Ecosystem Modeling group has developed many predictive models to forecast potential ecological impacts from water management, restoration project implementation, and climate change. Outputs from our models are used weekly for near-term water management planning as well as for restoration planning that looks decades into the future.

The outputs of our models show potential near-term and long-term ecological impacts. Although climate change was not explicitly considered in restoration planning historically, the implementation of restoration projects is expected to help protect freshwater aquifers from saltwater intrusion attributed to rising seas. As Everglades restoration progresses, predictive modeling can continue to help planners and manager identify actions that can yield desired ecological conditions.

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Groundwater Response to Natural Infrastructure in Dryland Streams in Baja California Sur, Mexico

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Rural communities in arid Baja California Sur, Mexico, rely on groundwater for water supply that is recharged during infrequent storms. Detention structures designed to disperse and slow flashy streamflow, known as Natural Infrastructure in Dryland Streams (NIDS), are a nature-based solution for restoring ephemeral channels. However, effects of NIDS on groundwater recharge have not been fully quantified. This study evaluates whether NIDS enhances groundwater recharge. Depth to water and streamflow duration are indicators of groundwater storage capacity and can be used to identify locations of bedrock springs or areas of potential alluvial storage. Groundwater levels and streamflow are compared in watersheds with and without NIDS to determine 1) how NIDS affect overall groundwater hydrology, 2) what hydrogeologic factors related to NIDS sites have the largest effects on recharge, and 3) what magnitude of change in recharge occurs at NIDS sites after considering variations in NIDS placement, geology, evapotranspiration, and precipitation?

To address these questions, we established a network of fifteen wells in four watersheds to assess event-driven changes in water levels. Six surface water gages and three meteorological stations supplement this network. Three storm events, including hurricane Norma, were recorded in 2023. Groundwater levels rose rapidly in most wells indicating recharge in response to precipitation. Groundwater levels receded at different rates in the alluvium, whereas levels rose after several weeks near suspected bedrock fracture zones. Lag and attenuation of peaks in the groundwater hydrographs indicated that flow is occurring through hydrologic units characterized by lower conductivity, greater storage capacity, longer flow paths or a combination of factors. The impacts of NIDS on recharge volumes will be further explored using geophysical data and groundwater modeling. Understanding the underlying hydrogeology at restoration sites can help optimize NIDS site selection and quantify the impacts of restoration on groundwater availability.

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Nature Positive, Recovering Ecological Function and Multiple Benefits in the Built Environment.

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According to the World Economic Forum, half of the global gross domestic product is highly or moderately dependent on nature; simultaneously the world is undergoing the sixth great extinction and a reduction of wildlife populations of nearly 68% since 1970, with 1 million identified species at risk of extinction in the coming decades. Identifying and implementing innovative strategies to recover ecological function and biodiversity, connect habitats, reduce pollution, manage invasive species, sequester and store carbon, and many other pressing needs are as relevant as conserving preserved and highly functional landscapes.

Nature Positive, expressed at the last Convention of Biological Diversity, can be applied to industries with major impacts and recognized degradation drivers. For the built environment, the minimization of impact can be transformed into the recovery and promotion of biodiversity; the application of Nature-based Solutions offers an effective framework to increase resilience, biodiversity, and other ecosystem attributes while adding value to projects and investment portfolios.

The presentation will explore frameworks, tools, and case studies, including The Ecology of Place imperative from the Living Building Challenge green building certification and the Engineering with Nature framework from the USACE. The role of restoration practitioners within the design table is essential; it marks the difference between regulatory compliance and regenerative design. This crucial role is expressed clearly by E.O Wilson:

“Expansion and stewardship may appear at first to be conflicting goals, but the opposite is true. The depth of the conservation ethic will be measured by the extent to which each of the two approaches to nature are used to reshape and reinforce the other.” E.O. Wilson *Biodiversity* 1988

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Water Quality Monitoring and Models for Decision Making

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Water quality modeling can be a key component in understanding system changes and designing restoration approaches. But have modeling capabilities kept up with the new technologies in water quality monitoring? With a plethora of water monitoring devices available, as well as improvements in the ease of auto sampling in the field and lab, it is now possible to obtain vast quantities of water quality and other observational data. The precision and accuracy of in-field monitoring, including remote sensing, has improved as well. New communications, informatics, and automated algorithms also allow for rapid application of observational data to water resource decision making. This presentation will explore the changing water resources datascape and discuss implications for water quality modeling through the use of a numerical model sensitivity study. Potential gaps and opportunities for the next generation of water quality models to inform restoration will be discussed.

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The H2Ohio Initiative Restoration Program: An Ohio Partnership for Better Water Statewide

***Eric Saas*[1], *Rachel DeNoewer*[1], *Kevin Nemer*[1], *Janice Kerns*[2] *and Lauren Kinsman-Costello*[3]**

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Ohio Governor Mike DeWine created the H2Ohio Initiative in 2019 as a comprehensive, data-driven approach to reduce harmful algal blooms, enhance water quality, and improve water infrastructure in Ohio. H2Ohio functions as an integrated, collaborative water-quality partnership among state agencies, non-profit conservation organizations, the research community, and others.

H2Ohio focuses specifically on incentivizing agricultural best management practices, upgrading water infrastructure and, under the auspices of the Ohio Department of Natural Resources (ODNR), restoring and enhancing wetland and related habitat to improve surface water quality. Since 2019, ODNR and their project partners have initiated over 140 grant-funded natural infrastructure projects and partnered on more than 150 private lands wetland and riparian restoration projects, setting in motion approximately 15,000 acres of wetland and associated habitat restoration. The ODNR prioritizes restoring wetland ecosystem function as a relatively low-cost mechanism to reduce surface water nutrient loading and eutrophication over the long term while also generating numerous beneficial add-on effects, such as the creation of habitat for endangered species and providing increased recreational opportunities. The ODNR H2Ohio Program has partnered with the Lake Erie and Aquatic Research Network's H2Ohio Wetland Monitoring Program to measure the impact of H2Ohio restoration projects on nutrient loading. This monitoring program will enable ODNR, its partners and others to make the best possible project selection and restoration design choices in the future.

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Vegetation Establishment to Promote Dust Control Using Natural Physical Barriers and Surface Hydrology at the Salton Sea, CA

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The Salton Sea is a hypersaline inland lake situated in the Imperial Valley of Southern California. Over the past 20 years the lake surface elevation has decreased by approximately 12 ft, exposing the dry lakebed (playa) and accumulated lakebed sediments containing metals, salts and likely a suite of degradation products resulting from chemicals used in production agriculture. The lake surface elevation is expected to drop another 18 feet over the next 20 years (CH2M Hill, 2018), thus exposing an additional 80,000 acres of lakebed. If no action is taken, the increase in exposed lakebed is anticipated to exacerbate the regional air quality problem.

A multi-disciplinary team led by the California Department of Water Resources, along with Tetra Tech, is designing a landscape-scale dust suppression and vegetation enhancement project over 2,500 acres. The primary aim of this plan is to prevent dust emissions. This initial planning effort has consisted of a review of plant establishment challenges on the playa, climatic and hydrologic factors, and edaphic and vegetative parameters associated with plant establishment. Roughness-based dust control methods consist of the construction of natural physical structures and establishment of *Allenrolfea occidentalis*, a keystone species in hyper-xeric halophytic settings. Ephemeral surface water inputs from surrounding watersheds are proposed to be utilized with surface contouring built in key landscape positions in order to retain stormwater flows on site and promote vegetation germination and establishment. The selection and rationale for structures and placement will be presented along with the modeling efforts and field data collection activities.

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Deepwater Horizon Restoration. Ecosystem Scale Restoration in Texas's Bahia Grande

Jamie Schubert

Jamie Schubert, NOAA Restoration Center, Galveston TX USA

On April 20, 2010, the Deepwater Horizon (DWH) mobile drilling unit exploded, caught fire, and eventually sank in the Gulf of Mexico, resulting in a massive release of oil and other substances from BP Exploration and Production's (BP's) Macondo well and causing loss of life and extensive natural resources injuries. As part of a 2016 settlement, BP agreed to pay up to $8.8B in natural resource damages. The settlement allocated over $238M in the Texas Restoration Area, administered by the Texas Trustee Implementation Group (TIG).

To maximize the restoration potential of this funding, the Texas TIG decided to focus much of their restoration efforts in regions of the Texas coast that have stakeholder developed ecosystem restoration plans, including the Bahia Grande in the Laguna Atascosa National Wildlife Refuge in South Texas. Efforts to restore the Bahia Grande have been ongoing for at least two decades. The Texas TIG has leveraged the DWH settlement funds with other funding sources to implement key projects in the Bahia Grade restoration plan. This presentation will focus on the TIGs collaborative efforts to restore the system's hydrology, fish and wildlife habitat, and to conserve key tracts of land into the Laguna Atascosa National Wildlife Refuge to expand the wetland and terrestrial buffer to the Bahia Grande.

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Coastal Beaver, Chinook, Coho, Chum Salmon, and Trout Response to Nearshore Changes Resulting from Diking and Large-Scale Dam Removals: Synergistic Ecosystem Engineering and Restoration in the Coastal Zone

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In this paper we assess long-term trends and habitat changes to understand the relationships between coastal beaver (*Castor canadensis*), salmon, shoreline alterations, large-scale dam removals and nearshore ecological restoration. From this work we conclude that the removal of two large-scale dams in the Elwha River has benefited beaver use of the coastal zone through water quality changes that allow beaver to re-establish high-quality zones and the expansion of riparian zones that provide extensive new food resources to beaver. However, the lower river hydrodynamic processes continue to be disrupted by a 200-meter earthen dike installed by local government and landowners for flood protection in the Elwha coastal zone in the 1960's. The dike acts as a driver of lower river geomorphology and has resulted in the formation of a large and persistent lateral bar along the lower river channel. Associated disrupted hydrodynamics are causing a critical coastal zone of the un-impounded lower river side channels to fill in. This channel habitat has decreased by 23%, with an annual average shrinkage rate of 13%, from pre-dam removal size, resulting in a decrease in both quality and quantity of nursery function for juvenile wild fish in a coastal zone that was historically documented to be the highest functioning for endangered juvenile salmon and trout. Inversely, physical changes including improved water quality in the adjacent impounded west side channel and continued expansion of riparian vegetation along the west delta lateral bar benefitted coastal beaver that recolonized the west delta after dam removals. The newly colonized coastal beaver may provide ecological engineering services to offset side channel loss as well as promote continued fish access. However, recreational use was found to negatively impact beaver use of the area. We therefore recommend a series of additional ecosystem restoration actions that incorporate beaver as an ecosystem restoration component of the coastal zone. These actions include a public outreach pro- gram to encourage passive recreation measures to prevent negative impacts to beaver, and legacy, ecosystem scale restoration projects that reconnect the hydrodynamics of the west delta to complete Elwha ecosystem restoration. Together, these steps, if implemented, will result in a synergistic ecosystem restoration throughout the watershed to the benefit of the coastal ecosystem, including both beaver and salmon, as intended by the large-scale dam removal project.

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Results of Long-Term Bat Mitigation Monitoring: Artificial Replacement Habitat Supports Rare Townsend's Big-Eared Bat, as well as Maternity Roosts of Common Bat Species

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Mitigation for the loss of bat habitat is often a requirement under the California Environmental Quality Act. However, artificial habitat does not always maintain the same habitat value as previously available habitat, particularly for habitat specialist species like the Townsend's big-eared bat (*Corynorhinus townsendii*) or habitat that supports maternity roosting bat colonies. From 2015 to 2023 the Midpeninsula Regional Open Space District, with technical expertise from H.T. Harvey and Associates, worked to develop and implement a bat exclusion and habitat replacement plan to address a loss of habitat due to the demolition of buildings found within Bear Creek Redwoods Open Space Preserve, in Santa Clara County, California.

This work included the construction of two new freestanding structures, as well as the modification of an existing structure specifically to attract and support Townsend's big eared bats, a California State Species of Special Concern, as well as a variety of more common crevice roosting species. The new and modified structures were monitored for bat activity by conducting annual emergence surveys during the maternity roosting season, as well as opportunistic daytime surveys during non-sensitive seasons. In-situ temperature probes were also utilized to determine annual thermal characteristics of the interior of the structures to determine habitat suitability and inform management decisions. Surveys have documented an increase in bat use through time, as well as confirmed maternity roosts of common bat species, at each of the replacement habitat structures. Townsend's big-eared bat have been documented utilizing the interior of the modified existing structure as a presumed bachelor roost. Exterior bat boxes on all structures support the majority of individual bats on-site and are utilized by four common species of bats. The habitat use, number of individual bats, as well as species composition on-site is similar to what was documented by surveys prior to the demolition project.

Habitat value at these structures is dynamic as exterior boxes degrade and require replacement, vandalization of structures requires ongoing maintenance and modification, and new crevice roosting habitat becomes available as the structures shift and degrade through time. The findings from this project can inform bat mitigation and monitoring work, particularly for Townsend's big-eared bat, and offer strategies for improved outcomes.

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Collaborative Problem Solving in the Colorado River Basin: An approach to co-developing solutions.

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Over twenty years of drought, invasion of nonnative species, endangered species challenges, increased risk of fire, and the need to support multiple demands for water have pushed the Colorado River Basin to its sustainable limit. In 2020, the USGS initiated a new approach to enhance science co-production, interdisciplinary science connections, and technology integration. The Actionable and Strategic Integrated Science and Technology (ASIST) approach serves as a framework for convergent research by identifying interdisciplinary science connections. While this effort is being developed for the Colorado River Basin (CRB) the framework is transferrable to any location. To support the land and ecosystem managers and other partners, the USGS is engaging with them to determine what their science needs are for advancing restoration in the CRB. USGS is working with those partners to prioritize and conduct science, interpret outcomes, and design changes on the landscape. USGS is working with those partners to determine if restoration measures lead to desired outcomes. Assessment of the results of restoration or management decisions can lead to optimizing decision-support tools to efficiently achieve desired outcomes. This process helps to eliminate uncertainty in future restoration implementation by engaging all parties from defining the problem to assessing the effects of restoration on the ground. The approach that ASIST has developed is transferrable to any landscape. In addition to the specific activities for the CRB, ASIST is also documenting this approach to make it readily accessible to others conducting science and implementing restoration on any landscape.

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Building Adaptive Foundational Resilience for Coastal Wetlands: An Everglades Experiment

***Fred H. Sklar**, Carlos Coronado-Molina, Michael Brown and Walter Wilcox*
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Sea level rise (SLR) is expected to affect natural and urban areas by shifting habitats and inundating coastal developments in South Florida. Given this challenge of SLR, building resilience within South Florida's natural communities is imperative, not only to protect the natural habitat where fish and wildlife species thrive, including important recreational and commercial fisheries, but also as a means of reducing risk to the built environment from coastal storm hazards and saltwater intrusion. For coastal wetlands to exist into the future, soil accretion must match or outpace SLR. Adaptive Foundational Resilience (AFR) is the ability of the foundational vegetation (freshwater marshes and mangroves) to adapt to SLR by building elevation as a function of water depth and hydroperiod, porewater salinity, water quality and flow. It is based upon some 20 years of understanding the process of peat collapse, subsidence and coastal accretion. As the goal of an "active adaptive management" experiment and as an implementation of AFR, an Everglades Mangrove Mitigation Assessment (EMMA) program has been designed to enhance scrub mangrove productivity and transgression into fresh and brackish marsh habitats as an adaptive mechanism for SLR and saltwater intrusion. The EMMA project is both a large- and small-scale, field manipulation of freshwater flow, phosphorus addition, and sediment increase to enhance the resilience of coastal mangroves, increase land elevations, and evaluate the ability of coastal plant communities to shift to communities that are resilient to SLR. This scientific experiment will primarily evaluate the ability of Thin Layer Placement (TLP), an innovative nature-based management measure that spreads "clean" dredge/spoil sediments across a scrub mangrove community, to enhance net primary productivity and increase sediment accretion rates within coastal wetlands of Miami-Dade County, Florida.

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Challenges for Restoring Agricultural Headwater Streams in the Midwest

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Agricultural headwater streams are common throughout the Midwest (Midwestern United States) and are often managed to facilitate agricultural drainage without considering the subsequent environmental impacts. The focus of restoration efforts for many of these streams is the improvement of water quality via reduction of nutrient, pesticide, and sediment inputs, while physical habitat improvement is rarely considered. Subsequently, many stream restoration efforts are not addressing the full spectrum of agricultural impacts. Holistic stream restoration efforts hold much promise for mitigating the effects of agriculture on headwater streams. However, challenges for restoring agricultural streams in the Midwest consist of: 1) a hesitancy of the agricultural community towards restoration; 2) a lack of understanding by the agricultural community as to their role in stream management; and 3) limited information on the ecological impacts of restoration practices on agricultural headwater streams, especially channelized agricultural headwater streams. Increasing our understanding of the impacts of restoration practices on agricultural headwater streams is a promising starting point for addressing the challenges associated with stream restoration. I will review long-term research results from agricultural headwater streams in Indiana, Michigan, and Ohio related to the evaluation of biota-habitat relationships and the effects of a widely used conservation practice (i.e., grass filter strips). These results indicate that future restoration strategies for agricultural headwater streams need to consider: 1) physical habitat conditions; 2) taxa-specific responses of the biota; and 3) the limited benefits of planting grass filter strips alone. These results suggest that increasing our understanding of the impacts of stream restoration practices will increase the knowledge base for restoration science, will provide information that help develop effective restoration strategies, and will provide information that can assist with increasing the agricultural community's buy-in of proposed stream restoration projects.

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A Laboratory for Learning: Large-Scale Ecosystem Restoration and the Legacy of Secretary Babbitt

Chadwin Smith, Ph.D.[1]*, Jason Farnsworth*[2]*, James Lee*[3]*, Howard (Howie) Gonzales* [4] *, and William (Bil) Stewart*[5]

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From 1993-2001, Interior Secretary Bruce Babbitt and his team worked at the cutting edge of developing some of the most unique large-scale restoration programs in the United States. The "big four" programs – the Platte River Recovery Implementation Program; the Trinity River Restoration Program; the Glen Canyon Dam Adaptive Management Program; and the Comprehensive Everglades Restoration Program – became a laboratory for adaptive governance structures and attempts at adaptive management. Still relevant today, the successes and failures of these programs are seen as examples to emulate or avoid, and the lessons learned speak volumes about the future of large-scale restoration programs. Senior agency personnel and managers, decision-makers, science coordinators, and restoration program stakeholders will benefit from this high-level panel discussion about the history and progress of large-scale ecosystem restoration, lessons learned about successfully implementing adaptive governance and adaptive management at large scales, and insight into the future of large-scale species recovery and ecosystem restoration programs in the United States.

Panelist Biographies:

Dr. Smith is the President of Headwaters Corporation and the Science Policy Coordinator for the Platte River Recovery Implementation Program and was recently the Refinements Coordinator for the Trinity River Restoration Program.

Mr. Farnsworth is the Executive Director of the Platte River Recovery Implementation Program.

Mr. Lee is the Implementation Branch Chief at TRRP and is employed by the U.S. Bureau of Reclamation. His current role focuses on stream habitat restoration projects on a dam-regulated river, with a special emphasis on increasing native runs of Pacific salmon. James has worked for the program since 2012 as the staff Riparian Ecologist (employed by the Hoopa Valley Tribe) and then Science Coordinator.

Mr. Gonzales is the Deputy District Engineer for Programs and Project Management, Programs & Project Management Division, U.S. Army Corps of Engineers Jacksonville District.

Mr. Stewart is U.S. Bureau of Reclamation Adaptive Management Group Chief and Program Manager for the Glen Canyon Dam Adaptive Management Program.

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Ecohydraulics and its Application to Ecosystem Restoration and Water Resource Infrastructure

David L. Smith
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Across the United States, the U.S. Army Corps of Engineers operates and maintains 25,000 miles of navigable river miles, which includes 196 lock and dam sites originally constructed to facilitate commercial shipping on U.S. waterways. The majority of these lock and dams were built during the 1930s -1960s. As commercial shipping declined in the latter half of the 20th century, the frequency of lock operations on many rivers also declined. In many cases, the locks provide the only potential passage route for migratory fishes. Decreased lockages may constrain seasonal migrations and movements of fish reducing aquatic ecosystem connectivity. The USACE and its partners have been exploring how fish use low-use locks and what engineering or operational changes could improve ecosystem connectivity. An emerging workflow combining field telemetry, laboratory assessment, and computational modeling suggests characteristics of locks that promote passage. Given that many locks and dams won't be removed lock passage may be the best immediate option for improving ecosystem connectivity.

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Body Size and Stable Isotope Ratios of Adult Net-Spinning Caddisflies (*Hydropsyche oslari*) Reflect Growing Conditions for Aquatic Insects During Flow Experimentation on the Regulated Colorado River

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Hydropower operations at Glen Canyon Dam have contributed to low diversity and productivity of aquatic insect assemblages in the Colorado River. In 2018-2020 a steady flow experiment was tested to improve ecosystem health. During the three years of the experiment, caddisfly abundance in standardized light trapping was 400% higher and algae production increased by 58% compared to the six-year pre-experiment baseline. However, favorable growing conditions for aquatic insects are often associated with a syndrome of population level responses that includes both high abundance and large adult body size. To better understand the effects of the experiment on growing conditions for aquatic insects, we measured adult body size (length) and stable carbon isotope ratios (indicating feeding habits) of adult *Hydropsyche oslari* (net-spinning caddisflies) that were collected before and during the experiment. We predicted that years with high *H. oslari* abundance would be associated with larger female body size (indicating more favorable growing conditions) and more negative carbon isotope ratios (indicating greater consumption of high-quality algae resources) than years with low *H. oslari* abundance. We measured the length of 241 *H. oslari* females collected between 2015 and 2020. We only considered female *H. oslari* to eliminate variation in size associated with sexual dimorphism and because female size is an indicator of fecundity. We found that body size declined, and carbon stable isotope ratios became less negative as a function of day of year. Although there was significant variation in size and stable isotope ratios across years, length and isotope ratios for *H. oslari* were not consistently different in Bug Flow years compared to non-Bug Flow years. This investigation provides an example of how adaptive management can implement flow experimentation to improve growing conditions for insects and restore aquatic food web functionality in regulated rivers.

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Interdisciplinary Environmental Models: Water Quality, Hydrology, Hydraulics

Todd E. Steissberg[1]*, Billy E. Johnson*[2]*, Anthony Aufdenkampe*[2]*, Zhonglong Zhang*[3]

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The flow of nutrients in watersheds profoundly shapes ecosystem resource utilization and health. However, disturbances like climate change disrupt nutrient cycling, leading to imbalances that can trigger cascading impacts, including invasive species outcompeting native ones. Currently, we lack the ability to understand and predict the spatial distribution and temporal evolution of biomes in response to changing conditions, hindering our predictive capabilities and ecosystem management strategies. This requires the ability to holistically simulate nutrient flow across watersheds, to understand and predict the spatial distribution and temporal evolution of biomes in response to changing conditions.

We address the knowledge gaps by improving our understanding of nutrient dynamics' influence on species distribution and interactions and improving our predictive capacity for targeted ecosystem restoration strategies, fostering ecosystem resilience. To achieve this, we are integrating flow, water quality, and ecosystem models. Our Corps Library for Environmental Analysis and Restoration of Watersheds (ClearWater) was linked with external hydrologic (GSSHA) and hydraulic (HEC-RAS) models using the Basic Modeling Interface (BMI). ClearWater simulates temperature and nutrient interactions, algae dynamics, dissolved oxygen, and organic matter, given inputs from the hydraulic and hydrologic models and observed meteorology and water quality data. To develop holistic environmental watershed models, ClearWater will be linked with ecological models, particularly aquatic and terrestrial vegetation models.

Our approach has broad implications for next-generation ecological modeling. Model linking via BMI facilitates seamless data exchange, fostering interdisciplinary collaboration among scientists. These integrated models offer a comprehensive view of ecosystem dynamics. This enables accurate predictions of nutrient flows and ecosystem responses to environmental changes, improving decision-making and ecosystem management. Applications include setting nutrient loading limits, designing buffer zones, and implementing best practices to safeguard water resources and ecosystem health. Our work represents a significant step towards a more integrated and sustainable approach to environmental modeling.

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Climate Change Effects on Restoration Projects: Lessons from Glen Canyon and Lake Champlain Basin

Laura J. Stroup
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Climate change effects on Earth are prevalent and increasing. As restoration practitioners, we need to both recognize this reality and be able to respond to it with effective planning, implementation and adaptation of projects: both anticipated and completed. I examine two cases of restoration projects: one anticipated in Glen Canyon in Utah and Arizona, and another implemented on the Winooski River for water quality improvement and increased flooding amelioration in the Lake Champlain Basin, Vermont. While all restoration projects are specific to place, human, and natural characteristics, these two cases offer a broad U.S. representation of both climate change effects as well as management strategies for effectually thinking about restoration in complex and rapidly changing conditions. Environmental change will be the hallmark of the 21st century. As a result, restoration scope, planning, and implementation will need to shift towards this new reality. Specifically, this presentation will examine changes in hydrology and resultant planning, needed training and education, changes in safety and user desires and needs for these systems, as well as effectively guiding restoration projects with a long-term perspective in the context of a rapidly changing planet to best support and sustain communities and their surrounding ecosystems. Interdisciplinarity, cooperation, and adaptability will be indispensable for implemented restoration projects to best meet the needs of today as well as future needs.

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A Hydrodynamic Waster/Groundwater Salinity Transport Model for Biscayne Bay and the Southeastern Everglades Restoration

Eric D. Swain[1]*, Khandker Ishtiaq*[2]*, and Tiffany Troxler*[3]

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Two regional hydrologic models, the Biscayne Southeastern Coastal Transport (BISECT) model of southern Florida and the Regional Simulation Model Glades-LECSA (RSMGL), are being used to test the effects of proposed water-management changes for the Biscayne Bay and Southeastern Everglades Ecosystem Restoration (BBSEER) project. The U.S. Geological Survey developed BISECT, which simulates coupled hydrodynamic surface-water/groundwater model with salinity transport. The RSMGL is a water-management model created by the South Florida Water Management District that extends further inland than the BISECT model and is used to test various water management scenarios, including changes in control-structure operations and other potential restoration actions. The RSMGL provided simulated boundary conditions to BISECT to evaluate shallow groundwater salinity for BBSEER.

Periodic porewater salinity measurements provided by an Institute of Environment study at Florida International University were used to improve the calibration of BISECT. Recalibration of the model resulted in increased near-shore evapotranspiration, lower dispersion, and increased surface-water leakage, compared to the previously calibrated model.

Canal stages for various restoration scenarios simulated by RSMGL were input to BISECT to simulate changes in coastal salinity. BISECT results were communicated to restoration managers through performance measures, which use the magnitude and duration of simulated pore-water salinities to evaluate restoration scenarios. This evaluation provides a clearly defined rating of restoration effects that managers can use for decision-making.

The BISECT simulation period, originally 2005-2017, is being extended to the year 2022 to provide a larger range of climatic variations for evaluation. This change would also allow for more recent field measurements of salinity to be applied for further calibration and reduction of the uncertainty in the resulting restoration evaluations.

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A Collaborative Process for Determining Environmental Flow Recommendations for the Rio Grande in New Mexico

***Paul Tashjian*[1]*, Tricia Snyder*[2]*, Enrique Prunes*[3]*, Brian Richter*[3]*, and Mark Briggs*[4]

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A scientifically defensible framework for setting environmental flow targets in the Rio Grande of New Mexico is long overdue. Aridification is increasing across the American West, exacerbating existing water management challenges, and increasing conflict between competing water uses as water availability diminishes. The Rio Grande Basin Study in New Mexico (Basin Study) was initiated on January 24, 2023. The Basin Study is a WaterSMART-funded initiative led by the US Bureau of Reclamation and the Middle Rio Grande Conservancy District, with the participation of 36 signatories representing multiple sectors, that aims to develop management resiliency strategies for the Rio Grande in New Mexico under climate warming scenarios. As part of this effort, water-use "sectors" are quantifying water needs that will be placed into tradeoff models and tools. The Non-Governmental Organizations Sectoral Committee of the Basin Study, comprised of 12 national, regional and statewide environmental organizations as well as associated partners, is embracing this opportunity to establish critically important environmental flow needs and associated feasible targets for the Basin.

The NGO Sectoral Committee effort is a reach-scale quantification process largely focused on aquatic and aquatic-dependent species within the Basin. The reaches include segments of the mainstem Rio Grande and the Rio Chama (a primary tributary) within central and northern New Mexico, all upstream of Elephant Butte Reservoir. Within each of the 6 main reaches being analyzed, indicator species are used to define environmental flow needs during all components of the hydrograph. For instance, the Southwestern Willow Flycatcher is a species found in all of our reaches and is dependent upon spring run-off 'pulses' and connected wetland habitats. Similarly, cottonwood trees and the endangered Rio Grande Silvery Minow are dependent on the timing and peak of spring pulses for regeneration as well as minimum flows for survival. The species needs, grounded by local hydrologic and geomorphic information, are being quantified and synthesized into reach-specific flow targets. Flow recommendations will include both low flow needs, monsoon peak flows and spring runoff peak-timing-duration needs for dry, moderate and wet years.

Quantifying reach-specific environmental water needs for the Rio Grande in New Mexico has multiple benefits including: 1) information for the Basin Study's trade off analysis that will identify management actions to improve environmental flows in the Rio Grande; 2) information for New Mexico's Strategic Water Reserve (a State-run water bank for endangered species and Rio Grande Compact water needs); and 3) information for many other projects that are trying to understand the environmental flow deficits in the Rio Grande of New Mexico and how these can be improved and protected. The initial recommendations by the Sectoral Committee are being compiled into a draft directory that collects and summarizes all relevant citations alongside the initial flow hypotheses for each reach. These draft hypotheses will be vetted through a peer-review workshop-- scheduled for the spring of 2024 – and will be memorialized into a final document that will both serve as a primary chapter in the Basin Study as well as a stand-alone directory that will serve multiple benefits.

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Mitigation and Public Lands: How Good Business and Good Restoration Can Expedite Ecosystem Recovery

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As we look toward the impeding ramifications of climate change it remains clear that ecosystem restoration will persist as a primary solution to this global issue. This makes it critical to understand the state of our public lands and how to maximize their ecosystem functions and services in the immediate future. A large percentage of public lands across the United States exist in a degraded state with little to no existing funding sources for management much less restoration. This creates a unique opportunity to connect private dollars to public lands via private mitigation and conservation projects. While many challenges exist with respect to facilitating privately funded restoration on public lands there are numerous examples of successful private and public partnership. These projects have often resulted in innovative mitigation solutions as well as benefits for species, aquatic resources, and the public. These projects also maximize funding opportunities, help realize local conservation strategies, and create added efficiencies in regulatory programs. Unfortunately, these successful private/public projects are few relative to available opportunities because of both real and perceived hurdles. Since 2019 a national group of regulators, land managers, consultants, investors and mitigation bankers have explored the hurdles and solutions to compensatory mitigation on public lands. Annual "working" sessions have taken place for the last 4 years, taking a deep dive into these hurdles for private mitigation on public land including public agency restrictions, suitable endowment holders or alternative mechanisms, identifying long-term funding sources, and managing risks. The workshops identified a series of short-term steps that included preparing a white paper, identifying case studies, as well as education and outreach. This panel will discuss the pending white paper, present a series of case studies, and discuss why expediting an influx of private dollars on public lands is critical to local and global ecosystem recovery.

Panelist Biographies:

Lindsay Teunis is a 20+ year restoration ecologist and mitigation program specialist passionate about facilitating rapid ecosystem improvements. Since 2019 Lindsay has championed and facilitated a national working group focused on mitigation on public lands including a stakeholder consensus workshop, annual working group meetings, conference presentations, case studies and a white paper.

Michelle Mattson is a *Stream and Wetland Ecologist with the U.S. Army Corps of Engineers' Institute for Water Resources (IWR) with over 20 years of professional experience as a consultant and regulator. She is a Compensatory Mitigation Subject Matter Expert focused on implementing the USACE Compensatory Mitigation Program and supports national and regional training courses in compensatory mitigation.*

Deblyn Mead is the *National Mitigation Coordinator for the Bureau of Land Management where she is responsible for mitigation policy development and implementation. Deblyn has been involved with mitigation and conservation banking policy development and practice both in the field and at headquarters for more than 20 years.*

Dr. Jeremy Sueltenfuss is an *Assistant Professor and ecologist at Colorado State University, studying restoration ecology in wetland and floodplain ecosystems. Jeremy is interested in the ecological impacts humans have on the natural world, and how to effectively restore ecological integrity and ecosystem functions.*

George Kelly has spent *the last 3+ decades in the field of mitigation and is now Chief Executive Officer for Earth Recovery Partners where the mobilize others through strategic advisory and capital support for companies and projects that relate to environmental markets, nature-based solutions and technologies that advance those solutions.*

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Modeling the Effects of Sites Reservoir on Floodplain Rearing Habitat in the Sacramento Valley

Jeremy Thomas, Chad Whittington, ***Reed Thayer***
Jacobs, Sacramento, CA, USA

Sites Reservoir is a proposed off-stream reservoir in California's Sacramento Valley that would be capable of diverting and storing up to 1.5 million acre-feet of excess winter runoff from the Sacramento River and using it to improve water reliability in drier periods. The operations of Sites Reservoir will influence the quantity and quality of off-channel rearing habitat for juvenile salmonids. We performed hydrologic, hydraulic, and ecological modeling to determine the relationships between flows in the Sacramento River and the total area of potentially suitable habitats in the Sacramento River channel, Sutter Bypass, and Yolo Bypass, considering various hydrologic conditions and Sites Reservoir operational scenarios. Existing conditions were evaluated against potential Sites Project diversion scenarios by evaluating changes in the frequency of potential inundation events for different flows that satisfied requisite duration criteria, and changes in average monthly inundated areas that satisfied physical criteria. This process is applicable to other watersheds.

Depending on reservoir operations and hydrologic conditions, Sites Reservoir had variable effects on rearing habitat acreage within the study area; for some scenarios Sites improved the frequencies of floodplain rearing habitat inundation, and for some scenarios, it slightly decreased the frequencies of inundation.

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Dredge Placement Beneficial Use Comprehensive Benefits Tool

Chuck Theiling*[1]*, *Justin Wilkins*[1]*, Ben Emery*[2]*, Burton Suedel*[1]*, and Colton Shaw*[1]

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Dredged sediment management is a substantial challenge for the US Army Corps of Engineers (USACE) who dredge over 200 million cubic yards of sediment annually. There is new emphasis on beneficial use of sediment with an agency objective to achieve 70% beneficial use by 2030. There are also new opportunities for beneficial use as the Corps' ecosystem restoration mission has matured and, in many cases, can be integrated into dredged sediment management. Coastal resilience is another important social benefit. The dredge placement Beneficial Use Comprehensive Benefit Tool (BUCBT) provides methods to evaluate the Ecosystem Goods and Service (EGS) benefits of sediment placement alternatives for individual dredge sites.

The BUCBT was requested by USACE Headquarters to support the vision of sediment as a resource for coastal resilience and ecosystem management. The development team envisioned a simple and rapid matrix approach to sediment placement alternative analysis that would be suitable to the rapid pace of USACE navigation operations planning. We also wanted to use terms and methods familiar to the USACE District staff, so we chose terms for dredge placement methods from approved Engineering Manuals. We also used a new USACE EGS Framework to provide the benefit metrics.

We developed a spreadsheet approach to matrix development and scoring, scoped it through USACE HQ for review, and tested the approach with dredgers and environmental staff in the USACE North Atlantic Division. The spreadsheet approach is limiting so FY24 funding allows development of a web application with greater database management capability and a simpler interface and reporting for District staff. We are also expanding outreach to other Divisions in regional workshops. The BUCBT is designed to be a simple, transparent, and site-based benefit accounting tool for local teams to compare sediment placement alternatives. The framework can be adapted to other resource management issues.

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Perspectives on the Comprehensive Everglades Restoration Plan Implementation Process

Craig van der Heiden[1], ***Cindy Thomas***[2]

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Congress authorized the Comprehensive Everglades Restoration Plan (CERP) in 2000 as a plan to "restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection." At an estimated $10.5 billion and a 35+ year timeline, CERP is the largest restoration project in the United States. To ensure that the goals and purposes of CERP were achieved, Congress also enacted programmatic regulations to establish processes necessary for implementing the plan. We will take a brief look at the process differences between a typical restoration planning study versus a CERP planning study. We will examine how the CERP planning process could benefit other restoration projects; and review lessons learned, and areas in need of improvement from a Federal agency and Tribal perspective.

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Providing Science to Inform Restoration Efforts Considering Climate Change for the San Francisco Bay-Delta Estuary

Karen M. Thorne
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The San Francisco Bay-Delta estuary has ambitious plans to maintain and restore over 130,000 acres of wetlands to provide habitat for protected species, flood protection, recreation opportunities, and carbon sequestration. However, given a changing climate and sea-level rise these goals have become uncertain. The estuary is experiencing about 2mm/yr of sea-level rise, along with changes in freshwater availability from prolonged droughts which reduce the amount of freshwater flow into the estuary. Managers and policy makers need information about how to maximize tidal wetland resilience and meet restoration goals considering these climate stressors. To meet these science needs we have conducted sea-level rise vulnerability assessment that have been used to prioritize restoration locations and accelerate restoration and enhancement timelines. Also, sediment studies have been done to answer key questions regarding sediment availability to build wetland elevations relative to sea levels. Then to understand how restoration can help meet California's greenhouse gas reduction goals studies about carbon sequestration have been done. Lastly, these studies have been scaled up to inform a Wetland Regional Monitoring Program that is implementing a long-term monitoring program to track change in the estuary. Using local studies to inform a regional monitoring program helps reduce uncertainty and informs restoration approaches to maintain wetlands over the coming years. I will present on a variety of research projects and how results from those have informed tidal wetland restoration and monitoring approaches.

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Stable Isotopes and Museum Samples Provide Baselines and Metrics for River Restoration

Thomas F. Turner
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River and stream restoration aims to reverse long-standing and undesirable ecological changes, but the effects may take decades to manifest. Stable isotope analysis (SIA) of samples held in biodiversity collections offers baselines and metrics for assessing conditions before restoration, and provides a means to track restoration progress if appropriate sampling is conducted. I explore this approach in the Rio Grande in New Mexico where various disturbances have impacted the ecosystem over the past century. Disturbances include channel incision from sediment deprivation, a dampened flow regime, and exponential human population growth. SIA of carbon and nitrogen was conducted on museum-preserved fishes. Metrics associated with trophic complexity and resource heterogeneity for fishes decreased significantly after flood-control structures were completed and these effects persist today. Increased nutrient inputs led to $\delta^{15}N$ enrichment in the entire fish community and effects were pronounced downstream of a major wastewater release point. Restoration of sediment supply, creation of low-lying riparian habitats and meandering river courses, and wastewater treatment improvements are expected to move SIA-derived metrics away from the disturbed state, helping track and assess the effectiveness of restoration efforts over time. I also discuss some limitations of this approach in detecting restoration-related changes.

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History of Restoration Along the Middle Rio Grande

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Historically, the Middle Rio Grande flooded laterally from snow-melt runoff, ranging from destructive floods to devastating droughts. To control the river's flow, five mainstem dams were constructed in New Mexico, along with hundreds of miles of levees and over 100,000 steel jetty jacks that confined and narrowed the river channel, effectively delinking the historic floodplain. This floodplain disconnection led to the decline of many native plants and animals, and there are currently five species listed under the Endangered Species Act, including the Rio Grande silvery minnow (*Hybognathus amarus*), southwestern willow flycatcher (*Empidonax traillii extimus*), New Mexico meadow jumping mouse (*Zapus hudsonius luteus*), yellow-billed cuckoo (*Coccyzus americanus*), and Pecos sunflower (*Helianthus paradoxus*).

In 2003, the U.S. Fish and Wildlife Service issued a biological opinion that directed federal agencies to "*…conduct habitat/ecosystem restoration projects in the Middle Rio Grande…"* Nearly 300 sites ranging 0.4–5 ha and totaling 1,600 ha, have been constructed to inundate at discharges of 500–3,500 cfs and provide habitat for riparian species. The efficacy of this habitat restoration has not been systematically evaluated or monitored, but the New Mexico Interstate Stream Commission (NMISC) has conducted studies and evaluations since 2008, with technical assistance from SWCA. In 2023, the NMISC and SWCA initiated a program to catalogue restored sites, determine their geomorphic changes, and identify and recommend priority sites for further improvement.

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Bringing Together the Everglades Restoration Community: Establishing a Collective Understanding of Monitoring Efforts Occurring in South Florida

Stephanie Verhulst *and Gina Ralph*
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South Florida hosts diverse ecosystems ranging from the Everglades headwaters of Lake Okeechobee to the freshwater Everglades to the coastal estuaries and bays. Drastic and damaging changes to the function, composition, and spatial extent of these ecosystems began when Everglades drainage activities started in the early 1900s and continued through the 1960s with the Central and Southern Florida Flood Control Project. Congressional authorization in 2000 for Everglades restoration approved the Comprehensive Everglades Restoration Plan (CERP) to restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region including water supply and flood protection.

Everglades restoration requires system-wide monitoring efforts throughout the various ecosystems to assess CERP success. REstoration, COordination and VERification (RECOVER), an interagency and interdisciplinary scientific and technical team within CERP, developed a Monitoring and Assessment Plan (MAP) to guide Everglades monitoring to reduce uncertainties about key ecological components and linkages within the distinct ecosystems and assess ecosystem responses to CERP activities. Recognizing RECOVER is one of many entities involved in Everglades restoration, RECOVER partnered with the South Florida Ecosystem Restoration Task Force Science Coordination Group to host a workshop for the south Florida restoration community to collectively identify current monitoring efforts occurring within the CERP footprint and future science and monitoring needs to address remaining uncertainties and assess CERP success. Two goals of the workshop were to (1) crosswalk monitoring occurring by various entities with RECOVER hypotheses and uncertainties and (2) identify overlaps and gaps in science and monitoring to support CERP restoration goals. The workshop brought together over 100 participants representing local, state, federal, tribal, and academic entities and provided opportunities for promoting and leveraging collaboration. Group discussions focused on specific aspects of Everglades restoration while developing a system-wide perspective of monitoring activities. The collaborative efforts of the restoration community produced an ecological and hydrological monitoring inventory for south Florida which includes spatial and temporal scales and monitoring metrics. Information gained during the workshop will inform a future RECOVER MAP update. Benefits extended beyond the product-driven workshop goals to include reestablishing a collective sense of community and shared restoration goals, developing new connections between participants, and developing effective and efficient communication tools for future RECOVER engagements.

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Special Project Authorities Associated with Ecosystem Restoration and Environmental Justice

*Warner Buchman, **Stephanie Verhulst**, Jennifer John*
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Working directly with communities and their specific needs can create the foundation and piecework for large impacts. Disadvantaged communities often cannot participate in large studies due to budgeting constraints. Smaller scale restoration efforts can be the most feasible first step towards recovery of a degraded area. These projects can allow economically disadvantaged communities to utilize federal resources for expert assessments, recommendations of solutions, and quicker response to construction. These efforts are especially important in vulnerable environments notably those with underserved residents.

The United States Army Corps of Engineers (USACE) has many ecosystem restoration-based or inclusive authorities. These authorities can be environmental justice focused and require consideration of natural and nature-based feature measures, including resilient and climate change strategized solutions. The Silver Jackets Program is a state-led interagency team which facilitates collaborative solutions to flood risk areas.

Ongoing projects at the USACE Jacksonville District include studies that will assess gray, green, and non-structural options for the betterment of the systems. For example, a Continuing Authorities Program 206 study aimed to restore flows into the Indian River Lagoon which has experienced fish die-off events, manatee mortality, and other environmental changes.

Another example is the FY23 Natural and Nature-Based Features Silver Jacket Team project. This project hones international guidelines into a resource driven educational website for access by homeowners to legislators. Other Silver Jackets projects within the USACE Jacksonville District include establishing framework for incorporating coral reef systems into flood risk management strategies, examining how to integrate green spaces into roadway designs ,and developing hazard education workshops for Puerto Rico.

These examples, among others, demonstrate some of the various options within the USACE congressional authorities for the utilization by environmental justice, natural and nature-based solutions, and resiliency focused communities. Awareness of eligibility for these programs is a USACE prerogative.

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Integrating Natural Areas Management with Small Scale Agriculture and Restoration

Larry Vickerman
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Managing and restoring natural areas for maximum biodiversity has many positive effects on adjacent small-scale agriculture. DBG Chatfield Farms has been integrating regenerative agriculture techniques to eliminate toxic pesticide applications while enhancing long term soil health, soil fertility, and soil water holding capacity in a vegetable cropping system. Actively restoring prairies and riparian areas on the property sustain pollinator populations and other wildlife that depend on high quality habitat. Healthy raptor populations that rely on riparian habitat are essential to controlling rodent and rabbit pests in the fields. Trap crops and flower strips in production fields further enhance pest control and increase beneficial insects as a sustainable alternative to insecticides.

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Assessing Large-scale Restoration Options using Fossil Data, Elk as a Case Study

***Maria C. Viteri**, Kelly Chauvin, Elizabeth A. Hadly*
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Ecosystems around the world are facing human-induced collapse of biodiversity and ecological processes. In the face of large-scale anthropogenic impacts, it is imperative to implement stewardship actions which enhance ecosystem-level resilience. Management actions which integrate lands across ownership, protection status, and human use provide both challenges and opportunities for conservation planning. The reintroduction of native megafauna to our landscapes, for instance, can enhance resilience to climate change, safeguard biodiversity, and provide ecosystem services to people. As California's largest native herbivore, elk (*Cervus canadensis*) may perform a role in restoring native grasses and oak woodlands. However, elk ranges and abundances have declined significantly from historical baselines. While elk reintroductions have been made in other parts of California, and the U.S. more broadly, the San Francisco peninsula still lacks this herbivore. Unlike many of the sites where elk have been reintroduced, this region is highly populous -- representing a diversity of human interests which must be incorporated in any landscape-level conservation planning. To contextualize current elk distributions and potential habitat, we assessed patterns in prehistoric, historic, and present elk occurrences in the San Francisco Bay Area using fossil and observational records. With this foundation, we are partnering with multidisciplinary collaborators to ascertain community opinions and encourage local engagement with nature. We hope the process identified by this study will serve as an example for future large-scale, multi-interest restoration projects in California.

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Build It, But Will They Come? Assessing the Benefits of Nearshore Habitat Restoration for Ecosystem Approaches to Fishery and Habitat Management

Bruce W. Vogt[1]*, Ian C. Zink*[2]*,Dr. Lydia Olander*[3]*, and Jessica Coakley*[3]

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This panel session will review approaches to assess the ecological and economic benefits of habitat restoration, the utility of these assessments in advancing ecosystem based management, and the lessons these assessments can teach to guide future restoration. The complexity in assessing habitat value continues to increase due to a desire to quantify not only use or even abundance, but how restoration advances food web functioning, ecosystem-level productivity, and broader social and economic benefits. Evaluation of habitat restoration projects is more important than ever as projects now seek to provide protection from the effects of climate change and to enhance habitat for fish, other living resources, and community stakeholders. The ongoing shift to nature-based infrastructure and interest in achieving multiple societal and ecosystem service benefits is leading to new habitat science and assessment techniques. Panelists will discuss restoration monitoring and assessment approaches that quantify fish use, movement, and productivity, engage stakeholders and value ecosystem services. Panelists will also talk about how the results of this science can be incorporated into future restoration projects and fishery management. The session is relevant to modelers, researchers, and agency managers locally and nationally and can inform future restoration planning, designs, and monitoring.

Panelist Biographies:

Mr. Vogt is an estuarine ecologist who has 15 years of experience as an ecosystem science and synthesis manager, leading, planning and designing quantitative fish and habitat science programs.

Dr. Zink is a restoration ecologist with 20 years of experience in offshore, estuarine, and aquaculture research and is currently leading assessment of fish-habitat linkages related to restoration of the Deepwater Horizon oil spill.

Mrs. Coakley has more than 20 years experience in fisheries management and science, and is the current lead on fish habitat initiatives for the Mid-Atlantic Fishery Management Council.

Dr. Olander is a Program Director at the Nicholas Institute at Duke University and adjunct professor at the Nicholas School of the Environment. She works on improving policy and implementation for nature-based solutions, natural capital accounting, ecosystem services, environmental markets, and climate resilience. She leads the National Ecosystem Services Partnership and spent two years with the Biden Administration at the Council on Environmental Quality as Director of Nature based Resilience.

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Developing and Testing a USACE Ecosystem Services Analysis Framework

Lisa A. Wainger[1] *and Elizabeth Murray*[2]

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Because the US Army Corps of Engineers (USACE) provides hundreds of millions of dollars in federal cost share for large- and small-scale ecosystem restorations, the methods it uses to assess and quantify ecosystem service benefits of environmental restoration, including nature-based solutions, could strongly influence restoration decisions in the US. To provide a strong scientific basis for decision-making, a team of researchers from academia and the USACE applied evidence from ecological, economic and decision sciences to develop a framework for ecosystem service (ES) benefit measurement. The framework shares elements with other national assessment frameworks but was adapted to the planning needs of the USACE in multiple ways. For example, the ecosystem service typology that was developed uses final services, to the extent possible, to clearly communicate the social benefits being produced through restoration actions.

The core of the framework is a conceptual model that establishes a series of causal relationships to link biophysical changes to social benefits. Biophysical changes are projected as a function of project design and expected performance using location context. Benefits are communicated using monetary and non-monetary benefit relevant indicators (BRIs). Both types of benefit measures incorporate magnitude of ecological changes, scarcity of services, public preferences, and other economic determinants of value.

A test of the framework using a case study revealed that a key benefit is improving the breadth of ecosystem services evaluated during project scoping and also communicating how project design was informed by expected benefits. Using the system can elevate stakeholder concerns that fall outside of project authorities which otherwise have the potential to derail implementation. Further, the approach generates products that communicate how tradeoffs among ES benefits were weighed during planning, rather than leaving connections and assumptions implicit, as is common in current planning communications.

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Designing a Nature-Based Solutions Project Database to Meet Decision-maker Information Needs Related to Restoration Benefits

Katie Warnell *& Lydia Olander*
Duke University, Durham, NC, USA

Ecological restoration projects are considered nature-based solutions (NBS) when they generate multiple benefits that address pressing societal challenges for both nature and people. For example, they can help ecosystems and communities adapt to the impacts of climate change and can store carbon, contributing to climate mitigation. The U.S. is among a number of countries that are elevating NBS, including restoration, as a critical tool for tackling climate change. This is part of an ongoing trend where ecological restoration programs are increasingly intended to provide social, economic and environmental benefits. However, local decision makers, engineers, federal grant makers, and others continue to raise uncertainty around the performance and reliability of restoration for achieving climate and other social and economic goals as a challenge.

Current efforts to collate NBS and ecological restoration project information are not sufficient to meet this need. Existing databases have inconsistent structures and differ in the details they provide about projects, making it difficult to compare across projects or approaches. Many provide limited information beyond project type, location, and a short description. While there are several relatively simple changes that could improve these databases, there are limits to what can be achieved given missing data. Data on many important project benefits are not collected given how difficult they are to measure (e.g., impact on flooding). The surging interest in and federal support for NBS (coastal habitats, dunes, floodplain restoration and protection, urban parks, etc.) has created unprecedented opportunities for data collection which could be designed to better meet decision-maker needs. To take advantage of this opportunity and do so in a way that most effectively aligns data collection with decision maker needs, we are: (1) co-developing a blueprint for a synthetic NBS project database with decision makers and engineers, and (2) building a research network focused on filling critical evidence gaps.

In this session, we will share results from a review of existing NBS databases and a review of social and ecological metrics for restoration, introduce a proposed framework for the synthetic database and research network, and ask for your ideas, suggestions, and partnership in building this into a collaborative and effective initiative. We envision a future where this synthetic database pulls in data gathered across the country and is used to justify and evaluate the benefits and costs of projects, to develop and update engineering and design guidelines and standards, and to build reliable modeling tools for evaluating the social and economic as well as the environmental benefits of proposed projects. There will be multiple opportunities for attendees to provide their input at NCER and beyond.

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Adaptive Management: Is it Robust Enough to Handle Climate Change?

David L. Wegner[1]*, Roger Pulwarty*[2]*, Charles Yackulic*[3]*, Fred Sklar*[4]* and Lorie Staver*[5]

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Since the mid-1980's the concept of adaptive management has been embraced as an alternative approach where system risk and expectations are high. Adaptive management, the concept, is built around the philosophy of learning by doing and embracing management actions as experiments. Three broad categories of adaptive management - passive, active and collaborative have been implemented in multiple venues with varying degrees of success. Adaptive management is increasingly utilized by federal and state agencies as the impact and risk of management actions on system and species responses are unknown. Climate change is adding to management risk and the complexity and potential unintended consequences of decisions. Management decisions, both short and long term, may have both short- and long-term consequences. Useful adaptive management in complex ecosystems requires the balancing of four key components, (1) the right science (monitoring, research, predictive modeling, and assessment), (2) appropriate governance authority, (3) administrative and budget support, and (4) rigorous scientific review. Collectively these four components will assist in developing a culture for adaptive management where flexibility and value of experimentation can feed into a structure decision making environment that can aid managers and decision makers. The Adaptive Management panel will explore the challenges of applying the concept from a policy and science perspective. The panel will include an initial overview of the panel charge (David Wegner) followed by a global policy perspective (Dr. Roger Pulwarty). With this as a setting three case studies of complex system studies and adaptive management will be presented. These include the Everglades (Dr. Fred Sklar), the Colorado River in the Grand Canyon (Dr. Charles Yackulic) and Chesapeake Bay (Dr. Peter Goodwin). The moderated panel discussion will focus on lessons learned and the challenges posed by climate change, exploring whether adaptive management is flexible enough to meet the future.

Panelist Biographies:

David Wegner is a senior strategic scientific consultant for Woolpert Engineering focusing on climate, water, energy and innovative financing of water and climate infrastructure. He has been worked for the Department of the Interior where he was the Director for the Glen Canyon Environmental Studies, worked for the U.S. House of Representatives as Staff Director for the Water and Power Subcommittee; served on the Transportation and Infrastructure Committee staff and on the National Academy of Sciences, Water Science and Technology Board; the EPA Environmental Finance Board; and on multiple academic committees on water and climate.

Roger Pulwarty is the Senior Scientist at the NOAA Physical Sciences Laboratory. He was previously the Senior Science Advisor for Climate, and the Director of the National Integrated Drought Information System (NIDIS) in the NOAA Climate Program Office. His over one hundred articles, book chapters, and technical reports, focus on climate science, risk management and information services in the U.S., Latin America, and the Caribbean. Roger has designed and led programs dealing with climate science and services, including the Regional Integrated Sciences and Assessments, NIDIS, the GEF Mainstreaming Adaptation to Climate Change project in the Caribbean, and the InterAmerican Institute Collaborative Research Network on Eastern Pacific Boundary Currents

Fred Sklar is the Director of the South Florida Water Management District's Everglades division. Dr. Sklar's expertise includes landscape ecology, coastal and wetland ecology, ecosystem modeling, adaptive management for wetland restoration, and computer applications in environmental science. His modeling experience was used in preparing the 2012 Louisiana Coastal Master Plan. Dr. Sklar serves as an Associate Editor for the Ecological Society of America's journal: *Frontiers in Ecology and the Environment*; an executive member of the steering committee for the Florida Coastal Ecosystem LTER Program, and a RECOVER Executive Committee member for the Restoration of the Everglades.

Lorie Staver is a plant ecologist and Associate Research Professor at the University of Maryland, Center for Environmental Science. She has a special interest in restoration of subtidal and intertidal plant communities, and the role of nitrogen in aquatic plant ecology. Her dissertation work was conducted on a large-scale restoration project in Chesapeake Bay, Poplar Island, where nutrient rich dredged material from the shipping channels in upper Chesapeake Bay is used to reestablish remote island habitat. She examined the trajectory of vegetation development; elevation change and nutrient budgets of the restored tidal marshes. She is currently continuing this work, focusing on the effects of nutrient availability on plant establishment, vertical accretion, vegetation health and resilience to sea level rise in restored marshes, including living shorelines.

Kim Dibble

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A Community of Practice Platform to Support Landscape-Scale Partnerships for Ecosystem Restoration

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Natural resource managers and restoration practitioners have voiced a need to increase coordination around key conservation challenges and to more effectively communicate lessons learned from on-the-ground experiences. This is particularly important when addressing landscape-scale challenges such as climate change or invasive species management. The Conservation and Adaptation Resources Toolbox (CART) is a multi-organizational partnership directed by the U.S. Fish and Wildlife Service, Bureau of Reclamation, and the University of Arizona that supports peer-to-peer communication through Communities of Practice (CoPs) focused on issue-based conservation and management challenges that span geographies and jurisdictions. CART currently supports four CoPs on introduced aquatic species, aquatic restoration, grassland restoration, and drought and climate adaptation. In support of these CoPs, CART develops decision-support tools and Case Studies that communicate lessons learned from on-the-ground activities and applied research. Furthermore, CoP partners co-develop research and management priorities as well as help direct additional CART activities including structured webinars and workshops for peer-to-peer knowledge sharing. To date, CART has published 111 Case Studies related to ecosystem restoration. Topics range from floodplain restoration for salmonid habitat in Washington to collaboratively improving seed-based restoration success on the Colorado Plateau. The model CART has developed to share Case Studies helps overcome common barriers to communication, including the lack of time, capacity, and technology to share project information. In addition, CART provides significant mentorship opportunities for students and emerging professionals. Working with CART staff and conservation professionals, student interns author the majority of Case Studies, allowing them to build their networks while gaining technical writing skills and learning from those doing work in the field. CART's modular and scalable platform and templates have enabled it to grow into an expanding partnership network that supports hundreds of active participants from federal, state, Tribal, and local governments, NGOs, research institutions, and private land managers.

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It's About Dam Time to Modernize Beaver Management Through Watershed-Wide Policy Change

Alexa Whipple
Methow Beaver Project, Twisp, WA, USA

North American Beavers helped shape our watersheds, expanded the diversity of species, and supported tremendous biological communities prior to near extirpation by the mid-19th Century. Though beavers are a tenacious, critical keystone species making their way back from the brink of extinction, beavers are managed by state regulatory agencies as furbearers with unlimited harvest opportunity, and more impactful, as a nuisance/conflict wildlife species with unregulated lethal removal. Yet, we do not have a grasp on beaver population sizes in any state nor comprehend what a functional or sustainable population size is in modern, highly modified watersheds in tremendously varied habitat across North America.

Additionally, climate adaptation priorities and public tax dollars are increasingly supporting partnering with beavers for broad, long-term, process-based ecological benefits, especially toward habitat restoration and recovering endangered salmonids and other freshwater dependent species. Despite beavers being a native, natural, self-maintaining, pragmatic, and publicly subsidized solution to many human caused climate challenges, not one state currently provides legal protection of any beavers. Even states piloting sanctioned beaver relocation programs do not offer enforceable protections of relocated beavers.

The last two decades have seen a broader recognition of beavers as a critical keystone species, a partner in restoring complex ecological systems, and one of the best strategies for rebuilding resilience to climate change but this isn't enough. This acknowledgement and prioritization of beaver-based restoration and climate resilience needs to be written into our state wildlife management policies as law and regulatory code.

Come explore how you can make critical headway towards modernizing beaver management in your state: where to start, partners to cultivate, leaders to engage, existing federal and state requirements to support your arguments. Beavers finally got a publicist, now they need legislation. Help secure a future for beaver-based climate resilience across the US!

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Assessing Impacts and Benefits of Riparian Zones with the Riparian Ecological Function Index (REFI)

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Riparian zones are important transitional areas between upland and stream ecosystems that improve water quality, provide ecological habitat and corridors, maintain natural hydrologic processes, and provide other important ecosystem goods and services. Riparian management has grown in prominence as these systems have become important foci of stream restoration efforts, stormwater best management practices, and greenspace corridors. Some regional tools have been developed to assess impacts and benefits of riparian zones, but no nationwide models or modeling frameworks adequately capture the effects of riparian outcomes. Existing tools tend to focus heavily into instream outcomes that follow a stream assessment protocol with the inclusion of minor riparian-oriented outcomes. Practitioners have an immediate screening need for multi-taxa tools that can function at national scale to assess impacts and benefits of riparian management actions. For this purpose, we develop the Riparian Ecological Function Index (REFI), which is a semi-quantitative, rapid assessment technique for the national application of riparian ecosystems. REFI structures a framework around three major outcomes: (1) the riparian zone's effect on instream outcomes, (2) its role in ecological connectivity, (3) how it functions as unique and important habitat. The model follows a semi-quantitative approach that relies on rapid field assessment protocols with optional, but heavily encouraged, desktop geospatial assessments. The REFI is intended for a variety of riparian ecosystems within the United States.

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Combining Environmental Monitoring and the Fossil Record to Support Coral Reef Management in the East Portland Special Fishery Conservation Area, Jamaica

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Global warming and human impacts continue to be devastating to coral reef systems. Jamaican reefs have been adversely affected by a variety of threats including hurricanes, coral bleaching, disease, and algal overgrowth, the impact of which has been exacerbated by overfishing and urchin mortality. Despite the dire situation, with proper protection, algal-coral phase shifts can be reversed. One area where efforts are being made to reverse this shift is the East Portland Special Fishery Conservation Area (EPSFCA). The EPSFCA is a marine protected area and "no take zone" monitored by the Alligator Head Foundation. The Alligator Head Foundation manages coral and mangrove nurseries and leads monitoring and community-driven restoration practices.

Although reefs in some parts of Jamaica, such as Discovery Bay, are well studied, few ecological studies have been extended to other regions around the island. The unique reefs of northeast Jamaica lack critical data necessary for conservation efforts; no baseline information on community composition had been done until the establishment of the Alligator Head Foundation in 2016. Reef management and protection requires information about how these reefs will respond on short, long, and geological timeframes. To obtain an ecological baseline, this project synthesizes environmental and water quality data (nutrient levels, alkalinity, temperature, and light) with community assemblage data (fish counts, benthic substrate assessments, and invertebrate counts) from EPSFCA reefs. The similarities and differences between these sites will be compared using ordinations. To address a longer timeframe, this project will use similar techniques on a nearby fossil reef to see how northeast Jamaican reefs have changed over thousands of years.

An analysis of EPSFCA reefs monitored from 2017-2022 found that many sites are distinct, but most reefs show signs of degradation (e.g., coral disease and high algal cover). Much of the variation between sites can be explained by the abundance of turf algae and the corals *Colopophyllia natans*, *Mussa angluosa*, *Dichocoenia stokesi*, and *Acropora cervicornis*. The goal of this project is to combine the EPSFCA data with environmental information to provide a road map for where conservation efforts are most likely to support the recovery of the protected area. Preliminary results from monthly sampling in 2022 and 2023 suggest that these reefs are closely tied to what is occurring on the land, with low salinities indicating freshwater input and occasional spikes in nutrient concentrations, especially during the rainy season. In addition, these reef sites are temperature stressed most of the summer.

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Dryland Soil Sequestration in Southeastern Arizona: Potential and Challenges

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Increasing soil carbon storage is part of a suite of approaches to reduce atmospheric carbon stock and address anthropogenic climate change. The soil carbon storage capacity, both organic and inorganic components, of a landscape is a function of ecological, edaphic, climatic, and anthropogenic factors. Landscape degradation is associated with a loss of soil carbon, but ecological restoration, installation of natural infrastructure in dryland streams, and different agricultural practices may reverse that trend. Soil organic carbon storage can be enhanced by increasing biomass in soil and certain agricultural practices. Soil inorganic carbon sequestration includes the formation of secondary carbonates (both pedogenic and biogenic) and leaching of bicarbonates into the sub-soil. Drylands occupy approximately one quarter of the conterminous United States and almost half the global land area and can play an important role in carbon storage, especially here in the southwestern US. Understanding how land management and agricultural practices affect carbon storage in our region can give us insight to global trends. 2023 was the first year of a 5-year study to quantify soil carbon storage at sites across southeastern Arizona, including lands managed by federal agencies, Tribal Nations, non-profit organizations, agriculture corporations, and private citizens. Basic analysis will be performed on individual samples and chemical analysis will be performed on composited samples. We will present the study design, sampling protocols, and the first-year field effort.

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The Past is Important – Conservation Paleobiology Data in Restoration and Conservation

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Resource managers are tasked with planning for ecosystem restoration and species conservation in a rapidly changing world. An added complication is that monitoring typically does not begin until an environment has already been altered by humans, so we often lack information about natural states and their variability. If restoration means returning to a previous condition, typically pre-anthropogenic disturbance, how do we get information about past states and how can we anticipate biological responses to future environmental changes? The emerging field of conservation paleobiology provides missing information about pre-disturbance conditions and gives insights into how ecosystems and species have changed over centuries to millennia by integrating information from geohistorical proxies, such as those available from sedimentology, paleontology, archaeology, and geobiochemistry. By studying biotic responses to past environmental change, conservation paleobiology examines the results of natural experiments (e.g., past warmer-than-present climates) that cannot be evaluated on the timescales available from standard monitoring methods. These long-term records provide the necessary context to make conservation and restoration decisions that align with the natural range of biological and environmental variation and anticipate future responses under a rapidly changing climate.

Conservation paleobiological studies can contribute to resource management in a variety of ways. For example, they can test preconceived notions about baselines and quantify historical ecosystem attributes (e.g., biodiversity, structure, function, and services). Here we give four examples: 1) In the Florida Everglades, paleontological data combined with hydrologic models provide the estimated ranges for salinity and flow prior to alteration of the hydrology that are needed to set restoration targets. 2) In Caribbean Panama, preserved fossil shark scales reveal long-term changes in coastal shark populations and shifts in community composition over the last several thousand years. 3) In the Arctic National Wildlife Refuge (AK), shed female caribou antlers indicate range shifts coincident with infrastructure development for one herd, and consistent use of calving grounds over the last 3000 years for another herd. 4) Across the landscape, geohistorical data identify which taxa have previously shifted ranges to track climate conditions and highlight which taxa are most vulnerable and in need of conservation strategies that can facilitate range shifts as climates change.

By expanding the timescales over which species and ecosystems are studied and examining the patterns and drivers of pre-disturbance change, conservation paleobiology provides resource managers with information that encompasses natural trajectories of change and ecological processes within the natural range of variability, allowing for more attainable and sustainable restoration and conservation targets.

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Bosque Ecosystem Monitoring Program – The Critical Role of Education, Equity, and Community/Citizen Science in Modeling Vegetation Response to Ecosystem Drivers

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The Bosque Ecosystem Monitoring Program (BEMP) combines long-term ecological research with outdoor science education and outreach by involving K-12 students and their teachers in monitoring key indicators of structural and functional change in the Middle Rio Grande riparian forest, or "bosque." Students participate in field data collection, lab processing, classroom activities, and events – all helping to increase their understanding and appreciation of science and their local riparian ecosystem. BEMP supports between 4000 and 9000 students from six counties in New Mexico, primarily from Title I schools. Data collected from 34 sites along 350 miles of the Rio Grande are used by federal and state agencies to make land management decisions. The current bosque is a remnant of the 1941 flood and the river regulations and manipulations of that time. Restoration of a cottonwood/willow forest and native mosaic under changing temperature regimes and decreasing water availability is a challenge that must also address water use and values of local communities. Understanding the history of changes, current constraints, implications of anthropogenic drivers, and the impact of new drivers like increasing aridity and fires on the river and its ecosystem can help us develop models to navigate successful management of the senescing cottonwood forest.

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Accelerated Chesapeake Restoration through Multi-Objective Targeting

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The Chesapeake Bay Program (CBP) is a unique regional partnership that leads and directs Chesapeake Bay restoration and protection efforts. The 2014 Chesapeake Bay Watershed Agreement established 10 goals and 31 outcomes that guide the actions of the partnership. The topics addressed by these goals and outcomes often relate to place-based management of fisheries, habitats, water quality, and watersheds.

The CBP partnership spends about $1.2B annually on activities toward achieving the goals of the Watershed Agreement, with a traditional focus on water-quality improvement. Recent funding increases, including the Bipartisan Infrastructure Law, provide additional opportunities to accelerate progress toward multiple Watershed Agreement outcomes while simultaneously achieving state and local benefits. A science-based approach to target resources, including these funding increases, is needed to use decision-support tools wisely and identify places to more effectively advance multiple outcomes and benefits.

In collaboration with CBP partners, including the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS) has developed a web-based portal that contains a wide range of existing decision support tools that can be used to target resources. The portal is an ArcGIS Hub implementation with integrated and cross-linked web mapping applications. The information is organized around several topics based on the goals of the Chesapeake Bay Watershed Agreement: (1) accelerate water-quality improvements, (2) improve fish, wildlife populations and habitats, (3) expand land conservation efforts, and (4) increase benefits to people, with all topics considering opportunities to enhance climate resiliency.

This presentation will provide an overview of the portal, sample use cases for selecting and applying several decision-support tools, and a description of how the Portal can be used for multi-objective ecosystem management.

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Culturally Significant Medicinal Plants Within Emory Oak (*Quercus emoryi*) Ecosystems

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Emory oak (*Quercus emoryi*) is a cultural keystone species that supports woodland and savanna ecosystems in Arizona. Within these systems are medicinal plants that hold value for the past, present, and future generations of the Apache Tribes (Yavapai, San Carlos, Tonto, White Mountain). There is little understanding of the dynamic between medicinal plant species occurrence within *Q. emoryi* ecosystems and climate change. This research relies on traditional ecological knowledge and scientific research to create a foundation that could help in future management decisions. These ecosystems are threatened by climate change (drought), fire suppression, invasive species, and human impacts. To better understand if there is a conservational connection with medicinal species occurrence with Emory oak ecosystems. Extensive research of existing cited literature is needed to create a database of all cultural significant plants. Followed by interviews with Elders to fill in the gap and gain more cultural knowledge. To recognize how will climate change affect the distribution of culturally significant medicinal plants in Emory oak habits. Spatial Distribution Models (SDM) will be used to predict environmental changes and trends for species under various climate change scenarios. Land Surveying is of interest in providing physical evidence in co-occurrence. Applying scientific knowledge and Apache wisdom is the start to protecting, preserving cultural significance plants.

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Canal Backfilling to Achieve Hydrological Restoration in Coastal Wetlands in Louisiana

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The freshwater deltaic wetlands present in the Barataria Preserve of Jean Lafitte National Historical Park and Preserve are among the most biologically productive ecosystems in North America. Canals were dredged here starting in the mid-1800s, primarily to support natural resource extraction. The dredged material was deposited in spoil banks alongside the canals. The canal channels brought marine influence into freshwater wetlands and spoil banks blocked natural flow of water across the landscape, altering hydrology at the landscape scale. The changes in hydrology have ultimately resulted in impoundment, saltwater intrusion, soil compaction, habitat modification, invasive species introduction, and wetland loss. The National Park Service (NPS) is implementing a hydrological restoration effort where 12 miles of canals have been backfilled to reduce marine influence and to increase hydrologic exchange between the canal channels and adjacent wetlands, restoring more natural hydrological and biogeochemical processes at landscape scales. CDM Smith, in support of NPS, is executing a robust environmental and ecological monitoring plan to evaluate restoration outcomes. Monitoring includes observation of water levels and quality, soil properties, vegetative cover and species composition, invasive species presence, nekton presence and abundance, net primary productivity, accretion and/or erosion, and subsidence.

Excavation of canals in wetlands for development or natural resource extraction is a worldwide problem, and restoring wetland function can restore ecosystem services essential for sustaining human communities. Degrading remnant spoil banks into canals is an underutilized restoration method that is a cost-effective approach to address historic degradation of wetlands. In our presentation we will identify which environmental and ecological properties responded rapidly to hydrologic re-connection and evaluate how these shifts support park management goals of reducing marine influence from the Gulf of Mexico. During the presentation we will discuss lessons learned and construction tradeoffs to the restoration approach.

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Invasive Species Distribution Model from the effects of climate change in Arizona

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As climate change rises, it sends a ripple effect with both land and water ecosystems. One of the effects is the rise of non-native species, because it involves the displacement of native plants, fisheries, and wildlife. These non-native species can also be poisonous or toxic to humans and livestock. Which leads to negative effects on crops and rangeland of an area. This gives exotic plants a chance to prosper if they are not controlled properly. These non-native species are very difficult to maintain and control because there needs to be proper identification, replacement with native species, and creating management plans. One method to help monitor these exotic species is creating Species Distribution Models (SDMs) to help calculate and give predictions of the level of invasion that these species have before and after restoration treatments. The data collected will display the distribution of Native and non-Native species that could potentially affect the Emory oak restoration management plans. There will also be data about climate change and how it affects both restoration management and the species distribution models. The future direction of these models will to be used to help Indigenous communities that are more impacted by climate change and the increasing rate of invasive species. This will be done by looking at Emory oak ecosystems because it is culturally valuable for the Western Apache tribe. These models will calculate varied invasive grasses and forbs that will be available for future land management and restoration practices. This will also be great information by using SDM to allow land managers and practitioners to utilize their focus on time and resources.

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Managing Subsided Lands in the Sacramento- San Joaquin Delta, California, USA

Edmund Yu

Delta Independent Science Board, Sacramento, CA, USA

Drainage of land in the Sacramento-San Joaquin Delta in California, USA has caused extensive oxidation of peat soils, lowering approximately 386 mi^2 of land from 10 ft to as much as 29 ft below sea level. Although decades of subsidence have already depleted peat soils in areas of the Delta, subsided lands continue to cause significant challenges, such as increasing costs to drain soils, declining arability for agricultural production, water quality degradation, vulnerability to levee failure and flooding, and substantial emissions of greenhouse gases in areas where drained peat soils remain. A broad cross section of stakeholders, including public agencies and private sector parties, are developing, and testing many different approaches to manage subsided lands. The scale of subsidence in the Delta and the severity of its consequences for Delta agriculture, greenhouse gas emissions, and water quality indicates a need to assess existing management of subsided lands and the social, cultural, and economic trade-offs among different management approaches. To help address this, the Delta Independent Science Board is working to synthesize and evaluate the state of science related to adaptive management of subsided lands and provide recommendations to address knowledge gaps. This poster will share emerging insights into scientific knowledge gaps, economic and decision-making perspectives from landowners and public agencies, as well as recommendations to improve the adaptive management of a complex Delta.

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Why the Trilogy Matters: Hydrology, Geomorphology & Ecology

Bill Zeedyk
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It is only in recent years that the restoration profession has begun to recognize the trilogy that links hydrology, geomorphology and ecology. Understanding the fundamental nature of this trilogy is essential to the effective restoration of all streams and wetlands. All three factors must be respected if any project is to be successfully planned, implemented, and the results assessed. This talk will explain how the trilogy functions and its application to any restoration project.

Hydrology focuses attention on the *availability* of water. In a project, there is no control over the *amount* of water available to work with or the *timing* of when it arrives. The only thing that can be altered is the *duration of time* that water is available. **Geomorphology** concerns the source of sediments, including their nature, transport, size, and deposition. **Ecology** highlights the way in which plant and animal species interact with the site and each other.

The lesson of the trilogy is that altering any one factor affects all the others. Changing the species composition and abundance (**ecology**) changes the water within an affected channel (**hydrology**), which changes the erosion or deposition of sediments (**geomorphology**). Any pressures affecting one factor will alter the others. To be an effective restorationist, it is essential to be ever-mindful of the interactions linking all three factors.

Although the idea of the trilogy is straightforward, the implications are profound. It is still common for many professionals to address the three factors in isolation. If restoration projects are to be effective, it is imperative that all professionals learn to think in terms of the trilogy**.**
The value of this knowledge will be demonstrated by providing examples of projects undertaken by the author over the past three decades.

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Incorporating Tribal Perspectives, Treaty Rights, and Knowledge in Ecosystem Restoration

Brian Zettle *and Mark Gilfillan*
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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.

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Evaluating Reservoir Selective Withdrawal Operations and its Impacts using CE-QUAL-W2 Model

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CE-QUAL-W2 (W2) is a 2D, laterally averaged hydrodynamic and water quality model with over 30 years of development history. The W2 model is capable of simulating multiple types of water bodies, including reservoirs and river systems. It can model a diverse range of water quality constituents, from general constituents and inorganic solids to bacteria, nutrient cycles, and eutrophication processes. The model generates detailed outputs for all simulated water quality constituents, available at any longitudinal, vertical, and temporal point. W2 has been successfully applied to hundreds of rivers, lakes, and reservoirs both in the U.S. and internationally. The model serves as a valuable management tool for assessing the direct and indirect impacts of various stressors, conducting thermal and water quality studies, updating reservoir operation manuals, and developing environmental impact statements.

This presentation will offer an overview of the latest capabilities of the W2 model, with a particular focus on its application to the F.E. Walter reservoir and riverine system. Specifically, we will apply the newly updated selective withdrawal algorithm in the W2 model to quantify the impacts on downstream water quality, especially temperature and dissolved oxygen, resulting from releases from the reservoir and river system. Given specific storage and flow conditions, various selective withdrawal strategies lead to unique outcomes in terms of cold-water storage utilization and downstream water quality during the reservoir release season. These strategies allow resource managers to evaluate how reservoir operations align with downstream environmental objectives. Key considerations in the current model development for the F.E. Walter reservoir included the representation of tower control structure levels, gate operations, and water blending from multiple levels. The presentation will discuss the W2 model development, results, and alternative analysis.

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