Nutrient Load Reduction Progress Across the Northern Everglades Watersheds

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As part of the Northern Everglades and Estuaries Protection Program (NEEPP) statutorily required protection plan updates, this study evaluated nutrient load reduction progress across the Lake Okeechobee, Caloosahatchee River, and St. Lucie River watersheds. The WY2020-WY2024 (water year (WY): WY2020 is May 1, 2019 to April 30, 2020) water quality data were compared against planning targets and estimated planned project reductions to determine additional load reductions needed to assist in achieving Total Maximum Daily Loads (TMDLs). Then to inform additional project planning, nutrient unit area loads, and runoff were reviewed across all three watersheds. In the Lake Okeechobee Watershed planned projects aim to reduce total phosphorus (TP) loads by 44 t by 2034, with 206 t of TP reduction still required to meet the planning target. A proven strategy has been to focus on areas with areas with higher unit area loads such as the S-191 Basin which has had the most projects and had decreasing trends in nutrient loads. In addition to the Taylor Creek/Nubbin Slough Subwatershed (0.58 lbs/ac) which includes the S-191 Basin, other subwatersheds with high TP unit area loads are Lower Kissimmee (0.42 lbs/ac) and Indian Prairie (0.40 lbs/ac). Those subwatersheds and areas with high runoff, such as the Upper Kissimmee Subwatershed (9.63 inches), are locations where additional projects may make the largest impact. In the Caloosahatchee River Watershed planned projects are anticipated to reduce total nitrogen (TN) loads by 117 metric tons (t) by 2034, leaving an additional 690 t of reduction still required. The West Caloosahatchee Basin is identified as a priority due to its high runoff (24.55 inches) and TN Unit Area Load (7.09 lbs/ac). However, most of the TN is not biologically available, reducing the potential effectiveness of conventional wetland treatment projects and highlighting the need for storage-focused projects to advance progress on the TMDL goals. The St. Lucie River Watershed is projected to exceed its needed reductions if all planned projects are successfully implemented. These assessments highlight the need for strategically implementing storage and nutrient reduction projects according to basin-specific challenges to meet ecological health goals in the receiving waters across all three watersheds.

Lithological Controls on Vegetation Patterns in Northern Boreal Peatlands: Implications for the Everglades Ecosystem

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Northern peatlands are characterized by unique vegetation patterns linked to specific peatland landscapes that share many similarities with the Everglades. For example, tree islands are typical in locations with disparate contrasting latitudes such as boreal systems in Minnesota and the Everglades. Additionally, the typical string and flark pattern in northern peatland systems resemble the ridge and slough landscape in the Everglades. Previous studies in northern systems have suggested that these surface patterns are controlled by lithological changes. In this study we completed an array of ground penetrating radar (GPR) surveys to investigate the lithological controls on vegetation patterning in 5 northern peatlands in Maine including Meddybemps, Baileyville, Crystal Bog, Vanceboro, and Crawford. Vegetation transitions included *Sphagnum* mosses, leatherleaf, dwarf heath shrubs, black spruce, as well as dwarf huckleberry. Peatlands also included the presence of open water pools with the exception of Crawford, used as a control site. GPR surveys were completed using 100 and 50 MHz frequency rough terrain antennas (RTA). Preliminary results confirm that factors like peat thickness or differences in the nature of the mineral soil exert controls on surface vegetation patterns that are consistent between sites. These results have direct implications for understanding how lithology controls surface vegetation (and thus potentially dictating groundwater flow) in places beyond northern systems such as subtropical peatlands, including the Everglades.

Effects of Bottom Morphological Features During Storms: A Case Study of Hurricane Isaac in 2011

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Hurricanes and storms are capable of disturbing ocean conditions and can cause significant damage to coastal communities. The probability of their occurrences has increased alongside their intensities. Several studies have investigated their occurrences and impacts of the resulting significant wave heights (SWH) on land elevation, sediment resuspension, and inundation. Also, there are many studies focusing on the dampening mechanisms of these wave heights or the factors responsible. However, they are often small-scale studies, and there is the need for more regional studies. Investigating these mechanisms is important in mitigating storm impacts and increasing the resilience of coastal communities. To investigate the wave height dampening by bottom morphological features, a regional modeling study of the passage of hurricane Isaac in 2011 through the Florida Keys is carried out. The Florida Keys is a low-level coastal community in South Florida, with abundant vegetation and the Florida Reef Tract (FRT), which is the third largest coral reef system in the world. It is also one of the most vulnerable regions with frequent storms. In August 2011, hurricane Isaac passed through the Florida Keys with a wind speed of about 60 mph, which led to an increase in water level and wave height. For this study, a regional ocean model for the eastern Gulf of Mexico and Florida shelf is coupled with a surface wave model (SWAN). To better resolve wave-bed interactions, a child model covering the Florida Keys and adjacent coastal areas with a spatial resolution of ~500 m is developed and nested in the regional model. Coral reefs and vegetation characteristics were included to parameterize their effects on bed roughness. Twin simulations were run with and without the effects of these benthic features. Results show that without considering benthic features, significant waves (SWH >1 m) can penetrate the Keys and Biscayne Bay while Florida Bay receive strong inflow of swell. With the presence of bottom features, not only SWH but also sub-tidal water level is greatly reduced throughout the Keys. Wave breaking, white capping, and bed friction are identified as key mechanisms responsible for dissipating waves. In particular, the outer bands of FRT (5-10 km offshore) serve as the major barrier where strong bottom friction is enhanced by the bottom features, greatly dampening the energy of the approaching waves and swell. This study demonstrates the importance of bottom morphological features for coastal protection. More studies, however, are needed to examine the responses of bottom morphological features to different hurricanes and storms, and when combining sea level rise and storms.

Integrating Multi-Source Data with Machine Learning Techniques to Upscale Wetland Carbon Dioxide Fluxes

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Accurately quantifying atmospheric carbon dioxide (CO_2) fluxes in wetland ecosystems is essential for understanding both regional and global carbon dynamics, particularly in the context of climate change. The high level of heterogeneity of these ecosystems poses challenges in developing models for reliable carbon flux estimations, which are crucial for predicting the role of wetlands in mitigating the effects of global warming. The objective of this research is to establish a framework to identify how CO_2 can be predicted across the Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) in South Florida, USA. This framework will integrate Object-Based Image Analysis (OBIA) and sophisticated machine learning (ML) techniques to link flux measurements at multiple scales from eddy covariance towers, airborne BlueFlux sensors, and satellite remote sensing products. Three machine learning algorithms, including Random Forest (RF), Support Vector Machine (SVM), *k*-Nearest Neighbor (k-NN), will be explored and compared to the traditional Multiple Linear Regression (MLR) method in the upscaling. An Ensemble Analysis (EA) will be used to integrate comparable model outputs to generate a more robust flux product. The study will cover three consecutive seasons, from 2022 through 2023, which enables the identification of spatial and temporal patterns in CO_2 fluxes. By combining these techniques, this research aims to characterize flux dynamics in heterogeneous wetlands using advanced ML and satellite observations and assist with regional and global carbon flux mitigation activities in global climate warming scenarios.

Assessing Biomechanical Properties of Mangrove Roots Across a Salinity Gradient in the Florida Coastal Everglades

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The Shark River and Taylor Slough basins within the Everglades National Park are ecologically significant regions that exhibit distinct hydrological and vegetative characteristics. The Shark River basin is influenced by tidal processes and characterized by dense woody vegetation, while the Taylor Slough basin experiences more stagnant conditions with lower vegetation density. This study examines the geotechnical properties of sediments in these basins, focusing on sleeve friction as a proxy for shear strength. Duplicate Cone Penetration Tests (CPTs) were conducted at each site, revealing distinct stratigraphic and mechanical behaviors within two defined zones: shallow and deeper root layers. The Shark River basin, characterized by abundant woody roots in the shallow zone, exhibited shear strength values ranging from 100 to 300 kPa, indicating variability in root-dominated sediments. In contrast, the Taylor Slough basin, with less dense root structures, showed lower shear strength values, ranging from 100 to 180 kPa. The shear strength was correlated with the soil properties and hydrological factors that include flooding duration, soil nutrients, and bulk density. The results demonstrate a strong correlation between the root shear strength and the flooding duration along with the soil properties. These results highlight the role of vegetation and depositional environments in influencing sediment mechanical behavior. The findings contribute to understanding sediment behavior under varying ecological and hydrological conditions, which is crucial for assessing the stability and resilience of these wetland ecosystems.

Strong Partnerships Are Key to a Successful Conservation Breeding and Recovery Program

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Depending on the scope and geographic distribution, conservation breeding and recovery programs for threatened and endangered species require coordination among stakeholders with different and often competing missions. The success of these programs requires building trust among stakeholders and developing strong collaborations around common goals and a shared vision. Even though the geographic distribution of the Florida grasshopper sparrow is small, inhabiting dry prairies and adjacent pasturelands endemic to south-central Florida, this species occurs on both private lands and on public lands that are managed by different state and Federal agencies. To promote recovery efforts across property boundaries with different ownership and land management techniques, stakeholders developed a Florida grasshopper sparrow working group in 2002. Participation in the working group is voluntary and has no binding authority but has served as an effective means of collaboration. In 2012, the Florida grasshopper sparrow working group started pursuing conservation breeding as a strategy to promote recovery of this critically endangered bird. In this talk, we will highlight the breadth of variation in stakeholders focused on the recovery of the Florida grasshopper sparrow and how these stakeholders work together to increase resiliency and restore and maintain habitat for this iconic species. By protecting the species and its landscape, stakeholders are promoting the resiliency of not only the Florida grasshopper sparrow but also other grassland-dependent species. All stakeholders realize that this resiliency adds value and flexibility to their missions and the missions of their public and private partners.'

Incorporating Miccosukee Tribe of Florida Indigenous Knowledge in Everglades Restoration Operational Planning

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The Miccosukee Tribe of Indians, a federally recognized sovereign Native American Tribe with a long history in the Central and Western Everglades, is an important partner in Everglades Restoration. The Tribe has unique knowledge of the Everglades and has shared some of their Indigenous Knowledge based upon interviews with the Everglades Advisory Committee, selected by the Chairman, whose counsel constitutes the consensus opinion of many different clans, age groups, and affiliations. The Tribe has agreed to allow a portion of this information to be integrated into Everglades restoration planning. The Tribe is coordinating the creation of a Performance Indicator informed by Indigenous Knowledge with the U.S. Army Corps of Engineers to be used in the Central Everglades Planning Project (CEPP) Operational Plan, an effort lead by the U.S. Army Corps of Engineers and the South Florida Water Management District to develop operations for certain infrastructure associated with Everglades restoration. There are two focus areas in the Performance Indicator: 1) Undesirable high water on hardwood hammocks, and 2) Occasional desirable low water conditions. The former focus is protective of selected sensitive tree island vegetation and function, while the latter is consistent with conditions remembered by Tribal elders and enables the dispersion of bear cubs, a species with associated cultural/traditional/medicinal values. The Tribe will use the results of this Performance Indicator to evaluate alternatives for the CEPP Operational Plan for consistency with Tribal knowledge. At the time of this abstract this Performance Indicator has yet to be formally applied as alternatives are still under development.

Poisson Point Process for Lake Okeechobee Minimum Flow and Level Exceedance and Violation Events

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Lake Okeechobee is the heart of water sources in South Florida. It is a vital ecosystem for wildlife, tourism, water supply and flood protection. Extreme highs or extreme lows of water levels have significant adverse effects on the Lake Okeechobee functions including a serious threat to its levee, Herbert Hoover Dike. The recent dike rehabilitation has forced water managers to change the old Lake Okeechobee (Water Supply and Environment) regulation schedule to a new (Lake Okeechobee System Operating Manual) regulation schedule geared towards lower stages posing a threat to more frequent Minimum Flow and Level violations as defined by Florida law. During this transition, Lake Okeechobee was regulated under an intermittent schedule (Lake Okeechobee Regulation Scheule 2008). South Florida Water Management District established Minimum Flow and Level Criteria for Lake Okeechobee in 2001. The objective of this study is to determine the likelihood of the Lake Okeechobee Minimum Flow and Level violations in the next 20 years. Lake Okeechobee water level, subject to rainfall and other stresses between 1965-2016 (52 years), is modeled under three different regulation schedules using the District Regional Simulation Model. For each scenario, exceedances and violations are defined and represented using Poisson Point Process where waiting time between events were fitted to exponential distributions. Monte Carlo simulation in the next 52 years yield comparable statistics of the original time series being modeled by the Regional Simulation Model. Results indicate that, under the old regulation schedule, there is a 90% probability of at most two violations occurring in the next 20 years (that is, a 10% probability of three or more events). In contrast, under the intermittent schedule, the probability of three or more violations rises to 66%, while the new schedule reduces this probability to 55%. These findings underscore the trade-offs involved in the transition to the new regulation schedule and its implications for the lake's ecosystem and water management policies.

Understanding Sea Level Rise Impacts in Florida Bay: Spatial Dynamics of Water Levels and Salinity

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The Florida Bay estuarine system is undergoing significant environmental changes driven by increasing water levels, fluctuating salinities and the impacts of sea level rise. These changes threaten the bay's unique ecosystems, such as seagrass and mangrove habitats, which support many marine and bird species. Historically, freshwater inflow helped maintain ecologically desirable lower salinity levels in Florida Bay. However, extensive upstream structural changes to the extant Everglades have significantly reduced these inflows, resulting in periods of hypersalinity. These conditions have been linked to widespread seagrass die-offs, algal blooms, and cascading effects on invertebrate, fish and bird populations. Sea level rise further compounds these challenges, as saltwater intrusion and tidal inundation alter salinity gradients and submerge critical habitats. Many restoration initiatives have been implemented in an effort to restore greater freshwater inflow to Florida Bay and support overall ecosystem health. Despite these efforts, challenges remain. The inshore regions of Florida Bay are particularly sensitive to salinity fluctuations and accelerated increases in water levels, emphasizing the need for adaptive management strategies to ensure the effectiveness of restoration efforts under future conditions. It is also important to consider the influence of additional climatic and hydrological variables on water levels and salinities, and how these relationships might change over space and time. This study aims to quantify and model the spatial dynamics of water levels and salinity across Florida Bay, and the factors that influence them. Data from long-term monitoring stations representing various regions of the bay were analyzed for prevailing trends over time. Generalized additive models (GAMs) were employed to investigate relationships with climatic and hydrological variables. The results will provide insight into the impacts of sea level rise on Florida Bay and challenges facing ongoing and future restoration efforts.

Regional Simulation Model Tree Island Tool

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Tree islands in the Everglades are a focal point of regional history, culture, and ecology, and a vital piece of evaluating possible effects of Everglades Restoration. As part of the evaluation of Comprehensive Everglades Restoration Plan implementation, a series of tools are in development to augment existing analyses, explicitly for visualizing the effects of modeled scenarios to tree islands. These address modeled alternatives by integrating various datasets, performing analyses, and creating output that can be readily interpreted and shared. These tools build on existing data and methods to monitoring actual conditions, such as the Everglades Depth Estimation Network and eTree, and integrate historic and contemporary aerial photography, lidar point clouds, environmental datasets, and modeling files to create visualizations of water levels as inundation maps, oblique three-dimensional views with water levels, heatmaps of hydroperiods, and graphs, as well as creating tabular summaries and time series statistics for tree islands. This approach also includes the application of the same statistics and classifications to the modeling data as used in eTree, allowing for comparison of possible scenarios to observed conditions. The draft tools are modular and explicitly created to allow for the easy modification and combination. This includes modules to generate information on tree islands not included in eTree, for the creation of secondary datasets such as the absolute and relative heights from processed lidar data, and for exporting the geometry of tree island heads and canopies. This effort was driven by the identified need in operations studies to include more islands across a broader area than currently in eTree, identify additional elevation thresholds other than maximum height of islands, and present potential scenarios in more intuitive ways. Fundamental issues remain in the base data, and ongoing efforts are planned to integrate additional data produced by scientists for vegetation, new digital terrain models, and other relevant information. The end goal is to produce not just more information but bring together multiple sources in a format that can be readily interpreted and shared to elicit meaningful input on modeled scenarios from stakeholders.

Testing Hydrological Effects on Fire Recovery from Remote Sensing and Field Data

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Everglades management relies on knowing the interplay between fire and flooding. Understanding how post-burn hydrology changes vegetation diversity in wet prairies is crucial in maintaining ecosystem heterogeneity, which is particularly challenging to account for at a finer scale. This study aims to understand how post-burn hydrology affects fire recovery in relation to vegetational community composition changes and specifically determine under which combination of hydrological conditions there is a shift in community trajectories. We took a mixed approach by combining remote sensing and long-term field data to explore these dynamics in sites west of Shark River Slough within Everglades National Park (ENP) burned in during 2020, the most recent year to experience widespread burning. We selected high spatial multispectral resolution WV data of northwestern Shark River Slough pre-burn and post-burn, spanning 63 transect sites sampled pre-fire between 2017 to 2019, and post-fire between 2021 to 2024. We used changes in the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Burn Ratio (NBR) indices to discern true areas burned within park-delineated burned area boundaries and subsequently characterized the degree of burning. Then, we separated burned and non-burned sites and plotted changes in community composition along hydrological gradients, including variation in hydroperiod, mean water depth, and number of dry days since the last inundation, and examined changes between sites sampled one-, two-, three-, and four-years post-burn. We predicted that sites that experienced lower water depths, shorter hydroperiods, and longer dry periods are more likely to return to pre-burn condition, and all burned sites should begin to shift to pre-burn condition after the second year. Future versions of this work should consider extending the geographic range of study to cover areas further south within ENP to account for greater hydrological and geological conditions. Our results ultimately support restorative efforts by allowing managers to account for fire-flooding dynamics prior to conducting prescribed burns and/or managing the effects of wildfires within the park.

Social Amplification of Risk in Coastal Tourism Destinations with Harmful Algae Blooms

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Harmful algae blooms (HABs) occur when photosynthetic microbes in water bodies encounter optimal conditions to grow out of control. Many species of these microbes release biotoxins that can poison seafood, drinking water sources, and may even go airborne and into people's airways. Furthermore, when blooms of these microbes die the decomposition process uses up the dissolved oxygen and leads to hypoxia or dead zones in the water. With increasing human populations, water pollution from sewage and fertilizers is leading to more frequent harmful algae blooms. The problem is occurring all around the world, and in conjunction with warmer waters due to climate change, threatens to get much worse in the future. The social and economic impacts of HABs can be widespread, but they are generally understudied. When they occur in tourism destinations centered around waterfronts, the destination may suffer impacts of such magnitude and depth that they seem disproportionate for a hazard caused by a microbe. The theory of social amplification of risk posits that social aspects could be responsible for the amplification or attenuation of risk. In other words, the magnitude of impacts from risk events could be increased or decreased depending on social factors. The theory highlighted the role of information and communication as amplifiers of risk, but other social aspects of risk have been identified. Prior studies on perceptions of harmful algae risk have identified the role of social amplification, but these studies have focused on establishing the differences in risk perceptions across different groups of people rather than on establishing a theoretical model to explain how risks of HABs may be amplified or attenuated by social factors. This study attempts to close this gap by exploring the case of Florida, USA, a global destination renowned for extensive beaches and human-made attractions and integrates insights from recent studies of the social and economic impacts of HABs on tourism and the destination more broadly to develop a general theoretical model of social amplification of risk in the context of waterfront tourism destinations plagued by harmful algae blooms. There is growing evidence supporting the social amplification of HAB risks in waterfront tourism destinations. The mechanisms for social amplification of risk are varied and interact with one another, transcending short term economic impacts on the tourism industry and the housing market, and threatening the social fabric of the destination in the long term by becoming a motivator for social polarization and conflict. The common thread tying these mechanisms together is the role of information and misinformation regarding the HABs, which erodes the destination's image and encourages divergent and conflicting perceptions of the problem and motivations to address it.

Using a Motion-Activated Camera to Document Wildlife Using a Drying Pool on the Kissimmee River

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Floodplain drying pools are a valuable resource for not only wading birds, but a variety of other species in the greater Everglades ecosystem. As water levels of Kissimmee River floodplain wetlands recede during the dry season months, the wetlands become attractive foraging sites for a wide range of species. These drying pools persist as stages continue to decrease and portions of the floodplain become dry. Fish and invertebrates become trapped and concentrated in these isolated pools, attracting other wildlife. Sampling of Kissimmee River floodplain wetlands and drying pools typically occurs on a monthly or biweekly basis due to time and personnel constraints. Intervals between sampling events may be a limiting factor in determining the full diversity of organisms making use of these ephemeral habitats. Over the course of a three-month period during the 2023-24 dry season we deployed a motion activated camera at a floodplain wetland as it transitioned from a deepwater pool to a completely dry condition. During this transition, the camera captured images of various wildlife species as they interacted with the wetland and other transient visitors. Over the course of the study, we documented 38 species, including 25 bird species, 2 reptiles, 4 mammals, and 7 others. Using generalized water depth assessments, the presence of specific organisms could be associated with overall wetland water depth. For example, white pelicans preferred to forage for a short duration of time at a specific water depth, while wood stork foraging spanned a wider range of depths over a longer timeframe. Scavengers such as racoons, vultures, and caracara only arrived when the drying pool had just a few inches of water remaining. The images captured over the recession event provide rare glimpses of wildlife using these refugia, as well as interactions among species. This monitoring technique can be readily implemented into wetland monitoring and research programs to help capture and document interactions, dynamics, dependencies, and relationships of wildlife with these ecosystems.

Managing Ascension and Recession in the Kissimmee River

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Successful restoration of the Kissimmee River is dependent on the operation of spillways located upstream and downstream of the river to reestablish pre-regulation flow patterns, especially characteristics of ascension and recession during floodplain inundation. A new regulation schedule is being developed for the Headwaters Lakes (Lakes Kissimmee, Cypress, and Hatchineha) called the Headwaters Revitalization Schedule that is intended to provide the flows needed to restore the river. Beginning in 2001, water has been released from the Headwaters Lakes to provide flow to the Kissimmee River Restoration Project using a previous Interim Regulation Schedule. While releases under the Interim Schedule were not expected to fully meet the needs of the restoration project, an evaluation of the resulting conditions can provide insights into how operations need to be improved by the new regulation schedule. Ascension and recession characteristics of floodplain inundation events in the Kissimmee River were evaluated for the 24-year Interim Period (2001-2024) and compared to those during a 31-year, pre-regulation Reference Period (1931-1961). Floodplain water depth, averaged for 5 stations in the Interim Period and 3 stations in the Reference Period, were used to quantify floodplain inundation events. The Interim Period averaged 2 floodplain inundation events per year (±0.3 SE), which was an increase of 43% over the Reference Period average of 1.4 events per year (±0.1 SE). The mean recession rate was 1.7 ft/30 days (±0.2 SE) during the Interim Period, which was an 89% increase over the Reference Period average of 0.9 ft/30 days (±0.21 SE). The faster recession rate was due in part to a 52% decrease in the mean duration of recession events from 146 days (±17 SE) in the Reference Period to 70 days (±7 SE) in the Interim Period. The increased frequency of inundation events with shorter recession durations and faster recession rates indicated that floodplain inundation was abbreviated during the Interim Period relative to the Reference Period, which has implications for wetland vegetation and fish and wildlife utilization of the floodplain. Development of the new regulation schedule should consider how to improve the continuity and duration of floodplain inundation.

Habitat Preference of Two Populations of Federally Threatened Raptors on Tribal Lands

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Audubon's crested caracara (*Polyborus plancus audubonii*) is a federally threatened species found within the Greater Everglades ecosystem. Two populations of this species can be found on the Big Cypress and Brighton Seminole Indian Reservations. The nest locations of these populations have been recorded for over twenty years. Using 2014-2016 Florida Land Cover Classification data, we leverage this long-term nest dataset by extracting landcovers at 1 and 2-km buffers around the nest locations. We compare the habitat preferences of the species on Tribal lands to published habitat preference data for the species in Florida. As in Florida, the Audubon's crested caracara on Tribal lands have a high proportion of improved pasture in the 1 and 2-km buffers around their nest locations. We also find concurrence between the published findings and our study in the proportions of agricultural landcovers (e.g., citrus groves, abandoned citrus groves, sugar cane, fallow cropland) within these 1 and 2-km buffers. There remain, however, differences in habitat preference within Tribal lands and in the literature for the species in Florida. There are also differences in habitat preference between the populations of Audubon's crested caracara on each of the reservations. Our findings have utility for others studying Audubon's crested caracara elsewhere in the Greater Everglades ecosystem. Most importantly, our analysis of this long-term nest dataset is meant to ensure the longevity of the Audubon's crested caracara on Tribal lands for future generations.

Applications of 2D & 3D Hydrodynamic Models to Kissimmee River Restoration Project

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Hydrodynamic modeling plays a critical role in the ongoing efforts of Kissimmee River Restoration Project (KRRP). This project, one of the most significant ecological restoration initiatives in the world, aims to reverse the adverse effects of historical channelization by restoring the natural flow regime of the Kissimmee River while maintaining flood control functionality. One of the key components is the S-69 weir, a downstream terminus hydraulic structure designed to regulate floodwaters and enhance ecological recovery. Damages caused by Hurricane Ian in 2022 at this weir necessitated a comprehensive hydrodynamic assessment to ensure the continued functionality and resilience of this key infrastructure. This study integrates advanced 2D (HEC-RAS) and 3D (ANSYS Fluent) Computational Fluid Dynamics (CFD) models to evaluate the hydraulic performance of the S-69 weir under pre-storm, post-storm, and refurbishment conditions. The 2D HEC-RAS model was utilized to simulate large-scale flow conditions, identify critical erosion-prone zones, and provide boundary conditions for more detailed CFD modeling. The 3D CFD simulations enabled high-resolution analysis of overall velocity distributions, near-bed velocity and shear stresses, and potential scour locations around the weir, accounting for both as-built and proposed refurbishment conditions. Results from the 2D HEC-RAS simulations revealed that concentrated flows at the weir's northwest and northeast corners led to severe scour and structural damage during Hurricane Ian. Subsequent 3D CFD simulations demonstrated the effectiveness of proposed refurbishment measures, including backfill of the upstream sump with particular reinforcing of the northeast and northwest corners of the weir, and partial backfill of the downstream scour holes with appropriate riprap erosion protection measures. This integrated hydrodynamic modeling approach has provided valuable insights for both immediate repair and long-term management of the S-69 weir. It underscores the transformative role of CFD in refining traditional hydraulic design and improving the resilience of water management infrastructure in the face of extreme weather events.

Measuring Performance for Habitat Improvement and Sustainability for Biscayne Bay Southeastern Everglades Ecosystem Restoration (BBSEER)

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The Biscayne Bay Southeastern Everglades Ecosystem Restoration Project (BBSEER) is being planned to restore natural areas in southeastern Miami-Dade County, Florida, including the nearshore estuarine zone together with the associated coastal and freshwater wetlands of southern Biscayne Bay, the Southern Glades, and the Model Lands, with benefits to both Biscayne National Park and Everglades National Park. In addition to being one of the largest estuarine restoration projects in the country and located in a major metropolitan area, BBSEER is one of the first projects in the country to incorporate 50 years of projected sea level rise into the planning. Scientific knowledge and tools were applied to inform ecologic performance measures that can be used to guide BBSEER habitat restoration and sustainability. The regional hydrologic computer simulation model (Regional Simulation Model – Glades / Lower East Coast Service Area [RSMGL]) was linked to two salinity models (Biscayne and Southern Everglades Coastal Transport [BISECT] and Biscayne Bay Simulation Model [BBSM]) to allow evaluation of anticipated effects of the project on wetland freshwater hydrology, coastal wetland salinities, and nearshore bay salinities. Land-surface elevations were adjusted in anticipation of how increased flows would result in accumulation of peat in sawgrass and mangrove wetlands. The BBSEER Ecosubteam developed nine ecological performance measures for evaluating restoration alternatives including timing and distribution of flows to Biscayne Bay, direct canal releases, water depth, hydroperiod, sheetflow volume, nearshore salinity, wetland salinity, adaptive foundational resilience, and ecological connectivity. The region was divided into indicator regions and transects which in turn were combined into five zones to allow more effective evaluation of plan alternatives. Intermediate output of performance measure calculations as well as final performance measure scoring were utilized to evaluate plan alternatives. Performance measures were translated into habitat units to meet U.S. Army Corps of Engineers project evaluation requirements. Significant lessons were learned in the development, utilization, and communication of performance measures and associated calculation of habitat units in this complex project.

Incorporating Fish Movement Data into Habitat Suitability Indices: A Conceptual Framework for Coastal Mesopredators

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Passive acoustic telemetry has proven to be an invaluable asset for researchers and resource managers to understand the movement ecology of numerous coastal fish species. The ability to track the movements of fish has allowed for an understanding of ontogenetic movements, migration patterns, and space use. The incorporation of telemetry data into habitat suitability models has not been widely applied in aquatic systems and presents an opportunity for best practices to be identified. The few studies that have incorporated telemetry data into habitat suitability indices have primarily used Boosted Regression Trees (BRTs), Resource Selection Functions (RSFs), and Step Selection Functions (SSFs). Telemetry data has been collected across a 41-receiver array in the Shark River estuary since 2012. These data have provided critical insight into the movement ecology of the Common Snook (*Centropomus undecimalis*) and Largemouth Bass (*Micropterus salmoides*). While the upstream-downstream movements of these ecologically and economically important mesopredators have been highly studied in the Shark River, there has been limited incorporation of their movements into habitat suitability indices. Here, we present how BRTs have been used to model habitat suitability of Largemouth Bass in the headwaters of the Shark River. We also present a conceptual framework to incorporate Common Snook movement data into a habitat suitability index for the species throughout the Shark River estuary using RSFs and SSFs. It is important that a preliminary understanding of the habitats most used by these species be generated so that comparisons with future conditions can be made. This is particularly important as the natural flow of freshwater through the Everglades is gradually being restored and the impacts of climate change are becoming increasingly impactful.

Northern Everglades Dispersed Water Management (DWM)

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The Greater Everglades is a vast subtropical ecosystem characterized by hydrologic variations due to alternating wet and dry seasons resulting from annual rainfall patterns. Water levels within the region are managed by the South Florida Water Management District to aid in ecosystem restoration initiatives, protect communities from flooding, and meet the region's water supply demands. Under typical wet season conditions, excess stormwater runoff must be stored throughout the regional water management system to meet these management objectives.

Since 2005, the District has worked with a coalition of state and local agencies, environmental organizations, ranchers, and researchers to enhance opportunities for storing excess surface water on private and public lands. The District's Dispersed Water Management (DWM) Program encourages private property owners to detain or retain direct precipitation and/or accept regional runoff for storage on their land rather than drain it. The vast majority of the DWM projects are located in the Northern Everglades where payment for environmental services partnerships between water managers and private landowners was established in 2011. Managing water on these lands reduces excess water delivered to Lake Okeechobee and discharged to coastal estuaries during the wet season; allows for groundwater recharge and rehydration of drained systems, improves water quality, and incentivizes landowners to provide greater environmental stewardship.

During the past six years, project implementation in the Northern Everglades Watershed has gradually expanded to include more Passive (rain-driven storage) and Active (rain-driven and pumping from the regional system) projects. Collectively, these projects can store or detain over 200,000 ac-ft of water each year. In Water Year 2024, DWM projects in the Lake Okeechobee Watershed stored or detained 75,033 acre-feet (ac-ft) of excess water, and approximately 9.6 metric tons (t) of total phosphorous (TP) and 133.1 t of total nitrogen (TN); in St. Lucie River Watershed 110,693 ac-ft, 32.7 t of TP and 199.5 t of TN; and in Caloosahatchee River Watershed 25,774 ac-ft, 4.3 t of TP and 44.4 t of TN, for a combined total of 211,000 ac-ft, 46.6 t of TP and 377 t TN. The objective of this presentation is to: (i) highlight the benefits of public-private partnerships to achieve environmental restoration goals, maintain regional flood protection, and incentivize private engagement for water conservation and ecosystem sustainability; and (ii) present a quantitative account of the success of the program within the past six years of operation.

Solute Transport in Seawater-Flooded Soils: Environmental Impacts and Insights from Experiments, Numerical Modeling, and Machine Learning

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The transport and accumulation of solutes in soil affect both the quality and quantity of agricultural products and contribute to environmental pollution. This study examined the interplay between sea level rise (SLR) and sea surface temperature in coastal areas of Florida. In addition, it investigated the transport of nutrients from calcareous soils in response to seawater flooding. Flooding experiments were conducted on Biscayne and Krome soils using PVC columns in a controlled environment with four flood durations—1, 7, 14, and 28 days—during which the soil columns were maintained under seawater-flooded conditions. Porewater samples were collected weekly from three depths and analyzed for concentrations of alkaline metals (Na^+, Mg^{2+}, K^+, Ca^{2+}) and nutrients (P, TP, NO_3-N, and NH_4-N). The data was used to develop a Hydrus-1D and three machine learning models, including Decision Tree (DT), Random Forest (RF), and Extreme Gradient Boost (XGB), to simulate the transport of solutes under saturated conditions. The spatial and temporal annual SLR trend showed a cumulative increase of up to 25 cm and 10 cm over 29 years, respectively. The results also revealed a significant increase in porewater concentrations of P and NH_4-N by factors of 147 and 324 in Biscayne soil and by factors of 16 and 51 in Krome soil, respectively. Conversely, seawater flooding led to increased adsorptions of Na, Mg, and K in both Biscayne and Krome soils. The Hydrus-1D modeling results demonstrated a promising performance in simulating Na and Mg transport with R^2 values of 0.59 and 0.81, and RMSE values of 1.44 and 0.29 mg cm^{-3}, respectively. The XGB model showed R^2 values from 0.53 to 0.84 and RMSE values from 0.3 to 1145 mg L^{-1} for simulating P, TP, NH4-N, Ca, K, Na, and Mg transport. Additionally, the DT and RF models also effectively simulated all the analytes, achieving acceptable R^2 and RMSE values. Overall, the machine learning models effectively simulated solute transport in saturated soils and could be considered viable alternatives to evaluate the multifaceted impacts of seawater flooding on agricultural soil and the environment, when required data is available.

A Multi-Level Approach to Assessing Nektonic Biodiversity and Community Structure of Seagrass Seascapes

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Seagrass seascapes are critical ecosystems that provide a range of ecological functions and services, including supporting high biodiversity. However, these systems are threatened by various stressors, including climate change, coastal development, and pollution. We assessed biodiversity and species composition patterns of nektonic community structure across Biscayne Bay, Florida, a subtropical bay where the northern part extends along the highly urbanized Miami and the southern part is surrounded by agriculture and coastal wetlands. Using a multi-level approach of seascape characterization through submerged aquatic vegetation (SAV) surveys, spatial pattern metrics, water quality parameters, and statistical models, we identified environmental drivers influencing nekton community responses: diversity, abundance, and biomass. Results showed that SAV composition significantly influenced diversity and abundance, likely driven by habitat structural complexity providing critical shelter for juvenile and small-sized nekton. Water quality variables, particularly salinity and turbidity, influenced all nekton responses, highlighting niche partitioning along environmental gradients. Seascape metrics, including patch density and the patch area and compactness, were also important predictors of nekton responses, highlighting the role of seascape structure in shaping biodiversity patterns. This study emphasizes the need for an integrated approach by incorporating many environmental drivers and mechanisms for understanding biodiversity in seagrass ecosystems, which is crucial for effective conservation and management.

A Historic Voyage Through the Everglades with an Eye on Modern Pollutants

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The Everglades are a crucial part of Florida's ecosystem, and one of the most extensive and renowned wetland ecosystems world-wide. Over the past 200 years, the Everglades have changed in size and health, and although there are efforts to preserve the remaining portion, there is concern that anthropogenic pollution is altering this ecosystem. In 2022, our team recreated an 1897 expedition by explorer and amateur scientist, Hugh Willoughby, who crossed the Everglades from the Gulf of Mexico to the Atlantic Ocean by canoe, collecting water samples that provided baseline water quality data prior to intense human development. The 2022 Willoughby Expedition provided a unique opportunity to assess the most remote regions of the Everglades ecosystem for contaminants of emerging concern, including the spatial patterns of these anthropogenic signatures as they relate to variations in ecosystem features and land use changes spanning the entire cross-section of South Florida over a relatively short timeframe. Contaminants that were evaluated included microplastics, PFAS (per- and polyfluoroalkyl substances), pharmaceuticals and personal care products (PPCPs), pesticides, metals, illicit drugs, antibiotic-resistant genes, and basic water quality parameters. We found gradients of contaminants within the Everglades, evaluated protected areas of the Everglades compared to the developed area external to the Everglades, and identified site-specific contaminant profiles. The results of this study provide insight into how surrounding land use changes over the past 125 years impact even the most remote areas of the Everglades, with implications for public, wildlife, and ecosystem health.

Active eDNA Monitoring of the Invasive Asian Swamp Eel in South Florida: Assay Development and Application

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Invasive species are a significant threat to a variety of ecosystems in Florida, with freshwater habitats being of particular concern. The Asian Swamp Eel (*Monopterus albus*) is an established-nonnative fish that is currently a priority for monitoring and management due to its impact on native aquatic species. Recent technological advances have seen the emergence of eDNA analysis as a useful tool for detection and monitoring of target species and to assess removal efforts. Here we present our advances in the development of a digital PCR (dPCR) assay that allow us to detect the presence of Asian Swamp Eels using minimal amounts of DNA shed by individuals into the water. We describe the optimization and validation process we went through to make sure we do not cross-amplify our target species with unwanted (native and non-native) species as well as to define assay sensitivity that allow us to discern between false and true positives (presence). We present results obtained in field from samples collected in canals and marshes across South Florida in both areas where the species has been defined as present (e.g., EDDMapS) and areas with no information. Field eDNA samples yielded varying levels of positive amplification for Asian swamp eel based on comparison of florescence levels to positive controls (both tissue extract and plasmids with appropriate inserts). Detectability of the species varied within the same sampling area (e.g., positive in one part of the canal but negative on the other side), highlighting the need for carefully consideration when defining sampling design. These data indicate that through careful assay design and stringent parameter optimization as well as understanding factors influencing species detectability, eDNA results obtained for monitoring of Asian swamp eel can be a viable and cost-effective strategy to detect the presence of the species as well as to evaluate the success of removal efforts.

Section 203 Flood Risk Management Study Modeling Approach for Broward County

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The South Florida Water Management District (SFWMD) is collaborating with federal, state, and local partners to advance the Central & South Florida (C&SF) Flood Resiliency Section 203 Study for Broward County (Planning Reach A). The more than 60-year-old gravity driven C&SF water management infrastructure system was not designed to manage the future conditions of combined runoff, storm surge, high tides, and high groundwater table. The Section 203 Study has been authorized to analyze the operation of the C&SF Project due to significantly changed physical, economic, and environmental conditions in the future. The Study aims to propose water infrastructure and management changes to reduce flood risks that affect population, property, and critical infrastructure in communities served by the C&SF water management system. The Study requires tools that can represent the C&SF system, which are able to simulate system response to hydrologic, hydraulic, and hydrodynamic stressors that drive flood risk in the area. Due to the unique geology of the region, the tools must be able to incorporate the effect of groundwater induced flooding. The District's Flood Protection Level of Service Program (FPLOS) has developed hydrologic and hydraulic (H&H) integrated/coupled surface-groundwater models for all watersheds within the Section 203 Project Study Area. These coupled H&H models are being utilized for this Section 203 application. The future conditions modeling incorporates future hydrological conditions in the Water Conservation Areas to the west of Planning Reach A, planned changes in the stormwater infrastructure, land use changes, and sea level rise conditions over a 50-year planning horizon. The C&SF system in the study area is heavily managed and the response of the system is significantly influenced by system operation and water management decisions. The coupled H&H models applied to this Study include logical control rules that simulate water management. The modeling approach for the Section 203 Study using MIKE SHE/HYDRO models is presented, which includes model updates/refinements that were needed to meet the goals of the Section 203 Broward C&SF Study, and alternative management measures.

Assessing Variations in Mangrove Growth and Nutrition Across a Hydrologic Gradient in Biscayne Bay

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Coastal wetlands, especially mangrove forests, are crucial ecosystems with high productivity in a dynamic, low nutrient environment. Of their many components, one which is likely to change under hydrologic restoration is vegetation biomass, thus leading to its use as an indicator of ecosystem change. Mangroves have been shown to do this by rapidly incorporating available nutrients from their surroundings into plant tissue, leading to an increase in above ground biomass and changes in leaf nutrient concentrations. Mangroves may then serve to sequester nutrients, having a potential positive impact on surrounding water quality. In the Biscayne Bay Coastal Wetlands (BBCW) of southeastern Florida, ongoing hydrologic restoration has aimed to utilize this ecosystem service by diverting discharges from coastal canals into the fringing mangrove forests via the construction of culverts. Changes in vegetation biomass are expected as a product of hydrologic alteration from these restoration efforts. A project was initiated in 2024 to assess changes in surface water nutrient concentrations and the response of mangroves to these changes. Within 6 hydrologically distinct blocks, three receiving canal waters through culverts and three without culverts, we have established plots for biomass estimation at sites located approximately 50 m east of the L-31E canal. Three 1 m2 subplots were established in July 2024 at each location and the following metrics were sampled: species composition, basal diameter at 30 cm height of each stem, total stem height, crown volume, and seedling count. Additionally, for red mangrove, the dominant species within the plots, leaf nutrient concentrations (CNP) were determined from an average of three individuals. Allometric equations developed in the same study area by Ross et. al (2001) were then used to calculate average above ground biomass for each location and used to compare with nutrient analyses as a function of differences in hydrology due to culvert presence. Preliminary data analysis shows differences in species composition and total estimated above ground biomass across sites, associated with varying hydrologic treatment. These sampled parameters are expected to provide a foundation for subsequent statistical analysis of associated continuous hydrologic data and quarterly surface water nutrient data. We hypothesize that increases in above ground biomass, as determined at the end of the project in June 2026, to be related to changes in concentrations of surface water nutrients. This research will provide insight on the effect of hydrologic management on the productivity of coastal wetlands and has relevance for understanding changes in long-term biomass storage and production.

Wading Bird Littoral Use Under Varying Hydrology

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Since 2010, the littoral zone of Lake Okeechobee has been systematically surveyed to assess the distribution of foraging wading birds during the nesting season. These long-term trends in wading bird foraging behavior serve as valuable indicators of habitat quality and provide critical insights into the effects of hydrology, restoration initiatives, and changes at other trophic levels. The distribution of foraging flocks is strongly influenced by lake stage water levels, which influence prey availability through mechanisms such as accessibility and prey concentration. Spatial analyses have identified key foraging patches where the timing of prey availability is crucial for creating optimal conditions to support wading bird nesting productivity. Recent data indicate a decline in the utilization of the littoral zone, likely driven by elevated lake stages and prolonged hydroperiods. These hydrological conditions delay the accessibility of critical foraging areas beyond peak nesting periods, contributing to below-average annual nesting abundance. Additionally, prey densities in the littoral zone appear to be decreasing, possibly indicating unfavorable ecological conditions that suppress prey production. Ongoing monitoring of wading bird foraging distribution is essential to improving our understanding of how lake level management influences foraging dynamics and nesting outcomes. This research underscores the need to align hydrological management with the ecological requirements of wading birds to support their long-term productivity and the overall health of Lake Okeechobee.

Effect of Lake Guard Oxy on Zooplankton Population in the Caloosahatchee River

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Lake Guard® Oxy is an algaecide designed by BlueGreen Water Technologies that has been shown to be effective in combating cyanobacteria harmful algal blooms (cyanoHABs) in various parts of the world. Freshwater cyanoHABs caused by Microcystis aeruginosa are known to contain toxins generally called microcystins, which have been known to cause a variety of detrimental impacts on human society. This includes but is not limited to liver diseases, deterring tourism, and contaminating agriculture. This study investigates the effect of Lake Guard® Oxy on non-target organism groups by measuring its impact on the freshwater zooplankton populations at the Julian Keen Jr. Lock & Dam (S-77), Florida, USA, during the summer Microcystis bloom season. From June to July 2024, three separate tests across 3 weeks were undertaken to apply Lake Guard® Oxy to the waters in and around the dam. Each test consisted of a control station and two other stations upstream of the dam, as well as three stations downstream of the dam. Each of these tests sampled zooplankton levels immediately before application of the product, immediately after product application, 24 hours after application, and 48 hours after application. Following this, a sample from each station was manually counted using a microscope and a Sedgewick Rafter plastic counting chamber. Finally, a two-way ANOVA was conducted, which found no significant impact of the Lake Guard® Oxy treatment on zooplankton populations ($p < 0.05$). Results show that the lack of significant impact on the abundance and species composition of the zooplankton community in

Apple Snail Management: A Critical Need for Population-Level Not Reproductive-Level Targets

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Within the Everglades, abundances of the Florida Apple Snail (*Pomacea paludosa;* hereafter FAS) have been too low to support substantial nesting effort of the endangered Everglades Snail Kite since the early-mid 2000s. FAS abundances are potentially regulated through reproduction, juvenile growth and juvenile survival, and it is well documented that dry season water depths of 20-50 cm are ideal for FAS reproduction. The current water management target for FAS, as posed by the Ecosystem Based Management (EBM) Multi-Species Transition Strategy for WCA-3A and COP BO Performance Measures and Assessment Metrics from the USFWS, aims to maximize the number of days between water depths of 20-50 cm from March 1st to June 30th to maximize FAS reproductive effort. Yet there has been no evaluation of the effectiveness of this target on FAS abundances because there has been no analysis of any long-term monitoring data for the FAS relative to this management target. This evaluation of the current FAS hydrologic targets is increasingly critical considering our own work on juvenile growth and juvenile survival on FAS population growth. The Modified Water Delivery (MWD) monitoring program for assessing crayfish and fish densities with throw traps in 19 slough sites across WCA 3A, Shark Slough, and Taylor Slough, has also collected FAS since 1996. We use the curated samples and historical records of FAS catches and locally corrected hydrologic conditions to evaluate the importance of depth-mediate reproduction (days within the target window). The time series of apple snail abundance suggests that populations have fallen to extremely low levels in the past decade in the sloughs of all three regions; FAS have not been encountered since 2021 at 18 of 19 sites. Preliminary analyses across all sites suggest FAS abundance increases from 0 to 75 days within the window of ideal water depths from March 1st to June 30th the antecedent water year. Beyond 75 days there was no further discernable benefit. But, despite many site-year combinations achieving 75 days within the target over the past 4 years, FAS abundance has not increased. Further, recent demographic modelling and measurements of juvenile survival indicate that juvenile predators exhibit strong top-down control of juvenile FAS when growing under the oligotrophic conditions in the Everglades; maximizing reproductive conditions with ideal water depths does not produce growing populations. The preliminary evaluation of the FAS hydrologic targets coupled with recent modelling work suggest that the current FAS target will be insufficient to re-grow FAS populations. A more comprehensive evaluation of the juvenile loss factors and an evaluation of the viability of the existing populations will be necessary.

Adapting an Aquatic Food-Web/Ecosystem Model to Simulate P Dynamics in Stormwater Treatment Area 2

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The comprehensive aquatic systems model (CASM) is a bioenergetics-based food-web/ecosystem model that was adapted to simulate phosphorus (P) dynamics in Flow Way 1 (FW1) of Stormwater Treatment Area 2 (STA-2) located north of the Florida Everglades. The model represented the physical structure of FW1 as three connected compartments that defined inflow, middle, and outflow spatial segments. The segments were functionally connected through simulation of FW1 hydrology described by a linked-node approach incorporated into the mathematical structure of the model. Data-driven inflows and outflows were used to derive parameters that determined daily flows through the segments, as well as corresponding simulated daily average water levels and current velocities for each of the spatial segments. The detailed biogeochemistry of P cycling within FW1 was incorporated into the model by adding state variables and functional relationships among dissolved and particulate organic and inorganic P in both the modeled water column and sediments. A key objective of the CASM STA-2 modeling effort was to examine the potential role of the consumer populations in influencing the internal P dynamics through excretion and bioturbation. The modeled food-web for FW1 correspondingly included generalized populations of phytoplankton, periphyton, submerged aquatic vegetation, emergent aquatic vegetation, zooplankton, and benthic invertebrates. Specific populations of mosquitofish, largemouth bass, grass shrimp, and tilapia also were defined. Physical, chemical, and biological data specific to FW1, as well as information and data from the technical literature and previous South Florida Water Management District studies, were used to construct necessary hydrological, phosphorus, environmental, and ecological (e.g., food web interactions) inputs to the model and derive estimates of model parameters that determined population growth and internal P cycling. The resulting CASM STA-2 simulates daily values for multiple years of growth and biomass of the food-web populations and P concentrations for the modeled P state variables. The model was calibrated using FW1 data reported for the period of 2005 – 2012 and subsequently verified with FW1 data for years 2013 – 2020. With the exception of sediment DIP, modeled values of sediment and water column P pools were within the ranges of FW1 observed values. Preliminary model results suggest that the effects of excretion and bioturbation on internal P cycling in FW1 are potentially important processes comparable in magnitude to physical-chemical transformations among dissolved and particulate P pools. Model results suggest that the average annual P retention efficiency for the 2005-2020 period was 77%. Continued refinements and application of the CASM STA-2 can help evaluate the effectiveness of management actions in meeting regulatory requirements for total P outflows from the STAs.

Python Management Efforts within the Picayune Strand State Forest

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The Conservancy of Southwest Florida has utilized radio-tagged adult male pythons, scout snakes, to locate reproductive female pythons and cull them from the local population since 2012. In 2019, the tracking program expanded into the Picayune Strand State Forest, which is currently being restored through the Picayune Strand Restoration Project. This Comprehensive Everglades Restoration Project will restore over 55,000 acres of natural habitat primarily through the plugging of 48 miles of canals and removal of the associated roads and spoil piles. Python telemetry data indicated a high use area along the existing canals during the python breeding season which occurs annually between December through March. The python tracking program coordinated with the U.S. Army Corps of Engineers and the South Florida Water Management District to remove additional pythons utilizing heavy equipment along the Faka-Union and Miller canals during the spoil removal phases. Between 2019-2024 radio-tagged scout snakes aided in the removal of 77 adult pythons (43F, 34M) and heavy equipment activities removed an additional 26 pythons (20F, 6M) from the Picayune Strand Restoration Project Area. These combined techniques are on-going and were effective at removing over 100 adult pythons weighing over 6,200 pounds (2,812 kg) supporting ecological recovery goals within a primary Everglades Restoration Project.

Managing Invasive Animals in Comprehensive Everglades Restoration Plan Projects

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The management of invasive species remains a critical challenge in the ongoing efforts to restore the Greater Everglades ecosystem under the Comprehensive Everglades Restoration Plan (CERP). Reptile removal and monitoring techniques improve significantly when they are focused on limited regions within these CERP sites. Collaboration between USACE, SFWMD and UF Croc docs to control invasive reptiles within ongoing restoration project footprints has resulted in many successes with reptile control. USACE projects, mainly geared towards hydrologic alterations, present new ways to implement control methods for aquatic invasive species. By tailoring these methods to water control features of different restoration sites, managers can enhance the efficacy of invasive species control. Case studies will illustrate the application of these targeted strategies, offering insights into optimizing management practices to support broader restoration goals.

Burmese Python Environmental DNA in Waterways North of the Greater Everglades Ecosystem 2019-2023

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The range of Burmese pythons in southern Florida has grown tremendously since introduction and led to declines of native biodiversity, including wading birds and small mammals. Management efforts are primarily guided by sightings and captures, leading most efforts to focus on southern Florida where the population numbers are expected to be greatest. However, the potential for pythons to expand into central Florida remains likely and highlights the importance of efficient detection of invasive python populations. The use of environmental DNA (eDNA) as a genetic tool has assisted in gaining valuable insights into the distribution of this invasive species and informing management as pythons colonize new areas and impact other native wildlife populations. Environmental DNA applications in the Everglades ecosystem of southern Florida have proven valuable (38-70% detection estimates) to assess large geographic areas where conventional trapping techniques are less effective (<1% detection rates) due to the elusive nature of Burmese python. Our objective was to use eDNA detections from water samples to delineate python range across the Greater Everglades and central Florida. We collected >700 water samples in 2019-2023 between the southern border of Lake Okeechobee and central Florida. All water samples were tested for Burmese python eDNA presence using probe-based droplet digital PCR technology for absolute quantification of target eDNA. We then used hierarchical occupancy models to account for imperfect detection in the hydrologic unit code 8 (HUC-8) watersheds including Caloosahatchee, Everglades, Florida Southeast Coast, Kissimmee, Big Cypress Swamp, Peace River, and Western Okeechobee. We found Burmese python occurrence estimates in watersheds around Lake Okeechobee were similar to those found in southern Florida years prior. The use of eDNA as a passive, but highly sensitive, tool in a large geographic area can help focus survey and management efforts and help estimate the true extent of this invasive species.

Supporting Ecological Functions in South Florida with the Minimum Flows and Levels Program

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Water across south Florida is protected by Florida Administrative Code Rule through the Minimum Flows and Minimum Water Levels (MFL) program of the South Florida Water Management District (SFWMD). The Applied Sciences Bureau working in conjunction with the Office of Counsel develops water resource protection criteria for water bodies whose ecosystems are at risk of ecological degradation and identifies hydrologic thresholds where further withdrawals would result in significant harm to the water resources or ecology of the water body. The SFWMD defines significant harm as the "temporary loss of water resource functions which result from a change in surface or groundwater hydrology, that takes more than two years to recover". Waterbodies that have experienced this condition include Lake Okeechobee, the Loxahatchee River, the Caloosahatchee River, and the Greater Everglades.

The process of creating or revising MFLs requires using best available data and analysis to understand cause-and-effect relationships between hydrologic variations and ecological functions. The water resource functions protected under Chapter 373, F.S., include flood control, water quality protections, water supply and storage, fish and wildlife protection, navigation, and recreation. Following the development of technical criteria, SFWMD conducts an independent scientific peer review of all scientific and technical data, methods, models and assumptions before beginning the rulemaking process. Stakeholders have several opportunities to review and comment on the proposed rules before they are submitted to the SFWMD governing board for adoption. The process also provides a window of time after adoption for anyone to object to the rule.

Three MFL reevaluations are included in the 2024 Priority Water Body List that is submitted annually to the Florida Department of Environmental Protection: The Northwest Fork of the Loxahatchee River, Florida Bay, and the Biscayne Aquifer. These reevaluations examine changing hydrological considerations including the Comprehensive Everglades Restoration Plan (CERP) and sea level rise over a 20-year planning horizon reflective of our water supply planning efforts.

Current Water Flow into Biscayne National Park and Biscayne Bay

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Joan Browder emphasized the importance of evaluation and careful monitoring for unintended consequences of ecosystem restoration and management, including operational changes to the primary and secondary canal system in South Florida. She viewed the Greater Everglades Ecosystem as an interconnected whole with a continuum of subtle links between components. Historically, without human influence, the Greater Everglades naturally functioned in this way, grading into each other with freshwater then flowing to coastal marshes and mangrove wetlands. Freshwater ultimately reached the coasts as groundwater and surface water flowing into Florida Bay, Biscayne Bay, and the west coast islands, sustaining their respective estuarine communities. The resulting oligohaline and mesohaline salinity conditions provided vital nursery habitats for hatching and juvenile animals. This is especially true for Biscayne National Park and the southern and central coastal areas of Biscayne Bay, where freshwater originally reached coastal areas from naturally high inland water stages via transverse glades, creeks, and groundwater flow. Canals were eventually added through transverse glades to convey water more efficiently for drainage. These canals directly drain water by conveying it more rapidly to the coast and by exchanging ground and surface water through the porous sides, creating a dynamic equilibrium between groundwater levels and canal drainage operations.

The Central and Southern Florida Project (C&SF Project) generally quickly routes water from terrestrial and freshwater landscapes to the coasts. An adequate amount of freshwater movement into southern Biscayne Bay is necessary to maintain healthy coastal estuarine conditions, which sustain the estuarine communities of Biscayne National Park and Biscayne Bay Aquatic Preserve. The C&SF Project and associated canal influence on downstream receiving waters makes it crucial to consider and preserve the role of fresh and lower salinity groundwater in restoring natural salinity to this area of Biscayne Bay. Over the past 25 years, since the Comprehensive Everglades Restoration Plan was approved by Congress, changes in water management have further altered habitat quality and hindered efforts to restore estuarine habitat in Biscayne National Park and Biscayne Bay. We summarize these interactions and resulting salinity patterns to evaluate the current conditions.

Incorporating Future Environmental Variability into Restoration Project Planning

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Understanding the potential effects of future environmental variation on proposed ecological restoration projects can aid in reaching desired restoration outcomes. Ecological models can assist in restoration decision making through the evaluation of potential outcomes of proposed restoration plans. Joint Ecosystem Modeling, JEM, is a collaboration among restoration partners that facilitates restoration decision making by providing accessible models, tools, and outputs for the Greater Everglades system. The Biscayne Bay and Southeastern Everglades Ecosystem Restoration Project (BBSEER), is part of the Comprehensive Everglades Restoration Plan (CERP), and seeks to identify opportunities for ecosystem restoration of nearshore conditions, coastal wetlands, and adjacent wetlands in the areas of central and southern Biscayne Bay and the Southeastern Everglades, including Barnes Sound, Card Sound, the Southern Glades, and the Panhandle area of Everglades National Park. Here, we compare environmental variation in BBSEER baseline conditions from soil accretion and sea level change and evaluate how variation in future baseline conditions affects ecological model outcomes for BBSEER restoration alternatives. Our results showed differences in baseline conditions for BBSEER owing to future environmental variation, which in turn corresponded to spatial and temporal variation in ecological model outcomes under different BBSEER restoration alternatives. Understanding how a changing environment can affect restoration projects in the future is valuable for decision makers in restoration and natural resources management planning.

Spatially Explicit Change Patterns of Rhizophora Mangle in the Southeast Saline Everglades

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The Southeast Saline Everglades (SESE) in Everglades National Park, experiences mangrove encroachment into glycophytic vegetation due to freshwater delivery changes and sea-level rise. While previous plot-based studies have documented vegetation transitions, accurately tracking and forecasting the patchy and spatially variable patterns and rates remains challenging.

To quantify mangrove encroachment in the SESE, we modeled mangrove cover change between 2010 and 2016. We first mapped vegetation from 2010 and 2016 Worldview-2 satellite imagery (2m spatial resolution), improving precision and accuracy by downscaling to 1m resolution and refining the 2010 map by incorporating high-resolution NIR aerial photography of 2009, and gridded LIDAR data of 2017 for the 2016 map. We then calculated changes in kernel density ratios at varying spatial scales for each vegetation type in both years. Finally, we modeled density change as a function of distance from the coast (proxy for salinity), distance from creeks (proxy for freshwater delivery), and distance from pre-existing mangroves (proxy for dispersal) using generalized additive models.

Here we present modeled vegetation cover change at 5-meter spatial resolution. Mangrove cover significantly increased from the coast to approximately 10 kilometers inland. The highest increase (~12%) occurred near the shoreline, followed by a 10% increase between 3.5 and 4 kilometers inland. This expansion primarily resulted from the decline of sparse herbaceous vegetation (aka the "White Zone") within 2.5 kilometers of the coast. Between 2.5 and 6.5 kilometers inland, herbaceous vegetation declined by ~5-17%, with the maximum decrease (~17%) occurring around 4 kilometers. This loss was compensated for by increases in both mangrove and sparse vegetation cover. Beyond ~6.5 kilometers inland, herbaceous vegetation was replaced by predominantly mangroves, sparse vegetation, and several other vegetation types. Mangrove cover also increased significantly along creeks, extending up to 2.25 kilometers distance. The highest increase (~7.5%) occurred closest to the creeks, primarily replacing herbaceous vegetation (~5%) and sparse herbaceous vegetation (~2.5%). The maximum decline in herbaceous vegetation (~8%) occurred 1 kilometer from the creek, replaced by mangroves (~4%), sparse herbaceous vegetation (3%), and other vegetation types. Finally, mangroves expanded by ~7.5% in locations very close to existing stands rapidly declining at larger distances.

This study provides a spatially explicit quantification of mangrove expansion across the SESE landscape, laying a foundation for explicit evaluation of restoration success. Importantly, this work shifts the paradigm from plot-based assessments to a landscape-scale approach, enabling the identification and quantification of subtle vegetation changes and informing more effective management strategies.

Investigating Spatial and Temporal Scales of Ecological Recovery Dynamics in the Southern Mangrove Zone

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The coastal mangrove habitats of the southern Everglades are a biome which is always under constant change. In short, this change occurs naturally due to seasonal cycles (wet and dry season) through water management practices, ultimately changing community composition in these regions throughout the year. However, we have noted that the fluctuations of these systems don't always function the same over spatiotemporal scales, with the ecological lag of the systems recovery appearing different in timing and location. This leads to the question: do we need to incorporate different scales when evaluating ecological communities in the Everglades coastal regions? Everglades Science Center have collected data (hydrology, prey base fish and submerged aquatic vegetation) at nine sampling for the past 26 years (1998 – 2024). Each of these areas have components of abiotic and biotic factors which interact with each other in slightly different ways; in larger scale these locations can be classified as high saline or low saline environments due to their connectiveness to the Atlantic Ocean. However, due to the rate of freshwater added into the system through restoration efforts, the morphology of the landscape, and the increasing effects from climate change, these environments have the potential for rapid change and altered recovery periods. This means that locations across the coastline would, in theory, be reacting at different spatiotemporal scales when comparing the rate of ecological restoration efforts throughout the system. We are evaluating how two spatially close long-term monitoring sites differ in their rate of ecological recovery, and how communities respond to change at small and large scales. Understanding differences in ecological lag within the coastal biome could be vital in predicting the rate which climate change is affecting the coastal regions of Everglades National Park.

DataForEVER: Everglades National Park's Relational Database System

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DataForEVER is a MySQL-based database system developed by the South Florida National Resources Center (SFNRC) to collect, store, assure quality, verify, and distribute data critical to Everglades restoration. SFNRC staff began developing the system in the early 2000s to support the integration of monitoring data and inform park management decisions. Originally designed to support SFNRC's long-term hydrology monitoring program, the **DataForEVER** framework focuses on the collection, management, verification, and backup of data throughout its lifecycle. Hydrology stations maintained by Everglades National Park regularly contribute raw data to the system through NOAA's GOES service. The data are then inspected and verified by SFNRC hydrologists to ensure integrity and to inform station maintenance needs. Verified data are made available to partners through direct distribution, publicly accessible data hubs such as SECOORA and NDBC, and a data request email service. The **DataForEVER** framework has also been expanded to support other monitoring programs, thus enhancing the potential for comprehensive, cross-disciplinary restoration efforts. This presentation will provide an overview of the history, current status, and future plans for this essential data resource, along with insights into the challenges encountered and lessons learned throughout its development.

Wetland-based Strategies for Reducing Nitrogen: The C-43 Water Quality Treatment and Testing Project Phase II

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Reduction of nitrogen discharges using wetland-based strategies to the C-43 Canal and Caloosahatchee River and Estuary is being demonstrated at a test cell facility constructed and operated by the South Florida Water Management District. The C-43 Water Quality Treatment and Testing Project is a constructed wetland demonstration project developed as part of the South Florida Water Management District's strategic priority to improve water quality in the Northern Everglades region. The Project is also a key component of the Florida Governor's 20-year plan for Everglades restoration and protection and is a coordinating agencies' project in the Caloosahatchee River and Estuary Basin Management Action Plans. The Florida Department of Environmental Protection has identified the Caloosahatchee River and Estuary as impaired for nitrogen. The majority of nitrogen in the surface water is in the form of dissolved organic nitrogen, which is difficult to remove. The mechanisms to remove various forms of nitrogen, especially dissolved organic nitrogen, via wetland treatment systems have not been studied as extensively as phosphorus removal in Everglades Stormwater Treatment Areas. The effort to meet the Basin Management Action Plan for the Caloosahatchee River Estuary target of 23% reduced total nitrogen loading to the downstream estuary is a challenge that requires additional study. Even with complete removal of inorganic nitrogen from the C-43, it is inadequate to meet the requirements of the TMDL as inorganic nitrogen comprises less than 23 percent of the average total load discharged to the Caloosahatchee Estuary. Using results from a mesocosm study, the test cell facility was designed to evaluate nitrogen reduction as a function of hydraulic loading rate, wetland aspect ratio, plant community configuration, hydraulic efficiency, photodegradation, and sand filtration. The test facility includes six 4-acre constructed treatment wetland cells, two 1-acre open water cells, and two 1-acre sand filter cells. This research will help to bridge knowledge gaps for total nitrogen and nitrogen fraction removal mechanisms in wetland treatment systems, especially for dissolved organic nitrogen and will assist to further reduce nitrogen levels to meet water quality standards. The Phase II project will determine if dissolved organic nitrogen can be altered to more removable forms with photolysis, if sand filtration after wetland treatment will provide meaningful removal through soil sorption and enhanced denitrification, if alternating aerobic and anaerobic conditions will enhance denitrification, and if altering hydraulic loading rate and wetland shape will impact nitrogen removal.

Monitoring Coastal Change with Synthetic Aperture Radar (SAR) in Everglades National Park, FL

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Everglades National Park and surrounding mangrove islets contain coastal wetlands with low topographic relief and are highly vulnerable to sea-level rise, increased storm intensity, storm frequency, and coastal erosion. Over centuries, physical processes from high energy events like hurricanes and tropical storms have significantly altered the shorelines of these islands. Though scattered archival data exists, the need for long-term disaster-impact and coastal-erosion monitoring studies is yet to be established. This study investigates the use of Synthetic Aperture Radar (SAR) to develop a remote approach for monitoring and detecting coastal change on Jim Foot Key in Everglades National Park. SAR data can be collected at a fine spatial resolution and can penetrate vegetation on the earth's surface at specific wavelengths, offering information on underlying surficial features. Leveraging weather- and daylight-independent data collection, SAR presents as an excellent method for detecting inundation and coastline changes even in areas obscured by canopy or clouds. The overarching objective of this study is to establish a method utilizing SAR data to remotely monitor areas vulnerable to erosion in Everglades National Park. Jim Foot Key, the study area selected to test the methodology, suffered extensive vegetation loss after Hurricane Irma in 2017, making it especially susceptible to the effects of accelerating sea level rise. This presentation will demonstrate water thresholding methods, report on identified trends in the SAR data (collected over two years) that can be used to quantify and visualize rates of coastal inundation and/or coastline change, and highlight any compounding factors (tides, seasons, and/or weather patterns) that could surface as noise in the results. Furthermore, limitations and challenges of this methodology will be discussed.

Wading Birds and Their Prey: Hydrologic-Driven Responses on the Kissimmee River Floodplain

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The primary goal of the Kissimmee River Restoration Project (KRRP) is to restore the ecological integrity of the river-floodplain system. Wading birds, including species in the families Ardeidae (herons, egrets, and bitterns) and Threskionithidae (ibises and spoonbills), are integral to the Kissimmee River ecosystem and considered important indicators of ecological health. While quantitative pre-channelization data are sparse, there is evidence the system supported an abundant and diverse bird population before the C-38 canal was cut through the river's meanders and dried out adjacent wetlands. Reestablishment of the physical and hydrologic characteristics of the Kissimmee River and floodplain is expected to reproduce the conditions necessary to support such an assemblage once again. Because many bird guilds, including wading birds, exhibit a high degree of mobility, they are likely to respond rapidly to restoration of appropriate habitat. We monitored wading bird response using monthly east-west transects randomly selected within the floodplain to cover 20% of the restored area (dry season: November-May); wading birds within 200m transect strips surveyed by helicopter were counted and identified. In a separate survey, aquatic prey (including fish, invertebrates, and herpetofauna) were collected and identified in 1 m^2 throw traps, with 24 samples completed per sampling event during the dry season. The availability of water depths suitable for foraging was estimated using a provisional spatial interpolation model for the period June 2019-June 2024. Restoration of the physical characteristics of the Kissimmee River and floodplain, along with future improvements in the hydrologic characteristics of inflows under the Headwaters Revitalization Schedule (HRS), are expected to produce hydropatterns and hydroperiods that will lead to improvement in the prey base and foraging conditions in the dry season, as well as development of extensive areas of quality wetland habitat, which should also lead to higher aquatic prey production. If followed by appropriate inundation and recession in the dry season, prey availability should be good for wading birds. Some of the best years so far on the Kissimmee River floodplain since physical reconstruction have shown this response with wading birds and their prey, and full implementation of HRS should expand on this trend.

Ecological Drivers of Mammalian Tree Island Use

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Everglades tree islands are regarded as crucial habitat, resource centers, and biological hotspots for most wildlife. Mammals may be the taxa most reliant on tree islands and most sensitive to related ecological conditions because mammals require dry land for most of their life history. Tree islands offer the only terrestrial refuge in the Everglades, but their areal extent of tree islands is very limited and tree island loss has been severe (~30 – 40% remain). However, mammal use of Everglades tree islands is poorly understood, and studies have been limited in scope. To achieve a better understanding of how mammals use tree islands and what ecological characteristics drive patterns of use, the Miccosukee Tribe of Indians of Florida launched a wildlife monitoring program in 2017. The monitoring program entails deploying trail cameras (i.e., camera traps) on 37 tree islands in Water Conservation Area 3A to continuously surveil the Central Everglades mammal metacommunity across a broad range of environmental conditions. Trail camera data were paired with landscape, hydrologic, and vegetative variables to analyze which variables best explained mammals' occurrences and spatiotemporal patterns of use. Findings to date reveal that species differentially used tree islands primarily based on local marsh water depth, but amplitude of water levels, tree island size, and availability of nearby neighboring tree islands also influenced metacommunity structure and species distributions. Tree islands with low levels of hydrologic stress (i.e., shallower marsh water depths) supported diverse mammal communities and exhibited higher levels of habitat use. Mammal diversity and habitat use steadily declined as water levels increased, until the community was predominantly composed of myomorphs and black bear, as these species are capable of occupying mesic sites while traversing deeply inundated matrices.

Tradeoffs is not a Four-Letter Word

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We make tradeoffs every day. Sometimes consciously and sometimes without realizing it. Everyone coming to this presentation is making a tradeoff between spending your time here or somewhere else. Is making that tradeoff a bad thing? What did you think about in making that choice? Chances are you had some objectives that you either explicitly identified or just felt. Perhaps you wanted to optimize your learning. In the case of your choice, you could reconcile that in your head. In decisions that involve others or have multiple objectives the process is more challenging as you must jointly agree on the choice to be made, the outcomes you want to achieve, how much each of you care about the consequences of the actions on the outcomes you desire, and how much you are willing to exchange in one thing to get more of another. Decision analysis practices provide ways to deal with these challenges in a structured way starting with dialog to clearly identify the decisions/choices to make, objectives to be achieved, measurable targets, and acceptable ranges for those targets. In decisions involving ecosystems there will undoubtably be perceived conflicts since it is not possible to optimize everything over the entire system at all times. Recognizing and agreeing that there will be conflicts in space and time can help to move the process to one that finds acceptable solutions over the long-term. Multiple conflicting objectives can be simultaneously addressed rather than optimized in isolation to balance competing objectives. This talk will explore, based on the previous talks in the session, where there may be impediments to applying tools for balancing competing objectives and what steps can be taken to remove those impediments.

SFWMD DBHydro Database Access and Data Retrieval

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DBHydro is the South Florida Water Management District's (SFWMD) primary system for storing and retrieving hydrologic, water quality, and hydrogeologic data. As a critical resource, DBHydro provides historical and up-to-date data for central and south Florida, serving as a foundation for reports and investigations related to water management, ecosystem restoration, and environmental compliance. The web application, DBHydro Insights, improves the user experience by providing direct access to this vast repository. Users can specify search criteria to retrieve data and metadata while utilizing an interface designed to streamline data discovery and analysis. DBHydro Insights also includes web services that support efficient data integration and sharing, further expanding its functionality. DBHydro supports over 190,000 station-years of data collected at more than 17,000 stations. Collaboration is a cornerstone of DBHydro's success. The system plays a central role in a cooperative data exchange program involving agencies such the United States Geological Survey, National Park Service, U.S. Army Corps of Engineers, Lake Worth Drainage District, and neighboring water management districts. This collaboration highlights the system's regional significance in advancing ecosystem recovery and management. By providing results from accurate data collection, detailed metadata, and user-friendly accessibility, DBHydro Insights exemplifies how collaborative platforms can drive positive outcomes for ecosystem restoration and water resource protection. This presentation will provide an overview of DBHydro Insights' interface, features, and its role in meeting SFWMD's mandates to protect and restore South Florida's unique ecosystems.

Interagency Efforts to Restore Florida's Coral Reef

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Given the dramatic decline in coral biomass over the last four decades and continuing stressors, Florida's Coral Reef has been significantly impacted beyond the point of natural recovery (on human timescales). This decline has lagged the largescale hydrological disruption to the greater Everglades ecosystem as South Florida's population has boomed. Interest in, and resourcing of, human-assisted coral reef recovery activities in Florida have similarly lagged well behind ongoing Everglades restoration efforts that are considered amongst the most robust ever employed anywhere on Earth.

In recognition of the ecological and socioeconomic importance of Florida's Coral Reef, and the common interests across federal, state, and local governments in both Everglades and Florida's Coral Reef restoration, several important interagency partnerships have emerged in recent years to reverse the decline of this precious natural resource, including the Florida's Coral Reef Resilience Program (FCRRP), the Florida's Coral Reef Coordination Team (FCRCT), and the Florida's Coral Reef Restoration & Recovery (FCR3) Initiative.

In particular, Governor Ron DeSantis directed the establishment of the FCR3 Initiative in 2023 through Executive Order 23-06. Overall, this initiative aims to develop the infrastructure, technology, skilled workforce, and logistics necessary by 2050 to support the long-term recovery of no less than 25% of Florida's Coral Reef. FCR3 is envisioned as a 25-year effort that will be implemented in three phases to: 1) augment necessary infrastructure for land based coral propagation facilities, 2) rapidly scale restoration capacity & capabilities, and 3) design and implement coral restoration sites across Florida's Coral Reef that secure ecological objectives and provide flood protection benefits for coastal communities.

Awarded projects to date have focused on land-based infrastructure expansion, workforce curriculum development, and restoration capacity for the first phase of FCR3. Through facilitating an evidence-based propagation and outplanting program, FCR will be repopulated with hardy populations of native corals and other keystone species to re-establish and strengthen natural reproduction, dispersal, and recruitment patterns.

Adaptive Management and Use of New Information in Decision Making

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Adaptive Management (AM) is an integral component of large restoration projects and was adopted early on by the CERP to address uncertainty and incorporate new scientific information into restoration efforts. Effective AM programs require governance authority and policy-level support, as well as clear and agreed-upon AM processes and objectives; AM is of growing importance with the increased uncertainty associated with climate change. The most recent National Academies' review considered AM and the use of new information to inform decision making at four scales: 1) project-level adaptation during design and construction, 2) project-level AM after operations begin, 3) operational adaptation at regional scales, and 4) program-level AM. The report notes that substantial AM guidance has been developed by RECOVER, and this guidance incorporates many key features of effective AM. The major issue with CERP AM is not the development of plans, but how effectively plans can be implemented. To date, much of the CERP AM has been at the 1st scale (project-level adaptation during design and construction), with important leverage related to accommodating endangered species. Overall, the CERP has developed thorough project-level AM guidance, but the process to incorporate new information often has been time consuming and burdensome, limiting the effectiveness of AM. There are few examples of post-operations AM (2nd scale), but it also has been time consuming, with a relatively simple change taking many years for the Deering Estate Flow-way. The report recommends that USACE headquarters review required approval processes associated with incorporating new information into design, construction, and project-level AM processes to ensure timely use of new information. Such an effort would benefit not only the CERP but all USACE restoration projects. Efforts to learn from new information at the 3rd scale (operational adaptation at regional scales) have been a strength of water management for Everglades restoration; the USACE and the SFWMD should continue their use of conditions-based operations to better adapt to changing conditions. Program-level AM (4th scale) has not been implemented in detail, and the Second Periodic CERP Update should provide valuable information for this. Overall, additional efforts are needed to provide the necessary foundation for successful AM in the CERP, including building expertise and a culture of AM, developing a robust, integrated science enterprise to support AM, and improving communication of restoration performance and implications for decision making. Establishing an annual AM workshop would be a valuable step towards building a culture of AM. All of these efforts will require strong direction from USACE and SFWMD leadership that AM is a CERP priority that adds value and improves efficiency toward restoration success, as well as improved engagement of Tribes, other government agencies, and stakeholders in the AM process.

ICEYE Flood Insights: Gaining a Regional Perspective on Flooding

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The ICEYE Flood Insights product provides maximum flood depth and extent derived from a variety of remote sensing sources including ICEYE's high resolution (4 meter) synthetic aperture radar (SAR) sensors. SAR sensors see through clouds and collect at night. ICEYE's constellation of SAR satellites is one of the largest and has the flexibility to target collection in areas forecasted to flood. Although there are other high resolution SAR data providers, the Flood Insights product provides analysis ready data that can be used upon delivery to respond to conditions on the ground. The South Florida Water Management District (SFWMD) became aware of the Flood Insights product during Hurricane Ian in 2022. To investigate the Flood Insights product value in defining regional rainfall and storm surge flood extents, SFWMD purchased the Ian event data. In the Upper Kissimmee Basin, ICEYE estimated flood extents were compared to stage gauge derived extents. In Southwest Florida, storm surge extents and depths were compared to USGS collected high water marks. Within the Kissimmee River Restoration Project footprint, flood extent was captured within the Headwaters Project as well as within the floodplain. The evaluation of the Ian data led to SFWMD purchasing an ICEYE Flood Insights product subscription and in 2024, SFWMD used that subscription to purchase ICEYE data for a June Rain Event, Hurricane Helene, and Hurricane Milton. This presentation will provide an overview of findings from the 4 purchased events and discuss the importance and value of collecting ground observations to verify flood locations and validate flood depths. As in all cases, remotely sensed data require ground verification. The challenge in collecting regional ground verification data is mobilizing resources within the impacted area to collect timely information. SFWMD is attempting to tackle this by hosting a public flood observation survey and a high-water mark survey that is available to stakeholders who participate and complete training. These data are shared with ICEYE to enhance their analyses and improve their delivered products. One of our agency's near-term objectives is to increase awareness of these data collection tools and their value in compiling and assessing remotely sensed data to document regional flood occurrence.

Patterns in Vegetation on Lake Kissimmee: Using Google Earth Engine to Develop a Long-Term Dataset

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As the largest and southernmost lake in the Kissimmee Chain of Lakes, Lake Kissimmee (about 40,000 acres) holds particular importance as habitat for a myriad of species, a high-quality largemouth bass and black crappie fishery, and the water source for an extensive restoration project to the south (the Kissimmee River Restoration). The littoral zone of Lake Kissimmee supports diverse vegetation, with plant communities representing a range of hydroperiods. Changes in their spatial extent over time may represent shifts in hydrology and habitat quality. A Google Earth Engine-based method was used to develop a long-term dataset of Lake Kissimmee's littoral vegetation using Landsat 7 satellite imagery from 2014 to 2024. Water and vegetation area was extracted from the imagery using Otsu's thresholding and change detection was conducted to identify areas of interannual difference. From 2005, when the amount of littoral vegetation on Lake Kissimmee was highest, until 2024 there was a decrease of about 3,000 acres of long hydroperiod wetlands throughout the lake, a loss of about 8 percent of the total area of vegetation. Comparisons to patterns in hydrology indicate that such losses are often associated with extreme high-water events like those associated with hurricanes, while increases can be attributed to periods of low water. Accuracy assessments were done by comparing results to high-resolution aerial imagery. Lastly, fine-scaled classification mapping was used at a series of 113-acre plots that included a range of plant community types to complement change patterns seen on a whole-lake scale. The integration of cloud-based geospatial analysis platforms can greatly enhance vegetation monitoring programs, enabling managers to create datasets based on a broad range of temporal and spatial scales.

Examining Spatial and Temporal Changes to the Littoral Zone of Lake Okeechobee using Otsu's method

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Numerous hurricanes have impacted South Florida, causing damage to its natural ecosystems, specifically the littoral zone of Lake Okeechobee. Notable changes in vegetation were apparent after each storm, especially in the lake's nearshore interface, Fisheating Bay, King's Bar, Eagle Bay, and South Bay. Satellite imagery taken before and after Hurricane Ian in September 2022 was examined with Otsu's method. This method is an automatic thresholding algorithm that uses binary classification to delineate water from vegetation. PlanetScope imagery with 4-5 meter resolution was compared to aerial imagery with 0.2-0.3 meter resolution to verify the consistency of Otsu's method; accuracy assessments were performed on specific areas of interest to verify the classification results. The area of water and vegetation, before and after the hurricane, were compared to assess losses in emergent vegetation. Results of this project support ongoing mapping efforts on Lake Okeechobee and can be used to help define the extent of impacts from powerful storm events, or long-term changes associated with higher lake stages.

Mainstreaming Environment and Equity in Resilience Infrastructure Assessment (MEERIA): An Alternative Valuation Methodology

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Federal policy guidelines and traditional benefit-cost analyses (BCA) that inform public infrastructure decision-making fail to address the environmental degradation and social inequities associated with project impacts. Recent policy recommendations emphasize evaluation of comprehensive project benefits (social, environmental, economic) for holistic resilience outcomes. We reviewed the common pitfalls and limitations of the BCA and developed an alternative decision-making framework and rubric, *Mainstreaming Environment and Equity in Resilience Infrastructure Assessments (MEERIA)*, with normative and evaluative components to incorporate environment and equity considerations in the traditional decision-making for infrastructure projects. The MEERIA framework guides users during the different stages of the project development cycle—and while using the traditional BCA—with recommendations, advanced tools and methods, and processes based on sound economic, ecological, and equity principles to improve the assessment of infrastructure projects. We tested the MEERIA framework and the in-built rubric by analyzing the feasibility studies of three United States resilience infrastructure projects against the rubric's normative criteria and assigned performance scores on considerations for ecosystem services and equity for each phase of the project cycle. Our study reveals several barriers limiting the inclusion of nature-based solutions and comprehensive benefits analysis of resilience infrastructure projects. These included lack of: (a) inclusive and transparent participatory processes, (b) equity goals and mechanisms to address conflicts and power asymmetries in public decision-making, (c) improved and diverse economic tools to quantify environmental and social values, (d) intangible and non-market costs and benefits with substantive implications for stakeholder welfare, and (e) distributional impacts analyses of risk and resilience projects, among others. By shedding light on the complex social-ecological environment within which a project operates and emphasizing ecosystem values and the procedural and distributional aspects of equity in the project development cycle, MEERIA offers a holistic and integrative approach enabling equitable and just distribution of comprehensive benefits from restoration and resilience projects.

Restoration Benefits Observed from the Biscayne Bay Coastal Wetlands Project

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The purpose of the Biscayne Bay Coastal Wetlands (BBCW) Phase 1 project is to contribute to the restoration of Biscayne Bay and adjacent coastal wetlands as part of the Comprehensive Everglades Restoration Plan (CERP). Project objectives include redistribution of freshwater from existing point source canal discharges to coastal wetlands adjacent to Biscayne Bay providing more natural and historic overland flow to remnant tidal creeks. Phase 1 of the BBCW project, has 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 various CERP adaptive management processes to enhance and improve project restoration benefits including modified operation of the Deering Estate pump station to improve hydrology and create more natural wetland hydroperiods. SFWMD successfully completed an L-31E flow way pilot pump test to verify size, location, and freshwater flow direction for one of the recommended pump stations and initiated L-31E S-705 pump test to identify an interim tailwater target stage that will prevent flooding and achieve project restoration goals to rehydrate Biscayne Bay Coastal Wetlands with freshwater.

Comparison of baseline and ecological monitoring data collected during the last 11 years indicate substantial progress toward achieving project goals. Nearshore water quality and salinity levels have improved as more freshwater is redirected from canals to coastal wetlands and the bay in all three BBCW components. Vegetation near the Deering Estate component is also responding to improved hydrology as demonstrated by replacement of upland vegetation with wetland species, expansion of sawgrass, and recruitment of *Eleocharis interstincta* (giant spikerush) and *Thelypteris patens* (maiden fern). Surface and groundwater salinities in the historic remnant wetlands located within the Deering Estate component 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 BBCW Project.

Use of Deep Learning to Assist in Vegetation & Microtopography Input Classifications for Regional Modeling

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Vegetation class and microtopography are important inputs to regional simulation model (RSM). Traditionally these data are commonly derived from aerial photography and a preselected classification system. In this study, a deep learning model based on convolutional neural network U-net was developed to classify vegetation types/microtopography using Sentinel 2 imagery (at resolution of 10 meter). The model was then trained and validated with field observations. The validated datasets were then applied in RSM model in DECOMP areas, and new model results were compared to those with traditional data to assess the improvements using the field surveyed data of stage and flow data at several sites. Similar methods can be applied to other areas and modeling efforts and integrated with other remote sensing data sets to improve hydrological modelling performance.

Treatment Performance Relationships in the Everglades Stormwater Treatment Area Complex

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The Everglades Stormwater Treatment Areas (STAs) are a complex of five large freshwater treatment wetlands (current total wetland surface area ≈ 25,000 ha/62,000 ac) constructed incrementally from 1991 through present day to support Everglades restoration. These STAs, operated by the South Florida Water Management District, are subdivided into discrete "cells" by internal levees with one or more cells organized into "flow-ways" to convey water from STA inlet to outlet. The primary function of the STAs is to reduce the total phosphorus (TP) concentration in agricultural and urban runoff before this water enters the oligotrophic Everglades ecosystem. These wetlands also sequester other constituents, such as nitrogen (N). STA treatment performance has been assessed primarily for TP reduction by individual STAs or select cells/flow-ways. This poster presentation takes a different approach: it documents long-term treatment performance relationships for the STA complex over its 30-year period-of-record (POR). Measurements of total P, total N (TN) and dissolved Ca (Ca) in weekly/biweekly grab samples collected at STA inlets and outlets, along with continuous inflow/outflow flow measurements, were pooled over all STAs by District water year (May 1 to April 30). From these pooled data, annual inflow/outflow constituent flow-weighted mean concentrations and areal loadings were calculated. Bivariate scatter plots and regression analyses of inflow versus outflow metrics are used to illustrate various treatment performance relationships. Both TP and TN loadings were highly correlated with hydraulic loading. The STA complex has been approximately twice as efficient at retaining TP mass compared to TN and these efficiencies were relatively constant over the POR for both constituents. Both TP and TN mass retention decreased with increased loading, while only TN mass retention appeared to reach an asymptote at the highest loadings. TN:TP molar ratios indicated that inflow to the STA complex was P limited in all but one year and that P limitation in outlet discharge increased markedly relative to inflow. These findings, together with other analyses in this poster, contribute to our overall understanding of how the Everglades STAs function as wetland-based treatment systems.

Biophysically Based Simulation of Wetland Surface Flow at the DECOMP Physical Model (DPM) to Assess Restoration Effectiveness

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A key component of Everglades restoration is enhancing wetland sheet flow to hydrate and restore overly dry wetlands. The multi-agency Decomp Physical Model (DPM) project provided a ten-year experimental framework to prototype the effects of re-routing flows through degraded wetlands to improve hydrology and ecological resources. To simulate present and potential future restoration outcomes we used *Bio*FRE, a biophysical flow rate expression developed where the key parameter, wetland flow resistance, is based on measurements of vegetation community type, stem density and diameter, spatial patch arrangement, and microtopography. Using *Bio*FRE avoids the typical approach of calibrating the effective roughness coefficient of surface flow models that only provides a site-specific result without providing guidance about potential future changes. The *Bio*FRE simulation approach can help anticipate possible unintended consequences of removing levees and rerouting flows though wetlands, such as overly shallow water depths that could potentially evolve as restoration proceeds and vegetation changes. We used *Bio*FRE to simulate steady-state high-flow releases through gated culverts at the S-152 structure that distributed water radially across the degraded ridge-and-slough landscape at the DPM. *Bio*FRE simulations were compared with detailed measurements of flow velocity, water depth, bed shear stress, suspended sediment concentration, and total phosphorus load at the DPM between 2013 to 2022. General consistency was demonstrated with observed flow velocities, showing a logarithmic decrease in flow velocity with increasing distance from culvert inflow. We tested effectiveness of the AMI (Active Marsh Improvement) program that had removed sawgrass and spikerush to re-open historical sloughs at DPM by decreasing ridge proportion from 0.88 to 0.73. AMI caused localized increases in flow velocity in restored sloughs and a negligible decrease in water depth. A simulation of potential future outcomes suggested that substantial increases in flow velocity and sediment transport, and a significant reduction in water depth could result If AMI were fully implemented by decreasing ridge proportion to its historical value of 0.42. Vegetation density and stem diameter were the most sensitive factors affecting water depth, flow velocity, and sediment transport, followed by ridge proportion, culvert discharge and spreading angle, microtopographic height and slough directional connectivity. *Bio*FRE is based in theory and widely available measurements of wetland landscape conditions, and it therefore be used to help anticipate future conditions by identifying optimal combinations of levee re-opening and wetland vegetation and microtopography that can achieve the most favorable outcomes for water storage and ecological habitat given the available supply of water to perform restoration.

What Do We “Know” about Historical Tree Island Ecology in the Central Everglades? New Insights from Historical Literature and Current Science

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Historical observations combined with current science will help us understand the structure and functional ecology of central Everglades tree islands that will, in turn, provide the information to better inform overall ecological restoration. An estimated 60% of tree islands have been lost from the historical central Everglades since 1945, when most remaining islands were “high and dry” due to drainage canals. Once the Water Conservation levees were constructed in the 1960’s the remaining islands became “low and wet”. These spatially discrete patches of woody vegetation embedded within the central Everglades support a diverse population of woody vegetation due to a higher ground elevation than the surrounding ridge and slough system, especially when the head of the island is not completely flooded or is flooded at a regularly low interval. While the patchwork of thousands of higher, drier, woody habitats was and is a magnet for biodiversity that includes microbes, plants, animals and humans, the structure and function of tree islands have experienced changes in responses to drainage and compartmentalization that remain poorly understood. This makes understanding them in a historical socio-ecological context relevant to the current effort of creating ecologically desirable targets for restoration. A literature review of the historical ecological observations in the late 19th century (pre-drainage) early 20th century (post drainage) was combined with observational and experimental studies conducted on tree islands to assist in the contextualization and development of those targets.

Are We There Yet? How RECOVER Determines Restoration Progress and Success

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REstoration, COordination, and VERification (RECOVER) is an interdisciplinary collaboration of agencies, tribes, and institutions that conducts scientific and technical evaluations and assessments to improve the ability of the Comprehensive Everglades Restoration Plan (CERP) to restore, preserve, and protect the south Florida ecosystem while providing for the region's other water-related needs. To facilitate its mission, RECOVER monitors a suite of indicator species that reflect ecological processes CERP is expected to influence. Information from the Monitoring and Assessment Plan (MAP) is then used by RECOVER to better understand Everglades' ecology, inform CERP project planning through predictive modeling (evaluation), and track real-world indicator responses to CERP implementation (assessment). Because planning and implementation of CERP is incremental, RECOVER is tasked with determining restoration progress along the way to a fully implemented CERP and conducts system-wide assessments at a regular interval. The 2024 System Status Report (SSR) provided RECOVER the first opportunity to compare real-world indicator statuses with a previously modeled expectations from the RECOVER Interim Goals and Interim Targets 2020 Report. Though few CERP components have been constructed, and little change was expected, the exercise of relating indicator evaluations and assessments allowed RECOVER to scrutinize its processes of reporting on the status of its indicators at a system-wide scale. RECOVER identified key areas for future work including the standardization of evaluation and assessment methods across indicators, developing ecologically informed indicator statuses and restoration targets, and working toward a common framework for anticipating, measuring, and communicating ecological benefits. Building on what lessons learned from the 2024 SSR, RECOVER is working to improve its ability to conduct system-wide assessments for all its indicators. With a robust and effective MAP combined with system-wide evaluation and assessment methods for its indicators RECOVER can ensure CERP achieves its goals and objectives.

Building Resiliency: Integrating Flood Protection, Water Supply and Ecosystem Restoration for South Florida’s Future

Ana Carolina Coelho Maran
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The South Florida Water Management District (SFWMD) is advancing resiliency efforts to sustain its mission through enhanced planning, data analysis, development and application of robust modeling tools, and infrastructure investments. The District focuses on Flood Protection, Water Supply, and Ecosystem Restoration to build resiliency to South Florida's communities and ecosystems.

Flood control has been central to the District's mission since its creation as the Central and Southern Florida Flood Control District in 1949. Its operations span over 4,000+ miles of canals and flood barriers, and 1600+ water control structures. Through its Capital Improvement Program (CIP), Structure Inspection Program (SIP), and the more recent Flood Protection Level of Service (FPLOS) Program, the District assess, maintains and enhances flood control assets and ensures its system’s ability to continue to meet the flood protection needs of the region into the future. A repository for historical and current flooding data, in collaboration with local partners, informs real-time operations and model calibration. Key flood resiliency projects, funded by state and federal programs such as the Resilient Florida Program and the FEMA Building Resilient Infrastructure and Communities Program, are being advanced under the Sea Level Rise and Flood Resiliency Plan.

To meet the water needs of South Florida's 9 million residents, the District develops and updates regional water supply plans every five years. These plans include strategies to address future demand, focusing on conservation and alternative water supplies. Sea level rise and climate impacts are being incorporated into planning, including the monitoring of saltwater intrusion. Future conditions saltwater intrusion scenario projections are being simulated as part of ongoing water supply plans and will be further characterized as part of an upcoming water supply vulnerability assessment. Formulation of adaptation strategies resulting from these assessments will be incorporated into the resiliency plan.

The District is also executing numerous ecosystem restoration projects to safeguard South Florida’s vital ecosystems, such as the Everglades the Kissimmee River, Lake Okeechobee, and coastal watersheds. Ecosystem Restoration projects increase the District’s ability to better manage anticipated extreme weather events and other evolving conditions, and strongly support systemwide resiliency goals. The restoration of beneficial freshwater flows throughout the system slows down saltwater intrusion promoting more sustainable aquifer recharge rates, healthier estuaries and bays, more stable coastlines, and reduced occurrence of marsh dry outs.

South Florida Water Management District Sea Level Rise and Flood Resiliency Plan, 2025

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The South Florida Water Management District (District) is addressing the impacts of sea level rise (SLR), extreme rainfall and other changing conditions on the District's critical assets, water management operations, and water and environmental resources in the region. The District's Sea Level Rise and Flood Resiliency Plan (Resiliency Plan) is the first District initiative to compile a comprehensive list of resiliency projects aimed at reducing risks from flooding, SLR, and other changing conditions on water resources and increasing community and ecosystem resiliency in South Florida. This goal will be achieved by updating and enhancing water management infrastructure throughout the Central & South Florida (C&SF) Flood Control System and the Big Cypress Basin and implementing effective, resilient, and integrated basin-wide solutions.

The Resiliency Plan's project recommendations are based on findings from technical vulnerability assessments developed through the District's Flood Protection Level of Service (FPLOS) Program. These assessments use extensive data and robust hydrologic and hydraulic models to characterize current and future conditions and associated risks and to identify cost-effective adaptation strategies. In addition, the District's Capital Improvement Plan (CIP) has been incorporating resiliency considerations into the design of infrastructure projects. Both FPLOS and CIP Programs, as well as post-storm assessments, have been successful at identifying resiliency investments that have now been organized and expanded upon in the Resiliency Plan. The District seeks to implement projects that benefit South Florida's communities, alongside state, tribal, private, and local governments partners, and taking into consideration the needs of impacted communities and environmentally protected areas. The Resiliency Plan includes a multicriteria ranking approach that was developed to support the assessment of vulnerable areas in South Florida, including metrics that help to identify the most critical infrastructure and vulnerable areas, while also considering basin-wide resiliency needs.

Additionally, the Resiliency Plan includes strategies for implementing nature-based solutions, sustainable energy strategies, and resiliency considerations for water supply and ecosystem restoration efforts. Finally, a newly published interactive web map has been included to provide GIS data on the location, extent, and details for each priority resiliency project included in the Resiliency Plan.

Non-Invasive Investigation of Methane Gas Fluxes in Subtropical Peat Soils in the Everglades Using Efficient Airborne Ground-Penetrating Radar (GPR)

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Peat soils are a critical component of the global carbon cycle as natural producers of biogenic greenhouse gases (i.e., methane, CH_4 and carbon dioxide, CO_2) that accumulate within the soil matrix to be episodically released into the atmosphere. Previous studies have showed the ability of ground-based non-invasive geophysical methods like ground-penetrating radar (GPR) to effectively characterize gas flux dynamics at scales that fill the gap between traditional point measurements and airborne datasets while providing high (i.e., cm scale) resolution. However, most of these GPR studies are still often limited by scale of measurement and the need for ground deployment, which may potentially cause disturbance of the gas regime. In this work we tested an airborne GPR system mounted on a small unoccupied aircraft system (sUAS) to efficiently identify the presence of hot spots and hot moments for biogenic gas accumulation and release in subtropical peat soils of the Water Conservation Area 2 (WCA-2) in the Everglades (FL). Two grid areas of about 0.02 km^2 were collected during January, September, and November of 2023 to target the effect of seasonality on gas content distribution. Drone-based multispectral sensor imagery was also concurrently collected to combine with GPR datasets and estimate gas contents at centimeter resolution using machine learning techniques. Fixed platforms for monitoring gas releases via gas traps were installed at one of the sites targeting two areas of contrasting gas content. Our results show: 1) the potential of airborne GPR to isolate the presence of hot spots of biogenic gas accumulation within the soil (up to 24.8 % volumetric gas content) that coincide with areas of higher gas release (reaching average values of 142.1 mg CH_4 m^{-2} day^{-1}), and 2) the ability of multispectral imaging to further refine gas content estimates (i.e., cm resolution). This work has implications for the upscaling of gas flux measurements that could help refining current estimates of releases while efficiently providing information to guide biogeochemical sampling both in space and time.

Are We Getting the Water Right for Wood Storks? New Insights from Landscape-Scale Foraging Patterns

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Recovery of historical trophic relationships sustaining nesting populations of wading birds is a primary goal of Everglades Restoration. The Trophic Hypothesis captures the concept that wading bird nesting is limited by the production and accessibility of aquatic prey communities which in turn are driven by spatial and temporal aspects of hydrology. Recovering appropriate water conditions at the right time and place at the scale of the broader Everglades landscape is considered fundamental to restoring foraging and nesting patterns, but such objectives have been difficult to define in the current over-drained landscape. Yet recent years of unprecedented hydrological conditions and nesting responses have provided opportunities to gain new insights into the locations and timing of critical foraging habitat that are needed to trigger large, successful nesting events. We quantified the spatial and temporal dynamics of foraging Wood Storks in relation to hydrological conditions across the Greater Everglades landscape using systematic aerial foraging surveys. Flights were conducted weekly by helicopter from November through June over a four-year period that included a year with hydrological condition and nesting responses comparable to the pre-drainage period, and during three years with hydrology and nesting patterns typical of post-drainage conditions. Survey locations were predetermined on a weekly basis using WADEM habitat suitability maps and hydrology was quantified with EDEN and Audubon Florida's coastal gage data. On encountering foraging birds, we recorded spatial coordinates and used photography to quantify flock size and species composition.

During the year with relatively wet antecedent conditions and exceptional nesting wood storks utilized a succession of increasingly longer-hydroperiod wetland habitats through the nesting period including shallow coastal marshes in the fall, short hydroperiod cypress swamps in the winter, and longer-hydroperiod ridge and slough habitats in WCA-3A in the late spring. In the dryer years with poor nesting, birds initially foraged along the coast but subsequent foraging in increasingly longer hydroperiod habitats across the landscape did not occur, significantly fewer storks foraged overall, and stork nesting failed shortly after coastal habitats dried. During the exceptional nesting year, birds foraged in areas with relatively deeper water and longer hydroperiods. These results suggest that successful wood stork nesting is contingent upon suitable hydrological conditions at specific locations and times at the scale of the larger Everglades landscape. The regional hydrological needs of wood storks have relevance to important management and restoration topics such as current regulation schedules, future restoration initiatives, and potential constraints to hydrological restoration such as the distinct loss of topographical heterogeneity in the ridge and slough landscape.

Seagrass Seascape Responses to Water Quality Across Spatial Scales in Biscayne Bay

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Seagrasses form highly productive coastal habitats that provide crucial ecosystem services worldwide. In Biscayne Bay, an estuarine lagoon along Miami's coastline (USA), extensive seagrass beds support rich biodiversity and ecosystem functions. However, declining water quality, primarily driven by freshwater discharges from coastal canals, has triggered concerning seagrass losses throughout the bay. These declines represent a critical challenge for environmental managers and highlight the urgent need to understand how water quality shapes seagrass habitat structure and stability. This study employs remote sensing techniques to examine the relationship between eutrophication levels and seagrass characteristics in Biscayne Bay. While seagrass landscapes are influenced by numerous biotic and environmental factors interacting across multiple spatial scales, traditional ecological studies often focus on single-scale analyses. This limited approach constrains our understanding of the dynamic processes governing seagrass habitat patterns and their responses to environmental stressors. To address this knowledge gap, we conducted a comprehensive multi-scale analysis investigating how seagrass habitat distribution patterns respond to varying water quality. Benthic habitat maps of Biscayne Bay underpin this project as they provide quantitative information on seagrass spatial structure. In this study, we integrated *in situ* data with satellite imagery to build a Random Forest classification model. Our model was then applied to a time series of satellite image data to create the habitat maps, from which spatial pattern metrics were extracted at multiple scales under variable water quality conditions. The relationships between spatial pattern metrics (response variables) and water quality parameters (predictor variables) were finally addressed using generalized linear models. Our research specifically aims to quantify the spatial scales at which seagrass seascape structure responds to eutrophication conditions. By identifying these characteristic response scales, this study provides environmental managers with crucial information for developing targeted conservation strategies.

RECOVER Tree Island Performance Measure

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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 internal levees and canals and improving the health of over 2.4 million acres by allowing water to flow nearly unobstructed throughout the south Florida ecosystem.

Tree islands are unique features of the Everglades landscape. These species-rich elevated forests provide essential habitat for a variety of wetland and aquatic species, while also serving as refugium for terrestrial animals during wet periods. Tree islands are also culturally significant to Native Americans and Gladesmen and their protection is of paramount importance as CERP progresses. In order to discern how CERP water management activities may affect these crucial features, REstoration, COordination, VErification (RECOVER) is in the process of developing an ecological performance measure for tree islands within Water Conservation Area 3 and Everglades National Park aimed at preserving the structure and function of these unique habitats. Ecological performance measures make the correlation between hydrologic output and ecosystem functions and evaluate the degree to which proposed alternative plans meet restoration objectives. Each performance measure has a predictive metric and a target representative of desirable conditions within the greater Everglades landscape.

Tree island specialists are converging to integrate current science, Indigenous Knowledge, monitoring, and modeling efforts to develop a RECOVER Tree Island Performance Measure and Adaptive Management Plan. The information gained from this effort will advise CERP evaluation and assessment and will inform water management decisions. Identification of existing data to assess primary and secondary cultural, biological, ecological, and landscape features to include in tree island tool. The purpose of this Performance Measure is to provide a biologically-and ecologically driven metric for predictive evaluation and assessment of improved water depths and frequency of inundation in freshwater wetlands of the ENP and the Water Conservation Area 3A and 3B. The desired targets are based on hydrologic requirements necessary to meet empirical or theoretical ecological thresholds. This presentation will focus on the data and metrics selected by RECOVER to include in a performance measure to evaluate and assess CERP's restoration efforts on tree islands.

Reeling in Data: Redesigning a Fisheries Reporting System to Improve Management in Everglades National Park

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Fisheries-dependent data are a cornerstone of effective fisheries management, providing critical insights into fish population trends, ecosystem health, and the sustainability of recreational fishing activities. In Everglades National Park (ENP), the absence of a reliable reporting system has led to significant gaps in data for numerous commercially and recreationally important fish species. Since the 2019 removal of the requirement for permitted fishing guides to report daily catch data, managers have struggled to monitor species dynamics and ensure sustainable practices. To address this issue, ENP is considering the reintroduction of an improved catch reporting system for permitted guides.

This study aims to redesign the reporting system to enhance participation, data accuracy, and information quality while fostering collaboration with the guiding community. A working group composed of fishing captains, researchers, and local non-profit scientists was convened to co-develop redesign options that prioritize user-friendliness and guide engagement. Based on the group's input, a survey was created and distributed to all ENP permit holders to assess preferences and identify the most viable reporting solutions. Beta testing was then conducted on the preferred option to refine and validate the system.

A novel feature of the redesigned system was the incorporation of stoplight indicators to evaluate and communicate the health of fish populations. This simple, color-coded system (green, yellow, red) provides guides and managers with an intuitive visual tool to monitor species trends and identify areas of concern. By making data actionable and accessible, this approach aims to foster transparency and enhance decision-making in fisheries management.

The input from the working group, survey findings, and beta testing results were synthesized into actionable recommendations for ENP. By developing a robust, user-friendly reporting system, this study has the potential to transform fisheries-dependent data collection, strengthen the relationship between guides and management, and support the sustainable management of recreational fisheries in Everglades National Park.

The Loxahatchee River Watershed Restoration Project: Monitoring and Adaptive Management for Project Success

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Flood control projects in the 1950s resulted in the channelization of the Loxahatchee River watershed, altering historic connections between the river and the surrounding natural areas. These modifications resulted in degraded wetland structure and function throughout the watershed, and periods of excessive or insufficient freshwater inflow to the Loxahatchee River and Estuary. The Loxahatchee River Watershed Restoration Project (LRWRP), a component of the Comprehensive Everglades Restoration Plan designed to restore hydrology in the watershed, is scheduled to begin construction in late 2026. This project will implement various methods of water storage and conveyance, land acquisition, and wetland restoration within the watershed to restore and sustain the flow of freshwater to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River. Expected ecological benefits include enhanced hydrologic connectivity, improved seasonal timing and distribution of water, and increased wetland extent and function throughout the watershed, supporting wetland plant communities and animals such as fish and wading birds. The project will also promote recovery of important floodplain and riverine habitats such as cypress and tape grass, as well as estuarine communities including seagrasses, oysters, and many fish species. Implementation of the LRWRP Ecological Monitoring Plan will assess progress toward ecosystem restoration and inform LRWRP Adaptive Management Plan ecological uncertainties. The information is used to inform refined design, implementation and operation and ensure project performance is on the right trajectory. Implementation of adaptive management increases the realization and resiliency of the project by providing management options to achieve improved performance toward restoration goals while remaining within the project constraints and authorized purposes. Ecological monitoring and adaptive management are vital in large-scale restoration projects such as LRWRP. This poster will present the purpose of the LRWRP, provide an overview of the project components and ecological benefits, and the methodologies and timeframes for implementing the Ecological Monitoring and Adaptive Management Plans.

Immobilization of Algicidal Bacteria for Management of Algal Blooms: A Case Study

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Application of algicidal bacteria may be an effective strategy to control harmful algal blooms (HABs). Nevertheless, several challenges exist for the application of bacteria in the aquatic environment. Repeated dosing may be required to maintain the effective concentration, and the widespread application of bacteria can raise biosafety concerns. Prior research investigated a technology to immobilize algicidal bacteria in nontoxic alginate hydrogel beads for treatment of HABs. The hydrogel beads may then be deployed in areas at risk of HABs to maintain the effective dose and can then be retrieved after the risk has passed. One such technology designated as "DinoSHIELD", is composed of the algicidal bacteria, *Shewanella* sp. IRI-160, immobilized in alginate hydrogel beads for the control of HAB dinoflagellates. DinoSHIELD continuously releases bacteria-derived algicides which target dinoflagellate growth while limiting bacterial dispersion. While the effectiveness of DinoSHIELD has been demonstrated in laboratory experiments, the impacts of DinoSHIELD application in the natural environment have not been evaluated. Here, we conducted a 6-day field mesocosm experiment to investigate the effects of DinoSHIELD on water quality and natural microbial communities in the absence of a HAB dinoflagellate bloom. DinoSHIELD was deployed in mesh bags suspended in custom-made 730 L enclosures containing water and natural microbial communities from Broadkill River, Lewes, DE. Results showed that DinoSHIELD had no significant effect on overall photosynthetic biomass, while 18S rRNA gene sequence analysis showed that DinoSHIELD significantly increased species richness in the treatment compared to controls. Importantly, measurements of total bacterial and *Shewanella* sp. IRI-160- specific cell densities demonstrated limited release of bacteria from DinoSHIELD with no change in total bacterial densities by the end of the experiment. Analyses of water chemistry parameters (dissolved oxygen and pH) indicated minimal effects of DinoSHIELD on the surrounding environment. Overall, these results indicate that immobilization of species- or group-specific algicidal bacteria in hydrogel beads such as DinoSHIELD may be an effective bio-control strategy for managing algal blooms without negatively affecting non-target microbial communities or the surrounding environment.

Predators and Parasitoids of *Lygodium* Biological Control Agents

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One of the most problematic invasive species in the Everglades is *Lygodium microphyllum*, whose snaking rhizomes create smothering blankets of vegetation which outcompete native plants, resulting in habitat degradation, diminished ecosystem functionality, and a decline in biodiversity. Biological control agents are an important facet of an integrated weed management plan for invasive plants as they introduce natural enemies reducing the health and vigor of these plants. Currently, two *L. microphyllum* biological control agents have successfully established in Florida. *Neomusotima conspurcatalis* is a moth that can defoliate entire *Lygodium* thickets during population outbreaks and *Floracarus perrepae* is a mite that forms galls on leaflets and apical meristems of *L. microphyllum*. *Neomusotima conspurcatalis* has been released for over a decade, and during this period an intricate web of parasitoids has developed which adversely affect its efficacy. The other approved agent, *Floracarus perrepae*, is also negatively impacted by both native and non-native predators. There are an additional three potential biological control agents waiting regulatory approval for release on *L. microphyllum*.

One of these agents, *Callopistria exotica* is a defoliating moth found in Southeast Asia. Given the detrimental impact parasitoids and predators have on our current biological control agents we are studying the parasitoids which prey upon its native congener, *Callopistria floridensis*. Through understanding the parasitoid feeding web on the native *Callopistria*, we aim to develop informed release protocols that will help determine the optimal number of agents needed for successful establishment at a site.

Synthesizing ITEK and Western Science to Refine Everglades Baseline Conditions and Achieve Balanced Multi-Species Management

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Since the late 19th century, intense development pressure and drainage has resulted in the Everglades becoming one of the world's most impacted and intensively managed wetland ecosystems. Despite efforts in recent decades to restore more natural conditions to the Everglades, the Everglades has exhibited continued and precipitous ecological declines. Restoration success in the Everglades, including species recovery, has been hindered by a weak understanding of pre-drainage (i.e., baseline) conditions that derives from: 1) limited documented historical information, and 2) reliance on a paradigm of post-drainage modelling and assessment. The Miccosukee Tribe of Indians of Florida (Tribe) has the unique capacity to improve current understanding of pre-drainage conditions in the Everglades by contributing Indigenous Tribal Ecological Knowledge (ITEK). Building upon Biden administration guidance, the Tribe has developed a robust, internal peer-reviewed process to gather, validate, and disseminate ITEK such as to meet information criteria standards required for inclusion with western science, at a level of parity, for informing federal decision-making processes. Tribal scientists have been working to synthesize ITEK with western science in order to refine/re-define Everglades baseline conditions, respective of hydrology and species distribution, that can better inform management practices and restoration planning, targets, and implementation. These actions are important to consider in order to restore Everglades fauna that has largely disappeared from the landscape. Preliminary findings suggest lower historic water levels in the central Everglades, coupled with dynamic wetland cycles that included consistent annual dry down, supported habitat stability, wider species distributions, higher species diversity, and higher relative frequency compared to what is currently understood and accepted from post-drainage baseline conditions modelling and assessment.

Simulation of Stormwater Runoff in the C-111 Basin Using the RSM-TVDLF Model

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Detailed water levels and surface flow vectors during major runoff events can be simulated only after studying the hydraulics and hydrology within a system with the necessary spatial and temporal detail. This is because the flooding that takes place during large storm events is partly caused by what happens at a smaller scale along small streams and flow paths determined by the microtopographic features of the system. Flow along such paths is often kinematic in the upstream reaches and diffusive in the downstream reaches. It is necessary to understand and simulate these features along with groundwater flow in the south Florida hydrologic system when understanding the overall flow patterns of south Florida.

Total Variation Diminishing Lax Friedrichs (TVDLF) method using linearized implicit numerical method is used in the model currently used to test the C-111 sub-watershed of south Florida to see if the method is capable of simulating the integrated surface and groundwater systems. This numerical approach is capable of solving such kinematic-diffusive flows along uneven local topography that exist in various parts of South Florida. This TVDLF method was implemented through the RSM model, which evolved as a model targeted at modernizing the 1980s version of the South Florida Water Management Model (SFWMM). It has been applied to the upper Russian River watershed in California.

The model results show flow patterns within the C-111 basin as well as the edge of the bay that are not commonly visible when using commercially available models. The results include water levels and discharges during the Hurricane Irma storm event at a much finer 200 m grid scale. Investigating the storm surge propagation along the C111 canal is also part of the study.

Bobcats in the Everglades

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Widespread throughout Florida, bobcats (*Lynx rufus*) in the Everglades inhabit the upland mosaic of ridges, levees, and tree islands, a landscape unique across the species' broad range throughout the United States. In the Everglades, bobcats are not a species of conservation concern but monitoring their populations and spatial ecology can provide insights into the trophic dynamics and water management shaping the system. Bobcats are monitored by the Florida Fish and Wildlife Conservation Commission (FWC) to understand habitat use, prey preferences, and exposure to disease. FWC uses both camera trapping on tree island and spotlight surveys on levees to monitor wildlife and bobcat use within Water Conservation Area 3 (WCA 3). High water depths in WCA 3 are common due to heavy rainfall events and water management regulations, but the impacts of high water are not well known for bobcats seeking drier ground. Here, we will discuss the insights this monitoring has provided to habitat managers about Everglades bobcat ecology and what future questions we can answer from these data. For example, bobcats could respond to the recovery of the endangered apex predator, the Florida panther (*Puma concolor coryi*) but also to declines in small mammal abundance from invasive predators such as the Burmese python (*Python molarus bivittatus*). Identifying bobcat responses to these trophic disturbances is further complicated by the hydrologic dynamics of the system which cause habitat patches to become inaccessible for periods of time.

U.S. Geological Survey Greater Everglades Invasive Species Science Plan, 2025–2030

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The U.S. Geological Survey (USGS) provides critical long-term environmental and natural resource information, systematic analysis, data, and decision-support tools for managing natural resources. The Greater Everglades Ecosystem is a priority landscape and science location for USGS's Ecosystem Mission Area. The Greater Everglades, a World Heritage Site, represents a diverse subtropical ecosystem in Florida that is an internationally recognized hotspot of native biological diversity and has important cultural heritage for Tribal Nations and local communities. The hydrology of this ecosystem plays an essential role in water filtering and purification, flood control, storm protection, nutrient cycling, and soil formation and supports various organisms, including approximately 180 plant and animal species recognized by the State of Florida as threatened or endangered species. Introductions of invasive species into this unique ecosystem can and have threatened biodiversity, restoration efforts, cultural resources, human health, and local economies. This science plan was developed by the USGS to guide invasive species research for the next five years that aligns with partners' and Tribal Nations' needs and ongoing restoration objectives for the Greater Everglades as determined by the Comprehensive Everglades Restoration Plan (CERP), a multi-agency effort led by the U.S. Army Corps of Engineers. For this presentation, the science plan will be outlined and the key priorities for the USGS and their partners and Tribal Nations will be presented. The authors intended to capture the importance of ongoing/long-term priority projects in the Greater Everglades, to enhance understanding of the basic ecology and impacts of invasive species and to support efforts to prevent, detect, and/or control their establishment and spread within the Greater Everglades region.

Climate Effects on Jim Foot Key's Mangrove Coastline, Florida Bay, Everglades National Park, USA

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The coastal habitats of the Greater Everglades Ecosystem are at risk from sea level rise and climate impacts, and according to climate models this risk will increase in the coming decades. The entire ecosystem is less than 5m above current sea level creating vulnerabilities for the South Florida landscapes. Long term tidal data show that Florida has undergone a 2.37 mm yr^{-1} increase in relative sea level during the 20th century and currently that rate is estimated to be 4.21 mm yr^{-1}. Also, research has shown that hurricanes have had significant impacts on coastal inundation and subsequent damage to mangroves over the last decade. For resource managers, it is a high priority to be able to accurately predict the impacts of sea level rise and climate change on Florida coastal communities. To investigate these impacts, on December 2, 2021 a time-lapse camera was secured on Jim Foot key to capture daily tidal process and inclement weather events. The mangroves and shoreline of Jim Foot Key were significantly impacted by Hurricane Irma in 2017, so we have selected this island as a test site for long term coastal impact studies. Images of the eastern berm were captured daily every four hours from 08:00 to 16:00. Throughout the three years it has been deployed, the camera recorded numerous storm events and various tidal conditions that were individually analyzed to view daily tidal effects on mangroves and onshore vegetation. The time-lapse camera also captured impactful weather events that caused damage to shoreline vegetation as well as tidal fluctuations that destabilized shoreline embankments. Time-lapse imagery will be combined with empirical data gathered from mangrove plots and surface elevation tables also deployed on Jim Foot to increase our understanding of the impacts of sea level, tides, and storms on the coastline of this island. We hope that this information can inform ecosystem-wide resource management decisions.

Fish and Invertebrate Assessment Network; A Tribute to Joan Browder and Mike Robblee's Research in South Florida

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The South Florida Fish and Invertebrate Assessment Network (FIAN) is a monitoring project within the Comprehensive Everglades Restoration Plan (CERP). It is an element of the Southern Estuaries module of the Monitoring and Assessment Plan (MAP). FIAN is designed to support the four broad objectives of MAP as they relate to fish and invertebrates: (1) to establish a pre-CERP reference condition including variability, for each of the performance measures; (2) to determine the status and trends in the performance measures; (3) to detect unexpected responses of the ecosystem to changes in stressors resulting from CERP activities; and (4) to support scientific investigations designed to increase ecosystem understanding, cause-and-effect, and interpretation of unanticipated results. FIAN is a regional scale monitoring program of seagrass-associated fish and invertebrate (penaeid and caridean shrimp and crabs) communities present in shallow waters of South Florida. The pink shrimp, *Farfantepenaeus duorarum*, is a species of special interest for conceptual models, and FIAN provides input to the pink shrimp performance measure. A 1-m^2 throw-trap is used to sample fauna with density measurements of seagrass/algae habitat, water depth, salinity, and turbidity and sediment depth. Twice annually, a random sample is collected in each cell of a 30-cell grid at each of the 19 monitoring locations. Data were collected from April 2003 – October 2011. Joan and Mike's science contributions with the FIAN project will be an everlasting legacy for future references.

Habitat Improvements that Benefit Apple Snails on Central Florida Lakes

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The Kissimmee Chain of Lakes (KCL) were identified in the 1980s to mid-1990s as important habitat for the endangered Snail Kite. Although management activities from the Florida Fish and Wildlife Commission (FFWCC) and other state and federal agencies considered a long list of species that can benefit from these management activities, apple snails (*Pomacea paludosa*) became a species of interest prior to the 1995 drawdown of Lake Kissimmee. Our research team was able to collect some before-and-after data from the 1995 drawdown. For this presentation we will briefly review the trends observed since 1995 through the present on the KCLs. In April 2023, some small-scale sampling from our University of West Florida (UWF) crew was done near Ox Island on Lake Kissimmee and showed that native apple snails are still prominent, and the habitat is much improved since initial observations going back to 1995 sampling. FFWCC has plans for a different approach for habitat management, focusing on hydrology and control of invasive plant species with management activities spread out over a period of several years. This is in contrast to the relatively short (approximately 5 months) draw down and substrate scraping done in 1995 on Lake Kissimmee. Our UWF team has a grant to collect some additional data from KCL in March 2025 which will be presented. We will review the hydrology and plant community data that shows that management activities have benefited native apple snails on the Kissimmee Chain of Lakes.

Advancing the Science of Long-Term Nutrient Accretion in Everglades Stormwater Treatment

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The Everglades Stormwater Treatment Areas (STAs), key components of the Comprehensive Everglades Restoration Plan (CERP), are designed to reduce phosphorus (P) and nitrogen (N) pollution from agricultural runoff, protecting the Everglades ecosystem and downstream regions such as Florida Bay. While short-term studies have highlighted nutrient removal efficiency and the role of vegetation types (submerged aquatic vegetation—SAV and emergent aquatic vegetation—EAV), limited research exists on the long-term dynamics of nutrient accretion and their implications for restoration strategies. This study provides an in-depth analysis of nutrient accretion rates and nitrogen-to-phosphorus (N/P) ratios across four STAs (STA-1E, STA-2, STA-3/4, STA-5/6) over 9–22 years of operation.

Soil cores collected from inflow, midflow, and outflow sections of six flow-ways were analyzed to calculate elemental accretion rates, providing insights into nutrient accumulation in soil layers over time. The results revealed significant variability in nutrient accretion among flow-ways. High-performing systems, such as STA-3/4 CFW and STA-2 FW4, exhibited the highest phosphorus accretion rates and increasing N/P ratios downstream, attributed to optimal hydrology, well-established vegetation, and sufficient nutrient storage capacity. In contrast, low-performing systems like STA-5/6 FW1 demonstrated low phosphorus accretion, primarily due to soil phosphorus saturation and aging infrastructure. The younger STA-2 FW4 showed efficient phosphorus accumulation, while STA-1E exhibited localized variability in nitrogen accretion due to uneven hydrological conditions.

These findings underscore the importance of adaptive management strategies to enhance STA performance, particularly in aging or low-performing systems. Tailored interventions, such as optimizing hydrological flow, rejuvenating vegetation to improve nutrient uptake, and addressing phosphorus saturation in soils, are essential for maintaining long-term nutrient accumulation efficiency. By providing valuable long-term data, this study informs Everglades restoration efforts and contributes to the resilience and sustainability of constructed wetlands, ensuring their effectiveness in mitigating nutrient pollution over time.

Determining the Origin of Migratory Birds Consumed by Burmese Pythons in Florida

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Burmese pythons (*Python bivittatus)* have long been identified as threats to native fauna, and pythons in Florida have been documented to consume a variety of birds, some of which are not year-round residents in the state. **In this study, we aimed to characterize the geographic extent of migratory birds consumed by Burmese pythons in Florida.** Stable isotope analysis offers a powerful tool in determining the origin of migratory birds, as predictable gradients in hydrogen isotope (δ^2H) values of precipitation can be used to identify the likely areas of feather molting. Birds incorporate the local δ^2H precipitation values into their developing feathers through diet and drinking water, leaving metabolically inert biological tracers that can be used to infer the likely areas where they were grown. For this study, bird remains recovered during gut content analysis from pythons captured in south Florida were sent to the Feather Identification Lab at the Smithsonian National Museum of Natural History for species identification. Eleven of the 58 species identified are not year-round Florida residents, and we performed δ^2H analysis of the recovered feathers. We determined the likely origin for 15 individuals and found that the geographic extent of Florida python diet may reach as far as Canada. These findings highlight the far-reaching impact of invasive Burmese pythons in Florida, demonstrating that their predation on migratory birds extends well beyond the state, with possible implications for bird populations across North America.

Everglades Restoration is Foundational to South Florida Resilience

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For South Florida, Everglades restoration and urban resilience are two sides of the same coin. Everglades restoration is focused on improving environmental conditions that build ecosystem resilience to a changing climate. Restoration also provides assurances for communities with respect to flood protection and water supply. South Florida resilience planning efforts are focused on the built environment, helping vulnerable communities and infrastructure adapt to climate change impacts such as sea level rise, flooding, storms, extreme heat, and water quantity and quality challenges. In addition to the myriad region-wide environmental benefits, Everglades restoration is critical to ongoing resilience planning efforts and community resilience. A key restoration objective is increasing water storage, which provides locations to store water when it is abundant and places to draw from when water is scarce and thus respond to potential and growing environmental changes. Likewise, current operational planning for the central Everglades and recent implementation of new Lake Okeechobee operations are made possible by new infrastructure, allowing water managers more flexibility in providing for the needs of the Everglades while also reducing water quality impacts for South Florida communities. Ensuring water quality standards is also essential to protecting Everglades habitats and our communities. While the focus of resilience planning is centered on communities, stronger, more resilient communities are essential to protecting the Greater Everglades Ecosystem, maximizing investments made in the environment, and strengthening South Florida's clean water economy. Just as the goals and objectives of Everglades restoration are aligned with and foundational to urban resilience, ongoing resilience planning efforts hinge on Central & Southern Florida (C&SF) infrastructure. Collectively, these efforts will provide mutually beneficial resilience outcomes for the environment and communities throughout the South Florida region.

Agricultural and Urban Pesticides in South Florida and Florida Manatees

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Agricultural and urban activities in Florida rely on pesticides such as insecticides, herbicides, and fungicides to manage pests and diseases for food production, landscape maintenance, and vector control. Florida's main agricultural production involves sugar cane, citrus, and cattle. These pesticides can potentially end up in the aquatic environment via surface water and groundwater pathways. Our goal was to analyze the prevalence of pesticides and pesticide transformation products (TPs) in Florida manatees (*Trichechus manatus latirostris*) and their aquatic environment, particularly in the Indian River Lagoon (FL). The vegetation and water collected can serve as potential routes of manatee exposure to pesticides. We performed a comprehensive analysis of 183 pesticides and their TPs on manatee plasma from 5 locations in Florida (n=131, 2015-2023). These samples include plasma collected during the unusual mortality event that began in 2021 on the Atlantic coast (n=60). Water and submerged vegetation samples were collected from the Indian River Lagoon in 2022 and 2023. Additionally, we sampled water from freshwater environments surrounding Lake Okeechobee (2023). Bifenthrin, a widely used insecticide, was found in Florida manatee plasma in all 5 locations. Manatees sampled during the unusual mortality event had lipophilic pesticides present (e.g. bifentrin, etofenprox, fenpropathrin, DDE), suggesting they may be linked to endogenous sources of exposure during fat tissue metabolism associated with starvation. Vegetation and water samples showed the presence of 13 pesticides including herbicides (e.g. atrazine and diuron) and insecticides (e.g., bifenthrin, imidacloprid). Imidacloprid was the pesticide with highest concentration present in 26% of the water samples, total pesticide concentration ranged from 1- 51 ng/L. Total pesticide concentration in vegetation ranged from 1-75 ng/g. Pesticides were found to be more prevalent in water samples proximal to Lake Okeechobee compared to other areas of south Florida, with 36 pesticides detected (total pesticides 53 to 803.7 ng/L). Atrazine was detected in all Lake Okeechobee water samples. The presence of multiple pesticides in water, vegetation, and manatees, in the Greater Everglades highlights a potential concern for restoration efforts. Continuous monitoring of these contaminants and understanding their prevalence in the environment is necessary, especially considering the water flow direction changes under the Everglades restoration initiative.

Non-native Fish and Habitat Sampling on Tribal Managed Lands in the Everglades: Quantifying Species-Habitat Relationships

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The Everglades wetlands and their biodiversity are vital resources for the Miccosukee Tribe of Indians of Florida. However, these essential resources face significant threats from the encroachment of non-native fish species originating from nearby urban waterways in south Florida. The Tribe is particularly concerned about Water Conservation Area 3A (WCA-3A), where there is a notable lack of publicly available, spatially referenced data regarding non-native fish species in comparison to other areas of the Everglades (www.nas.usgs.gov). This insufficient data impedes the Tribe's ability to develop effective management plans for invasive species. In this prospective presentation, we detail the collaboration between the Miccosukee Tribe of Indians of Florida and the United States Geological Survey (USGS) to enhance our understanding of the distribution, abundance, and life history of non-native fish species in WCA-3A. Our presentation focuses on the collection of non-native fish and their habitat information during the dry season of 2024. We share insights into the success of various collection methods targeting non-native species, including electrofishing, throw traps, fyke nets, specially designed eel traps, and minnow traps. Additionally, we provide a summary of the non-native species collected and the habitat conditions observed at these sites. We analyze the species assemblages, which comprise both native and non-native species data, and analyze the relationships between species and their habitats. We also present on the utility of the data in testing the performance of non-native species distribution models developed under future climate scenarios in freshwater ecosystems of Florida. Collectively, our work highlights the critical intersection of ecology, cultural heritage, and resource management, emphasizing the importance of addressing invasive species in the Everglades. By understanding non-native fish species and their impacts, the Miccosukee Tribe can better protect their resources, biodiversity, and heritage, while contributing to the broader conservation and restoration goals of the Everglades ecosystem.

Cape Sable Seaside Sparrow Conservation: Challenges and Potential Solutions in a Rapidly Changing Hydroscape

Tylan Dean
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The Cape Sable seaside sparrow has been characterized as one of the most sensitive species In the Everglades ecosystem, requiring "just-right" hydrologic and habitat conditions to survive. Demographically, the species exhibits low annual survival rates but benefits from high recruitment during favorable conditions. Its habitat, characterized by a diverse assemblage of plant species, is subject to rapid changes—often within three years or faster in response to fires or climatic events. Over the past 3 decades, management efforts focused on consistently providing favorable hydrologic conditions in the specific areas where sparrows and sparrow habitat have occurred most consistently. However, this approach may have reduced natural variability, potentially impacting long-term habitat suitability across the species' range. While stabilizing conditions seems beneficial from a demographic perspective, the sparrow may be better adapted to the natural variability inherent in the Everglades ecosystem, which includes years with both favorable and unfavorable conditions for sparrows. Acknowledging this adaptability suggests that a resilient population may be best supported by allowing a broader range of conditions, both good and bad, over large areas and multiple years. Embracing this variability could also help resolve apparent trade-offs among species and improve ecosystem-wide benefits across the Everglades.

Water Quality and Environmental Protection in Big Cypress National Preserve: History, Science and Management.

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Monitoring and assessment programs can be based on clear or perceived threats, or the need for baseline information prior to actions in the watershed that could affect environmental conditions. The trigger for water quality monitoring within Big Cypress National Preserve was the construction of the Miami-Dade Transition Airport (Jetport) in the late 1960s. The Department of Interior recognized that the ecological resources of Big Cypress were integrated around a common need for water quality, and a concern about nutrient enrichment was identified. The United States Geological Survey began monitoring in 1969, mostly at locations near the Jetport, and modified programs continued until about 2000. The National Park Service and South Florida Water Management District conducted a collaborative long-term water quality sampling program in the Preserve at 16 marsh stations from 1990 - 2011. Since 2011, there has not been a long-term marsh monitoring program in the Preserve. USEPA employed a unique multi-media random probability-based Regional Environmental Monitoring and Assessment design in 1995 - 1996 (47 stations) and 2023 (38 stations). All monitoring designs have advantages and disadvantages. Preserve water quality reports or publications are scarce, with the most recent in 2010. One of the goals of the Western Everglades Restoration Plan (WERP) is to restore oligotrophic conditions. However, the Preserve does not have a numeric water quality standard for phosphorus, even though phosphorus data date from the 1960s. Consequently, a challenge faced by WERP scientists, planners and managers is determining how clean the water needs to be in order to protect the ecology of the Preserve as well as the downstream waters of the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Indians.

Implementing an Applied Science Strategy to Restore, Protect, and Preserve Southwest Florida

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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 consists of a series of restoration projects that aim to improve the quantity, quality, timing, and distribution of water throughout South Florida with the goal of supporting the health and well-being of more than 2.4 million acres of the Everglades while providing for the region's water supply needs and flood protection. To track hydrologic and ecological responses and reduce uncertainties related to CERP, an Applied Science Strategy is implemented by REstoration, COordination & VERification (RECOVER), the interdisciplinary collaboration of agencies, tribes, and institutions that conducts scientific and technical evaluations and assessments to improve CERP's ability to achieve restoration success. As part of this strategy, RECOVER utilizes a Monitoring and Assessment Plan (MAP) to assess the system-wide response of the ecosystem to CERP implementation.

This poster presents an overview of proposed monitoring to be incorporated into the MAP for the Southwest Florida region spanning from the headwaters of the Greater Big Cypress Basin to the western and southern coasts. The proposed monitoring plan was developed using information on the current science and monitoring efforts within the Southwest Florida region gathered from scientists and other experts at a pre-GEER workshop in April 2023 along with conceptual ecological models that identify indicators of the ecosystem's response to CERP implementation. Data collected through this monitoring plan will be used to evaluate how well proposed restoration projects are likely to meet their targets as well as to assess the success of implemented restoration projects. Utilizing this information to inform the design of proposed restoration projects and to adjust the implementation of existing projects through adaptive management reduces uncertainties and improves the probability of achieving CERP success.

Analyzing the Probability of Spoonbill Nest Production in Florida Bay Using Negative Binomial Regression

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The productivity of spoonbill nests is a critical factor influencing population dynamics, conservation strategies, and ecosystem management. Understanding how the initial number of eggs in a nest impacts the number of successfully fledged chicks provides key insights into reproductive success and environmental stressors affecting this species. This study modeled the relationship between spoonbill clutch size (number of eggs) and chick production using data from a long-term monitoring project in Florida Bay. To account for variability in ecological count data, we used a negative binomial regression model, allowing us to estimate chick production in relation to the number of eggs while considering covariates such as nest location and nesting year. Our analysis shows a positive, non-linear relationship between the number of eggs and predicted chick production, with regional variation influencing outcomes. The Central, Southwest, Northwest, Northeast, and Southeast regions of Florida Bay exhibit distinct patterns of clutch success, suggesting that ecological factors vary by location. While larger clutches generally predict more fledged offspring, environmental factors had an impact on the model. When examining the period before and after 2010-11 hydrologic year, the year of the notable Gulf Stream Current slowdown that accelerated the rate of sea level rise, the model suggests a change in chick production. This reduction in Gulf Stream flow and sea level rise is linked to broader ecological shifts, potentially impacting spoonbill prey availability and nesting success. Incorporating these drivers into a negative binomial model allowed us to refine our predictions and account for variability across regions and egg numbers. Understanding how sea level rise is affecting ecological processes in Florida Bay is critical to our ability to assess the potentially positive impacts of restoration activities that may be masked by the negative impacts of sea level rise. The negative binomial regression framework effectively handled the skewed distribution of nest outcomes, accommodating overdispersion better than simpler models. The study's findings deepen our understanding of spoonbill reproductive biology by underscoring the importance of both biological factors and environmental conditions in determining nest success. By predicting which nesting conditions are most likely to lead to successful chick production, managers can prioritize conservation actions in key areas and optimize efforts to mitigate the impacts of environmental change. Future research could further explore how specific environmental drivers—temperature fluctuations, hydrological changes, and prey availability—interact with nest-specific factors to shape reproductive outcomes. Ultimately, this research contributes to a broader understanding of how organisms adapt to dynamic ecosystems and how targeted conservation measures can enhance their resilience to global environmental challenges.

Application of Computational Fluid Dynamics (CFD) to Inform Engineering and Maintenance Solutions at S333

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Reducing Total Phosphorus (TP) transport in the Everglades is critical to restoring its ecological balance. Discharges through the S-333 and S-333N spillways often carry elevated TP levels, suspected to be driven by sediment accumulation during dry periods and resuspension during early wet season flows. To investigate this issue, a comprehensive hydrodynamic modeling study, utilizing HEC-RAS 2D and 3D Computational Fluid Dynamics (CFD), was conducted to evaluate sediment dynamics and develop engineering solutions aimed at mitigating sediment and TP transport and supporting restoration goals. The study simulated flow patterns and velocity fields around the S-333/S-333N complex under various scenarios, including baseline conditions, muck removal with additional low sill weirs, and further canal dredging. These interventions were designed to reduce near-bed velocities, minimize sediment mobilization, and enhance nutrient retention within the canals. Additionally, a preliminary HEC-RAS 2D sediment transport model, empirical sediment entrainment threshold velocities were employed to assess the effectiveness of these measures. Results indicated the existence of velocities that are capable of sediment resuspension during high and medium flow events and low stages. The removal of muck and further dredging of the canal reduced near-bed velocities in critical segments by up to 30%, promoting sediment deposition and minimizing downstream transport. Dredging also increased canal capacity, reducing the likelihood of sediment resuspension during high flows. Velocities below 0.25 ft/s were shown to favor sediment deposition, while higher velocities increased the risk of resuspension. This study highlights the importance of managing hydrodynamic changes to mitigate sediment transport and optimize flow distribution. By integrating advanced modeling techniques with practical engineering solutions, this study provides actionable recommendations for sustainable sediment and TP management at the S-333/S-333N complex. This work also presents scalable methodologies applicable to similar restoration challenges across the Everglades.

Mapping Surface Water Flow Connectivity Between Shark River Slough and Taylor Slough, Everglades National Park

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Regional flow patterns in Everglades National Park (ENP) are traditionally derived from hydrological models calibrated for water levels and occasionally for discharges at structures. However, these models often lack the resolution to provide detailed flow vectors (magnitude and direction) due to incomplete knowledge of hydraulic resistance and preferential flow paths. Shark River Slough (SRS) and Taylor Slough (TS) are two primary freshwater conveyance systems connecting upstream freshwater deliveries to Florida Bay. Understanding the extent and variability of connectivity between these sloughs is critical for water management and ecological health. Here we utilized a data-driven approach using field-observed data, and analytical methods to map surface water connectivity and flow direction between SRS and TS. A network of 24 water level sensors, deployed in eight triads along the SRS-TS boundary, measures water levels every 30 minutes. By analyzing water level fluctuations, surface slopes, and lag times between sites, we calculate flow direction and assess connectivity. The method defines a water surface plane from three equidistant points, with its 2-dimension gradient indicating flow direction. Vegetation effects on lag times are also evaluated. This approach provides a clearer understanding of flow dynamics, complementing models and improving water management strategies for ENP.

Aquatic Carbon Fluxes from a Marsh Ecosystem within the Florida Everglades

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Anthropogenically induced sea level rise threatens the integrity, extent and the ecosystems services provided by coastal wetland ecosystems. In such ecosystems like the Florida Everglades, field studies have observed recurring dry-down events followed by stepwise increases in soil porewater salinity levels during subsequent rewetting periods. This phenomenon has been attributed to strong groundwater upwelling of brackish water when surface water disappears during dry-down and evapoconcentration. Salinity levels of these brackish waters may become amplified as sea level rise persists. While the literature studying the impact of dry-down and saltwater intrusion into wetland ecosystems on atmospheric losses of carbon is robust, the consensus on how saltwater intrusion impacts dissolved organic carbon (DOC) and particularly dissolved inorganic carbon (DIC) losses from these systems remains unclear. By using a benchtop approach free of the effects of confounding variables found in field studies, this study seeks to investigate how dry-down events followed by increases in porewater salinity during rewetting influence porewater DOC and DIC release. Twelve intact cores were collected from both a brackish and freshwater marsh in Everglades National Park. Using waters collected from both sites, we subjected cores to four 11 – 14 day treatment cycles of dry-down and rewetting, with an 11 – 14 day flooded period in between each rewetting/dry-down cycle and salinity increases of approximately 5 ppt from ambient levels per re-wetting cycle. Preliminary results indicate that in earlier dry-down cycles, DOC release was significantly lower in brackish water cores treated with waters of increasing salinity, although this effect was muted as the experiment continued suggesting microbial adaptation to increasingly salinized conditions. In later dry-down cycles, DOC release was significantly greater in freshwater cores that were treated with waters of increasing salinity than in those treated with ambient waters, and DIC release was greater in brackish water cores treated with waters of increasing salinity than in those treated with ambient water. Lastly, DOC and DIC concentrations were significantly higher in surface and porewaters from the brackish water control cores (i.e., no salinity or dry-down treatment) than both the cores treated with ambient and increasingly salinized water across all flooded four flooded cycles, suggesting a negative relationship between dry-down and aquatic carbon production. These results highlight the impact of increased salinization from sea level rise and dry-down can have on aquatic carbon losses, especially regarding the less-studied dissolved inorganic carbon losses from brackish water wetlands.

SAV in the STAs: Insights into Phosphorus Retention

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The Everglades Stormwater Treatment Areas (STAs) are constructed wetlands that use aquatic vegetation to reduce phosphorus (P) from stormwater runoff before it is discharged to the Everglades Protection Area. Photosynthesis from submerged aquatic vegetation (SAV), which occurs entirely within the water column, increases water pH causing P to coprecipitate with calcium carbonate that settles into the underlying soil layer. Based on STA guidance documents, SAV communities are necessary for STAs to meet outflow P compliance targets. Assessments of P removal by SAV have typically been limited to modest experimental (mesocosm) scales. The relationship between whole flow-way performance and SAV coverage has not been thoroughly explored. SAV have been monitored throughout STA operational history at a fixed network of survey points established throughout downstream cells of the STA flow-ways through estimation of SAV coverage classes near each survey point. This long-term dataset is used here to assess the relationship between SAV communities at the flow-way scale and STA P removal/retention. Period of record flow volumes and P loads were downloaded from the South Florida Water Management District’s DBHYDRO database and used to calculate flow-weighted mean concentrations and P loading rates for all STA flow-ways surveyed for SAV (n = 16). Hydrologic and nutrient loading parameters were then related to flow-way SAV coverage using graphical and regression analysis. Median SAV coverage is generally higher during the wet season compared to the dry season. Inflow volumes and P loads increase substantially with the onset of the wet season, and again when tropical storm activity increases, which can influence a flow-way's P removal ability. Flow-ways that contain at least moderate SAV coverage before large seasonal events are typically affected less in terms of P removal ability, suggesting that a minimal threshold of SAV coverage is needed for resilience to loading events. Wet season loading events can account for 30-40% of a flow-way’s annual P load intake, highlighting the importance of SAV based resilience for STA P removal, and further documenting the importance of SAV coverage to meet STA regulatory targets.

What Could be Lost if Lostmans Slough Gets Lost in the Hydro Shuffle?

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An important working paradigm for Everglades restoration focuses on "getting the water right" to recover, or improve, ecological functions that were present in the predrainage ecosystem. Determining where, and exactly how, to get the water right for some functions is a challenge given historical uncertainties and sparse data, but research and monitoring advancements should allow us to better refine our concepts over time. Drainage and development had dramatic, and well-documented, impacts in the eastern and central Everglades through the 20th century, and thus hydro-restoration has focused on improving water deliveries and hydrologic connections in the central Everglades. To jump-start restoration of the central Everglades water has been recently shunted away from the western Everglades and down Shark River Slough (SRS). But not all functions of the historical system can be restored by routing current or projected water under the bridges through SRS. One function of the predrainage Everglades was the trophic support of large aggregations of nesting wading birds (especially White Ibis, *Eudocimus albus*) in coastal regions of the southern Everglades. Regular nesting at the coast and the return of high wading bird nesting numbers in the southern coastal Everglades has not been achieved. In this talk I will discuss our understanding about coastal nesting ibis and the importance of hydrating the wetlands in and around Lostmans slough. The uncertainty about the past hydrologic conditions in the prairies west of SRS will be discussed along with recent observations of ibis nesting patterns, prey use, and the attendant hydro-patterns. Large coastal nesting events in 2018 and 2021 were driven by timely storms and pulses of water late in the year. Everglades crayfish (*Procambarus alleni*) were important prey resources for ibis nesting in the southern Everglades. Their populations require annual dry periods because of their sensitivity to fish predators. But hydroperiods < 7 months that promote marl prairies are so short that they force crayfish belowground in the winter, rendering them unavailable to breeding or pre-breeding ibises that are nesting from March-May. The best understanding of the requirements for colony formation in the coastal region is that additional hydration of prairies around Lostmans slough will be required. The hydrologic needs for increased crayfish availability, that could encourage wading bird coastal nesting, are qualitatively consistent with predrainage hydrologic re-constructions of the region. Existing and proposed hydro-restoration plans do not appear to support this function.

The BlueFlux Campaign: Daily Blue Carbon Flux Upscaling from Tower and Airborne Sources Reveals 20-Year History of CO_2 and CH_4 Ecosystem Fluxes in the Everglades

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The goal of the NASA Carbon Monitoring System's BlueFlux campaign is to develop data-driven prototype products to inform coastal management on recent blue carbon ecosystem fluxes through the combination of ground-based and novel airborne measurements that capture increased temporal and spatial variability of wetland fluxes due to vegetation, disturbance, and management in the South Florida Everglades ecosystem. We upscaled multi-source CO_2 and CH_4 flux observations from 8 eddy covariance towers dating back to 2004 and from 5 airborne deployments of the NASA Carbon Airborne Flux Experiment (CARAFE) instrument spanning the South Florida region in 2022-2024. Multiscale flux measurements were scaled with remote-sensing observations of MODIS optical reflectance using an ensemble random forest machine learning approach to predict daily mean flux and uncertainty at 500-m resolution from 2000-2023. Upscaling models successfully captured the variability in daily mean CO_2 and CH_4 fluxes.

BlueFlux data-driven upscaling facilitates high resolution regional insights to both long-term CO_2 and CH_4 fluxes over the dynamic and highly managed Everglades ecosystem. Ongoing efforts are underway to further improve and expand BlueFlux upscaling through increased multi-scale collections and data integration, and to assess drivers of blue fluxes important to regional partners tasked with the management and protection of valuable blue carbon ecosystems.

Updates to Conceptual Ecological Models Inform Science-Based Water Management Projects

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REstoration COordination and VERification (RECOVER), a collaboration of scientists, modelers, planners, and resource specialists, applies a system-wide perspective to the planning and implementation of the Comprehensive Everglades Restoration Plan (CERP). To accomplish this mission, RECOVER uses several tools to evaluate and assess CERP projects to ensure the most up-to-date science is incorporated in project design and implementation. Conceptual Ecological Models (CEM) are non-quantitative planning tools that identify drivers and stressors, ecological effects, and attributes that can be found in each landscape with the Everglades. CEMs are the primary communication, planning, and assessment link among scientists and policy makers. Hypothesis clusters that depict causal relationships among ecosystem components and describe how these relationships are expected to change with restoration are derived from the CEMs. Together, CEMs and hypothesis clusters document our collective understanding of how the ecosystem functions, and they form the scientific rationale for RECOVER's Monitoring and Assessment Plan and inform adaptive management solutions. In 2022, in recognition of the unique landscape of southwestern Florida, RECOVER created the Southwest Florida Module. The SWFL module encompasses a variety of landscapes from the Big Cypress National Preserve to the Ten Thousand Islands NWR, and its unique ecological relationships require the development of a new series of CEMs and HCs. The SWFL CEMs will identify key drivers and stressors to better represent the ecosystems managed in Southwest Florida. This poster identifies what CEMs are and how they are applied in CERP and discusses the present updates within the Southwest Florida Module. Observers should gain an understanding of the RECOVER applied science strategy, the importance of CEMs, and application in large-scale ecosystem restoration. Examples of current CEM updates will be provided along with their intended uses to inform project development and implementation to ensure ecological restoration.

Spatial and Temporal Patterns in Mercury Concentrations of Native and Invasive Forage Fish in the Florida Everglades

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The Greater Everglades is among the most unique and significant ecosystems in the world, providing environmental, economic, and cultural benefits to the region. However, the health of the Everglades ecosystem faces numerous interactive threats. Mercury (Hg) contamination and invasive species are two critical stressors that may impact ecological communities and human health. The risks posed by Hg vary spatially and temporally in response to both biogeochemical drivers that influence methylmercury (MeHg) production and transport, as well as ecological drivers that regulate the movement of Hg through food webs. Invasive species can alter food web structure, ultimately influencing the efficiency of Hg biomagnification within food webs and exposure to wildlife and humans. Forage fish are a crucial component of the aquatic food web because they reflect relatively short-term patterns of MeHg availability and serve as vectors to higher trophic level fishes. To understand the influence that non-native forage fish may have on Hg bioaccumulation in the food webs of the Everglades we examined Hg concentrations in six species of native and two species of invasive forage fish across 72 sampling sites in the Everglades National Park (ENP) over a ten-year period (2007-2018).

We used a combination of fish samples from diverse habitats across Shark River Slough (SRS), marl prairie freshwater marshes near and around Taylor Slough, marsh/mangrove coastal zones, and northern and eastern canal boundaries. Across more than 2,000 samples, preliminary findings indicate that Hg concentrations (ng/g wet weight) ranged between 3 and 802 ng/g, averaging (± standard deviation) 54 ± 72 ng/g. After accounting for variation due to species, site, and sampling year, preliminary analyses indicate that Hg concentrations (least squares mean ± standard error) in non-native species (78.5 ± 8.4 ng/g) were 1.6x higher than in native species (49.0 ± 4.3 ng/g). Concentrations were highest in African Jewelfish and lowest in Sailfin Molly. Across sites, average Hg concentrations (accounting for species) ranged from 17 to 266 ng/g. Concentrations were generally highest in the SRS and coastal region, and lowest in the freshwater marsh sites. These observations correspond to geochemical measurements of aqueous MeHg, sulfate, and organic carbon, which were highest in SRS. When controlling for site effects, Hg concentrations decreased between 2007 and 2018 in African Jewelfish, Bluefin Killifish, and Flagfish, and increased in Marsh Killifish and Dollar Sunfish. These findings provide initial insight into how invasive species might be altering Hg bioaccumulation in the Everglades ecosystem and may inform future trajectories of food web exposure.

Linking Movement Strategy Selection to the Trophic Dynamics of an Estuarine Predator

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The degree of variation in environmental conditions, resources, or risks within a landscape, referred to as spatiotemporal heterogeneity, can shape how animals move and lead to distinct, repeated patterns in movement. These patterns, known as movement strategies or syndromes, represent suites of correlated movement traits that are influenced by an animal's responses to environmental cues and cognitive abilities. Movement strategy selection has broad implications, affecting species interactions, population dynamics, ecological niches, and even ecosystem function. Despite their importance, most research on movement strategy selection has focused on terrestrial ecosystems, with relatively little attention given to aquatic environments. Our recent study highlighted how heterogeneity in environmental conditions influences movement strategy selection in Common Snook (*Centropomus undecimalis*), a mesoconsumer fish species, within two neighboring subestuaries (Alligator Creek and McCormick Creek) in Everglades National Park. Building on this work, we explored the trophic implications of movement strategy selection by combining Snook movement classification with stable isotope analysis. This approach allowed us to examine how movement strategies relate to energy channel dependence and trophic niche partitioning. We found that energy channel dependence differed between movement strategies in both subestuaries. In Alligator Creek, Snook exhibited a stronger reliance on pelagic energy pathways, while Snook in McCormick Creek depended more on demersal energy sources. Additionally, in the Alligator Creek system, Snook using the resident movement strategy, characterized by the lowest movement frequency and range use, displayed compressed trophic niches. In contrast, in McCormick Creek, Snook classified as using the resident movement strategy had among the largest trophic niches and Snook employing the transient movement strategy, characterized by the highest movement frequency and range use, exhibited the smallest trophic niches. Interestingly, trophic level was not associated with movement strategy selection in either system. This supports our earlier findings that Snook movement strategy selection in these two systems is likely to be more greatly influenced by extrinsic factors such as hydrology and resource dynamics rather than intrinsic factors like body size, age, or sex. Enhancing our understanding of how water management and ecosystem health influence animal behavior and trophic dynamics can better inform conservation and management strategies for estuarine-dependent fish species. This is particularly crucial as Everglades restoration efforts advance and anthropogenic impacts increasingly alter estuaries worldwide.

Impacts of boating Activity on Foraging and Breeding Sail Kites (*Rostrhamus sociabilis plumbeus*)

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Anthropogenic disturbance is an increasing threat to animals as the human population continues to grow and spread to natural environments. One avenue of human-driven disturbance is through recreational boat traffic, which can negatively impact foraging and nesting success of bird species. Management strategy to reduce these impacts often includes restricting human activity near important locations for sensitive species, including the use of buffer zones. Many of these zones are calculated using flight initiation distance (FID) established by experimental studies. Flight initiation distance is a common metric to represent the trade-off between fitness benefits and costs in a species in its response to disturbance. The Everglade snail kite (*Rostramus sociabilis plumbeu*s) is an endangered wetland-dependent raptor species that benefits from the use of buffer zones around its nesting habitat. These zones were established using FID from perched snail kites without reference to nesting locations, yet they are currently applied to breeding birds. To test whether there are differences between FID of breeding and non-breeding birds, we measured FID of snail kites at nests and on individuals not displaying breeding behavior. The purpose of this work is to determine whether these potential differences can refine currently established buffer zones. Due to the fact that managers often conduct their management in regards to the snail kite breeding season, it is important to give specific recommendations. These results provide a balance between both the conservation of an endangered species and the needs of both wetland managers and the public.

Digital Elevation Models for the Everglades Depth Estimation Network with Elevation Uncertainty Treatment

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Over the last several years, high-resolution light detection and ranging (lidar) based digital elevation models (DEMs) have been produced for South Florida. However, due to limitations with the ability of airborne lidar sensors to penetrate dense vegetation, DEMs for coastal wetlands often have a high amount of elevation error, which can lead to an overestimation of elevation of more than 0.5 m. This level of error can be problematic for geospatial analyses in low-lying coastal areas, such as the Everglades, where small changes (centimeter-level) in elevation can influence hydrology and inundation frequency. In this study, we used high-resolution lidar data to produce DEMs with a spatial resolution of 50 m and 10 m for the Greater Everglades that included a reduction of elevation error. Our first step was to assess the elevation error in the original DEMs using information from benchmarks, elevation checkpoints associated with lidar data collections, and elevation data collected using global navigation satellite system receivers. We found that vegetated areas had a root mean square error (RMSE) for elevation of 0.22 m and 0.27 m for the 10-m and 50-m DEMs, respectively. Next, we used these elevation error estimates, land cover data, and estimates of the spatial autocorrelation of elevation, to develop 1,000 potential DEMs via Monte Carlo simulations. For each spatial resolution, we combined the Monte Carlo simulation outputs to produce a DEM with reduced elevation error in coastal wetlands. For this process, we used validation data from the U.S. Geological Survey's high accuracy elevation dataset, an extensive dataset with over 45,000 ground surface elevation observations throughout the Greater Everglades. The percent decrease for the RMSE for elevation of the DEMs produced in this study varied by zone (i.e., hydrologically distinct areas) and ranged 18% to 68% with a mean of about 48% for the 10-m DEM and 5% to 67% with a mean of about 40% for the 50-m DEM. The products from our study will be used to enhance daily depth estimations produced by the Everglades Depth Estimation Network by incorporating elevation error and improving the spatial resolution from 400 m to 50 m. Beyond enhancing depth estimates, data we produced in this study can also be useful for restoration modeling and assessment, sea-level rise modeling, and species distribution modeling. Along those lines, we conducted a case study that highlighted how these data can affect the delineation of potential Cape Sable seaside sparrow nesting habitat, which is impacted by hydroperiods during breeding season. Our presentation will provide a high-level overview of the Monte Carlo approach, results of the error treatment, and how these products impacted the delineation of nesting habitat for the Cape Sable seaside sparrow.

Synthesizing Effects of Soil Dryout, Vegetation Disturbance, and Other Perturbations on Everglades STA Treatment Performance

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A ~250-km^2 network of Stormwater Treatment Areas (STAs), constructed as part of a regional effort to reduce P inputs to the Everglades Protection Area, are subject to disturbances that affect their P removal performance. This study quantifies the incidence of disturbance in individual STA flow-ways (n=22) and STAs as a whole (n=5), and the effect of disturbances to outflow total phosphorus (TP) concentrations. The study evaluates three types of well-documented disturbances: 1) vegetation loss from tropical storms, herbivory, and other causes, 2) periodic dry-out due to severe dry season cycles or non-routine operations and 3) construction and maintenance activities. Extensive documentation including annual reporting, spatial imagery, vegetation surveys, and hydrologic data identified locations and times of disturbances in STA flow-ways over the past 25 years of operation. Of the available 361 post-startup data years, 96 were flagged as disturbed by dry-out, 61 by vegetation loss, and 9 by construction/maintenance. A significant difference was found between the annual outflow TP concentrations from years categorized as disturbed when compared to periods from the 211 data years categorized as ‘undisturbed’. The median outflow TP was over 2.5 times higher for disturbed compared to undisturbed years. Among undisturbed data years, a breakpoint was found between outflow TP concentrations and inflow areal phosphorus loading rates (PLR), that occurred around a PLR of 1.5 g/m^2-yr. Undisturbed STAs and flow-ways consistently produced outflow TP concentrations less than 25 µg/L when PLR was below 1.5 g/m^2-yr but produced higher and variable concentrations at higher PLRs. Among disturbed years, the relationship between outflow TP and PLR was obscured, indicating that disturbance interrupts typical wetland nutrient removal processes, thus highlighting the importance of accounting for the effect of disturbance in treatment wetland performance analysis or modeling. At the STA scale, outflow TP concentrations tend to increase as the fraction of flow passing through disturbed flow-ways increased. Disturbance events will affect STA performance into the future and should be considered when formulating long-term performance expectations.

Long-term Mangrove Research in South Estero Bay, Florida

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We report on the progress of research associated with a long-term one-hectare mangrove plot in the Imperial River Preserve in association with Florida Gulf Coast University's Vester Marine Field Station, and additional study sites and restoration initiatives. This plot was established following Hurricane Irma, and was subsequently impacted by Hurricanes Ian, Helene, and Milton. The objective of our monitoring program is to document impacts of hurricanes, factors affecting the vectors of recovery, and the long-term dynamics of climate change impacts (rising sea-levels, higher sea surface temperatures, and changing patterns of rainfall and hurricane disturbance) on the sustainability of a mangrove forest in southwest Florida. We identified, mapped, measured, and tagged trees (>4 cm dbh), and quantified damage and mortality from these storm events. Additional subplots were established to investigate spatial variation in litterfall and seedling re-establishment, including the role of course woody debris. These 'tape-measure' ecology approaches across a large plot have provided opportunities to ground truth remote sensing technologies, including UAV-based photogrammetry and LiDAR, which is facilitating the ability to expand assessments across the landscape. The framework of a large plot has provided a context for a variety of work at small scales, including physiological responses of trees and gas exchange at the leaf and soil interfaces, furthering our ability to accurately estimate carbon dynamics. Our monitoring at the stand level quantified significant delayed mortality associated with fine particle deposition in the rooting zone. Although we are tracking significant re-establishment of seedlings, our data has raised concerns that the changes in frequency and intensity of cyclonic storms, driven by climate change, may be exceeding the mangrove system's ability to fully recover. The insights from this work on impacts and recovery informs our efforts at mangrove restoration in the region.

Metagenomics Characterization of Periphyton Nutrient Cycling in the STAs

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Everglades Stormwater Treatment Areas (STAs), constructed to reduce total phosphorus (TP) to the Everglades Protection Area, are mandated to meet strict TP limits. Outflow regions and surface waters discharged from the STAs have very low TP concentrations, composed primarily of dissolved organic and particulate P. This organic P must be further broken down by phosphatase enzymatic activity to be used by the microbial community, which is very poorly characterized in the STAs. The objectives of this research were to compare the periphyton communities (defined here as the microbial film of algae, bacteria, and fungi on aquatic macrophyte stems and leaves and microbial mats) associated with different aquatic macrophytes and understand their effect on P cycling in STAs. Spatial and temporal dynamics of their periphyton community were investigated through field periphyton sampling collected across wet and dry seasons from STA-2 Cell 4 at two different sites representing mid-flow (D112) and outflow (D139) areas. Microscopy and metagenomics (DNA analyses) characterized the abundance, functional potential, and P cycling potential of the periphyton associated with *Chara* spp. (submerged aquatic vegetation, SAV) and *Typha* spp. (emergent aquatic vegetation, EAV). Microcosm experiments using different organic P additions evaluated differences of P processing by SAV and EAV periphyton through evaluation of phosphorus gene activity and phosphatase. SAV supported higher densities of algal cells and overall phosphatase enzyme activity generally making SAV better at removing organic P from the water column than EAV. SAV and its associated periphyton are likely best at P cycling in the outflow regions of STAs where SAV algal cells are densest and environmental conditions are best for healthy SAV growth. Transcripts showed SAV periphyton are more adapted to use and store inorganic P, resulting from greater phosphatase enzyme activity acting on organic P, where EAV periphyton are more adapted to use organic P forms that were not previously detected in STA surface waters (phosphonates). These differences reflect greater enzyme activity and subsequent organic P removal in SAV dominated areas. The inorganic P resulting from SAV enzyme activity is absorbed to calcium carbonate or rapidly taken up by periphyton cells and is an important component of P storage and removal in the STAs. Periphyton P metabolism genes varied seasonally and spatially, and gene composition and activity differed between periphyton from SAV or EAV. Collectively, the genomic information from both SAV and EAV demonstrates the functional capacity and diversity needed for growth of periphyton in low TP environment of the STAs. This suggests that mixed marsh conditions would be best for maximizing P retention.

Shifts in Food Web Topology and Biomass Accrual of Wetland Consumers Along an Experimental Discharge Gradient

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The Everglades was historically a flowing system, and hydro-restoration is expected to increase wet-season discharge for hundreds of km^2 of shallow wetland habitat. Increased discharge may provide bottom-up support to the Everglades food web by affecting periphyton nutrient availability and uptake. The impacts of restoring faster flowing conditions (> 1 cm/s) to the Everglades sloughs have been little studied until the Decompartmentalization Physical Model (DPM) was created and monitored. The DPM created a gradient of flow velocity with distance from the S-152 culvert, where low-nutrient water (TP < 10 ppb) has been seasonally discharged along a 2.5 km transect of interconnected sloughs since 2013. While flow in the DPM region has been shown to support the growth of grazers by improving periphyton food quality, it's unclear whether this will affect higher trophic levels, like small omnivores. To evaluate the bottom-up effects of flowing water on food web functions, we conducted 6-week *in situ* enclosure experiments during the dry season of 2018 and the wet seasons of 2018, 2019 and 2020 at 3–4 sites in the DPM region that were located along an experimental discharge gradient. One-meter^2 field enclosures were placed perpendicular to water flow in each site and were supplied with 2000 mL of periphyton mat and 'periphytometers' (plastic black sheeting attached to a wire frame) that served as a substrate for biofilm growth. One week after initial enclosure set up, three species of consumers representing a diversity of diets and feeding strategies (at least one grazer and one omnivore) were added to either all the enclosures (2018) or half of the enclosures (2019, 2020) in abundances that represented ambient densities while controlling for size-structure across replicates. At the end of the experiment, food web components (biofilm, floc, periphyton, and consumers) were collected and all samples were analyzed for stoichiometric ratios (C:N:P) and stable isotopes ($\delta^{13}C$, $\delta^{15}N$). For the latter two experiments, consumers were measured and weighed, and fish stomachs were dissected for gut contents. We ran an ANOVA to test for variation in stoichiometric ratios, and trophic positions and biomass of consumers between the sites receiving the most discharge compared to the two sites receiving low/no discharge. Periphyton and biofilm at the two high-flow sites had the lowest stoichiometric ratios (C:P, N:P) in each experiment, consistent with better food quality. Consumer body composition exhibited strict stoichiometric homeostasis, but omnivorous taxa decreased trophic position in the high discharge sites. While animals at the highest discharge site generally accrued the most biomass, only for two taxa (sailfin mollies and grass shrimp) in one study year (2019) was this difference statistically significant. Our results suggest that flow restoration can impact bottom-up energy flow by improving food quality of basal resources and alter food-web functions.

Characterization of DOM using TIMS-UHR-MS/MS and Graph-DOM routines

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Comprehending the global carbon cycle and ecological processes requires understanding the molecular composition and structure of Dissolved Organic Matter (DOM). Despite extensive characterization efforts, due to complexity of DOM, its intricate molecular structure remains elusive, especially at the structural level, as the separation, detection, identification of individual components, and the delineation of transformational pathways pose challenges. Due to this, there is a critical need for advanced tools capable of revealing the structural fingerprint of DOM across diverse environments. We have developed tools based on tandem high-resolution ion mobility and ultra-high-resolution FT-ICR mass spectrometry to study the molecular signature of DOM in several regions. Multiple molecular signatures are typically observed in the 2D-IMS-MS plot at the level of nominal mass. The 2D-IMS-MS of DOM is mainly composed of a single trend line of singly charged species, regardless of the sample. The MS projection can be characterized by a single, broad Gaussian distribution centered at m/z 400. An average of six and up to 12 isomers are observed per chemical formula and characteristic isomers to each section of the river continuum. A decrease in the chemical complexity and diversity (both in the number of molecular formulas and number of isomers per chemical formula) is observed with increasing salinity; this trend is representative of the biogeochemical transformations of DOM during transport and along source variations, showing both degradation products and formation of new components along the salinity transect. While the estimated number of isomeric DOM compounds consistently declines downstream, a small set of terrestrial-derived DOM components remain structurally unchanged (isomers with ΔTIMSCCSN2 values < 8%). The inclusion of the isomeric content at the molecular formula allows for the differentiation of isomeric species that are present along the transect (lignin-type components) and responsible for the DOM refractory nature. Comparison between TIMS-FT-ICR 7T MS and FT-ICR 21T MS revealed that many (~ 2/3) features were not extracted using 7T FTMS processing but were observable in 2D IMS-MS. This suggests that the ion mobility domain can be used to enhance molecular coverage and the identification of potential isomeric species with better chemical formula assignments.

Developing an Invasive Species Prioritization Tool for Everglades Restoration

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In 2020, Congress passed the Water Resources Development Act, directing the South Florida Ecosystem Restoration Task Force to develop and update a priority list of invasive species. The list is meant to represent an assessment of ecological risk and includes invasive plants and animals that have the potential to significantly impact ecological communities, native species, habitats, or key indicators of Everglades restoration progress. To meet this directive, we conducted expert elicitation exercises through stakeholder workshops involving biologists and resource managers across all levels of government (local, state, federal, and tribal), academia, and non-profit organizations. These workshops were used to generate questions quantifying the relative risk of invasion and potential impacts of non-native species. Questions were grouped into the following six themes based on their relevance to invasiveness and potential impacts to South Florida ecosystems and their restoration: abiotic factors, biotic factors, management feasibility, human impacts, ecological impacts, and system-wide impacts. Using Bayesian Generalized Linear Mixed Modeling (GLMM), we identified questions with the highest consensus for assessing invasion risk and Everglades restoration impacts. These insights were integrated into an R Shiny web application, enabling practitioners to evaluate non-native species and systematically prioritize them based on their potential threat to Everglades restoration. The tool uses model estimates from the Bayesian GLMM and dynamically updates species' priority scores as new assessments are made, producing a real-time prioritized list of invasive species. Such decision support tools are essential for effective restoration implementation and management in a changing climate, where non-native species introductions are ever-increasing and the need for prioritizing management efforts becomes ever more important. The ability to rapidly screen emerging threats to the Greater Everglades is critical for early detection and response, providing increased opportunity for timely management and effective restoration outcomes

From Release to Recruitment: Designing and Testing Release Protocols to Maximize Population Growth

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We live in a rapidly changing world, and critical action is needed to address species declines. Conservation breeding programs are a tool that can boost existing populations, repopulate areas undergoing local extinction, and rescue species from extinction. However, conservation breeding and releases are labor-intensive and costly, and must be accomplished precisely. Major information gaps can limit the effectiveness of release efforts and therefore species conservation. In particular, the degree to which factors related to the individuals and release conditions may impact settlement and recruitment is poorly understood. These issues are especially relevant for grassland birds, which are declining faster than any other group. The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is an endangered and critically imperiled grassland bird, and prior to conservation releases in 2019, there were an estimated 23 breeding pairs in the wild. The conservation breeding and release program aims to augment the wild population to prevent extinction while research continues to identify long-term solutions to the population decline. We tested the effect of age, sex, and release timing on post-release fates of conservation-bred Florida grasshopper sparrows. Released birds were color-banded, and a subset was fitted with VHF transmitters to determine short-term survival (ca. 30 days). For 2019 and 2020 cohorts, settlement and recruitment rates were significantly higher for birds released as juveniles (n=181; 25%, and 18%, respectively) compared to birds released as adults (n = 86; 13%, and 5%, respectively), and this pattern was consistent across years. Age class at release was the main factor explaining the likelihood of resighting birds at the release site in the subsequent breeding season and the main factor explaining which birds were detected breeding. We fitted generalized linear models (GLMs) to determine which factors influenced the likelihood of juveniles released from 2019 to 2023 (n=321) settling and breeding at the release site. Juveniles released later in the season had a lower probability of recruitment than birds released earlier. Together, these results inform the release strategy and contribute to observed population growth. Continued monitoring and interagency coordination are critical for ensuring that conservation goals are effectively met. This study provides valuable information for avian conservation and may serve as a framework for similar programs.

Forecasting Water Levels Using Machine (DEEP) Learning to Complement Numerical Modeling in the Southern Everglades

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Water level is an important guide for water resource management and wetland ecosystems, defining one of the most basic processes in hydrology. This research seeks to investigate the possibility of complementing numerical modeling with a Machine Learning (ML) model to forecast daily water levels in the southern Everglades in Florida, USA. An exact analytical solution to water level may not be possible, but using the computational methods afforded by ML, the traditional numerical techniques may be enhanced to generate more robust, scalable predictions. Five locations were chosen for application of the Time-Delayed Neural Network (TDNN) and Long-Short Term Memory Recurrent Neural Network (LSTM-RNN) ML models, which were built to estimate water level with 1-, 2-, 3-, 7- and 10-day forecasts using a simulation step of 1 day. The results showed that rainfall forecasts from weather models could improve water-level forecasts if the accuracy and performance of the weather models can be improved. The ML models presented here improve water-level predictions from a historical hydrologic model for a 24-hour forecast horizon.

Anticipated Benefits from the Western Everglades Restoration Project Authorized Plan

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The purpose of the Western Everglades Restoration Project (WERP) is to improve the quantity, quality, timing, and distribution of water needed to restore and reconnect the western Everglades ecosystem. WERP will reestablish ecologic connectivity from the northwest portion of the study area, across the Miccosukee Tribe of Indians' West Ranch, the Seminole Tribe of Florida's Big Cypress Reservation and into Big Cypress National Preserve and ensure applicable water quality standards are met. The authorized plan, known as Alternative Hybrid Natural Flow Revised (ALTHNFR), would achieve these benefits by redistributing water to several major remnant flow ways that lie directly south and southwest of the Lard Can Canal and southeast of the Wingate Mill and West Feeder Canals, including Kissimmee Billie Slough and Cowbell Strand. Construction and operation of the North Feeder Stormwater Treatment Area by the South Florida Water Management District within the C-139 Annex will direct treated water from the North Feeder Canal sub basin to northwest Water Conservation Area (WCA) 3A via the L-3 Canal. Rerouting water from the West Feeder Canal sub basin south into the forested wetlands of the study area by backfilling portions of the Wingate Mill and Lard Can canals will facilitate hydropattern restoration in portions of the Miccosukee Tribe of Indians' West Ranch, the Seminole Tribe of Florida's Big Cypress Reservation, the Big Cypress National Preserve, and the L-28 Triangle area, which is located entirely within the boundaries of the Miccosukee Tribe of Indians' Alligator Alley Reservation. Backfilling portions of the L 28 Interceptor Canal and the L-28 North Canal, in combination with degrading portions of the associated levees, will re-establish a flowing system in areas adjacent to Mullet Slough. Full backfill and degrade of the L-28 Tieback Canal with full backfill of the L-28 South Canal south of structure 344, in combination with the construction of three adjustable control structures and a plug in the Tamiami Trail Canal, will reconnect portions of WCA 3A to BCNP. Southern portions of BCNP, including New River and Sweetwater Strands will receive increased flows. The Chief's Report was signed September 11, 2024. The Record of Decision to support the Final Project Integration Report and Environmental Impact Statement was signed November 15, 2024. The project was authorized in the Water Resources Development Act of 2024.

North Fork St. Lucie River Floodplain Restoration: An ecological function-based approach

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The North Fork St. Lucie River is one of the most biodiverse coastal rivers in North America due to its oligohaline salinity conditions and tidal influence from warm, tropical ocean currents. The U.S. Army Corps of Engineers, in partnership with St. Lucie County, FL, is conducting a feasibility study under the Corps' Continuing Authorities Program to restore portions of the North Fork St. Lucie River that were previously channelized and disconnected from the adjacent floodplain. Specific objectives for this project include increasing hydrologic connectivity between the NFSLR and its floodplain, restoring floodplain wetlands along the North Fork St. Lucie River and its headwaters, and improving habitat for economically and ecologically important fish species, as well as rare peripheral tropical fish species that utilize the NFSLR for phases of their life cycle. This study seeks to utilize a holistic, ecological function-based approach with multi-disciplinary and multi-agency involvement to identify priority restoration sites and management measures. The project delivery team will analyze an array of potential restoration measures utilizing hydrologic and hydraulic models to assess performance in increasing floodplain connectivity and flow through remnant channel oxbows. Ecological assessment tools will subsequently be used to link hydrologic changes to improvements in floodplain wetland quality and fish habitat across an array of project alternatives.

An Introduction to Biscayne Bay Benthic and Planktonic Diatoms

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To honor the legacy of Joan Browder, I present an introduction to the diatom flora of Biscayne Bay and discuss how diatoms are used to inform about ecosystem health. Recent potentially harmful plankton blooms of *Chaetoceros* spp. and *Pseudo-nitzschia* in Biscayne Bay are described along with plankton spatial distributions. The rich epiphytic diatom communities on Biscayne Bay seagrasses are also introduced. *Proschkinia browderiana*, a recently described benthic diatom from Biscayne Bay seagrasses is presented.

A Look at Water Quality and Algae Blooms in Florida Bay

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Florida Bay has been exposed to a series of events in the past that has led to major ecological changes. Beginning with the seagrass die-off of 2015, water quality began to deteriorate, and a subsequent phytoplankton bloom began in the late wet season of 2016. Since then, Hurricane Irma along with other wind and rain events appear to have contributed to the persistence and intensification of these blooms. During the last decade, Everglades National Park has conducted extensive monitoring and research of the Florida Bay ecosystem to document long term trends in water quality and to gain insights into the dynamics of these phytoplankton blooms. Chlorophyll-a pigment concentrations, a proxy for phytoplankton biomass, were measured in water samples collected across the bay documenting the intensity and extent of each bloom event. These chlorophyll-a measurements alongside consistent monitoring of other parameters such as dissolved organic matter and nutrients allow for a comprehensive assessment of Florida Bay water quality across space and time. Results indicate that algae blooms within the bay typically exhibit patterns showing highest concentrations (and a possible point of origin) in Garfield Bight and Terrapin Bay with subsequent expansion in a southward natural flow regime or driven west by winds and tides. This work on phytoplankton blooms and nutrient concentrations in Florida Bay provides essential insights to inform the implementation of the Comprehensive Everglades Restoration Plan (CERP) for improving water quality in Florida Bay by restoring the freshwater flows.

2025 Northern Everglades and Estuaries Protection Plan (NEEPP) Regional Simulation Model (RSMBN) Update

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This effort provides an update to the Northern Everglades Watershed Protection Plan (WPP) modeling, focusing on the Northern Everglades Regional Simulation Model (NERSM), now enhanced and renamed the Regional Simulation Model – Basins (RSMBN). The RSMBN model uses a 1965–2016 climatic simulation period to evaluate hydrology in the Northern Everglades watersheds: the Lake Okeechobee Watershed (LOW), St. Lucie River Watershed (SLRW), and Caloosahatchee River Watershed (CRW). Key updates to the model include the integration of the three Northern Everglades watersheds, the incorporation of the Lake Okeechobee System Operating Manual (LOSOM) regulation schedule, and the inclusion of Dispersed Water Management (DWM) and restoration features. This update also factors in existing and planned Comprehensive Everglades Restoration Plan (CERP) projects, such as the C-44 Reservoir, C-43 West Basin Storage Reservoir, Lake Okeechobee Component A Reservoir (LOCAR), and Everglades Agricultural Area (EAA) Reservoir, providing scenarios for both current baseline and future conditions.

A key objective of the updated model was to inform future project implementation across the Northern Everglades by including existing, planned, and conceptual projects and evaluating the efficacy of long-standing watershed storage objectives. Results were assessed via contemporary environmental metrics for Lake Okeechobee stage, Northern Estuaries salinity, and water supply. Overall, this updated modeling effort affirms the existing storage goals of 900,000 to 1,300,000 ac-ft in the LOW, 200,000 ac-ft in the SLRW, and 400,000 ac-ft in the CRW and provides new projections for system performance. Each of the simulations demonstrated that the addition of projects further improves hydrology.

To date, there has been significant advancement toward storage goals. The LOW's planned projects are expected to achieve 31-45% of its goal of 900,000 to 1,300,000 acre-feet (ac-ft) of storage upon completion. The SLRW's planned projects, including the CERP Indian River Lagoon-South (IRL-S) projects, are expected to surpass the 200,000 ac-ft storage target. The CRW's future projects will meet 47% of its 400,000 ac-ft storage goal. These results demonstrate the critical role of ongoing and planned projects in improving water storage capacity across the Northern Everglades, supporting long-term hydrologic, ecological, and water supply goals.

Multitemporal Geophysical Mapping of Saltwater Intrusion in the Southern Region of the Everglades National Park

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The Everglades National Park is a critical ecosystem increasingly threatened by climate change, particularly rising sea levels. Geophysical methods like Vertical Electrical Soundings are used to assess groundwater properties such as salinity. Vertical Electrical Soundings help characterize subsurface resistivity providing insights into the distribution of fresh and saline water, which is crucial for understanding the extent of saltwater intrusion. This study used Vertical Electrical Sounding data collected at eight locations on the main park road of the Everglades National Park, which extend 20 km inland from Florida Bay. Soundings were collected in May 2021, May 2022, November 2022, and May 2023 using the AGI Super Sting RI IP resistivity imaging system with an expanding Schlumberger array with 6 AB/2 lengths ranging from 0.5 to 16 meters. This provides an effective depth resolution of about 6 meters. Greater array lengths were used but did not produce consistent results for all the sites and dates. Sounding data were inverted to smooth multilayer resistivity-depth models. They were then interpolated into a south-north profile and converted to salinity models by applying Archie's Law with a formation factor of 5.5 and a standard formula. Results indicate spatial and salinity changes in the aquifer, where the saltwater intrusion front is around 12 to 15 km north of Florida Bay, just north of Nine Mile Pond. This coincides with the surrounding vegetation, where mangroves dominate near the bay, and then transitions to freshwater marl prairies. At the end of the dry season (May), the saltwater intrusion front at elevations of -1 to -3 meters moves 1 to 3 kilometers inland relative to the end of the wet season (November). These variations suggest a dynamic interaction between groundwater and surface water, potentially in factors such as rainfall patterns and tidal forces. Deeper groundwater dynamics below -3 meters are more complex due to natural aquifer heterogeneity and data noise, however, clear and reliable salinity patterns are observed above this depth. Further investigation is needed to enhance data collection and assess whether the brackish to fresh boundary is moving further inland due to sea level rise.

South Florida Deer Study

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White-tailed deer (*Odocoileus virginianus*) are one of the most valued game species in Florida. In South Florida, deer are also the primary prey of the endangered Florida panther (*Puma concolor coryi*). Harvest and aerial monitoring data suggested deer have experienced population declines in portions of South Florida where environmental conditions and the predator community have changed substantially since the 1990's. However, the specific causes of the declines were unclear. To investigate the potential causes and to gain a better understanding of deer ecology in South Florida, in 2015-2018 Florida Fish and Wildlife Conservation Commission partnered with University of Georgia and others to conduct a large-scale, multi-year deer research project in Big Cypress National Preserve and Florida Panther National Wildlife Refuge. The two main objectives were to (1) assess the effects of hydrology, hunting, and predation on population dynamics of white-tailed deer and (2) to develop a monitoring method using remote-sensing cameras. We captured 294 deer and fitted 263 (172 females and 91 males) with GPS collars. We used telemetry data to evaluate cause-specific mortality, annual and seasonal survival, and factors influencing mortality risk for adult deer. Females had greater survival probability than males, except during fawning season. Predation was the primary cause of death and majority of predation events were attributed to panthers. Increasing water depth decreased female survival but had little impact on male survival, and drowning was never a cause of mortality. Hunter harvest had a negligible effect on the deer population, however, only a portion of the deer were potentially eligible for harvest. We deployed 180 trail cameras across the study area in three grids and developed camera-based methods to investigate spatiotemporal trends in detection rates for deer and their predators. We combined the camera and telemetry data to develop a generalized spatial mark-resight SMR model to estimate density and abundance of deer. This novel method allowed for density and detection parameters to be estimated even when the vast majority of camera detections were of unmarked individuals. We provide an overview of white-tailed deer populations in South Florida and discuss the challenges of research and management of deer in this unique ecosystem.

Elevated Science: Drone use in STA vegetation research

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The Everglades Stormwater Treatment Areas (STAs) are designed to remove phosphorus (P) from agricultural and urban stormwater runoff prior to delivery to the environmentally sensitive Everglades Protection Area. Wetland vegetation communities within STAs are an essential component for effective P removal from surface waters and retention in STAs. Several research projects conducted through the South Florida Water Management District's Restoration Strategies Science Plan (RSSP) evaluated mechanisms of P removal and management of STA vegetation communities to optimize P removal and retention. High-resolution drone imagery has been incorporated into multiple areas of District operations including environmental monitoring and research projects. This presentation will review drone use within recent RSSP studies to illustrate how drone imagery can be leveraged to assess changes in wetland vegetation at unique spatial and temporal scales. Case studies include field-level comparisons of emergent vegetation loss due to prescribed burn alone or in combination with prior herbicide treatment, monitoring fish herbivory on establishment and growth of submerged aquatic vegetation (SAV) and a draw-down study where germination and recovery of SAV after extended dry out was monitored upon rehydration. The use of drones to quantify vegetation cover and 'ground truth' satellite imagery to improve accuracy of satellite-based vegetation classification maps across the STAs will be discussed. Drone technologies will continue to improve and provide unprecedented flexibility in collection of large spatial scale, high resolution datasets. It is encouraged that all wetland scientists and managers evaluate the potential of drones to help elevate their future research and monitoring efforts in these important ecosystems.

Integrating Restoration Strategies Science and STA Management: Part III Field Scale Trial of Soil Consolidation and SAV Recovery

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Everglades Stormwater Treatment Areas (STAs) are constructed wetlands designed to reduce phosphorus (P) concentrations entering the Everglades Protection Area. Research studies carried out by the South Florida Water Management District's Restoration Strategies Science Plan (RSSP) have improved our understanding of P retention and wetland sustainability within STAs. RSSP studies demonstrated at a laboratory scale that drawdowns consolidate STA soils, improving soil stability and reducing water column total phosphorus (TP) levels. Additional mesocosm studies demonstrated soil consolidation and drying supports short-term germination of *Chara* spp., which may reduce P flux into the water column. Germination triggered through consolidation may be an effective management strategy for encouraging submerged aquatic vegetation (SAV) recovery in areas where populations have declined. STA-1E Cell 2 was recently drawn down for approximately 12 weeks to repair erosion following tropical storm events. This repair activity created an opportunity to evaluate response of STA soils and SAV species to drawdown driven consolidation at the field scale. This field trial evaluated SAV germination and recovery following rehydration, persistence of soil consolidation, and the interaction between the SAV presence and soil consolidation. Sixteen plots within four transects across non-vegetated portions of the cell were monitored for water column depth, depth of unconsolidated soil, and SAV presence and coverage changes for 22 weeks. Soil samples were periodically collected to determine differences in bulk density and organic matter concentration, as well as changes in vegetation biomass over time. *Chara* spp. germination occurred within the first week of rehydration and total coverage increased over time at all locations. *Chara* spp. coverage at two northern transects increased faster than southern transects potentially due to soil turnover by construction activities. Measures of water column depth, unconsolidated soil level and bulk density indicate nominal and variable soil expansion over time with changing water stages. There was little to no difference in soil consolidation metrics across SAV coverage and time. Results from this field trial point to the efficacy of drawdowns in encouraging SAV germination within STAs. Methodology and lessons learned from this field trial offer useful information for ongoing and future studies assessing soil and vegetation dynamics across variable STA conditions.

Indigenous Traditional Ecological Knowledge and Species Distributions Update Water Level Targets

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Despite continuous improvements to researchers' and managers' understanding of Everglades ecology and hydrology, the Central Everglades continues to experience declines in wildlife, loss of floral biodiversity, and degradation of landscape features such as tree islands. These ecological impacts are largely related to decades of unnatural high-water levels in the region. Tribal researchers are melding indigenous traditional ecological knowledge (ITEK) and modern scientific techniques to develop an improved understanding of what the natural high-water levels were in the Central Everglades. ITEK is being used to identify the current and former locations of hardwood hammock plant species because these flood-intolerant plants could only exist where elevation was sufficiently high to evade prolonged inundation. Thus, the elevation at which hardwood hammock species occur(ed) reflects the upper threshold at which water levels naturally occurred. The locations and elevations of hardwood hammock plants identified through ITEK is being surveyed using GNSS and other methods with high vertical accuracy. Tribal researchers are collaborating with the United States Army Corps of Engineers and National Parks Service to synthesize the ITEK and elevational data to recommend an ecologically based high-water threshold that more closely resembles natural hydrologic conditions and improves the ecological well-being of the Central Everglades.

Comparing Wetlands on Tribal Lands to Similar Systems in an Adjacent National Preserve

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The Big Cypress Seminole Indian Reservation, located in Hendry and Broward counties, includes a 14,980-acre natural area which abuts the northern boundary of the Big Cypress National Preserve. The dominant natural communities within the "Native Area" include cypress strands, pine flatwoods, wet prairies, and mixed swamp forest. These natural systems have been impacted by regional drainage projects, fire suppression, and historical logging operations. Within a larger EPA-funded floristic inventory, a component of the project sought to compare deep water wetlands (dominated by bald cypress - *Taxodium distichum*, pond apple - *Anona glabra*, and pop ash - *Fraxinus carolinensis*) within the Big Cypress Seminole Indian Reservation to downstream sites within the Big Cypress National Preserve. The sites selected within the national preserve, being farther from major canals, were presumed to be less hydrologically impacted and chosen to serve as "reference sites" for comparable on-reservation sites. A total of 258 vascular plant species were documented in the study. More than 95.7% of the species are native to Florida. The study documented 20 species listed as endangered, threatened, imperiled, or critically imperiled. Contrary to the working hypothesis, floristic quality index scores of the sites within the reservation were higher than the reference sites despite the proximity to major drainage features. It appears that deep water wetland systems (dominated by *Fraxinus* or *Taxodium*) may be relatively resilient to the landscape-level disturbances that have altered the greater Big Cypress ecosystem while the effects of canalization are more perceptible at higher elevation sites because of a greater disruption to the fire regime.

Physical Stability of Typha and Marl Soils in Everglades STAs

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As new soil accumulates in treatment wetlands over time, soil characteristics including physical or chemical stability may change, potentially affecting vegetation conditions and water treatment performance. Turbid waters have been observed where vegetation is absent in regions of the Everglades Stormwater Treatment Areas (STAs), large, constructed wetlands that require phosphorus (P) removal to very low levels. This has raised concerns over soil stability, particularly where inorganic marl soils formed by submerged aquatic vegetation (SAV) have accumulated in many STA middle and outflow regions. These marls can occur as fluid, unconsolidated material, and contrast in several ways to antecedent, predominantly organic soils (Histosols) upon which many STAs were constructed, and to higher-organic matter (OM) soils associated with emergent aquatic vegetation (EAV) communities dominated by *Typha* spp. in the STAs. Drying of the soils is a potential method to increase stability and reduce resuspension and was evaluated here with soil core experiments that demonstrated that drying reduced soil volume and temporarily increased physical stability upon rehydration. To minimize P flux associated with drying, we also investigated amendments of low-P OM on these inorganic marl soils. These amendments did not enhance soil stability nor reduce P flux following consolidation and rehydration, compared to unamended controls. In laboratory experiments without vegetation present, this study demonstrated that higher-OM soils associated with EAV communities had greater P flux after drying and were more susceptible to resuspension than marl soils associated with SAV. Results indicated it may be beneficial to moderate the OM enrichment of soils in downstream cells by controlling the expansion of EAV to avoid instability, reduce potential for internal soil P flux and improve STA performance. The effects of drying on consolidation and physical stability were also negated after 12 weeks of rehydration. A separate experiment found that consolidation through drying supported *Chara* germination within a week of soil reflooding, recruitment of which could improve soil stability and P retention in previously non-vegetated areas. Therefore, consolidation through drying may provide a temporary window of opportunity for SAV germination and regrowth in bare soils.

Characterization of Spatial and Temporal Dynamics for Vegetation in the Everglades Stormwater Treatment Areas through a Spectrally Focused Remote Sensing Approach

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Everglades Stormwater Treatment Areas (STAs) are constructed wetlands designed to remove phosphorus from agricultural and urban runoff before it is discharged into the Everglades. Vegetation in the STAs play a critical role through processes that include nutrient uptake, soil stabilization, and water flow regulation. The study was initiated to detect and document the temporal and spatial changes for the vegetation communities in these systems using 8-band PlanetScope images. This research employed the Spectral Angle Mapper (SAM), which is a supervised classification technique (a method that relies on training data to guide the categorization of spectral data) to map and quantify various vegetation classes. Ground validation data confirmed that the detailed vegetation maps generated in this study were highly accurate and consistent based on imagery collected in November 2023, February 2024, June 2024, and August 2024. This method was then applied to examine historical seasonal vegetation changes dating back to 2021, providing a broader understanding of long-term trends. This approach also facilitated the monitoring of various management activities in STAs, such as evaluating the impact of vegetation on water stage drawdown, assessing outcomes and recovery rates from herbicide or prescribed fire treatments, and optimizing vegetation composition percentages. These findings are crucial for guiding STA management, as they offer insights into how vegetation dynamics have evolved over time. This approach was more cost effective and accurate than traditional airboat surveys, making it a valuable tool for ongoing STA vegetation management and optimization.

Hydrologic Determinants of Everglades Crayfish Presence and Aboveground Biomass in the southwestern Everglades

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The recovery of historical wading bird nesting aggregations in Everglades National Park is a major goal of Everglades restoration. Everglades crayfish (*Procambarus alleni*) are important prey for nesting wading birds, are sensitive to hydrological conditions and management, and can directly link restoration efforts to wading bird nesting effort. Despite their demonstrated importance to nesting wading birds in the Everglades, there has been no recent effort to model *P. alleni* abundance in relation to antecedent hydrologic variation using available long-term datasets. Moreover, the seasonal wetlands they consistently inhabit have been less frequently monitored than long-hydroperiod sloughs. We used data from multiple multi-year monitoring studies to determine the major hydrologic predictors of *P. alleni* presence and aboveground dry biomass (g/m2) in the southwestern Everglades with the ultimate goal of assessing how predicted crayfish abundance relates to known wading bird nesting. As a first step of this modeling effort, we analyzed the effects of multiple hydrologic predictors on Everglades crayfish presence and biomass density in the wet and dry season, separately, using boosted regression trees and interpreted the effects of each variable from model predictions. In the wet season (October), *P. alleni* was most likely to be present when average long-term (2- to 5-y) hydroperiods were < 300 days, while in the dry season (January–February) presence was promoted with average long-term hydroperiods from 250–325 days. The major determinants of *P. alleni* presence were the number of days since water depth was < 5 cm (DSLDD) in the wet season and the length (severity) of the most recent hydrologic disturbance (days with water depth < 5 cm; LD5) in the last dry season, with the likelihood of P. alleni presence increasing when DSLDD was low and LD5 was high. The biomass model fits were poorer overall but predicted that aboveground dry biomass was greatest when average long-term hydroperiods were 300–340 days, decreasing precipitously when average hydroperiods approached permanent flooding. Biomass in both the wet and dry season was predicted to be greatest when the length of the dry disturbance was > 80 days long, depth at the time of sampling was between 25 and 45 cm, and when average depth had been relatively deep (> 30 and 70 cm in wet and dry season, respectively) over the past 6 months. The results of both analyses consistently indicate that *P. alleni* populations require a seasonal drying event (depths < 5 cm), that drying for up to 80 days can increase observed biomass, and yet that deeper water over the past half year of the wet and dry season can have positive effects on biomass. Our work provides the best description of the complex relationships between hydrologic conditions and Everglades crayfish abundance that will be crucial in developing evaluations of hydro-restoration expectations for Everglades crayfish in the southwestern Everglades.

Variation in Adult Burmese Python (*Python molurus bivittatus*) Survival in Southern Florida

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Burmese pythons (*Python molurus bivittatus*) are a damaging invasive species within the Greater Everglades Ecosystem with a population that is regionally expanding. Age-specific survival estimates, currently unknown for pythons, can be used to inform managers of population size estimates, determine if localized populations are increasing or decreasing, understand what level of removals are required to achieve population decline, and target vulnerable life stages for removal. From 2005 to 2023, we used VHF radiotelemetry to track survival of 224 free-ranging adult Burmese python from six locations spanning much of their invaded range in southern Florida. We estimated sex-specific survival at each location (i.e., southwest Florida, two locations in Big Cypress National Preserve, Everglades National Park, Francis S. Taylor Wildlife Management Area, Crocodile Lake National Wildlife Refuge). Results from the known fate Cormack-Jolly-Seber models indicate that annual survival estimates varied across the regions sampled, but were higher for males (67-94%, n=145) than females (52-90%, n=79). We found no influence of size on male or female survival estimates. Estimates were lowest in Everglades National Park (ENP) for both sexes (females, 60%; males, 74%) even when factoring in a historic cold snap occurring in 2010 (females, 52%; males 67%). Our results provide the first estimates of adult python survival in the invasive range and indicate that there is landscape scale variation in this demographic parameter. These estimates are an important component of ongoing efforts to complete a Burmese python life table, with the goal of providing informed abundance estimates to examine influence of removals on the python population trajectory. Survival estimates can be incorporated into modeling efforts to help managers predict spread, population growth, or decline, and therefore our results may have implications for successful management of pythons in different areas across their invasive range.

Integration of Resilience Efforts through Federal, State, and Local Governments.

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Building resilience requires coordinated efforts from all levels of government; no single entity can build resilience alone. The problems related to long term resilience are uncertain, broad, and complex and it is essential to survey and assess relationships among all public and private sector deliverables and capabilities at local, regional, state and federal levels – to determine the most appropriate and effective packaging of programs, projects, and services to accomplish resilience and sustainability objectives. Each level of government has an important part to play and partners like those in Miami-Dade, Palm Beach, and Broward counties and the SFWMD are already working on their parts. USACE ongoing and future projects across business lines are part of the federal resiliency.

In low lying areas like south Florida, the inland and coastal drivers of flooding must be viewed together to understand the risks to these coastal communities and how to plan projects to increase community resilience. The inland drivers and coastal forcings tend to meet in the coastal ridge area resulting in compounded water levels and increased damages. Increased rainfall runoff, due to loss of inland storage resulting from urbanization and loss of natural ecosystems, combines with higher groundwater levels, exacerbated by sea level rise, to negatively impact flood risk in these communities. To address the many drivers of flood risk, the multiple lines of defense concept are being employed to combat different climate change variables and increase community resiliency. Federal, state, and local efforts from the coast to inland areas work together to address the various sources of flooding. This presentation will explore the mechanisms of integration and the focus areas that may lead to successful resilience outcomes.

Examining near term hydrologic forecasts for the Greater Everglades

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The Everglades Forecasting application, EverForecast, is a hydrologic and multi-species web tool designed to support natural resource management in the Everglades. At the start of each month, the tool simulates water levels for the upcoming six months across the Greater Everglades and models potential impacts on the habitats and populations of numerous species such as: American alligator (*Alligator mississippiensis*), Cape Sable seaside sparrow *(Ammospiza maritima mirabilis)*, and wood stork (*Mycteria americana*). To produce these monthly simulations, EverForecast combines precipitation forecasts from the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center's 3-month average precipitation outlooks with historical water stages from the Everglades Depth Estimation Network (EDEN). It then calculates the central tendency of water stages and generates 150 stochastic simulations using Monte Carlo to capture the range of possible future hydrologic outcomes. While EverForecast was validated using a hindcast, current forecasts are not regularly evaluated. To evaluate EverForecast's performance under ongoing ecosystem restoration and changing climatic conditions, we compared the forecasted water stage values to recorded water stage values at approximately 200 gages located across the Everglades. This comparison aims to answer questions such as: (1) does the forecast capture the range of natural variation in the recorded water levels? and (2) how closely does the forecast predict recorded water levels? These metrics highlight gage locations where the forecast performs better in the dry season versus the wet season and if there is a spatial pattern in performance across the Everglades landscape. The results of this analysis enable informed decision making by providing users with critical insights into the accuracy of EverForecast's predictions for different seasons and at each gage across the Everglades landscape.

ETree: Everglades Tree Island Indicator Web Application

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Tree islands, which are elevated tree-covered mounds within the Everglades, provide some of the most biodiverse and socio-culturally revered parts of the wetlands. Of critical cultural importance, the tree islands are the traditional homes of the Miccosukee and Seminole Tribes of Florida, and several contain their ancestral remains. Due to flooding and water management, degradation and destruction of the islands continue. ETree is a decision support tool that shows real-time and historical flooding status on hundreds of tree islands in Florida's Everglades. Decision makers can use ETree to help manage water flows and depths to protect these critical sites. In 2022, USGS began co-designing the ETree dashboard with the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida to determine inundation metrics of importance for tree island condition. The USGS consulted additional state and federal partners on ETree functionality while developing the ETree dashboard. Published in early 2024, ETree continues to be edited and improved with continued additions planned, based on feedback from users, collaborators, and managers. The USGS is currently collaborating with REstoration, COordination, VErification (RECOVER) to leverage ETree in the development of a RECOVER Tree Island Performance Measure to establish hydrologic targets for tree islands within different regions of Water Conservation Area 3A and Everglades National Park.

Eastern Palm Beach County Flood Protection Level of Service Assessment for Current and Future Conditions

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The South Florida Water Management District (SFWMD) is conducting a system-wide review of its regional water management infrastructure to assess the Flood Protection Level of Service (LOS) for water management facilities within Eastern Palm Beach County. The Flood Protection LOS evaluates the level of protection offered within a watershed, taking into account sea level rise (SLR), future development, and known water management issues. The results from the LOS study will help SFWMD and local partners identify areas where improvements to the design, retrofit, construction, or operation of water management facilities are needed or beneficial.

This project covers the L-8, C-51 West, C-51 East, C-17, C-16, C-15, and West Palm Beach watersheds, which are characterized by a mix of urban, natural, and agricultural land uses. These interconnected watersheds include operable structures that can discharge to both inland and tidal areas, depending on system conditions. Inland discharges may route flows to Lake Okeechobee, the adjacent S-5A watershed, or stormwater treatment areas (STAs) that reduce nutrients before discharging to Water Conservation Area 1 (WCA-1) within the Everglades Protection Area. The tidal areas include the Lake Worth Lagoon and Coral Reef watersheds.

An integrated surface water and groundwater model was developed and calibrated to simulate design storm events for both current and future conditions. Four design events with return periods of 5, 10, 25, and 100 years were simulated. Future conditions incorporated land use changes, rainfall adjustment factors, and three SLR scenarios, including the effects of SLR on groundwater conditions. Simulation results were evaluated using six performance metrics.

Acoustic Monitoring to Assess Restoration Strategies

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Acoustic monitoring is a valuable tool for tracking ecosystems and wildlife populations by analyzing the soundscape, which includes biophony (wildlife sounds), anthrophony (human-made sounds), and geophony (natural, non-wildlife sounds like wind and rain). This method involves recording sound, converting it into a spectrogram using a Fourier transform, and analyzing it with acoustic indices to assess variations in frequency and amplitude. The Acoustic Complexity Index detects changes in amplitude, potentially indicating animal calls, while the Acoustic Diversity Index tracks frequency variations to estimate species diversity. Acoustic indices are particularly useful for evaluating restoration impacts on cryptic or under-surveyed species. In a previous study in Water Conservation Area 2A, it was found that reclaimed areas, previously dominated by cattails, exhibited increased usage by waterfowl and wading birds, while secretive marsh birds remained in the cattail stands. To better understand bird and amphibian use of the reclaimed habitat, six acoustic recorders were placed across various habitats: two in restored cattail areas, two in non-restored cattail areas, and two in natural ridge-and-slough habitats. Results from the January 2025 acoustic monitoring study show soundscape differences across the three habitats, factors driving variations in acoustic indices, and the wildlife identified in each habitat. Using acoustics to understand the habitat usage of cryptic and under-surveyed species, will help managers better assess the broader impact of different restoration strategies on the wildlife community.

Everglades Depth Estimation Network: Data, Maps, and More

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The Everglades Depth Estimation Network (EDEN) is an integrated network of water-level gages, interpolation models, and applications that generates daily water-level and derived hydrologic data across the freshwater portion of the greater Everglades landscape. EDEN utilizes real-time water-level data from gages operated by the US Geological Survey, South Florida Water Management District, and the National Park Service. Each day, water-level data from these sites are recorded, compiled, and reviewed using an automated process that utilizes univariate filters and empirical models to screen the data for erroneous or missing values. Following the automated screening, the data is reviewed by a hydrologist for approval. Reviewed data are available from a web service, along with multiple data products designed to provide decision support in the management of water resources and ecological health. These data products include water surface level maps, flow vector maps, statistics, and more. This talk will provide background information about EDEN and highlight recent advances in data management and pipeline resiliency.

Estimating Burmese Python Abundance in Their Invasive Range in South Florida

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Management of invasive species benefits from information on abundance and changes in abundance, but abundance metrics can be difficult to obtain for many species. For Burmese pythons in south Florida, traditional abundance estimation techniques such as capture-mark-recapture are difficult to apply due to the species' cryptic nature and because methods are counter to management goals (i.e., removal). Ideally, data collection for abundance estimation complements and integrates data collected through the management process. We developed a removal model that uses site-specific removal counts and relevant covariates and applied it to a subset of Burmese python removal data available through a statewide removal program. We also explored incorporation of telemetry data to define the spatial extent of abundance estimates to generate the often more useful density estimates. Here, we report and compare methods and results of the initial removal model and the combined telemetry information model. We discuss current interpretations and limitations of the models and discuss how they may be further improved upon. Ultimately, we plan to use these removal models to develop a multi-season model to estimate python density in the Everglades Francis S Taylor WMA and aid science-based management efforts of Burmese pythons in South Florida.

Biodiversity Hotspots of Satellite-Tracked Marine Turtles in the Florida Keys National Marine Sanctuary

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Use of marine protected areas (MPAs) to preserve habitat for imperiled marine vertebrates is an important tool for conservation managers. The Florida Keys National Marine Sanctuary (FKNMS), one of 14 MPAs that comprises the U.S. National Marine Sanctuary System, was designated in 1990 in response to a series of ship groundings, mounting threats from coral disease, and declining water quality. The sanctuary covers 9,947 square kilometers of waters surrounding the Florida Keys; these waters are part of the Greater Everglades Ecosystem and include the third largest coral barrier reef ecosystem in the world with more than 6,000 species of marine life and important cultural resources. In order to assess the use of habitats within FKNMS by marine turtles, we satellite-tracked 200 imperiled marine turtles from 2008-2021 including threatened loggerheads (*Caretta caretta*), endangered green turtles (*Chelonia mydas*), endangered hawksbills (*Eretmochelys imbricata*), and endangered Kemp's ridleys (*Lepidochelys kempii*). Tagging sites were located in Florida (Florida Keys, Dry Tortugas National Park, Everglades National Park, Biscayne National Park, Broward County), Alabama (Gulf Shores), and the Yucatan, Mexico. We used various movement modeling tools including a switching state-space model, utilization distributions, and kernel density estimation (KDE) techniques to quantify turtle habitat use. We overlaid individual turtle KDE polygons onto a 5 km x 5 km grid of the study area, which covered the continental shelf on both coasts of Florida from Tampa Bay in the north to ~ 75 km south of Key West. We then summed overlapping polygons in each non-zero grid cell and enumerated these values visually to show counts of species and diversity of tagging locations. Finally, we visualized the turtle high-use zones within FKNMS. Multispecies hotspots were located both inside (60%) and outside (40%) currently designated national wildlife refuges, FKNMS, and national park boundary lines. Several important hotspots serve as year-round habitat for adult marine turtles, including Dry Tortugas and an area to the east of the Marquesas in the Key West National Wildlife Refuge. This unique geospatial dataset provides managers with a marine spatial planning tool, as currently proposed sanctuary protection areas and other areas of human use may be evaluated against high biodiversity zones that have persisted across 14 years of telemetry studies.

Nature-based Flow Re-connection of Everglades Wetlands to Sustain Water and Ecological Resources

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Freshwater is a limited resource in the Everglades under pressure to meet societal demands while sustaining ecological resources. Water management presently makes use of a legacy system of canals that originally served for wetland drainage and flood control. Later, levees were added to store water in Water Conservation Areas (WCAs), which established the canals as the principal conveyance pathways, largely disconnected from wetlands. Canals have limited capacity to store excess water, which during storms requires that the flood waters that historically sustained downstream wetlands in Everglades National Park be shunted through canals to the Ocean. Nature-based re-plumbing of the wetlands is now underway by Federal and State partners in the Central Everglades Planning Project-South (CEPP-South), including selectively removing levees, modifying canals, and managing vegetation communities. The intention is to remove impediments to increase wetland sheet flow that can improve water storage, habitat quality, and downstream delivery to better hydrate wetlands of Everglades National Park.

A challenge for Everglades restoration is, when engineering controls are lessened and more water is routed through the wetlands, the changing hydrologic regime can cause vegetation and water quality to evolve toward uncertain and sometimes, undesirable endpoints. Scientific projects that anticipate a more free-flowing Everglades are presented, including 1) summary of findings of the Decompartmentalization Physical Model (DPM) team who investigated prototype high-flow releases between wetland basins and hydraulic and ecological responses over a decade, 2) hydrologic modeling of flow restoration ranging in spatial scale from a few kilometers to the whole system, on timescales from days to decades, and 3) potential applications of satellite remote sensing to observe future changes in vegetation condition and water level as restoration progresses.

Implications for how sediment and nutrient transport conditions may evolve under restoration are explored to assess how much flow is restorative in the Everglades and what hydrologic thresholds are potentially excessive and harmful to habitats. Research outcomes can provide useful guidelines for adaptively managing Everglades restoration. The measurement and modeling approaches also advance a general understanding of wetland biophysical interactions that can inform water managers about hydrologic and ecological balance points that support valuable natural functions, societal values, and multiple uses of wetland ecosystems.

Performance Standards from a Biophysical Simulation of Everglades Sheet Flow

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A central challenge for water managers is to adaptively manage water availability to meet societal needs while simultaneously protecting ecosystems. Progress restoring Everglades wetlands requires simulations of how increased flow can rehydrate and restore functions of downstream wetlands without causing unintended harms. Our biophysical flow rate expression (*Bio*FRE) simulates flow of surface water based on hydraulic theory and measurements of spatially variable vegetation and microtopography throughout the Everglades. *Bio*FRE simulations of surface flow compared well, without calibration, against independently measured hydrologic data at five sub-basins representing various levels of wetland degradation throughout the Everglades. To help understand how changing vegetation and microtopography altered historical Everglades flows, we benchmarked *Bio*FRE simulations against published simulations of historical Everglades hydrology using the Natural Systems Regional Simulation Model (NSRSM v 3.5.2).

*Bio*FRE simulations of present and historical Everglades hydrology indicated that the surface flow capacity of the Everglades has decreased by approximately half compared to the historical Everglades, primarily because of the loss of sparsely vegetated deepwater sloughs. Remaining sloughs are fewer, less well connected, and more densely vegetated, causing increased hydraulic roughness, lower flow capacity, and diminished water storage, habitat value, and drought and flood resilience. We quantified the sensitivity of simulated flows to biophysical variables such as ridge proportion, microtopographic height, vegetation stem density, and slough connectivity, and we assessed their potential value as restoration performance measures.

The BioFRE simulation approach can be used in the Everglades and other wetland floodplains to anticipate changing conditions and to help mitigate potential negative outcomes associated with excessive dry downs, floods, and phosphorus pollution. The relative importance the role of individual biophysical attributes was ranked. Ridge proportion and slough vegetation density were the most important factors, followed by ridge vegetation density, microtopography, and metrics of ridge shape and directional connectivity of sloughs. Some of those attributes can be considered for use as restoration performance measures because of their close association with ecosystem function and societal values. Although vegetation mapping is common, there has been little attention to measuring vegetation density and landscape metrics such as ridge proportion as performance measure, despite their importance to water storage, flood heights, habitat quality, and others. We close by demonstrating how commonly available remote sensing data could be periodically analyzed to quantify the vegetation and landscape characteristics that can help assess restoration performance and outcomes for society.

Monitoring Restoration and Recovery of Impounded Mangroves in Oleta River State Park

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Hydrologic alterations such as berms or roads can stress mangrove forests by limiting circulation and creating prolonged periods of standing water. Hydrologically stressed mangrove systems may maintain live vegetation but remain fragile and can be driven towards mortality by additional stress. Oleta River State Park, located in Miami, Florida, is the largest urban state park in Florida and lost 11 hectares of mangroves due to park roads restricting surface water flow, resulting in ponding. Hydrologic restoration, including culvert installation and channel clearing, improved tidal connections between Biscayne Bay and the impacted mangroves. Ecological conditions and hydrologic characteristics were monitored pre- and post-installation of culverts, following a before-after-control-impact monitoring design. Three areas in Oleta River State Park were characterized as either low, medium, or high stress based on visual indicators including tree mortality. Three 5 x 5-m plots were established in each of the stress conditions and monitoring occurred semi-annually at each plot. Pre-restoration data from Oleta River State Park surface sediment analyses show higher percent organic carbon and lower dry bulk density (g/cm^3) in stressed, impounded forests than in healthy forests. Following restoration, salinity significantly increased in the impounded mangrove forest and dissolved organic carbon decreased as a result of improved tidal connectivity with Biscayne Bay. Mangrove growth continued to improve in the impounded forest. Information gained from this study will offer valuable insight on future mangrove restoration efforts and create quantifiable goals for ecosystem recovery.

Use of Curcumin for Mitigation of the Toxic Dinoflagellates *Karenia brevis* and *Alexandrium monilatum*

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The mitigation potential of curcumin, a phytochemical and the primary bioactive compound found in turmeric (Curcuma longa), a member of the ginger family (Zingiberaceae), for the mitigation of both cells and toxins associated with blooms of the toxic dinoflagellates *Karenia brevis* and *Alexandrium monilatum* was investigated in a series of laboratory and mesocosm experiments. A dose of 5 mg/L curcumin was effective in reducing *K. brevis* cells concentrations by 89% and total brevetoxins by 60% compared with controls (no addition) within 24 hours in 1.5 L beaker experiments. Similar efficacies were observed in replicated large volume (1,400 L) mesocosm experiments with curcumin and *K. brevis*, with no impact observed on the mortality rates and behavioral responses of hard clams (*Mercenaria* spp.), sea urchins (*Lytechinus variegatus*), and blue crabs (*Callinectes sapidus*) after 48 hrs. A dose of 10 mg/L curcumin reduced *A. monilatum* cell concentrations by 28.9% within 24 hours in laboratory experiments, suggesting that while effective against other HAB species, the optimum curcumin dose is species specific and likely higher for thecate dinoflagellates. Once state and federal permitting requirements are met, curcumin will be tested in situ within a *K. brevis* bloom using replicated limnocorrals.

Temporal and Spatial Trends of Air Temperature, Precipitation, and Drought Characteristics in Florida: Implications for Climate Change Adaptation

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Changes in weather patterns have critical implications for agriculture and infrastructure, with extreme events such as intensive storms and droughts expected to become more frequent and severe due to global warming. However, understanding how quickly these patterns are changing, especially at local and regional scales, remains complex. This study analyzed historical weather records from Florida to assess the progression of climate change in subtropical and tropical regions, aiming to support data-driven decision-making for mitigating potential impacts. Using daily weather observations from 950 stations across Florida between 1892 and 2022, compiled from the Global Historical Climatology Network (GHCN)-Daily database of NOAA, we quantified key climate characteristics, including air temperature (hot days, tropical nights and cold days), rainfall (depth, intensity, duration, and pauses), and drought indices. These variables were assessed for statistically significant trends by stations and regions. The study found that annual average air temperature, potential evapotranspiration (PET), and rainfall increased by 1.0% (0.2°C), 3.0% (35.4 mm), and 0.3% (4.4 mm) respectively, in the recent 30 years, compared to the entire analysis period. Notably, the daily minimum temperature increased more rapidly than the maximum. The frequency of hot days and tropical nights rose by 0.9 and 7.4 days, while cold days decreased by 0.1 days, on average. South Florida exhibited more pronounced increases in temperature and PET, suggesting a northward shift in hardiness zones and a potential rise in drought frequency and severity, which could increase agricultural water demand. In contrast, North Florida saw greater increases in daily rainfall event depths and return periods, with more frequent rainfall in recent decades. These results highlight an increased occurrence of extreme weather events and underscore the need to reassess where agricultural crops are grown within the State and the appropriate agricultural management and infrastructure design practices to address the changing climate. The results also emphasize the critical importance of creating and applying adaptive strategies that are guided by comprehensive data and customized to address the distinct climate challenges encountered by various regions across the State. This study enhances our understanding of climate change's trajectory in Florida and provides valuable insights for mitigating its impacts through informed decision-making.

Asian Swamp Eel Prey Use and Selection in the Everglades

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The Asian Swamp Eel, *Monopterus albus/javanensis*, is a tropical fish that was introduced to Miami in the 1990s and invaded the Everglades around 2005. It has already been associated with crashes in several species of small animals in Taylor Slough of Everglades National Park. We quantified prey use, prey importance and selectivity of the Asian Swamp Eel in marshes across the Greater Everglades, their energetic dependence on different prey types, and the relative vulnerability of different prey to consumption. Our specific objectives were to (1) understand and quantify the energetic importance of different prey types across ontogeny and populations of Asian Swamp Eels from regions with different establishment histories, and (2) assess prey selection for larger collections of eels (N≥10) by comparing prey densities in the diet to prey densities collected from long-term prey availability data corresponding sites where eels were captured. We dissected 843 swamp eels (42–924 mm total length (TL)) collected over a 15-year period from Everglades conservation areas and Everglades National Park with 79% (N = 662) having contents in their gut for analysis. We predicted that recently established eel populations would exhibit greater reliance on fish and crayfish, while longer established populations would demonstrate greater reliance on odonates. Additionally, we expected that swamp eels would show an ontogenetic dietary shift, with smaller eels consuming higher proportions of insects and small crustaceans. Lastly, we anticipated that some species, like crayfish, would be overrepresented in the diet relative to their abundance (i.e., more sensitive to predation) while others, like shrimp, would be under-represented (i.e., more resistant). Asian Swamp Eels consumed at least 44 different species of aquatic prey (some could not be identified below genus). We observed an ontogenetic diet shift with smaller eels (< 250-300 mm TL) consuming more amphipods and coleopterans and larger eels consuming more crayfish. Odonates (predominantly dragonfly naiads), crayfish (*Procambarus* spp.), fish (mostly cyprinidontiformes), grass shrimp (*Palaemonetes paludosus*), and hemipterans were energetically important prey for swamp eels. In general, eels collected from recently established regions depended heavily on crayfish, while those in regions with longer-established populations relied more on fish. Crayfish and odonates were the most consistently selected prey across eel populations, while fish, shrimp, and hemipterans were under-represented in eel guts compared to their relative abundance in the environment. The Asian Swamp Eel is a generalist predator that exhibits consistent over-use of slow-moving, crawling, macro-invertebrates. Predation on swimming prey occurred more frequently when water depths were shallower. After populations of sensitive prey have been eliminated from a wetland it appears that the swamp eel populations subsist on odonates and smaller prey.

Windthrow in South Florida Pine Rocklands 30 years Later: Plant Microhabitat Associations on Pine Island

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In 1992, Hurricane Andrew uprooted trees across south Florida. Understanding windthrow events and their impact on a landscape is critical to assessing forest health and composition under climate change. In 1994 and 1996, a study was done to examine long-term windthrow effects on forest structure resulting from pit and mound microhabitat associations. Vegetation transects were sampled in Pine Island, Everglades National Park, which had experienced windthrows due to Hurricane Andrew. In 2025, we resampled the transects to determine changes in composition within pit and mound, and to examine the broad effects of these features on the pine rockland understory. Our results suggest that the uprooting of pine trees during periodic hurricanes creates long-term ecologically significant substrate variation in the Rockland surface still evident 30 years later. Hurricane-initiated windthrow events contribute to fine-scale structuring in understory species assemblages and leave an indelible mark on the landscape that spans decades.

Impacts of Large Fishes on SAV Growth and Establishment in the STAs.

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Maintaining stable submerged aquatic vegetation (SAV) beds supports stormwater treatment and phosphorus sequestration process in the Everglades Stormwater Treatment Areas (STAs). SAV beds in STAs occasionally die off and have difficulty re-establishing in areas of bare flocculent sediment. The reasons for these die-offs and the lack of growth in bare areas are not well understood, but herbivory and bioturbation by large fish have been hypothesized. Invasive tilapia (*Oreochromis* spp.) are herbivorous/omnivorous fish that make up the greatest proportion of fish biomass in the STAs and are suspected to be the greatest contributor to SAV disturbance by large fish. Effects of large fish on SAV growth were examined in a two-part fish exclusion study. Part 1 was located in the STA-3/4 Upper SAV Cell and excluded fish from 25 m2 plots in two different sites from June to September 2023. One set of exclosures was set up on bare flocculent sediment and the other on patchy SAV beds. Mesh netting was used to exclude larger fish while still facilitating water flow. Full netted exclosure plots, partially netted (structure) control plots, and open (un-netted) plots were replicated at each site. SAV cover was measured weekly for 12 weeks, and biomass samples were collected monthly. In the site with patchy SAV, we observed no significant differences in cover or biomass after 12 weeks. In the site with bare sediment, both SAV biomass and cover were significantly higher in the fully netted exclosures compared to the partially netted and open control plots. These results suggest that large fish may suppress SAV by preventing the establishment of new SAV beds in bare sediment areas, but they may not impede growth of already established SAV beds in the wet season. Part 2 of the study was executed in STA-2 Cell 3 starting in September 2024; additional exclosure plots were set up to test the reproducibility of Part 1 results in a different STA in the late wet season. Plots were 25 m2 and arranged within three blocks on bare flocculent sediment. Each block contained equal numbers of fully netted exclosure plots and open control plots. Plots were monitored biweekly for 12 weeks to determine changes in SAV coverage. Phase 2 data are still being collected, but preliminary results suggest that significant SAV growth occurred in the netted exclosures in all blocks. At the end of the 12-week exclosure period, the nets will be removed and SAV will be monitored for an additional month to determine SAV persistence in the absence of exclosures.

Economics in the Greater Everglades System

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Economic frameworks help us understand how the structure and function of ecosystems generate goods and services that shape economic well-being. At the Everglades Foundation, we work to build a sustainable, resilient South Florida economy by restoring and protecting the Greater Everglades' natural capital. The Greater Everglades covers 18,000 square miles of interconnected upland, freshwater, estuarine, and nearshore marine environments. Degradation of the system has prompted intergovernmental efforts to restore hydrological processes, protect habitats and species, and foster compatibility between natural systems and the built environment. At the core of our approach is the view of natural capital as a 'stock' producing vital 'flows' of goods and services, sustaining our economy within and outside traditional markets. South Florida's climate and natural resources attract residents and visitors, enhancing quality of life and driving economic activity. Many of the region's largest industries, from real estate to tourism, depend directly and indirectly on these ecosystems, contributing significantly to regional GDP. As a result, ecosystem degradation poses significant risks to the well-being of residents and visitors, economic output, and government revenue. This presentation introduces our organization's approach for understanding how Everglades restoration affects our economy by examining: (1) the value of natural capital, including the economic valuation of specific ecosystem services; (2) implications for economic activity, demonstrating key South Florida industries reliant on natural capital; and (3) the critical role of ecosystem health in generating government revenue—especially relevant in Florida's fiscal landscape, where government revenue tied to sectors such as real estate, tourism, and financial transactions support vital public services. Restoration and protection of the Everglades must integrate ecological and economic outcomes. This presentation highlights our efforts to plan and conduct system-wide assessments and targeted empirical studies to inform policy and aid long-term restoration and protection efforts. It combines a conceptual overview with selected results of completed and ongoing research.

Evaluating the Impacts of Invasive Waterhyacinth on Aquatic Communities in the Everglades and Lake Okeechobee

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Water hyacinth is an invasive floating plant that rapidly grows across water bodies, creating dense mats that disrupt local ecosystems. Our goal was to measure the impact of water hyacinth on aquatic communities in the ecosystems of the Everglades and Lake Okeechobee. We tested the hypotheses that water hyacinth supported different fish and invertebrate species than native aquatic plants, used more dissolved oxygen (DO), and provided different levels of support to abundant invertebrates like amphipods. We sampled fish communities in the littoral zone using 1m^2 throw traps and backpack electrofishers. We compared invertebrate community assemblages by collecting samples of roots from both plants. We compared the size distributions of amphipods, the most abundant invertebrate, from under both plants. We compared DO used by native plants and water hyacinth in outdoor aquariums. Fish communities did not differ among plant types, although there were slightly more under native plants. Throw traps were more efficient overall, with more than five times as many fish obtained than the electrofisher. More invertebrates were found in the roots of water hyacinth than native plants, but no significant difference was found between the community assemblage. Amphipods collected from water hyacinth roots had greater masses than those from native plant roots. Water hyacinth and pennywort used equal oxygen- for both, DO increased during daylight hours and higher plant densities led to lower DO levels. We followed with experiments to determine what contributes to the greater number of invertebrates under water hyacinth. We performed choice experiments to see if small fish showed a preference for environments covered by water hyacinth or native plants. We tested the hypothesis that there were more inverts due to greater root surface area by dipping roots of native plants and water hyacinth in a soapy solution and comparing the difference in mass. We tested the hypothesis that predation rates were greater under native plants by using tethered bait under both plant types. We also compared DO levels in the field to determine if lowered oxygen might explain observations of the community. We found that fish, especially those naïve to water hyacinth, showed slight preference for native plants, but predation rates and DO levels were similar between the plant types. Water hyacinth plants had greater root surface area than native plants, providing more space and refuge for epiphytic invertebrates. These findings establish a critical baseline for assessing water hyacinth management strategies and their ecological implications in Florida's aquatic systems.

Recent Progress Towards Achieving Natural Ecosystem Restoration Goals in the Florida Everglades

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In its 2024 report to Congress, the National Academies' Committee provided its independent scientific review of recent progress towards restoring the Florida Everglades. Record levels of federal and state funding in fiscal years 2022 and 2023 enabled a remarkable pace of restoration that aligned with the ambitious targets set forth in the 2022 Integrated Delivery Schedule. Six CERP projects are under construction (Picayune Strand, C-43 Reservoir, IRL-South, Biscayne Bay Coastal Wetlands, Broward County Water Preserve Areas, and CEPP), one CERP project (Melaleuca Eradication) and two major project components (CEPP New Water, C-44 Reservoir and STA) have been completed, and one additional project (C-111 Spreader Canal Western project) is essentially complete. Restoration benefits are already evident for some of these projects including improved flood control from CEPP New Water and evidence of recovery of flora and fauna from restoration of hydrology in Picayune Strand. Likewise, biological control efforts for invasive species have contributed to a 75 percent reduction in area dominated by Melaleuca and have largely controlled air potato reproduction to the extent that air potato is no longer a priority invasive species. However, other invasive species such as amphibians and fish continue to cause challenges with monitoring and may hinder the recovery of local fauna. Sampling methods for some species (e.g., amphibians) need to evolve to generate a clearer picture of what native species are responding to restored hydrology in areas like Picayune Strand. Initial monitoring results also indicate that the Combined Operations Plan is meeting expectations in achieving hydrological and ecological restoration. Most notably, the rehydration of Northeast Shark River Slough in Everglades National Park represents the largest step yet towards restoring the hydrology and ecology of the central Everglades. However, the committee recommended additional research in response to concerns that increased flows, flow velocities, and canal-to-marsh interactions might mobilize legacy phosphorus that could impact periphyton and plant communities. The committee concluded that maintaining the recent fast pace of restoration progress requires continued funding for construction and support for other agencies responsible for facilitating restoration implementation (e.g., permitting, monitoring). In addition, the committee recommended new mechanisms for centralized, multi-agency reporting and synthesis of project-level restoration outcomes to better support interpretation of progress, identify emerging challenges, and ultimately facilitate adaptive management.

Carbonate Sediment Production in Coastal Wetlands: Periphyton Contributions and Diatom Indicators

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Coastal ecosystems rapidly transform as sea levels rise faster than ecosystems can build elevation through biological processes that accrete organic matter and inorganic sediment. Benthic microbial communities (periphyton) are a crucial driver of sediment accretion in coastal wetlands by forming, trapping, and stabilizing sediments. Inorganic sediments can be either generated *in situ* by mineral-accreting organisms (e.g., calcium carbonates by periphyton), or materials can be transported from a different origin when sediments become resuspended and displaced, such as during high-wind weather events. *In situ*-generated sedimentary materials may contribute significantly to elevation gains. This study examines the drivers of coastal periphyton mineral production and whether periphytic diatoms may be used to characterize gradients in these drivers.

Periphyton mineral production rates and diatom assemblage composition were measured along three coastal gradients of surface water salinity, conductivity, pH, and periphyton nutrient content in the Biscayne Bay Coastal Wetlands of South Florida. Periphyton mineral production rates ranged from 0.20-0.53 $g/m^2/d$ and were greatest at sites with the highest periphyton total carbon and mineral content while lowest at sites with the highest periphyton organic content and total nitrogen and soil depth. Diatom assemblages that sorted consistently along the coastal salinity gradient were reliable indicators of periphyton mineral production, with seven taxa indicating high rates and seven indicating low rates. Diatoms can provide a helpful link between biotic and abiotic processes, indicating where periphyton-driven mineral production contributes most to inorganic carbon cycling and mineral-driven elevation recovery and, hence, to resiliency to sea level rise.

Invasive Species Management in Everglades National Park

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Invasive species continue to pose significant challenges to ecosystem restoration efforts in Everglades National Park, where nearly 30% of the documented reptile and plant species are non-native or invasive. Many of these species have complex, landscape-level impacts that are difficult to quantify and likely lead to cascading effects that undermine current restoration initiatives. In response to the increasing frequency and severity of invasive species threats, the park focuses on three key management strategies: controlling invasive species with significant impacts, implementing early detection and rapid response (EDRR) measures for emerging invasive species threats, and collaborating with federal, state, and local partners to enhance long-term management and research coordination. Despite limited control tools and constrained resources, the park maintains invasive species management programs for Burmese pythons, Argentine black and white tegus, and several priority invasive plant species, including Melaleuca, Australian pine, and Brazilian peppertree, and Old World climbing fern.

Evaluating Long-Term Performance of Everglades Stormwater Treatment Areas Using Structural Equation Modeling

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Phosphorus (P) retention in Stormwater Treatment Areas (STAs) is influenced by various external and internal variables, making it necessary to employ multivariate techniques to understand the complex relationships among them. This study used 14 years of monthly data from four STAs (STA-1E, -1W, -2, and -3/4) to achieve the objective of exploring the factors influencing long-term STA performance and function related to P retention. Structural Equation Model (SEM) with predictive variables of inflow total P (TP), total nitrogen (TN) and calcium (Ca) concentration, hydraulic loading rate (HLR), and water pH and temperature was applied to evaluate similarities and differences among individual STA performance. The SEM results suggested an improvement in operational performance of STAs over time. All models explained a substantial portion of the variation in retention rate of TP ($R^2 > 0.63$), but only a small portion of the variation in outflow TP concentration ($R^2 < 0.24$). Notable differences were observed among the four STAs. The relationship between inflow and outflow TP concentration differed among the STAs. Furthermore, inflow TN concentration was positively correlated with the TP retention rate in STA-1W, and outflow TP concentration in STA-2, while the co-precipitation of P with Ca likely played a critical role in STA-3/4. These findings highlight the complexity of P removal in STAs and emphasize the need for site-specific management strategies. Further studies should consider incorporating long-term observation of key vegetation and soil variables (e.g. vegetation coverage and soil TP content, etc.) to inform more effective approaches to optimize P removal and enhance the performance of STAs in water treatment and ecosystem restoration efforts.

Biscayne Bay Water Quality Model Development and Applications

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Biscayne Bay, like many of Florida's estuaries, is facing ecological challenges driven by changes in key water quality constituents (e.g., phosphorus and nitrogen). While tremendous effort has been devoted to collecting continuous and discrete hydro and water quality data, integration of such monitoring data with modeling activities is needed. Supported by the Florida Department of Environmental Protection (FDEP), a Delft3D-based hydrodynamic and water quality model system for Biscayne Bay, FL, has been developed. The water quality module (D-Water Quality) is integrated with the hydro-model (D-Flow FM + SWAN) within Delft3D, the software suite developed by Deltares. The major water quality (WQ) substances include inorganic matter (IM1 & IM2), NH4, NO3, PO4, Si, Opal-Si, POC1, PON1, POP1, phytoplankton, etc. The WQ processes can internally use some variables from the hydro-model, such as bottom shear stress, salinity, and temperature. Three model domains, i.e., the large-scale Gulf-Atlantic domain, the regional Southern Florida domain, and the local Biscayne Bay domain, are set up for nesting computation. Vertically, seven σ layers are adopted for three-dimensional (3D) simulations. Their layer thicknesses are 5, 10, 20, 30, 20, 10 and 5 % of the total water depth, respectively. To consider the impact of groundwater on coastal salinity in Biscayne Bay, dozens of freshwater sources are added along the coast in the regional and local domains. The District RSMGL (Regional Simulation Model for Glades-LECSA/Lower East Coast Service Area) can provide discharge sources data for both surface water (at Layer 1) and groundwater (at Layer 7). The 3D k-∈ turbulence closure model is used to determine vertical eddy viscosity and diffusivity. Horizontally, the calibrated value 0.5 m^2/s is applied. The years 2018 and 2016 are selected for model calibration and validation, respectively. The model-data comparisons include water level, salinity, temperature, and some selected WQ substances. After that, based on the 2016 validated run, a few scenario runs are carried out to study the impacts of sea level rise and proposed structures on salinity and temperature in Biscayne Bay. This is an ongoing study. We are working on further improving WQ calculations and optimizing designs for model applications. Detailed results will be presented at the upcoming GEER conference.

Detecting Reptiles with eDNA Metabarcoding

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Environmental DNA detection can be useful in early detection and rapid response frameworks for invasive species. Approximately 60 species of invasive reptiles have been established in Florida, causing potential harm to native species by disrupting natural ecosystems, competing for resources, predating native species, and/or spreading disease. To improve the detection of known, for example *Pogona vitticeps* (Central bearded dragon), *Python regius* (Ball python) and *Phelsuma grandis* (Giant day gecko) and unknown invasive/non-native reptile species and to investigate impacts to native reptile communities, we developed a novel eDNA metabarcoding assay designed for general reptile detection. Additionally, we provide field-based data to show the application of our developed assay in eDNA analysis. These findings indicate that our eDNA assay is a promising tool for the detection of reptiles, including common, rare, and invasive species, offering a more sensitive approach than traditional monitoring surveys and improving the efficacy of early detection efforts.

Engineering and Maintenance Solutions for Addressing the Elevated Total Phosphorus Concentrations at S-333

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Water deliveries to Everglades National Park (ENP) through the S-333 structure when the canal water level is low are generally elevated in total phosphorus (TP) concentration. To address this, initial engineering and maintenance solutions are underway. The initial engineering and maintenance solutions includes canal maintenance dredging and the installation of low-sill weirs, upstream of the S-333 structure and nearby reaches of the L-29 and L-67A canals. These solutions were informed by an initial set of studies, known as the Phase I studies and included a sediment characterization study and a hydrodynamic study using Computational Fluid Dynamic (CFD) modeling of flow scenarios and the potential effect on sediment entrainment. The Phase I studies were designed to be preliminary studies to inform initial actions.

Canal maintenance dredging has the potential to reduce sediment scour and particulate phosphorus laden sediment transport by removing sediment from the canal bottom returning these canals to their originally constructed cross-section profile. It is anticipated that removing the particulate matter will mitigate the resuspension of sediment material contributing to the increased TP concentrations at the S-333 structure. All dredged material will be processed through a hydrocyclone separating the sediments from the water. The effluent water will be treated, and the sediments temporarily deposited within a dredged material management area, tested for potential contaminants, and disposed of properly.

Low-sill weir installation in both the L-67A and L-29 canals has the potential to reduce near bed velocities and particulate phosphorus laden sediment transport. The goal of the project is to facilitate the settling and restricting movement of sediments in the L-67A and L-29 canals' water columns. In this application, a removable low-sill weir will be placed and tested along the bottom of a canal's cross-section to control localized water flow energy and reduce the velocity of water as it passes over the sill near the canal bottom. Reducing the water velocity with a low-sill weir would promote the settling of sediments preventing TP transport through the S-333 structure.

The overall effectiveness of the canal maintenance dredging and installation of the low-sill weirs will be evaluated over time through the implementation of a monitoring plan and assessment plan. This plan will determine sediment accretion rates and locations, and correlated water quality improvement, to identify optimization opportunities and inform future actions.

Engineering and Maintenance Solutions Monitoring and Assessment Plan

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As part of the canal maintenance project to potentially reduce sediment scouring and phosphorus (P) laden sediment transport to the Everglades National Park (ENP), a monitoring and assessment plan (MAP) was designed to monitor the effectiveness of the canal dredging and low-sill weir installation project. The MAP will be implemented upon project completion.

Removal of P enriched sediments from the bottom of the canals coupled with installation of low-sill weirs along the bottom of the canals are anticipated to improve water quality entering the ENP by reducing total P peak concentrations. To achieve the objectives of the project, the MAP will require sampling of water and sediment quality, along with hydrologic/hydraulic measurements, at different spatial and temporal scales.

Cross-sectional canal monitoring will be performed to assess water quality with samples collected at several depths in the canal. Samples will be collected at set intervals up to 1500 ft from the S-333 structures. Water quality samples will be measured for total P, soluble reactive P, total dissolved P and total suspended solids.

Sediment samples will be collected using sediment traps and from the canal bottom. Sediment traps will be deployed in pairs over a six-week interval and will be processed for particle size, sediment mass, and organic and inorganic carbon (C) and P. Canal sediments will be collected at set intervals up to 1500 ft upstream of the S-333 structures during high, medium and low flow conditions measured at these structures. Sediment samples will be analyzed for inorganic and organic C and P, and fractionation of P into labile P, iron/aluminum-P, calcium-P, organic P and recalcitrant P.

Additionally, flow measurements will be taken concurrently with water quality and sediment sampling. Continuous measurements of flow velocity and direction will be collected at three locations. Bathymetric surveys will also be conducted to investigate re-accumulation of sediments in the canal and in front of the S-333 structures.

Data collected under the MAP will be used to evaluate the effectiveness of the engineering and maintenance solutions, inform design optimization and future actions.

Analysis of Benthic Environment Trends at Biscayne National Park

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Coral reef communities play a vital role in supporting fisheries, tourism, and marine biodiversity. They sustain a rich variety of wildlife, including fish, invertebrates, and other marine species. However, the coral reefs of the Florida Reef Tract have faced significant challenges in recent years, including die-offs and phase shifts. These reefs are impacted by both short-term events, such as vessel strikes, extreme water temperatures that cause coral bleaching, and storm damage, as well as long-term stressors like coral disease, overfishing, ocean acidification, eutrophication, and pollution, all of which negatively affect their health.

Marine benthic communities are considered the highest priority of the 44 vital signs monitored by the South Florida/Caribbean Network (SFCN) of the National Park's Inventory and Monitoring Program. Since 2004, SFCN has been conducting annual marine benthic monitoring at two reefs within Biscayne National Park (BISC). These reefs are surveyed using standardized protocols for benthic monitoring and underwater videography. Ball Buoy Reef and Amanda's Reef were selected in 2004 for focused monitoring due to management interest and to provide comparisons with historical data.

This study aimed to assess trends in the average percent cover of key taxonomic groups, including stony corals, octocorals, sponges, and algae, over 15 years of monitoring. It also examined coral community structure, the prevalence of coral disease and bleaching, and the abundance of the keystone herbivore *Diadema antillarum*. By analyzing long-term monitoring data, the study classified trends in reef structure to evaluate changes in the health and function of coral reef ecosystems within South Florida's National Parks. Results indicated a decline in stony coral cover at BISC monitoring sites, a reduction or complete loss of crucial coral functional groups on some reefs, and an increase in bleaching events and disease prevalence. These findings, presented in reports and resource briefs, help park scientists and resource managers communicate ecosystem trends and monitoring outcomes to policymakers and stakeholders.

Evaluating Future Trajectories of Florida Everglades Scrub Mangroves Under Sea Level Rise

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Coastal mangroves provide various ecosystem services such as shoreline stabilization, storm surge attenuation, and carbon storage and sequestration. Mangrove forests are sensitive to accelerated rates of sea-level rise (SLR), with impacts resulting in decreased mangrove productivity and biomass, and increased relative submergence. The survival of mangrove forests therefore relies on their capacity to adapt and build elevation relative to SLR (e.g., wetland adaptive capacity). To understand the trajectory of mangrove forests soil accretion capacity, we developed the dynamic Coastal Wetland Equilibrium Model (CWEM). We used 23 years of surface elevation measurements from four Florida Everglades scrub mangrove sites to parameterize the CWEM and compared the simulated elevations with the measured data (mean bias error: -0.48 to 0.13 cm). The study sites are non-tidal, include vegetated and non-vegetated mangrove sites, and do not receive mineral sediment inputs. Applying the calibrated CWEM, we first tested how the lower limit of the mangrove elevation at which biomass approaches zero (Z_{min}) responds to SLR where Z_{min} represents the survival potential of the mangroves (e.g., below Z_{min} mangroves will convert into non-vegetated wetlands). Second, we evaluated future trajectories of mangrove vegetation under six projected SLR scenarios through 2080. The Z_{min} sensitivity indicated that under rising sea level, the survival potential of mangroves declines with lower Z_{min} values. The trajectory analysis showed that non-vegetated sites along the coastal scrub mangrove fringe would likely collapse and become fully submerged within the next 40 years under all but the lowest projected SLR scenarios. However, the vegetated sites continued to build elevation under the IPCC Median SLR projection (61.87 cm of SLR in 2080 relative to 2000) while becoming submerged with higher SLR projections. These findings provide valuable insights for developing management strategies to reduce coastal vulnerability and improve resilience to SLR.

Lessons from BBSEER and Beyond: Modeling to Improve Wetland Resilience to Sea-Level Rise

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The Biscayne Bay Southeastern Everglades Ecosystem Restoration (BBSEER) project supports the restoration and enhancement of wetland resilience to sea-level rise (SLR) in the coastal wetlands of the Model Lands, Southern Glades, a part of the Everglades National Park, and Biscayne Bay. BBSEER is the first Comprehensive Everglades Restoration Plan (CERP) project that considers wetland resilience and SLR in project planning. To assess BBSEER alternatives for wetland resilience to SLR, 'Wetland Salinity' and 'Adaptive Foundational Resilience' performance measures (PM) were developed. 'Wetland Salinity' evaluates the likelihood of exceeding the target salinity for different vegetation types. 'Adaptive Foundational Resilience' calculates soil accretion rates as a function of wetland salinity, freshwater inflow, and inundation, and represents them as a measure of coastal resiliency. Output from the calibrated Biscayne and Southern Everglades Coastal Transport (BISECT) model was used to estimate these PMs. Water level and flow data from the Regional Simulation Model (RSM) were integrated into the BISECT through an RSM-BISECT crosswalk for simulations. The RSM-BISECT crosswalk and the BISECT model provided critical understandings into the resilience and trajectory of the coastal wetlands within the BBSEER footprint, particularly under the U.S. Army Corps of Engineers (USACE) Intermediate SLR projection for 2085. Additionally, the BISECT modeling offered meaningful lessons on future enhancements, including a longer RSM-BISECT crosswalk and an extension of the BISECT model calibration to the Biscayne Bay wetlands. Beyond BBSEER, there are opportunities to expand PMs for future CERP planning projects for coastal wetlands. Enhancements could include expanding the current 'Wetland Salinity' PM to a larger spatial scale, extending the simulation period, and improving the constant accretion rates assumed in the 'Adaptive Foundational Resilience' PM. The Coastal Wetland Equilibrium Model (CWEM) is being developed to understand the trajectory of wetland soil accretion, which could provide valuable information to include in the 'Adaptive Foundational Resilience' PM. CWEM incorporates vegetation-inundation feedback to dynamically estimate accretion rates for different planning horizons. Twenty-three years of surface elevation measurements from four Florida Everglades scrub mangrove sites were used to parameterize CWEM and compare simulated elevations with measured data. The lessons learned from BBSEER provide useful insights for advancing our understanding of the coastal ecosystem trajectories in the face of SLR and developing adaptive management strategies to reduce coastal vulnerability.
The work on BISECT modeling and the 'Wetland Salinity' PM for BBSEER is conducted under a contract between the South Florida Water Management District and Florida International University.

Investigating Greenhouse Gas Dynamics Using Ground-Penetrating Radar (GPR): from Laboratory to Airborne Field-scale Measurements.

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Peatlands are large producers of carbon-based biogenic gases (such as methane and carbon dioxide) that are formed by decomposition of organic material under anerobic conditions, and that play a crucial role in the carbon cycle as major sources of greenhouse gases to the atmosphere. Previous studies during the last two decades have advanced our understanding of gas distribution in peat soils at a variety of measuring scales, however many uncertainties remain to properly understand differences in the spatial distribution of hot spots for gas accumulation and release at the matrix level that consider: 1) different scales of measurement, including both field and laboratory scales to investigate how methodology may influence imaging of spatial extent; and 2) different types of peat soils, including peat from different latitudes to investigate how physical and chemical properties of the peat matrix may influence the spatial and temporal distribution of gases within the peat soil. Furthermore, increasing efficiency in data acquisition is needed to enhance data coverage and better capture the heterogenous nature of gas accumulation in peatlands. In this study we expand on past measurements by: a) measuring biogenic gas dynamics at multiple scales of measurement (from laboratory to airborne measurements); and b) incorporating samples from a wide array of latitudes (boreal, subtropical and tropical) that are measured following the same laboratory experimental setup. These results may therefore have implications for better understanding how scale of measurement or peat soil type may influence the spatial and temporal distribution of biogenic gases in peat soils.

Tracking Cattail Expansion with Drone Imagery Following Restoration Efforts in WCA 3B

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The Decompartmentalization Physical Model (DPM) Project was designed to test the effects of sheet flow restoration in Water Conservation Area (WCA) 3B. DPM consisted of ten controllable gated culverts, 3000 feet of levee degrade, and three levels of canal backfill treatments (none, partial, and complete backfill). Despite canal water only entering the marsh through the structure when phosphorus (P) concentrations were ≤10 µg/L, relatively greater flow rates close to the structure and downstream of the levee degrade adjacent to the no canal backfill treatment resulted in high P loading and accumulation in the benthic flocculent sediments at nearby sites. Vegetation composition is highly sensitive to changes in nutrient availability and flow velocity and responses can be observed over multiple timescales; days for floating *Utricularia* sp. to sink or be eroded downstream, years for cattail (*Typha domingensis*) to become established. To capture the long-term effects of sheet flow restoration, we collected aerial imagery annually of sloughs along a flow gradient. We also used 0.25 m^2 quadrats to ground truth percent cover of submerged and emergent vegetation. At the highest flow sites (>4 cm/s), cattail invaded the sloughs during the seven years of sampling. DPM experienced non flowing conditions, with closed culvert gates, for the last three of those years due to high water levels in WCA 3B but legacy P accumulation and cattail establishment at the high flow sites resulted in continued increase in cattail coverage. Cattail's high growth rate and leaf turnover contribute to its resilience, outcompeting other slough vegetation and resulting in an eventual monotypic habitat. This study helped us better understand vegetation changes due to flow restoration and P loading. It demonstrated the importance of lowering flow velocities to restorative targets (nominally 1-3 cm/s in sloughs) at structures and levee degrades to prevent nearby downstream marsh habitat from becoming a cattail stand. This could include structures such as spreader swales downstream of culverts to disperse flow or strategic backfilling of canals adjacent to degraded levees.

Integrating Restoration Strategies Science and STA Management: Part I Synthesis of Findings

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The Restoration Strategies Science Plan (RSSP) is a framework to guide scientific research to improve understanding of key mechanisms and factors affecting phosphorus (P) retention in the Everglades Stormwater Treatment Areas (STAs). The RSSP was developed as part of the South Florida Water Management District's 2012 Restoration Strategies Regional Water Quality Plan to reduce Total P (TP) concentrations from agricultural and urban runoff before discharging into the Everglades Protection Area (EPA). Of the 21 studies conducted through the RSSP, an improved understanding of P retention and wetland sustainability emerged. Three major processes operate to remove TP from the runoff discharged to each flow-way (FW) within the STAs: removal from water, soil accretion, and internal loads. Removal occurs through particulate settling of inflow water by emergent aquatic vegetation (EAV) that reduces water flow, uptake by submerged aquatic vegetation (SAV) and periphyton--the microbial community attached to plant leaves and detritus, and coprecipitation of P with CaCO3 that forms due chemical reactions caused by photosynthesis. The accumulation of P into the soils retains approximately 80% of the external P load. The other 20% is returned to the water column through resuspension, translocation from rooted plants, fauna bioturbation and excretion. These three processes act on the inflowing P at a spatial scale along each STA FW spiraling along the flow path with a reduced amplitude until the water is discharged into the EPA.

What Happened to Snail Kites in the Water Conservation Areas?

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The Everglades has undergone extensive anthropogenic change over the past century including drainage, impoundment, changes in water regulation (flow, timing, and distribution), increased nutrient flow, and introduction of invasive species. The identification of these effects will help minimize negative impacts and improve conditions for species in the Everglades. The snail kite (*Rostrhamus sociabilis plumbeus*), like many other species, are influenced by these environmental changes. Historically, the Water Conservation Areas have had the highest proportion of active nests and young fledged as well as population size of snail kites in all the wetlands surveyed. Starting in 2007, there was a shift of individuals and nesting from the southern Everglades to the central (Lake Okeechobee) and northern (Kissimmee Chain of Lakes) Everglades. This shift in distribution has been attributed to landscape scale hydrologic modification, drought, prey availability, and establishment of exotic apple snails. We examined thresholds developed for snail kite nest initiation and nest survival as well as population counts and presence/absence data for apple snails from 1996-2024 to help evaluate the shift in distribution. The average number of weeks per year from January to May (typically when the breeding season starts to the peak) that are outside of the nest initiation threshold has increased over time from averaging 2 weeks per year in the late 1990's to over 6 weeks by the early 2000's, with some years having 8 or more weeks (out of 20) outside the threshold. High recession rates and ascension rates before and during the breeding season have also increased over time reducing the probability of nests being initiated. These hydrologic parameters have also impacted prey availability/survival where the native apple snail occurrence has decreased over time. The exotic apple snail was observed more often than the native snail starting in 2015, but their number of detections have also decreased since 2019. Our results show that prey availability is tightly linked to hydrology and that snail kite nest initiation rates declined in southern Florida over the past decade. Overall, these results indicate that managing hydrology is needed as an approach for the snail kite and apple snail to promote population recovery.

Phosphorus Dynamics in Stormwater Treatment Areas: Changes in Phosphorus Forms and Concentrations from Inflow to Outflow

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The Phosphorus Dynamics (P Dynamics) Transect study examined phosphorus (P) forms and concentrations within six Everglades Storm Water Treatment area (STA) flow-ways (FWs). The FWs selected for this study have variable total phosphorus (TP) concentrations, at the outflow, over their period of record. These FWs are classified as performing or underperforming based on TP concentrations being above or below 19 µg/L. FW performance measured during this study closely matched historical performance for the selected flow-ways. Water samples were collected between January 20 21 and October 2023 capturing wet and dry seasons over 18-week periods. TP concentrations and phosphorus (P) speciation were measured along transects within these FWs. Surface water hydraulic loading rate (HLR) and phosphorus loading rate (PLR) were calculated for each STA flow-way during their sampling periods. P species, TP, total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP) were measured directly from the surface water samples. Particulate phosphorus (PP) was calculated as the difference between TP and TDP and dissolved organic phosphorus (DOP) was calculated as the difference between TDP and SRP. Across all flow-ways TP percent reduction was higher during the wet season than dry season. STA-5/6 FW1 saw the greatest overall TP reduction for both seasons with a 91% (wet) and 78% (dry) reduction. STA-3/4 CFW reduced TP by 86% during the wet season and 57% during the dry season. STA-1E EFW reduced TP by 86% during the wet season and 65% during the dry season. The poorest performing FW, in terms of TP percent reduction, was STA-2 FW3, which reduced TP by 47% during the dry season and 60% during the wet season. During the wet season, SRP was the dominant form of TP in most of the FWs. During the dry season, PP was the dominant form of TP in most of the FWs. DOP was relatively consistent across transects, and SRP steadily decreased to the minimum detection limit (MDL) across most transects. PP was the most inconsistent of the P species measured. Increases in PP proportions were often representative of depth and vegetation conditions at sites. Overall, this study was valuable in assessing the patterns of P removal across FWs with variable performance. It provided valuable insight on possible sources of internal P loading within FWs and confirmed trends observed in the other P Dynamics sub-studies.

Dissolved Organic Matter Optical Properties in Treatment Wetlands: Associations with Plants, Soils and Treatment Performance

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Dissolved organic matter (DOM) is increasingly recognized as an influential constituent in a wide variety of wetland biogeochemical processes. In south Florida, USA, the Everglades Stormwater Treatment Areas (STAs) are large treatment wetlands that remove phosphorus (P) from agricultural and urban runoff to protect the oligotrophic Everglades ecosystem. As is typical for wetlands, bioavailable P species are readily and effectively retained by the STAs. P exiting the STAs (total P ~10-25 ug/L) is primarily associated with DOM (operationally, dissolved organic P, DOP) and particles (particulate P, PP), which can be recalcitrant. This increases the difficulty of achieving the discharge P concentrations required by operational permits. DOM quantity (as dissolved organic carbon, DOC) and character (as optical properties, including specific ultraviolet absorbance at 254 nm, SUVA, and spectral slope of absorbance between 275-295 nm, SS_{275}), and DOP concentrations were measured in two mesocosm-scale experiments and a full-scale STA (STA-3/4), to understand process limitations on P reduction from surface waters. In these studies, two main ecosystem types were represented at each scale: organic, muck soil colonized by submerged macrophytes, and calcareous limerock substrate colonized abundantly by periphyton. Differences in DOM character and DOP concentration between ecosystem types may occur from: 1) enzymatic hydrolysis of DOM by periphyton, leading to more thorough depletion of P from the DOM pool; 2) differential internal DOM/DOP generation; and 3) photolysis partially impaired by DOM compounds with high UV absorbance, associated with certain sources. At both mesocosm and field scale, the limerock/periphyton ecosystem type was associated with lower DOP concentrations and optical properties of the surface water indicative of smaller, less-aromatic DOM molecules (lower SUVA, higher SS_{275}) than the muck/macrophyte systems. Notably, P-acquiring enzyme activity was generally elevated in limerock/periphyton systems. DOC concentrations did not differ between ecosystem types, so the calculated DOM C:P ratio (DOC:DOP) was higher in the limerock/periphyton systems, suggesting that the DOM pool was more P-depleted. The mesocosm studies included additional treatment groups involving muck soil under a surficial limerock gravel 'cap', with and without macrophytes. These groups tended to have intermediate DOP concentration and DOM optical properties between the limerock/periphyton and muck/macrophyte end-members. We hypothesize that muck/macrophyte ecosystems generate DOM with structural properties that reduce the bioavailability of the associated DOP. Conversely, the smaller, simpler and more P-depleted DOM in limerock/periphyton systems was associated with lower DOP concentrations. These findings provide insight into the biogeochemical process-bases for achieving low P concentrations often observed in limerock/periphyton systems in the Everglades STAs.

Modeling seagrass distributions in the greater Florida Bay and impacts of climate change

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The southwest Florida coastal waters and the Florida Bay form an important marine ecosystem supporting abundant seagrass (submerged aquatic vegetation, SAV), coral reefs, and fish. At the center of this complex system, Florida Bay is a shallow estuary with fragmented flows due to complex bathymetry and mudbanks. The system has experienced two major seagrass die-offs in the last several decades and frequently experiences strong cyanobacteria blooms, raising significant concerns. This is also a critical buffer zone allowing freshwater inputs (nutrients and organics) from the Greater Everglades to slowly be filtered before reaching the Florida Reef Tract. To better understand the fundamental ecosystem dynamics including nutrient cycles, phytoplankton blooms, and seagrass in the region, a coupled physical-biogeochemical-SAV model has been developed. The physical model is based on the Regional Ocean Modeling System (ROMS). The water column biogeochemical model includes 2 types of nutrients (nitrogen – N and phosphorus – P), 5 phytoplankton groups (diatoms, dinoflagellates, cyanobacteria, *Karenia brevis*, picophytoplankton), 2 zooplankton groups (micro- and meso-zooplankton), bacteria, and dissolved and particulate organic N and P. The benthic module consists of one SAV group, an epiphyte group, and nutrients and organics, which is directly coupled with the water column module. The model is driven by freshwater inputs from upstream rivers and watershed runoff, surface meteorological forcing, and ocean forcing including tides and the Florida Current. A two-year (2011-2012) simulation has been performed and results calibrated with available data. The results show a weak seasonality in seagrass biomass, consistent with available observations. An analysis of the results indicate that both seagrass and epiphytes may significantly affect the nutrient cycles and phytoplankton blooms by consuming nutrients in the water column. In turn, phytoplankton blooms may also significantly affect seagrass growth by reducing light availability to the benthic environment. Several numerical experiments are conducted to examine the impacts of sea level rise (SLR), warming temperature, and re-allocations of Everglades freshwater inputs. The results suggest that these changes would drive complex and sometimes conflicting responses from phytoplankton and seagrass in the bay. More modeling is needed to better assess the impacts of climate change and to assist in restoration planning.

Restoration Resilience in Plan Formulation

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Biscayne Bay and Southeastern Everglades Ecosystem Restoration (BBSEER) is the newest planning study in the 2000 Comprehensive Everglades Restoration Plan (CERP), which kicked off in September 2020. BBSEER's goal is to restore a more natural freshwater/saltwater gradient by improving water quantity, quality, timing, and distribution in the wetlands of the Southern Glades, Model Lands, and Biscayne Bay Coastal Wetlands, and the nearshore areas of Card Sound, Barnes Sound, Manatee Bay, and Biscayne Bay including Biscayne National Park. The CERP vision for the BBSEER project is to reduce drainage, capture and store freshwater that otherwise releases offshore, and redistribute stored water across the landscape in flow patterns which will provide more natural wetland vegetative patterns and improved habitat, and more estuarine habitat in the nearshore. In addition, project benefits include increased resilience of the ecosystem to sea level rise (SLR) as additional freshwater pushes against saltwater intrusion and as the landscape promotes plant productivity and soil accretion. Through the U.S. Army Corps of Engineers (USACE) Planning Process, alternatives were developed and modeled that included in-ground storage possibilities, multiple dynamic wetland flow-through and water preserve areas, pump stations and spreader canals to move water into degraded natural areas, adaptive infrastructure to allow water around critical habitat for protected species, and seepage features for flood risk management. These alternatives provide the desired habitat benefits to freshwater and brackish water marshes, coastal mangroves, nearshore estuarine areas and provided ecosystem resilience to SLR. At the end of the initial rounds of evaluation, ecosystem benefits were determined to be similar for each alternative. To help distinguish between alternatives, Planners evaluated benefits beyond ecosystem restoration benefits. A comprehensive benefits analysis is a USACE planning tool put into practice in 2021 that requires all projects to consider an array of benefit categories beyond ecosystem restoration benefits, including national and regional economic impacts as well as quality of life and social effects. Using the broad comprehensive benefits analysis framework, the BBSEER Team qualitatively evaluated the ability of an alternative plan to reduce saltwater intrusion to drinking water wells in the study area, provide improvements to the regional economy through recreational opportunities, and provide benefits from an improved nearby ecosystem. The comprehensive benefits analysis, in addition to the ecosystem restoration benefits and cost effectiveness evaluation, allows the team to utilize a multitude of evaluation metrics to compare plans holistically in their ability to provide ecological benefits as well as improve other aspects necessary for human existence including protection of freshwater wells and resilience of the built environment against SLR.

Documenting the Impacts of Sawgrass Encroachment in Sloughs of the Central Everglades

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The drainage, compartmentalization, and cessation of sheet flow in the Everglades has degraded the spatial patterning of the ridge and slough landscape. In many areas the sawgrass has grown from the elevated ridges down into the historically deeper waterlily and spike-rush sloughs, but the impact on aquatic communities (composition and standing stocks) has never been carefully examined. As part of the Central Everglades Planning Process-South (CEPP-S, part of CERP MAP), the removal of sawgrass by herbicide is being conducted in eastern WCA 3B to restore sloughs and encourage reconnection of the system. To document the consequences of sawgrass encroachment (i.e., degraded slough condition) for animal communities, we quantified densities of fish (< 8 cm standard length) and macroinvertebrates with 1-m^2 throw traps and bottomless pull traps in 12 degraded sloughs and 12 adjacent remnant sloughs in a paired design. All habitats were sampled in the dry season (March) and wet season (Sept) of 2023 and 2024. Water depth did not differ between the habitats, mean depths were 23-87 cm at the time of samplings and the region did not dry to depths < 5 cm in the year before sampling or during the sample years. Mean total fish densities were 5x higher in the dry season and 4x higher in the wet season in the remnant sloughs. Total biovolumes of metaphytic algal/microbial mats were 3.2x higher in the dry season and 10x higher in the wet season in the remnant sloughs. Mean aquatic insect densities were 2x higher in the degraded sloughs in the dry season, but did not differ in the wet season. Mean grass shrimp densities did not differ by habitat in either season. Crayfish densities were relatively low overall (means < 1.5 /m^2) but mean densities were 3x higher in the degraded sloughs in the dry season and 8.4x higher in the wet season. The community composition of fishes and macroinvertebrates also differed between habitats with proportionately more bluefin killifish (*Lucania goodei*) in the remnant sloughs and more Everglades pygmy sunfish (*Elassoma evergladei*) in the degraded sloughs. Our preliminary quantifications may be a conservative measure of the impacts of slough infilling by sawgrass as they do not estimate potential larger scale impacts of slough shrinkage, microtopographic flattening, and lack of connections among sloughs (i.e., remnant sloughs in WCA 3B may have relatively low densities of fish). The results indicate that slough degradation by sawgrass encroachment in WCA 3B has reduced fish standing stocks and trophic support for wildlife. It also suggests the restoration effect of vegetation removal could provide significant changes to the trophic functions of the wetland.

Lake Okeechobee Water Quality Trends and Lingering Impacts

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A once natural waterbody, Lake Okeechobee has been extensively managed for many decades, and now almost all aspects of its surface water hydrology are highly regulated. The constrained lake is no longer able to periodically flood and flush its contents over the southern boundary and into the Everglades; a process that deposited the highly productive soils of what is now the Everglades Agricultural Area. Without those sporadic purges, more of the organic-rich detritus remains within the confines of the Lake and contributes to internal nutrient loading and reduced water clarity. Lake Okeechobee has a large surface area, shallow depth, and an extensive fetch which exacerbates water quality declines because strong winds from most directions can agitate the water sufficiently to resuspend unconsolidated bottom sediments. At low lake stages the water surface is closer to the mud zone in the center of the Lake, possibly enabling easier suspension of sediments. At higher lake stages the littoral zone is fully inundated and there is more connectivity between the nearshore zones and the mud zone, decreasing water quality inshore while also exporting detrital matter offshore. Despite the prediction for LORS08 to result in frequent low lake stage, water levels were above the ecological envelope for close to 40% of the time, and the mean lake stage was similar to the preceding 10-year period. This presentation aims to summarize Lake Okeechobee water quality trends over the past two decades, and to illustrate how lake stage management decisions and environmental conditions can interact to potentially influence nutrient budgets and sediment characteristics.

Adapting Lake Okeechobee Habitat Management to Changes in Lake Stages

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Much of Lake Okeechobee's habitat is heavily influenced by lake stage with vegetation coverage increasing or decreasing, depending if the lake has been high or low. In the past few decades, multiple lake regulation schedules have been implemented and each of them has changed not only the habitat but has also impacted the abundance of wildlife such as fish and birds. In summer 2024, LOSOM (Lake Okeechobee System Operating Manual) was implemented, with models showing the lake will be held higher for longer compared to the previous LORS08 schedule. These higher lake stages are expected to negatively impact habitat and an adjustment in management activities and monitoring will be needed to provide the best and most diverse habitat that the lake can achieve under these new conditions. Increased vegetative monitoring and mapping using satellite imagery will show trends in emergent vegetation species each year, and side-scan sonar imagery will help show how densities of submersed aquatic vegetation (SAV) and emergent species in the nearshore (outside, deeper water marsh edge) change each year. Higher water, turbidity and increased wave action are expected to lead to a loss of vegetation, particularly in the nearshore zone. This will likely lead to increased formation of organic berms and tussocks from by uprooted vegetation and will need to be removed using mechanical equipment. Some novel techniques, such as wave attenuation devices, may help protect this vulnerable nearshore zone in select large areas, such as coves. Because vegetation is expected to be lost in the nearshore zone, a shift in focus to improve the littoral zone (shallow water marsh) is more important than ever and may become a prime area for fish and wildlife in upcoming years. Invasive species that form thick monocultures, such as torpedograss, need to be managed to allow for diverse healthy habitats for fish and wildlife to use. A plan to reduce torpedograss lake-wide over the next 5-years, using herbicide, has been developed and has been in action since 2019. Since 2015, bald cypress and other wetland trees and shrubs have been planted on the lake bottom in preparation of higher lake stages. This woody structure will help provide refuge for wildlife species when water is high, particularly when willow begin to die out from high water. Planting upland spaces, such as man-made spoil islands, with native trees and shrubs will also help provide refuge for wildlife. Planting and preservation of declining species such as sawgrass have also been considered. Experiments to determine the best way and places to plant sawgrass in the marsh have started this year and herbicide projects to remove encroaching cattail from sawgrass areas have also begun. As habitat continues to change on the lake, new strategies and management will continue to occur and evolve.

Balancing Estuarine Light and Salinity with Restoration and Operations on the Resiliency Superhighway

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Seagrass communities are vitally important ecosystem components that support organisms across tropic levels in estuarine systems. Therefore, understanding the drivers of seagrass distribution and extent in estuary systems is valuable for conservation and restoration efforts. A critical driver of seagrass distribution is how light moves through the water column (i.e. light attenuation) and the availability of light to reach the estuary bottom. Light attenuation combined with the depth of seagrass colonization is used to estimate the percent surface irradiance (%SI) and an indicator of seagrass light requirements. However, factors that affect light attenuation (i.e. color, algae, suspended sediments, etc.) and water depth can influence the %SI and in some cases limit the amount of light reaching the photic zone for seagrass communities. Over the past half-century, southwest Florida has experienced ~ 200 mm of relative sea level rise with an additional 178 (low) to 816 (high) mm of projected rise in the next 50 years. The objectives of this study were to 1) evaluate optical water quality parameters within the Caloosahatchee River Estuary (CRE) relative to changes in freshwater discharge conditions and 2) evaluate potential effects of sea-level rise. During the study period, freshwater discharge significantly increased resulting in an increase of stressful and damaging discharge events to estuarine indicator species. Concurrent with changes in freshwater discharge conditions, changes to optical water quality parameters including color, chlorophyll-a, total suspended solids, and light attenuation were detected along the estuary. Using photo-interpreted seagrass coverage data combined with bathymetric data, the depth of colonization was estimated for three survey years (2008, 2014, and 2020). Light attenuation was predicted along the estuary using spatiotemporal generalized additive model (GAM) resulting in a relative model fit (R^2) of 0.70. For the three survey years, %SI was estimated across the entire estuary. Over the study period, %SI significantly increased across the lower CRE concurrent with high freshwater discharges. For the past decade (2009 – 2020) the occurrence of stressful and damaging discharge events has significantly increased, concurrent with this increase light attenuation has significantly decreased resulting in an increase in %SI across the lower CRE impacting seagrass communities. However, changes to the water management with the implementation of the Lake Okeechobee System Operating Manual can improve freshwater discharge conditions to the CRE aided by restoration infrastructure.

SPCU Reporting and the Programmatic Application of Information in CERP

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The Comprehensive Everglades Restoration Plan (CERP) is the largest ecosystem restoration project in the world. Authorized by Congress in 2000, CERP intends to improve the health of over 2.4 million acres of wilderness while providing for other water related needs including water supply and flood protection. CERP consists of 68 components to treat, store, and convey water to reconnect the remaining Everglades. Since 2000 much progress has been made. Construction is nearing completion on the first generation of CERP projects, with others in various stages of planning, design or construction. However, CERP was built upon an adaptive management framework which requires continuous review and incorporation of new information to ensure attainment of CERP's vision. The Second Periodic CERP Update (SPCU) was undertaken by the U.S. Army Corps of Engineers and its partner, South Florida Water Management District to determine whether CERP, as it has been modified throughout the years via various planning efforts, along with other restoration efforts performed by our state and federal partners, will meet its goals and purposes as originally envisioned more than 25 years ago. The SPCU incorporates the latest modeling tools, environmental data, and information about CERP features, to evaluate a future projection of CERP. The SPCU is not a reformulation or a modification of the authorized CERP, but is a tool to evaluate CERP performance, show the degree to which the goals and purposes of CERP are being achieved, and calculate the total quantity of water expected to be generated for the natural system and the human environment. The information gained from the SPCU, including a systematic comparison and evaluation of hydrologic targets by **RE**storation, **CO**ordination, **VE**rification, will provide findings and recommendations to the CERP Implementing Agencies to inform decisions regarding areas where adaptive management may be needed to best achieve CERP goals and purposes. In addition, CERP managers may use the information generated to advise Integrated Delivery Schedule project sequencing for planning, construction and regional operations. Future periodic CERP Updates are envisioned to build on the technical tools and incorporate changes to the system to assess CERP progress as intended in the CERP Programmatic Regulations.

Vision in Fruition: Envisioning and Evaluating the Future with CERP

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To ensure that the goals and purposes of the Comprehensive Everglades Restoration Plan (CERP) are achieved, CERP programmatic regulations direct the South Florida Water Management District and the U.S. Army Corps of Engineers to conduct an evaluation of CERP using new or updated modeling that includes the latest scientific, technical, and planning information. It is not a reformulation or a modification of the authorized CERP. These periodic evaluations are intended to provide information to determine if the goals and purposes of CERP are being achieved, to ensure new information is regularly incorporated, and to update the quantity of water expected to be generated through CERP implementation for the natural systems and the human environment. The initial phase of the second periodic CERP update (SPCU) was a substantial endeavor that included application of the latest model and extended period of record, updating performance measures, and determining how full CERP implementation would be represented. While it may sound straight forward, given the components were conceptualized in 2000, the large spatial scale, broad temporal span of project implementation, and changes to the landscape over the last 25 years add complexity in how to envision the future with CERP scenario at a current snapshot in time. The second phase of the SPCU includes modeling the future with and future with CERP, including sea level change, and the technical evaluation comparing the scenarios, which is conducted in coordination with the subject matter experts from the multi-agency Restoration Coordination and Verification (RECOVER) team. This presentation provides an overview of the periodic CERP update objectives, the approach to envision full CERP implementation for the SPCU, and the challenges navigated through the process.

Creation of the Sample Frame for Big Cypress REMAP 2023

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Placement of random sample points in Big Cypress National Preserve created challenges for survey designers. The prevalence of woody vegetation required a new approach for locating points that were both unbiased and safely accessible by helicopter. We used the digital version of the 2019 Ruiz classified vegetation map of eastern Big Cypress (imagery date 2014) to identify polygons where woody plants were sufficiently sparse to enable a skilled pilot to land on a random point. Several iterations of desk-top reconnaissance were performed before it was concluded that only non-woody classes of vegetation were feasible for sampling. The Ruiz map was post-processed using ESRI ArcPro to identify those areas that were composed solely of graminoid and herbaceous classes. These polygons amounted to only 15 % of the total area of eastern Big Cypress, and most of them were very small (as small as the Ruiz minimum mapping area of one 0.25-hectare grid cell). Nevertheless, we used R statistical software in combination with the survey package to successfully distribute 42 random points within the frame covered by these polygons. That number was the sample size estimated to be required to meet survey Data Quality Objectives. An extreme example of random point placements was a station in a 25-meter-wide ponded area in the center of a cypress dome. Aerial reconnaissance of the points in the sample draw was conducted prior to the survey. Only 2 sites were rejected *a priori* as unsafe, because there was more woody vegetation than expected.

A Unique History: Long-Term Ecological Data at the FCE LTER Program

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At the core of all science, data are fundamental to capturing information that advances knowledge and understanding. Everglades restoration integrates a wide range of science and data, including long-term ecological data from the Florida Coastal Everglades Long Term Research (FCE LTER) Program. FCE datasets encompass unique, publicly accessible, temporally extensive (2000-ongoing) data that range across 5 core research areas. FCE data also compliment data from collaborators that are rich in spatial extent. Together, they inform Everglades restoration. There are now more than 200 published FCE datasets (including monitoring, experimental, and modeling data), but how did we get here? This presentation will investigate the growth and evolution of FCE data, and how FCE has advanced in managing and publishing those data. I will also highlight a selection of FCE datasets that contributed to key findings informing Everglades restoration along the way. The results of this investigation will illustrate the unique history of FCE data, their management, and their use in collaborative research informing Everglades restoration. Knowledge gained through this presentation will promote greater understanding of the history and the contributions made by FCE data, and it will provide insights into best practices in data management and publishing.

Development of a Tool to Evaluate Impacts of Constructed Features on the Hydrology of the Southern Everglades

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Everglades National Park (ENP) protects a vital ecosystem supporting biodiversity and water resources, particularly in the ecologically important Southern Everglades. The park faces significant hydrological challenges, including altered flow regimes due to a network of roads, culverts, and canals. To enhance the overall understanding of the system and establish predictive capabilities, the National Park Service (NPS) developed a detailed DHI MIKE-based hydrologic and hydraulic model. The model couples 3D MIKESHE with MIKE11-MIKE1D to simulate surface sheet flow, groundwater, and evapotranspiration integrated with this network of man-made features. Detailed definitions of the main hydrologic landscape features of the Southern Everglades are included, such as Taylor and Shark River slough and their connection with Florida Bay. The model was calibrated against field measurements (1987-1997) for water balance analysis and stage variability. To further improve understanding of how these man-made features are affecting local hydrology, we are upgrading the model. This includes: (1) upgrading to the 2025 versions of MIKESHE and MIKE+ Rivers; (2) improving definitions of surface sheet flow, (3) implementing finer grid resolution to capture detailed landscape features such as the finger glades; (4) adding a more detailed representation of man-made features such as canals, roadways, and culverts; and (5) updating model inputs such as roughness, vegetation, and boundary conditions. The updated modeling system serves as a critical tool to simulate natural hydrological conditions in the absence of anthropogenic alterations, evaluate a range of climate change scenarios, and assess the impact of altered land cover within the ENP.

Near-Real Time Runoff Estimation for Operations and Emergency Modeling

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Hydrologic models use diverse approaches that can be classified into mechanistic, conceptual, and data-driven categories. The first two are more traditional types and often need large numbers of inputs and computational resources. Recent advancements in system identification, also known as data-driven modeling techniques, have opened opportunities for developing robust decision support tools for real-time applications in water resources management. In South Florida, Lake Okeechobee (LO) water management is at the core of water supply and flood control decisions. The Lake Okeechobee Systems Operating Manual includes protocols that need consideration of anticipated conditions at the downstream locations.

The objective of this study was to develop deep learning-based models to estimate local runoff in the Caloosahatchee (C43) and St. Lucie River (C44) basins to support water release decisions with rainfall and near-term historical runoff as the only predictive variables. A 10-year period (2011-2020) was selected to develop training datasets for rainfall and runoff. Cumulative daily rainfall was obtained from the SFWMD's Gage-Adjusted Radar-Rainfall while the daily runoff timeseries' were calculated from observed flow at pairs of structures at LO and respective basin outlets. A Recursive Neural Network (RNN) hyperparameter optimization framework was employed using the Tensorflow software library. To construct a single model 60% of the data was randomly chosen and partitioned into training (60%), validation (20%), and testing (20%) sub-sets. A phased approach was used to identify a final set of models for each basin. In the first phase just a few candidate models were shortlisted from the pool of 500 models developed by this framework using multiple goodness of measure criteria. In the second phase, shortlisted models were evaluated over the 10-year period with and without data assimilation. Predictive ability to simulate storm events was also assessed. Ensembles of 8 and 6 models were selected for C43 and C44, respectively. In general, ensemble mean models performed well with NSE ranging from 0.78 to 0.97 for C43 and 0.57 to 0.88 for C44 across above evaluations. PBIAS performance was more variable with values ranging from -2.2% to 3.6% and from -15% to -67% for C43 and C44, respectively.

Considering the overall goodness of fit, the performance of these models was deemed satisfactory with scope of improvement for C44 which exhibited substantial systematic bias. Automated processes run the ensemble member models on daily basis to estimate runoff for three quantitative precipitation forecasts over a 6-week timeframe using observed runoff over the previous 90 days. Runoff forecasts are integrated into other tools to assist LO water managers for situational awareness towards weekly release decisions. Also, over the last two hurricane seasons these models have been successfully implemented in near-real time applications for LO during emergency situations.

System-wide Modeling Recommendations as Potential Solutions for Current Issues in Central Everglades

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The Central Everglades Planning Project (CEPP) Operational Plan increment 1 (CEPP1.0) is the first incremental update to amend the Combined Operational Plan (COP) Water Control Plan (WCP) and incorporate operations of new infrastructures constructed under the CEPP by 2027 as well as other projects, such as the Tamiami Trail Next Steps Phase 2 features and the Lake Okeechobee System Operating Manual. The current COP WCP has been implemented since 2020 to operate the completed Modified Water Deliveries and the C-111 South Dade projects. In addition to integrating new infrastructure, the CEPP1.0 seeks to incorporate some lessons learned from the implementation of the COP, which experienced challenges from a multi-species perspective. The high-water conditions in southern Water Conservation Area 3A (WCA-3A) and the unnatural dry conditions of the northern WCA-3A have negatively impacted the ecological conditions in this ecosystem. During the last four years, to protect WCA-3A tree islands and the culturally significant sites of the Miccosukee Tribe of Indians of Florida, temporary operational deviations of COP were implemented. To assist CEPP1.0 planning effort, we conducted a series of analyses to update slough vegetation and marl prairie hydrological targets using the Natural System Regional Simulation Model (NSRSM). In addition, we are proposing potential operational solutions to address conflicting challenges for a regional scale modeling evaluation using the Regional Simulation Model (RSM). Condition based operations for specific structures as well as flexible regional operations were assessed to improve system-wide ecosystem.

Estimating the Economic Impacts of Greenhouse Gas Emissions in the Everglades Agricultural Area

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Peatlands are among the most carbon-rich ecosystems but become major greenhouse gas (GHG) emitters when drained for alternative land uses. In Florida's Everglades Agricultural Area (EAA), decades of drainage have led to peat oxidation followed by peat soil loss (subsidence) and substantial emissions of GHGs namely, carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4), posing significant climate implications. This study quantifies present-day and historical GHG emissions from sugarcane operations in the EAA and applies the Social Cost of Carbon (SCC) to evaluate climate damages. We apply the novel concept of "Climate Wealth Borrowing" (CWB) from prior literature to past emissions from peat oxidation in the EAA, reflecting the present value of climate damages caused by peat drainage related EAA emissions that have reduced the climate-related natural capital wealth over time. Our analysis estimated annual GHG emissions from sugarcane operations on organic and inorganic soils based on the latest IPCC guidelines and using EAA-specific data. We applied interim U.S. Interagency Working Group (IWG) SCC values to monetize present-day emissions. To capture the broader, long-term impacts, we employed the Historic DICE model to calculate the CWB associated with peat oxidation since 1962. Currently, sugarcane cultivation in the EAA results in 7.37 million metric tons CO_2-equivalent emissions, with peat oxidation accounting for over 84% and pre-harvest cane burning accounting for less than 2% of the total emissions, respectively. At a 3% discount rate, the 2020 GHG emissions from sugarcane cultivation in the EAA cost roughly $376 million in global climate damages. Between 1962 and 2020, costs from peat oxidation range from $2.16 billion to $79.27 billion, depending on discount rates and subsidence assumptions. These findings highlight the large climate damage arising from peat drainage in the EAA. For Everglades scientists and resource managers, our findings point to the opportunity for integrated land-use strategies that meet broader environmental goals, including peat conservation, water management, and climate mitigation.

Integrating Restoration Strategies Science and STA Management: Part II Management Strategies

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The Restoration Strategies Science Plan (RSSP) was completed in 2024 and included a total of 21 studies conducted over the last 12 years. These studies were developed primarily to support the design, operation, and management of the Everglades Stormwater Treatment Areas (STAs) to achieve and sustain total phosphorus (TP) concentrations to meet the water quality based effluent limit (WQBEL). These studies improved our understanding of P cycling, P retention and factors inhibiting P retention within the STAs. Study results proposed 20 management strategies to optimize P retention in the STAS to achieve the WQBEL. P retention varies among the STAs, due to their different land use histories, soil types, soil TP content, inflow waters, topographies, vegetation, hydrology, and type, location, and number of control structures, therefore not all of these strategies are appropriate for each STA.

These strategies include management of water and P delivered to the STAs, water depths, vegetation, and soils. STA performance is best when annual phosphorus loading rates (PLR) are at or below 1.3 g P/m^2/yr and annual hydraulic loading rates (HLR) are approximately 3.5 cm/day. In addition, maintaining flow rates between 5 and 15 cm/day during periods of flow resulted in the lowest outflow TP concentrations. Avoiding water depths of 2.8 feet or more for greater than 8 consecutive weeks was damaging to cattail, therefore these conditions should be minimized to extent practicable. It is suggested that outflow regions of cells be maintained as a mix of emergent aquatic vegetation (EAV) and submerged aquatic vegetation (SAV), which supports a diversity of periphyton that mineralize organic P and remove inorganic P. In addition, more open water areas containing SAV support the breakdown of organic matter by sunlight (photolysis) leading to more P removal. PSTA (periphyton based STA) created by scraping away high P soils to bedrock, is very effective in achieving low outflow P concentrations. Capping high P soils with limerock in outflow regions is another option to reduce soil P flux to achieve low outflow P concentrations.

Maintaining EAV as windrows in outflow cells supports SAV by reducing the damage from storm events on SAV. However, these windrows must be managed to prevent EAV encroachment into the SAV areas. *Chara* and *Naiad* are the preferred SAV communities in outflow regions as they support the most P retention and low P concentrations. When SAV collapses, drawdowns can be used to promote SAV germination. The low water depths reduce fish density and thus herbivory, which allows the SAV to recover. Drawdowns also can reduce fish densities and nesting, which resuspend and recirculate P from the soils, through enhanced predation by birds and alligators. These management strategies will support P retention in the STAs to achieve the WQBEL.

Fecal Microplastic Accumulation and Associated Changes in Gut Microbiome in Florida Manatees (*Trichechus manatus latirostris*)

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Microplastics, defined as plastic debris measuring 5 millimeters or less in size, are a pollutant of emerging concern that are known to be in nearly all aspects of marine environments including the air, sediment, waterbodies, plants, and animals.

Specific to Florida, the peninsula is surrounded by the Gulf of Mexico and the Atlantic Ocean, both of which are known to be polluted with microplastics. This leads to a high availability for ingestion across trophic levels, including marine megafauna. When introduced to the body, microplastics can cause mechanical damage to the digestive tract by causing perforations or abrasions to the gut mucosal lining, the first line of defense against pathogens and bacterial translocation. Microplastics can also influence the type or amount of food being eaten which leads to gut symbionts being deprived of crucial nutrients and substrates which could change the overall gut community.

This study proposes an innovative, noninvasive method that pairs the investigation of microplastic presence and microbiome changes in Florida manatees (*Trichechus manatus latirostris*) by examining their fecal matter. Studies on other animals have been conducted using fecal samples as a proxy for gut microbiome, but this approach introduces microplastic accumulation as a possible explanation for microbiome changes in a novel species.

Floating fecal samples in Everglades National Park and Biscayne National Park were collected from the water and analyzed for microplastic presence and sequenced to analyze microbiome conditions. In collaboration with the US Geological Survey, fresh fecal samples were collected in 2023 and 2024 from Brevard County, in 2025 from Crystal River, and archived samples from manatee health assessments were obtained from 2011-2022 from Brevard County, Crystal River, and Everglades National Park. Microplastics and microbiome results were compared across collection years and locations. Analysis to evaluate for statistically significant temporal, spatial, and sex differences is ongoing, while also considering unusual mortality events (UMEs) as a factor.

Initial analysis suggests that there were microplastics present in manatee fecal samples dating back to 2011 in addition to changes in the manatee gut microbiome across locations and years. This study will provide insight into the health of manatees affected by microplastic ingestion.

Developing Early Detection Tools for Monitoring the Spread of Invasive Tegu Lizards in the Everglades

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New monitoring technologies such as environmental DNA (eDNA) and image detection algorithms derived with artificial intelligence (AI) can expand the scale at which detecting species is possible while minimizing limited resources. Although these methods are rapidly evolving and increasingly being applied in the field, they are subject to an age-old monitoring issue—imperfect detection. However, the sources of imperfect detection differ between survey methodologies. Sources of imperfect detection for AI image detection algorithms include 1) camera brand, 2) camera settings, 3) camera deployment location/position and 4) accuracy of the image detection algorithm. Sources of imperfect detection for eDNA include 1) sampling methodology, 2) substrate sampled, and 3) timing of the sampling (i.e., how long ago the target species was in the area). Quantifying detection probability for these potential pathways of imperfect detection can allow managers to design more robust monitoring strategies for implementing these technologies. Here, we use invasive tegu lizards in Everglades National Park as a case study to explore optimizing detection of individuals at low densities. We focus on using two methods of detection: 1) terrestrial eDNA sampling and 2) deployment of cellular cameras and analyzing images using an AI image detection algorithm. We discuss tradeoffs and present frameworks for estimating detection and implementing monitoring for tegus using each of these technologies.

Where Do We Go from Here? System-Wide Synthesis and Uncertainties for Everglades Restoration

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REstoration, COordination, and VERification (RECOVER) is an interdisciplinary collaboration of agencies, tribes, and institutions that conducts scientific and technical evaluations and assessments to improve the ability of the Comprehensive Everglades Restoration Plan (CERP) to restore, preserve, and protect the south Florida ecosystem while providing for the region's other water-related needs. In 2024, RECOVER published a new System Status Report (SSR), the first to present an assessment of CERP project performance in the natural and human systems. In previous SSRs, RECOVER reported on status and trends of ecological indicators of restoration from its Monitoring & Assessment Plan (MAP). There are now four CERP projects with components in the operational testing and monitoring phase, or fully implemented and in operations. RECOVER compared expectations from hydrologic and ecological modeling of future increments of CERP implementation with real-world data from the MAP to report on restoration progress. Findings from the 2024 SSR showed the status of most indicators as "Poor" or "Fair" based on quantitative and qualitative metrics developed by RECOVER scientists. Due to the relatively small number of projects in operations as of the 2024 SSR reporting period, little to no change resulting from CERP implementation was expected. Some benefits were observed locally from the operational CERP components and updates from water management operations, and RECOVER expects more progress as additional projects come online. Looking ahead to future reporting, effective assessment and communication will require synthesis of MAP and CERP project-level monitoring data, water management operations, and impacts from weather and major climatological events, climate change, sea level rise, and invasive species. All these factors introduce uncertainty and complicates identifying causal relationships between CERP implementation and restoration outcomes. The timing of CERP project implementation, individual and collective project performance, and response time of ecological indicators to hydrologic change will affect when and where we see restoration progress. Continued monitoring, targeted scientific studies, and agency buy-in for consistent staffing and coordination to conduct synthesis will be key.

Co-Variation of Macrophyte and Microbial Mat Standing Stocks along Wetland Resource Gradients

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Macrophytes and benthic microbial communities regulate carbon and nutrient storage and cycling, soil formation and accumulation, and resources for higher trophic levels in wetlands. Hydrologic conditions and nutrient availability can influence macrophyte and benthic microbial community standing stocks, but few studies have evaluated how the two co-vary along resource and stress gradients. The goal of this study was to quantify macrophyte and benthic microbial community (mat) standing stocks along established hydrologic and nutrient gradients in the Everglades and compare these values to those found in other shallow freshwater habitats around the world. Macrophyte dry biomass and microbial mat ash-free dry biomass along with both communities' carbon, nitrogen, and phosphorus standing stock were measured in three ridge (drier) and three slough (wetter) 1 m^2 plots at three sites in Shark River Slough (higher phosphorus) in 2021 and three sites in Taylor Slough (lower phosphorus) in 2023 during the wet season (June-August). A synthesis of other Everglades studies and of other freshwater habitats was conducted to place Everglades macrophyte and microbial mat co-variation in the context of other systems. In this study, macrophyte biomass, phosphorus, and nitrogen standing stocks were on average 50x, 160x, and 23x higher than that of microbial mats, respectively. Macrophyte standing stock was 40% greater in ridges than sloughs while microbial mat standing stock did not differ. Macrophyte biomass and carbon standing stock did not vary along a gradient of microbial mat phosphorus content, but microbial mat biomass and carbon standing stock exponentially declined as mat phosphorus concentrations increased. Microbial mat biomass and carbon stock also declined while macrophyte biomass increased with increasing mat total nitrogen concentrations. Macrophyte and microbial mat biomass from other Everglades studies followed the same trend along the phosphorus gradient. Further analysis will reveal macrophyte and microbial standing stocks in other freshwater bodies. It is expected that mass and carbon stock values will be much higher for microbial mats in the Everglades, which is common in karstic wetlands, while macrophyte values in the Everglades will be similar to other systems; phosphorus and nitrogen stocks of Everglades microbial mats are also expected to be much lower than other systems due to naturally low nutrient concentrations and phosphorus limitation.

The Pulse of Freshwater Fish and Aquatic Invertebrates in Everglades National Park

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Freshwater fish and aquatic invertebrate assemblages occupy a critical role in Everglades food webs and have been a focus of ecological monitoring and assessment efforts since the 1960s. Results from these monitoring efforts have demonstrated that species have predictable responses to hydrological conditions that enabled the development of performance measures and assessment methods used to evaluate the response to restoration and water management actions. These assessments have been used in various reporting efforts including the State of Conservation Reports to the World Heritage Committee. The desired state of conservation is to maximize abundance of small-sized freshwater fishes and aquatic invertebrates in a manner consistent with their expected populations in the pre-drainage Everglades ecosystem. However, stressors such as invasive species and sea level rise may influence our understanding of responses to hydrological conditions. Recent assessment results and status and trends of freshwater fish and aquatic invertebrate populations relative to the desired state of conservation will be discussed including trends observed with invasive fishes in Everglades National Park.

Perspective of Scale in Estuarine Management: Climate Change Makes it Imperative

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Climate change is ushering in a less predictive environment in which to manage natural resources, including coastal estuaries of the Everglades. Future climate scenarios for Everglades' Coastal Marine Foundation Communities assessed a decade ago by the authors identified seagrass ecosystem stress from multiple drivers that coalesce to enhance hypoxia in the system. These drivers, elevated temperature, salinity and recurring algal blooms that reduce light to the benthos and cause hypoxia, also stimulate sulfide toxicity in tropical carbonate seagrass systems such as Florida Bay. This is consequential, as hypoxia and sulfide toxicity have been reported to be one of the leading causes of recurrent large-scale seagrass mortality events in Florida Bay, as well as globally. Our research over the last 25 years has been focused on gaining a more complete understanding of seagrass internal and water column oxidation and factors leading to seagrass decline and die-off events in Florida Bay. However, we now require a vehicle to translate these data into climate change driven projections. We present an ongoing initiative to parameterize and validate a seagrass ecosystem model with physiological data to cross scales and provide a modeling tool for seagrass management under various scenarios of climate change within southern Florida estuaries.

The Florida's Coral Reef Unified Water Quality Monitoring Dataset Aggregation and Analysis

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Water quality issues are one of the many natural and anthropogenic stressors facing Florida's Coral Reef ecosystem. Due to the wide geographical range, variation in biophysical factors, and differing proximity to population centers, many different projects and groups conduct water quality monitoring across the reef. As a result, detecting patterns or analyzing effects of water quality requires finding and combining data from disparate sources. Thus, we developed a unified water quality monitoring dataset and protocol made up of an inventory, inclusion criteria, and aggregation of nutrient and turbidity data. Eight discrete monitoring programs met the criteria and were aggregated into a unified dataset and were used for trend analyses, maps, and visualization tools to depict spatial and temporal patterns. We also conducted a separate inventory and methods analysis of programs monitoring temperature, salinity, pH, and dissolved oxygen including discrete and continuous sampling. Further, we are working to integrate the dataset and protocol into an existing monitoring database to automate updates while providing a 'one-stop shop' for Florida's Coral Reef water quality data. The unified dataset is being used to help support multiple state-wide efforts to better understand the effects of water quality and restoration activities on the health of Florida's Coral Reef. One such effort is supporting the Florida's Coral Reef Coordination Team's work to develop a unified monitoring framework to help understand how restoration of Everglades hydrology may affect the reef. The unified water quality dataset will continue to be updated with new monitoring data and programs as they become available and will be incorporated into management tools such as an upcoming coral reef decision support system.

Contaminants of Global Concern: Under-investigated Issues for the Greater Everglades

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In the Greater Everglades, point and nonpoint sources from urban and agricultural activities are likely generating a complex mixture of contaminants of global concern (CGCs). Mounting evidence suggests that exposures to CGCs and mixtures of CGCs can cause various deleterious effects to aquatic and terrestrial organisms, including humans. To minimize contaminant exposures and potential corresponding environmental effects to the Greater Everglades, it is necessary to understand their sources. While some CGCs (e.g., nutrients and mercury) have been well studied in the Greater Everglades, others have limited information regarding their environmental exposures via the various anthropogenic inputs. Under-investigated sources of CGCs in south Florida include urban stormwater runoff, municipal wastewater treatment plant discharge, food/beverage/feedstock processing plant discharge (e.g., meat processing, fruit/vegetable processing, biofuel production), urban and agricultural pesticide use, and applications of biosolids and livestock manure on farmland. Previous research in other areas of the United States has documented that these sources generate mixtures of numerous and varied CGCs. Examples of under-investigated CGCs in the Greater Everglades include: (1) microplastics, (2) per- and polyfluoroalkyl substances (PFAS) (e.g., precursors, terminal PFAS - including trifluoroacetic acid and other ultra-short chain PFAS that have recently been documented as being prevalent in the environment), (3) pesticides and their transformation products (e.g., neonicotinoid insecticides, herbicide glyphosate and its major transformation product AMPA), (4) pharmaceuticals and personal care products (e.g., metformin, fexofenadine, cotinine), (5) tire wear components (e.g., 6PPD and its transformation product 6PPD-quinone), and (6) hormonally active compounds (e.g., biogenic and synthetic hormones, phytoestrogens). Upstream releases of CGCs could impact wildlife health in downstream regions, including Everglades National Park, due to the hydrologic connectivity of this critical ecosystem. Thus, restoration efforts to return regional water flow to more historical conditions should include holistic (e.g., multi-matrix, multi-contaminant) research on CGC exposures and effects using an approach recognizing the interconnection between, people, animals, plants, and their shared environment.

Shifting Freshwater Hydrology and Saltwater Intrusion Characterize Changing Dissolved Organic Matter Along Coastal Wetland Gradients

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Dissolved organic carbon (DOC) concentrations and dissolved organic matter (DOM) sources and compositions are changing in inland aquatic ecosystems with uncertain impacts on the global carbon (C) cycle. In coastal aquatic ecosystems, shifts in DOC and DOM are linked to climate-driven changes in organic matter processing and changes in water sources associated with freshwater management and sea-level rise. The Florida Everglades is a model system to test how water management and rapid sea-level rise are changing C cycling along freshwater-to-marine gradients across diverse ecosystems that include peat and marl marshes, mangroves, and seagrass meadows. We analyzed long-term (2001-2024) DOC concentrations and (2011-2022) DOM compositions from monthly surface water samples collected at n = 14 sampling stations along two hydrological distinct transects: 1) a larger, deeper peat-dominated marsh and tidal mangrove estuarine drainage (Shark River Slough, SRS); and 2) a smaller, shallower marl-dominated marsh and non-tidal mangrove estuarine drainage (Taylor Slough/Panhandle, TS/Ph) in Everglades National Park (Florida, USA). We used optical fluorescence measurements of DOM to develop excitation emission matrices coupled with parallel factor analysis (PARAFAC). We quantified six distinct PARAFAC components that varied with both subtropical seasonal (wet-dry season) hydrology and pulsed inputs from freshwater restoration activities. Hydrologic controls (i.e., seasonal water level, pulsed water deliveries) on DOM composition varied between both transects, indicating differences in connectivity to upstream terrestrial and agricultural sources. DOM at TS/Ph sites shifted over 10 years from more autochthonous, protein-like DOM to more humic and microbial sources. Across all sites, we observed small, but significant, long-term decreases in the fluorescence index (i.e., more terrestrial/humic) and increases in the biological index (i.e., higher autochthonous productivity). Upstream freshwater restoration in peat marshes is mobilizing humic C into downstream mangrove estuaries. Saltwater intrusion from sea-level rise is increasing and shifting marine and mangrove C inland in marl drainages, while upstream restoration in marl marshes is increasing humic DOM from allochthonous peat marshes. Pulsed releases of upstream DOM with storms and rising water level from inland freshwater restoration converge with saltwater intrusion from sea- level rise in Florida Bay, resulting in a more homogenized DOM chemical composition at estuarine mangrove and seagrass sites. In coastal ecosystems, changes in upstream freshwater management and saltwater intrusion from accelerating sea-level rise are altering DOC concentrations and DOM composition, especially in estuaries where C sources are mixed. As climate and human changes continue to transform coastal ecosystems, integrated approaches that conserve and maximize C storage are critically needed.

Negative Correlations Between Mayan Cichlid and Native Sunfish Catch Rates

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Mayan cichlids are an established, non-native species of fish with generalist diets that have inhabited wetland habitats of the Florida Everglades for more than 30 years. Evidence for predatory impacts of Mayan cichlids on small marsh fishes (potential prey) has been variable, while their impacts on similar-sized native sunfishes (*Lepomis* spp.) of similar trophic status has been less-well-studied. We used abundance data collected from the Loxahatchee Impoundment Landscape Assessment (LILA) wetlands to investigate whether variation in Mayan cichlid catch rates were negatively correlated with populations of native sunfishes. LILA consists of four replicate 8 ha wetland macrocosms, located within Arthur R. Marshall Loxahatchee National Wildlife Refuge. Quantification of the fish communities has taken place twice per year from 2008-2012 and 2018-2024. In 2008-2012 there were fewer Mayan cichlids present in the LILA wetlands, and this was partly a function of the 2010 cold snap, while several species of *Lepomis* were present in all the wetlands during both periods. Mayans recolonized all wetlands by 2018. Fyke and hoop nets (collectively: trap nets) were set in the deep sloughs of each wetland overnight during both the wet (July-August) and dry (March-April) seasons and were cleared every 20-24 hours. Fish ≥ 5 cm (standard length, SL) were identified, measured, and released. Nightly catches were standardized as the sum of mean catches per net type per night, and the mean catch-per-unit-effort (CPUE) of each fish species was calculated using three nights of sampling each season. Throw trap densities of small size classes of sunfishes (76% < 5 cm SL) were also quantified with 1-m^2 throw traps in the deep slough of each wetland during both seasons. The mean density and mean CPUE of different sunfish species were log transformed and correlated with log transformed CPUE of Mayan cichlids. All macrocosm, year, and season combinations were used in the initial analyses (N = 75). Pearson correlations (r) were used to quantify the evidence for a negative correlation. Catch rates of larger Mayan cichlids (≥5 cm) had no discernible correlation with the mean throw trap densities of any sunfish within LILA. However, when considering the catch rates of sunfish within trap nets (sunfish ≥5 cm SL), we found significant negative correlations between Mayan cichlid CPUE and the CPUE of the three most abundant sunfishes at LILA. Mean catch rates of Warmouth (*Lepomis gulosus*: r= -0.35), bluegill sunfish (*Lepomis macrochirus*: r= -0.34), and dollar sunfish (*Lepomis marginatus*: r= -0.47) were negatively correlated with Mayan cichlid mean catch rates. When just examining wet season (July-August) catch the negative correlations were somewhat stronger for bluegill (r= -0.40) and dollar sunfish (r= -0.52). Taken together the results suggest that Mayan cichlid populations may have a negative effect on recruitment of native sunfishes in LILA.

Storm Wave Propagation Along C-111 Canal During Hurricane Irma

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Hurricane Irma struck Florida on September 10, 2017, causing storm surges that traveled unusually long distances along Florida canals, including the C111 canal. The speed and height of the surge observed during this event are crucial for flood risk assessments. The notably large seepage component in Florida significantly impacted both the speed and amplitude of these storm surges, highlighting the need to re-evaluate standard analysis practices used here that are developed areas with less seepage. A better understanding of this analysis may lead us to reassess the tools useful in evaluating surge behavior for design purposes.

To evaluate the wave propagation behavior in the C111 canal, we employ analytical methods for wave propagation. These methods are based on full St. Venant equations for canal flow, fully coupled with governing equations for groundwater flow. Spectral solutions to this problem reveal three dimensionless parameters: (1) the ratio of inertial and gravitational forces, known as the Froude number; (2) the ratio of frictional to gravitational forces; and (3) the ratio of aquifer to canal storages. These parameters fully determine the solution to the problem.

We aim to track the propagation of normal tides along the C111 canal and compare it with the propagation observed during Hurricane Irma, specifically noting when the water moved inland, the water surface gradient was directed toward the ocean. By using the dimensionless numbers and analytical solutions, we will identify which forces dominate the flow behavior during hurricanes, and how variations in hurricane conditions or ground conditions influence this behavior. Our goal is also to demonstrate the benefits of using analytical models when benchmarking numerical models.

Landscape-scale Evaluation of Vegetation Cover and Hydrologic Conditions Along the Southwest Coast of Everglades National Park

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Coastal wetlands provide myriad ecosystem services yet face an uncertain future due to the legacy of anthropogenic impacts and 21st century sea-level rise. Vegetation responds differently to hydrologic changes at landward (freshwater) and seaward (marine) edges which can be expressed through changes in land-cover. Coastal sawgrass marshes are particularly sensitive to these hydrologic changes as they are highly organic and increasingly stressful hydrologic conditions have been shown to drive sawgrass dieback thereby increasing open-water cover (e.g. peat collapse). Evaluating these land-cover patterns across broad coastal landscapes can elucidate new process-based questions that aim to link patterns to processes. The objective of this study was to conduct a landscape-scale assessment of whether hydrologic conditions known to drive vegetation change at site-scales are indicative of vegetation patterns observed at landscape-scales within the Florida coastal Everglades, USA. Our evaluation focused on the estuarine zone along the southwest coast of Everglades National Park where we hypothesized that sea-level rise and reductions in freshwater delivery has driven the conversion of sawgrass marsh to either (1) open-water or (2) woody mangroves, and thus, hydrologic conditions should differ across these three land-cover types. To evaluate this, we compared coarsely simulated (500 x 500 m) hydrologic conditions from 2013 - 2016, and high-resolution (3 x 3 m) remotely sensed, vegetation percent cover metrics based on April 2021 satellite imagery to determine whether increasing water depths and porewater salinity are positively correlated with increasing open-water or mangrove cover. We identified a weak negative quadratic relationship between water depth and porewater salinity ($r^2 = 0.29$) but found no clear relationships between hydrologic conditions and percent cover of vegetation or open water. This null result may be due in part to a paucity of model validation data for this specific study area and/or to present-day vegetation patterns being more reflective of the legacy of freshwater hydrologic alterations. While progress has been made with respect to restoring the volume of freshwater flows to the coastal Everglades, more empirical data is needed across the southwest estuarine region to understand links between vegetative cover and hydrology to improve data paucity and enable more accurate predictions of future landscape trajectories.

Determining Spatial and Temporal Sources of Water in a Coastal Wetland System Using Geochemical Tracers, Southeast Florida

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An objective of both the Comprehensive Everglades Restoration Plan (CERP) and the EPA South Florida Program is to reduce point source discharges of freshwater from canals into Biscayne Bay. In the Biscayne Bay Coastal Wetlands (BBCW) Phase 1 Project, hydrologic restoration is underway which has begun diverting canal water through adjacent coastal wetlands dominated by mangrove forests. The South Florida Water Management District is monitoring conditions within areas of water diversion. However, a comparison of the hydrogeological dynamics within the BBCW not receiving additional inputs of freshwater is lacking. An objective of this study, initiated in 2024, is to understand the spatial and temporal inputs of water (i.e. groundwater, bay water, canal water, precipitation) and the proportions of these sources of water that contribute to the coastal wetlands. To address this objective, we chose six hydrologically independent blocks of mangrove basins within BBCW. Three basins receive passive freshwater additions from the adjacent L-31E Canal through culverts while three others do not have culverts. Water sampling events occur quarterly among 4 sites (A, B, C, D) that have been strategically placed from west to east within the mangrove basins and coastal mangrove fringe area; the A site is located approximately 50 m from a levee that is adjacent to the L-31E Canal, the B site is located approximately 100 meters from the levee, the C site is located at the headwaters of tidal creeks and the D site is approximately 50 m from the mouth of the tidal creek nearest to the bay. Other water sampling stations include one nearby groundwater well, a northern and a southern water sampling site along the L-31E Canal, a northern and a southern Biscayne Bay water sampling site. Natural geochemical constituents such as stable isotopes of oxygen and hydrogen and strontium/calcium mixing ratios and salinity are used in geochemical mixing models to determine the spatial and temporal inputs of the sources of water. Preliminary results from the isotope data and strontium/calcium mixing ratio data suggest that most water sampling stations are influenced by canal water and some locations are influenced by groundwater. The overall salinity across all sites ranges from 0.4 to 24.9 PPT, with groundwater consistently having the lowest salinity range of 0.5 to 1.7 PPT and the bay water sites consistently having the highest salinity range of 16.2 to 22.9 PPT. The results of this investigation will provide further insight for coastal managers regarding the hydrologic connectivity and hydrogeological dynamics of these mangrove basins.

Tree Island Restoration in the Everglades and Francis S. Taylor Wildlife Management Area

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Tree island habitat represents a relatively small portion of the spatial area within the Florida Everglades, but this habitat type is essential to the functional integrity of the entire Everglades ecosystem. Anthropogenic manipulation within the Everglades, which began over 100 years ago, contributed to the degradation of many tree islands. This tree island restoration project examines invasive vegetation control, native planting techniques, wildlife use, and species survival rates for tree island restoration. Since the early 1990s, the Florida Fish and Wildlife Conservation Commission has been working to restore tree islands, including removing invasive vegetation (e.g., Brazilian pepper [*Schinus terebinthifolius*]), planting native trees and shrubs, and collecting associated survivorship data in the Everglades Complex of Wildlife Management Areas. Although survival rates vary by species and by individual islands, the importance of the promotion of plant diversity and subsequent benefits for wildlife, such as food and cover, cannot be underestimated. Monocultures of invasive plants significantly reduce diversity and available food resources in these areas. Planting techniques are based on island characteristics and survivorship. Species typically planted include cocoplum (*Chrysobalanus icaco*), elderberry (*Sambucus nigra*), red maple (*Acer rubrum*), firebush (*Hamelia patens var. patens*), dahoon holly (*Ilex cassine*), hackberry (*Celtis occidentalis*), myrsine (*Myrsine cubana*), pop ash (*Fraxinus caroliniana*), strangler fig (*Ficus aurea*), sweet bay (*Laurus nobilis*), and pond apple (*Annona glabra*). Restoration tree islands are maintained annually to keep invasive vegetation levels low and native planting survival rates high. Other restoration tools include prescribed fire to reduce fuel loading in the sawgrass marsh surrounding tree islands to protect them from wildfires. The Everglades is a fire-adapted ecosystem, and regular fire return intervals enhance wildlife habitat, promote diversity, and reduce the likelihood of catastrophic wildfires that would negatively impact wildlife. Tree islands support wildlife species such white-tailed deer (*Odocoileus virginianus*), Florida panther (*Puma concolor coryi*), black bears (*Ursus americanus floridanus*), black (*Laterallus jamaicensis jamaicensis*) and king rails (*Rallus elegans*), amphibians and reptiles, as well as a variety of wading birds, marsh birds, and songbirds. During high water conditions, tree islands provide dry areas for terrestrial wildlife to take refuge and forage. Wildlife monitoring includes year-round remote motion-sensor camera trapping and browse surveys during high water conditions. Vegetation assessments inform plant survivorship and future planting efforts and evaluate management objectives for tree island restoration success. Monitoring tree islands helps guide management and restoration efforts throughout the Everglades.

A Change Detection Analysis of Lake Tohopekaliga Using Historical High-Resolution Aerial Imagery

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Lake Tohopekaliga (Toho) is a large, shallow lake with a surface area of 9,200 ha and mean depth of 2.1 m. It is one of five lakes of the “Kissimmee Chain” that deposits into Lake Okeechobee. Anthropogenic alterations imposed over the century have led to decadal changes in hydroperiod, limnetic conditions and biological communities. Regulated water conveyance designed to stabilize lake levels has created environmental conditions conducive to the expansion of littoral areas. In this study, we sought to understand how aquatic vegetation communities on Lake Toho have changed over time by analyzing orthorectified, high-resolution imagery from aerial surveys conducted in 1944, 1968 and 2021. Manual feature classifications were conducted with digitized grids for each timepoint to distinguish open water, agriculture land, trees, urban/residential land, organic shoreline, sandy shoreline, littoral tussock. Since 1944, drastic changes to the lake system were observed including the loss of 602 acres of white sand shoreline and the expansion of 5,406 acres of littoral tussock. In a 2021 vegetation survey, non-native, submersed hydrilla was the dominant species, particularly in open water. However, the majority of littoral and shoreline communities were over-represented by native emergent species. Decreasing the maximum lake level and stabilizing depth fluctuations have led to a boon in aquatic vegetation resulting in a positive feedback loop with accumulations of organic matter building up over time altering the shoreline and creating large expanses of floating island tussocks colonizing the open water further supporting a diverse macrophyte community.

Revising Regulation Schedule: Balancing Hydrology and Ecology in WCA-2A

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Water Conservation Area 2A (WCA-2A), a vital part of the Everglades, is a mosaic of ridges, sloughs, and tree islands. Over time, water management practices combined with phosphorus inputs and regional topographic gradients, have dried out the northern areas and flooded the southern ones, leading to habitat loss, cattail spread, and changes in microtopography. As a result, WCA-2A is hydrologically complex, with the 1989 regulation schedule contributing to the challenges of water management. To address these issues, we developed a revised regulation schedule that aligns water management with ecological needs. By combining data from an extensive data-logging network, elevation surveys, vegetation maps, and hydrological models, we set specific water level targets that account for elevation, seasonal changes, and ridge-slough topography. We tested several models to find an approach that reduces stress on vegetation, maintains slough inundation, balances wet and dry seasons, and introduces hydrologic improvements like shorter, better-timed dry seasons, lower peak water levels, and natural yearly variability. Key outcomes of the revised regulation schedule include optimal water recession and ascension rates, less stress on sawgrass, and reduced cattail dominance. However, challenges remain, such as managing inflows and addressing how berms within WCA-2A affect water flow. Overall, the revised schedule will enhance biodiversity, support hydrologic restoration, and set the stage for future projects under the Central Everglades Planning Project.

Seasonal Dissolved Organic Matter Dynamics in Two South Florida Estuaries

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In South Florida, Lake Okeechobee (L. Okeechobee) has two main discharge estuaries: the Caloosahatchee River Estuary (CRE), which discharges westward into the Gulf of Mexico, and the St. Lucie Estuary (SLE), which discharges eastward into the Atlantic Ocean. This region has faced long-standing water quality challenges, including Harmful Algal Blooms (HABs). We characterized dissolved organic matter (DOM) in both estuaries on a monthly basis to monitor water quality and identify DOM sources in the region. In both systems, dissolved organic carbon (DOC) and humic-like fluorescent DOM (FDOM) showed strong correlations with salinity across seasons (r^2=0.66 –0.77, p<0.0001 for CRE and r^2=0.50 –0.78, p<0.0001 for SLE), indicating that humic-like FDOM and DOC primarily originate from freshwater sources and behave conservatively in both estuaries. In the CRE, the highest DOC and FDOM concentrations were observed at the C-43 canal in August to October 2022, possibly related to high flow conditions leading up to Hurricane Ian. During the wet season, with low discharges from L. Okeechobee, the primary DOM source was terrestrially derived, likely from the C-43 canal and surrounding watershed. In the SLE, the highest DOC and humic-like FDOM concentrations were observed in the C-24 and C-23 canal, located on the northern side of the estuary. Occasionally, elevated humic-like FDOM concentrations were also recorded in the C-44 canal, which drains L. Okeechobee in September and October 2024. Notably, one site situated near an urban area, exhibited high DOC and FDOM concentrations likely due to anthropogenic inputs. In contrast to humic-like FDOM, protein-like FDOM varied monthly, driven by biological production. In CRE, high concentrations of tyrosine-like FDOM were observed in June 2022 and July 2023, coinciding with freshwater algal bloom events (> 60 µg/L chlorophyll-*a*). In the SLE, elevated tyrosine-like FDOM concentrations were recorded in March 2024 and January 2024, particularly at the uppermost site near L. Okeechobee and the seaward euhaline site. These findings underscore the importance of understanding DOM dynamics and sources in each estuary to improve water quality management and target pollution reduction efforts.

All Drains Lead to the Everglades: A Review Hg Research in Inland Freshwaters of Florida

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While a notable amount of aquatic mercury (Hg) research has been done in northern ecosystems, less is known about Hg dynamics in sub-tropical ecosystems. Our collective understanding of Hg bioaccumulation is particularly lacking in freshwater ecosystems across Florida, USA, which is dominated by uniquely shallow and polymictic solution lakes, as well as numerous black-water rivers. To understand the state of information and direct future studies, we conducted a literature review on the research available on Hg dynamics in inland freshwater ecosystems across Florida. We notably excluded research in the Greater Everglades National Park, which has been well studied and is a known Hg hot spot. However, we will discuss the similarities, differences, and implications of our findings for the Park. Literature searching was done through Web of Science and ProQuest under the guidance of a research librarian through the University of Florida. Covidence was used as a screening tool for paper inclusion based on pre-determined criteria. In total, 54 peer-reviewed papers, governmental reports, or research theses were found with data on methyl or total Hg in lakes, rivers, or stormwater across Florida. Papers are discussed in 5 broad categories: water, sediments, primary producers or consumers, fish, and reptiles. Across these sectors, our preliminary findings indicate significant variation in concentrations of both total and methyl Hg, suggesting considerable spatial variability. Temporal variability was mixed, with some studies showing strong seasonal influences over Hg dynamics, while others showed more limited changes. Overall, concentrations, particularly in predators (i.e., fish and alligators) were high when compared to other regions in the United States, but lower than in the Greater Everglades region. Current gaps in our understanding of Hg dynamics in solution lakes, including the impact of invasive species, lake management practices, extreme weather events, and known drivers of Hg methylation (e.g., dissolved organic matter), will be discussed.

Using Fisheries-Independent Monitoring Data to Assess Nekton Assemblage Change Across Everglades National Park in Response to Disturbance and Restoration

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A primary goal of restoration is to recover the ecological functions and services present prior to disturbance through the rebuilding of original habitat structure. To assess the progress or success of restoration efforts, effective monitoring post-restoration requires the assessment of a restored habitat's community assemblage to assure that desired functionality returns to a restored system. The Florida Fish and Wildlife Conservation Commission (FWC) Fish and Wildlife Research Institute's (FWRI) Fisheries Independent Monitoring (FIM) program surveyed nearshore nekton assemblages within the Everglades National Park twice annually for 5 years, providing an opportunity to investigate the dynamics of nekton assemblages across time and space and therefore the efficacy of restoration efforts within this timeframe. Here, we use this community dataset to examine spatiotemporal status and trends in nekton community assemblage across the Everglades, assess the impact of restoration projects, compare these assemblages with those of other estuaries across Florida to understand change in the productivity and health of the Everglades ecosystem in response to restoration and extreme events. We also combine these community data with trophic and functional trait information to quantify community functionality to determine if ecosystem function has returned to restored areas. This study provides insight into the impacts CERP activities have had on Everglades coastal ecosystems and provides guidance for future efforts.

Cross-sectional Monitoring at S333 to Investigate Flow Dynamics and Gate Structure Impacts on Phosphorus Entrainment

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Understanding phosphorus (P) dynamics in canal systems is important for advancing Everglades restoration. This study focused on examining how cross-sectional flow variations upstream of the S333 gate influence total phosphorus (TP) transport and sediment entrainment. TP, total suspended solids (TSS), and laser particle size distribution were monitored as a cross-section at ~75 ft upstream of S333 during seven sampling events in 2022 (April through June). Laser particle size differential volume curves were used with a 200 mm threshold to estimate the mass of entrainable sediment, which can be entrained at velocities greater than 1.5 cm/s (0.05 ft/s). Concurrently, Acoustic Doppler Current Profiler (ADCP) measurements captured vertical and horizontal flow dynamics at the same location, enabling an assessment of sediment entrainment under varying flow conditions. Results revealed substantial horizontal and vertical flux variations near the canal bed, coincident with elevated TP concentrations, implicating sediment re-entrainment as a relevant driver of elevated nutrient levels in the water column. Analyses of the laser particle size differential volume curves resulted in 25 to 85% of the particle sizes being below the 200 mm threshold, indicating the canal bed sediments are a source of P. On June 27, about ~75% of flows at S333 occurred in the southern half of the canal. Other sampling dates had varying spatial flow patterns. Gate structure and operation were found to alter flow velocities and spatial flow patterns. At S333, higher flows occurred towards the canal bottom, influenced by the S333 lift gate, which forces water to pass through the bottom of the canal. Further, sediments are transported toward the S333 structure as bedload movement is associated with velocities in the L67A canal. These deep canal flow-canal bed interactions appear to exacerbate sediment transport and contribute to elevated TP concentrations. Our initial findings underscore the importance of implementing engineering solutions such as canal dredging and gate operation modifications to augment existing restoration efforts targeted to improve water quality delivered to the Everglades National Park. Ongoing efforts should integrate these insights into long-term monitoring programs to develop cost-effective, adaptive strategies that reduce TP transport and safeguard the Everglades' ecological integrity.

Waterscapes and Wading Birds: Unraveling the Hydrology Behind Nesting Shifts in Everglades National Park

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The coastal Everglades ecosystem experiences dynamic annual hydrologic fluctuations, directly impacting its suitability as a nesting habitat for wading bird species such as the wood stork (*Mycteria americana*) and roseate spoonbill (*Platalea ajaja*). These species rely on specific hydrologic conditions to sustain the prey availability and nesting habitats critical for successful reproduction. Historically, natural hydrologic connectivity and climatic variability would determine optimal foraging and nesting conditions in the coastal Everglades. However, hydrologic alterations to the Everglades, combined with shifting rainfall patterns have introduced greater variability in the timing and amount of water delivered to this region. Recent restoration efforts have aimed to stabilize hydrologic conditions and enhance freshwater inflows into the southern portion of ENP, potentially benefiting wading bird populations. This study examines long-term nesting trends of wood storks and roseate spoonbills in relation to annual hydrologic changes, including water depth, duration of inundation, and precipitation amounts. Data from nesting surveys and hydrologic monitoring stations along the coastal Everglades were analyzed to identify key drivers of interannual variability in nesting amounts. Graphical and statistical analyses were applied to explore the relationships between hydrologic variables and nesting abundance for both species. The findings reveal distinct responses of wood storks and roseate spoonbills to hydrologic changes, underscoring the importance of adaptive management strategies that address the interplay between ecological and hydrologic processes. These insights contribute to a better understanding of the impacts of restoration efforts and environmental variability on wading bird populations and highlight the need for continued monitoring to guide effective water management practices in the coastal Everglades.

A Comprehensive Assessment of the Non-native and Invasive Species in Florida, USA

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The various climates and high levels of human disturbances in Florida have facilitated the introduction and establishment of numerous non-native species, making the state an invasion hotspot and posing significant threats to native ecosystems. Although varies institutes have evaluated different invasive taxa, we still lack a comprehensive checklist summarizing all the non-native plants and animals. Here, we integrated the existing global, continental, national and state level evaluations, and developed a checklist covering all the reported non-native species in Florida. Angiosperms and Arthropoda are the two largest non-native taxa in Florida, which are 5,384 (1,707 of them are invasive) and 3,823 (593 of them are invasive) species, respectively. Among all the taxa, the non-native species in bacteria, fungi and Mammalia contains the highest proportion of invasive species (> 50% of the non-natives are invasive). Diversity patterns of the invasives are similar across different taxa, where large cities and the coastal regions in southern Florida harbored the most abundant species. The Simpson dissimilarity across the invasion hotspots is similar, indicating that these regions were generally invaded by similar non-native species. The average range sizes are larger in the invasives than in the non-invasive non-natives, and the range sizes of the invasives increase faster through time than the non-invasives. Our study revealed the current invasion status in Florida, emphasizing the need for continued monitoring and management.

Using LiDAR and InSAR for Soil Subsidence Analysis in the Everglades Agricultural Area, South Florida

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The Everglades Agricultural Area (EAA) faces soil subsidence challenges, requiring effective monitoring strategies for sustainable land management. This study aims to analyze subsidence patterns in the EAA using 3DEP LiDAR-based Digital Elevation Models (DEMs) from U.S. Geological Survey and Sentinel-1 C-band, Interferometric synthetic aperture radar (InSAR) data from European Space Agency (ESA).

LiDAR DEMs from 2007 and 2016 were analyzed to quantify elevation changes and identify spatial subsidence patterns. Soil and crop vector layers were utilized to correlate subsidence trends with soil properties and cropping practices. While InSAR holds promise for surface deformation monitoring, sugarcane cultivation across much of the EAA causes low radar coherence, leaving only limited plots viable for Small Baseline Subset (SBAS) InSAR analysis. For these areas, deformation trends were extracted and cross-referenced with LiDAR results to validate findings.

The analysis revealed spatially variable subsidence patterns, with significant correlations between subsidence rates, soil types, and crop distribution. However, challenges with radar coherence due to sugarcane crops limit the broader application of InSAR. The upcoming launch of NASA’s NISAR L-band satellite, with its longer wavelength (23.5 cm) compared to ESA Sentinel-1’s C-band (5.6 cm), is expected to improve data availability in the EAA.

These findings underscore the value of integrating high-resolution LiDAR data with targeted InSAR analyses to monitor land deformation effectively. This study highlights the need for innovative geospatial methodologies to address subsidence in agriculturally intensive regions and supports evidence-based strategies for sustainable agricultural and land-use management in the EAA.

South Florida Reef Fish Communities in Dry Tortugas and Biscayne National Park

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South Florida fisheries are a critical component of the region's tourism industry and play an essential role in supporting the local economy. Additionally, fish communities contribute significantly to the health and balance of coral reef ecosystems. However, in recent years, these communities have experienced declines due to fishing pressures, prompting national parks and other management agencies to implement protective measures. These measures include size limits, bag limits, and the establishment of marine reserve areas to aid in the recovery of declining fish populations. Using Reef Visual Census (RVC) survey data, the status of seven key species was analyzed: mutton snapper (Lutjanus analis), gray snapper (Lutjanus griseus), yellowtail snapper (Ocyurus chrysurus), hogfish (Lachnolaimus maximus), white grunt (Haemulon plumierii), red grouper (Epinephelus morio), and black grouper (Mycteroperca bonaci). These species are subject to intense fishing pressures, making it vital to monitor population trends through metrics such as density, abundance, length frequency, biomass, and occurrence. To analyze these metrics, ArcGIS was used to clean and spatially refine the data within the boundaries of the national parks. RStudio was then used to process and analyze RVC data spanning from 1999 to 2023, producing visual summaries of the population trends. The visualizations indicate an overall decline in black grouper populations across both parks. From 2008 to 2012, however, most species exhibited a significant peak, particularly in the Dry Tortugas region. Mutton snapper populations, in contrast, show positive trends across both parks, suggesting that species-specific regulations are being effectively implemented. These findings highlight the importance of continued monitoring and adaptive management strategies to ensure the long-term sustainability of South Florida’s vital fish communities and coral reef ecosystems.

Evaluation of a Recent Macroalgae Overgrowth Event Nearshore of Sands Key, Biscayne National Park.

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Biscayne Bay is a coastal lagoonal estuary, with a wide range of hydrological and physical conditions, adjunct to the most densely populated County in Florida. In 1986 Miami-Dade County Department of Regulatory and Economic Resources' Division of Environmental Resources Management (RER-DERM), through the Restoration and Enhancement Section and in partnership with the SFWMD, established the Biscayne Bay Benthic Habitat Monitoring Program. The information collected through this long-term monitoring is used in the assessments and response of events, such as seagrass die-offs and algae blooms.

The Sands Key nearshore habitat is characterized by mangroves and seagrass beds composed of *Thalassia testudinum*, *Halodule wrightii*, and *Syringodium filiforme,* benthic rhizophytic algae dominated by the genera *Halimeda* and *Caulerpa,* and drifting mats including species of the genera *Laurencia* and *Dictyota*. This island is located between Elliott Key and Boca Chita Key, within Biscayne National Park. On November 11th, 2024, a small-scale algae event reported in the northwest portion of the island through the Southeast Florida Action Network (SEAFAN) resulted in a rapid-response assessment to determine the extent of the algae bloom and its impact of the area.

Surveys were conducted by RER-DERM and Florida International University (FIU) on December 10th, 2024. Water quality analyses included In-situ measurements of physical parameters with a YSI sonde at four stations and three different depths. Water samples were collected at 0.5 m for nutrient analysis and submitted to RER-DERM laboratory for analysis. Additionally, macroalgae samples were collected by FIU for species identification. Survey protocols for bloom assessment included percent coverage at the four sampling locations using 0.25 m^2 grids, as well as transects to determine proximity from shoreline across the algae area and tracing of the algae boundary.

Preliminary observations indicate this is likely a seasonal bloom, as normally occurs along shorelines and mangrove areas during the dry season. Samples sent to FIU for identification confirmed the presence of benthic macroalgae of the genera *Polysiphonia*, *Laurencia,* and *Dictyota* as major components of the bloom. *Halimeda*, a rhizophytic macroalgae, had high abundance below the drifting algae along the mangrove line. Total algae coverage >50% (including drifting macroalgae) extended 20-50 ft from the mangrove line. A seagrass and macroalgae mixing zone, up to 400 ft from the shoreline, had patches of macroalgae >25%, with non-blooming, common macroalgae occurrence up to 1,000 ft. *Thalassia* abundance progressively increases to more than 50% cover moving away from shoreline. Salinity was above 35 ppt and DO was above 90% at all depths and sites. At this moment, the highest macroalgae coverage area (>50%) seems to be limited and not likely to expand to nearby seagrass beds.

Comparing Methods of Monitoring Nesting Success of Florida Bay's Roseate Spoonbills: Mark/Revisit Versus Camera Traps

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Roseate Spoonbills are recognized as an ecological indicator species for Everglades restoration activities. Audubon's Everglades Science Center has performed annual surveys of Florida Bay's nesting population intermittently since 1935 and continuously since 1987. Because spoonbills historically nested in large colonies at about 30 predictable locations in Florida Bay from Nov. 1 to Dec. 31 each year, these surveys, while highly labor intensive, could be implemented with a relatively high degree of predictability and success. Beginning in about 2000, however, the effects of sea level rise began to alter foraging patterns of nesting spoonbills which only intensified after the 2011 El Nino event. These changes apparently resulted in spoonbill nesting in Florida Bay to become much more plastic in timing and spatial distribution such that spoonbills now nest at more than 70 locations and initiate nesting anytime from Dec. to Apr. The new nesting strategy was further characterized by colonies that are much smaller and more numerous relative to pre-2000 colonies and nest initiation much less synchronous. As a result, nesting surveys need to be done over a much longer period at more than twice the locations with less probability of finding nests because the small colony size makes them much less conspicuous. In short, nesting surveys have become much costlier, time consuming and much more disturbing to all species nesting in Florida Bay. In an effort to minimize costs, reduce the number of visits and minimize disturbance, we began to explore the possibility of reducing effort through the use of trail cameras to monitor individual nests. By systematically comparing our results from traditional surveys to those collected using only trail camera photographs we were able to determine that both methods had their shortcomings and that a combination of using both methods appears to be the most accurate way to collect these data. Therefore, our findings, in the strictest interpretation, had the opposite effect to our intensions in that using both methods in tandem increased costs, field and office time and disturbance factors associated with monitoring spoonbill nesting success. The exercise did have some merit however, because the uniqueness of each colony sites presents its own pros and cons for each method. For example, colonies with a large presence of crows cannot be sampled using physical surveys because of the increased egg and chick predation potential. Placing camera traps at these nests before eggs are laid gives the option of gathering valuable data that otherwise would have been missed. Cameras also provided very valuable ancillary data, such as identifying nest predators and causes of nest mortality, frequency of feeding and the platooning of adults at the nest. In conclusion, although nest cameras are currently not advanced enough to fully displace the need for human surveys, they are a tool that can be beneficial to both birds and researchers.

Host-Pathogen Dynamics and Biocontrol Strategies for Invasive Melaleuca in South Florida

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The invasive tree *Melaleuca quinquenervia* has posed significant ecological threats in South Florida for centuries by disrupting native ecosystems and reducing biodiversity. This study investigates the dynamic interactions between *Melaleuca*, the fungal pathogen *Puccinia psidii* (Myrtle rust), and biological control agents to better understand the resilience and vulnerability of *Melaleuca* populations under changing environmental conditions. Through a population dynamics model, we examine host growth dynamics, increased mortality driven by pathogen infection, and the compounding effects of herbivory from biocontrol agents. Results suggest that environmental variables influence fungal infection rates and pathogen spread, while biocontrol agents can either amplify or mitigate these effects depending on foliage availability and host density. This work emphasizes the importance of integrating multiple factors into invasive species management strategies. Future directions include incorporating spatially explicit data from remote sensing to validate field-scale interactions and improve predictive modeling for long-term management planning. By addressing the intersection of invasive species control and climate variability, this study contributes to the broader goal of ecosystem resilience in the Greater Everglades restoration efforts.

Flood Modeling and Adaptation Innovations to Support Coordinated Flood Responses Across South Florida

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Achieving flood adaptation that is both effective and equitable is extremely challenging. Flooding dynamics are complex and uncertain, decision-making must be coordinated, and participatory processes are time consuming. Here, we report on resident and policy surveys in South Florida, combined with advances in simulation technology, which together allow interactive and inclusive exploration of adaptation options at neighborhood to regional scales. First, we have introduced innovations within the Parallel Raster Inundation Model (PRIMo), a dual-grid, rapid-simulation flood model, to enable fast flood simulation for South Florida. The model now resolves infiltration of rainwater and seepage of groundwater into the substratum and drainage canals, while also resolving the effects of gates and pumps (Sanders, Mach, Martin, Schubert, and Sukop, in prep.). This approach is demonstrated with a single application across the C2–C6 basins, with calibration and validation now underway. Model simulations capture the influence of compounding flood drivers (e.g., rainfall, tidal, surge, groundwater), under different antecedent conditions and gate and pump operations, and support estimates of metrics relevant to adaptation (e.g., canal levels; flood extent, depth, and duration; exposed populations, properties, and critical infrastructure). Second, we have conducted a representative survey of residents of Miami-Dade County to understand resident perceptions of flood risks and participatory processes, actions to increase household preparedness, and preferences for government investments (Larson Mohr et al., in prep.). Public awareness of flooding is very high yet trust in government institutions is only moderate; residents who have higher trust in government flood responses are more likely to prepare their households for flooding. We developed this survey in combination with an analysis of planned flood responses across levels and agencies of government, comparing government strategies to resident preferences (Tavarez et al., in prep.). Finally, to support next steps, we have piloted an interactive online platform to enable municipalities and residents to explore and comment on flood simulations under different response scenarios and prioritize actions. In early 2025, we are conducting workshops with flood management professionals and modelers to get feedback on these collaborative flood modeling functionalities and generate ideas for approaches to use these functionalities in engaging residents and municipalities towards more coordinated and effective flood adaptation. In summary, these activities will allow us, in our next steps, to test interactive, responsive platforms for flood simulation, in support of flood responses in a highly flood exposed and socioeconomically diverse region. Insights that arise could help climate adaptation across the United States and beyond to be more time-sensitive, equitable, and cost-effective.

Analysis of Lacustrine Sediments and Their Effect on Submerged Aquatic Vegetation in Lake Okeechobee

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Lake Okeechobee, the largest freshwater lake in Florida, is experiencing ecosystem shifts due to eutrophication, sediment resuspension, and altered nutrient dynamics. Nutrient loading may have modified the lake's sediment composition, especially in nearshore areas with high autochthonous particulate nutrient loading and associated high organic matter content. This can create conditions that promote increased microbial respiration and chemically reductive processes, which may hinder the recruitment and growth of submerged aquatic vegetation (SAV), such as *V. americana*.

This research investigates the relationship between sediment physiochemistry and SAV persistence in Lake Okeechobee, where reduced rhizosphere oxygen availability may inhibit the growth and resilience of SAV, compounding habitat loss and altering nutrient cycling.

The study objectives are to examine the reduction-oxidation (redox) potential, organic matter content and bulk density of sediments across distinct ecological zones in the lake, and to assess their influence on SAV growth and distribution. Sampling will be conducted in four historical SAV zones along the lake's periphery. Key sediment metrics, including organic matter percentage through Loss on Ignition and redox potential, will provide insight into the availability of oxygen as a terminal electron acceptor and resulting bioavailable nutrients within the surficial sediments of Lake Okeechobee. Ex-situ mesocosm experiments with *V. americana* transplanted into sediment samples will simulate SAV response to varying sediment conditions, further clarifying the influence of increased nutrient loading and oxygen availability on SAV viability.

Preliminary findings from sediment redox measurements, organic matter, and bulk density assessments will highlight the influence of hypoxic conditions and nutrient availability on SAV root oxygenation and nutrient uptake. This study aims to inform lake management and restoration strategies by improving the understanding of how sediment properties affect SAV recruitment and persistence in Lake Okeechobee.

The Florida Grasshopper Sparrow: Natural History, Decline, and Recovery of a Critically Endangered Songbird

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The Florida Grasshopper Sparrow is a non-migratory endangered subspecies endemic to grasslands of south-central Florida. Early records (i.e., early 1900s) suggest that the sparrows were abundant and widespread across the region, however the population experienced major declines during the 1980s to early 2000s, and by 2016 the total Florida Grasshopper Sparrow population size was estimated at fewer than 75 singing males. Only seven known breeding aggregations now remain across five managed native and agricultural grasslands. Though the causes of the declines remain unclear, they have been in part, attributed to habitat loss and degradation, resulting from anthropogenic land conversion (primarily agriculture), with less than 10% of original Florida prairie now remaining. Florida Grasshopper Sparrows are ground-nesters, breeding from late March through early September. Their nests, like those of other grassland birds, are subject to high rates of nest mortality, due to predation from mammals, snakes, and red imported fire ants, as well as flooding. Efforts to monitor, restore, and maintain extant populations began in the 1990s by U. S. Fish and Wildlife Service and the Florida Fish and Wildlife Conservation Commission. Conservation efforts now include an array of partners, including the U. S. Department of Defense, Florida Department of Environmental Protection, Archbold Biological Station, and Audubon Florida, with the formation of the species working group in 2002. In 2012, these efforts were intensified, with the development and implementation of creative tools to increase the success of Florida Grasshopper Sparrow nests. Predator exclusion fences, nest lifts, and fire ant treatments are now applied at most nests found by field crews at the five managed sites. These actions have been shown to significantly increase nest survival and the probability of a given nest fledging. Furthermore, a conservation breeding program was established by the Service in 2015, which has since contributed over 1,000 released hatch year sparrows to the population. Through these efforts and collaborations, the population has begun to increase, with an estimated 110 singing males in 2024. Monitoring, management, and research remain essential for the recovery of Florida Grasshopper Sparrows, and conservation actions will continue to be adjusted in accordance with the ever-changing needs of a growing population.

Implementing DataOne, A Hosted Data Management Application, to Achieve Interagency Data Management Success

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DataOne is an XML database fronted by a web application, that manages archival and access to data from environmental research and restoration science in the CERP, CEPP and RECOVER programs. The application's primary advantage is no data format requirement. Datasets, interpretive reports, and dataset assessments can be archived in their native format. Required metadata elements based on the Ecological Metadata Language standard, (EML), strengthens searchability and documentation. Data access and management success are directly proportional to metadata and data content quality. However, as with all web applications, a caveat is dependency on the internet. DataOne contains many features that facilitate documentation, access, publication, citation and collaboration. The DataOne node, Cerp-sfwmd.dataone.org, demonstrates best practices and a highly functional data management implementation for interagency scientific environmental restoration programs.

Trends in River and Floodplain Water Depths During Ascension and Recession Events on the Kissimmee River

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Completion of the construction component of the Kissimmee River Restoration Project led to substantial changes in the hydrology and hydraulics of the river and floodplain system. Understanding these fundamental aspects of how water moves through the ecosystem is integral to ensuring ecological restoration is a success. Flow through the restoration project area is largely controlled by S-65A, the gated spillway located upstream. We investigated the spatiotemporal trends of how water inundates and subsequently drains off the floodplain when discharge levels from S-65A are changed. Our objective was to gain a better understanding of the system's hydrology and create a visual representation of the complex dynamics of flood pulses in the restoration area. The project area has 8 stage gauges within the river channel and 35 stage gauges in the adjacent floodplain, which record water levels at 15-minute intervals. Using spatial interpolation, we were able to estimate a continuous water surface across the floodplain. Combining this water level data with rainfall and flow data, we conducted analyses on how water moves laterally and longitudinally across the floodplain as river stages ascend and recede during and after flood pulse events. Specific events were chosen for closer analysis, including major flood events resulting from Hurricane Irma in September of 2017 and Hurricane Ian in September of 2022. These events had a noticeable hysteresis effect wherein the average floodplain depth increases at a faster rate in relation to increasing discharge than the rate at which it declines with decreasing discharge. This pattern was observed during Hurricane Irma and Hurricane Ian, as well as in more moderate flood pulse events that are typical of the wet season. This hysteresis effect, along with other characteristics of the system, make it difficult to describe the effects of a flood pulse with a standard stage-discharge relationship. We show that visual representations of how water levels vary across the floodplain during a flood pulse can help improve understanding of these complex dynamics. The trends observed from these analyses and visual representations may inform how different ecological aspects of hydrologic restoration such as water quality, vegetation, and wildlife are influenced by different flood pulse characteristics. Ultimately, this information could help improve decision making for the operation of S65-A for the benefit of the Kissimmee River Restoration Project.

Partnerships and Consistency, The Key to Managing Aquatic Invasive Plants on Lake Okeechobee for over 100 years

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Lake Okeechobee, the heart of the Everglades, has faced ongoing challenges from floating aquatic invasive plants for over a century. This presentation highlights the vital role of state and federal partnerships, as well as consistent management efforts, in combating invasive species and preserving the lake's ecological balance. Over the years, various agencies have collaborated to implement an integrated pest management (IPM) approach aimed at reducing invasive plant populations throughout the lake. Attendees will learn how these combined efforts have successfully brought floating invasive plant levels to a manageable state, as well as the valuable lessons learned over the course of these decades-long efforts.

BBSEER and Beyond: Future Priorities for Ecological Restoration and Conservation of Species

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The Biscayne Bay and Southeastern Everglades Ecosystem Restoration Project (BBSEER) is one of the largest estuarine restoration projects in the country. The BBSEER is located in a major metropolitan area and is one of the first CERP projects to incorporate 50 years of projected sea level rise (SLR) into the planning (i.e., sea level circa 2085). The BBSEER project area has over 52 at risk species and designated critical habitat for 10 species listed under the Endangered Species Act, some of which can benefit from ecological restoration. The BBSEER goals and objectives are to (1) improve the quantity, quality, timing, and distribution of freshwater, (2) improve habitat quality of the Model Lands and Southern Glades, (3) focus on creating a 500-meter strip of mesohaline conditions in the nearshore areas of Card Sound, Barnes Sound, Manatee Bay, and Biscayne Bay including Biscayne National Park, (4) maintain or increase habitat quality of the transition zones between freshwater and mesohaline zones with more freshwater delivery, (5) increase the quality of freshwater wetlands with more freshwater delivery, and (6) improve resiliency of these coastal habitats in response to SLR. The BBSEER is designed to rehydrate and reconnect historical freshwater sloughs and coastal wetlands and recharge groundwater to eliminate or reduce saltwater intrusion. The BBSEER will provide targeted wetland vegetative patterns and habitat, increase oligohaline/mesohaline (0.5-18 practical salinity units) habitat in the nearshore, and improve resilience of the ecosystem to SLR as additional freshwater pushes against saltwater intrusion and as the landscape remains vegetated and builds soil. BBSEER features include adaptive infrastructure to allow and/or control how water is distributed for important at risk species. The BBSEER Ecosubteam utilized Ecological Planning Tools (EPTs) and nine ecological performance measures (PMs) for evaluating plan alternatives including nearshore salinity, direct canal releases, timing and distribution of flows to Biscayne Bay, water depth, hydroperiod, sheetflow, wetland salinity, adaptive foundational resilience, and ecological connectivity. These EPTs and PMs were used to evaluate both beneficial and negative effects of proposed alternatives on at risk species and new features were incorporated to maintain and/or improve critical habitats across the landscape for the crocodile, manatee, eastern black rail, and Cape Sable seaside sparrow (CSSS). Model output of these improvements result in increased wading bird foraging habitat, greater crocodile growth and survival salinity index scores, lower nearshore salinity, and increased accretion rates in the marsh to mangrove ecotone. However, increased overland flow in the Southern Glades decreased CSSS Marl Prairie Index scores which can be improved by adaptively managing the flow into this area.

A Multi-species Perspective of CEPP Performance

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The Central Everglades Planning Project (CEPP) is a key component of the Comprehensive Everglades Restoration Plan (CERP). The goal of CEPP is to improve the water flow, quantity, quality, timing, and distribution within the central Everglades by implementing various infrastructure projects to restore more natural water patterns in the region. Particularly, the purpose is to direct more water south towards Water Conservation Area 3A (WCA-3A), Everglades National Park (ENP), and Florida Bay; essentially aiming to "re-capture" water lost to the coastal estuaries and redirect it to the critical areas of the Everglades ecosystem. The ability to move water south is expected to provide benefits to Lake Okeechobee and the Caloosahatchee and St. Lucie estuaries. CEPP consists of dozens of components which must all be assessed for their impacts to the ecology of south Florida. Direct effects from construction footprints as well as effects from water operations have the potential to positively or negatively impact a variety of species and their habitats relative to the location of the projects. Reduced flows to the estuaries can benefit submerged aquatic vegetation (SAV), oysters, and other estuarine species. Flows out of Lake Okeechobee can reduce stages and may affect SAV, littoral zones, Everglade snail kites, wading birds, and fisheries. Flows south to WCA-3A and ENP may affect tree islands, marl prairie, ridge & slough, and pine rockland habitats, and the species that occupy these areas including Cape Sable seaside sparrow, Everglade snail kite, Florida panther, and wading birds. The USFWS evaluates the effects to these various species through the Fish and Wildlife Coordination Act (FWCA) and Endangered Species Act (ESA). The FWCA plays a key role in Everglades restoration by providing a legal framework for the USFWS to research, monitor, and implement conservation actions aimed at protecting and restoring the diverse fish and wildlife populations within the Everglades ecosystem, ensuring that restoration efforts prioritize the health of native species and their habitats. The purpose of the ESA in Everglades restoration is to ensure that any restoration efforts actively protect and promote the recovery of endangered and threatened species that inhabit the Everglades ecosystem, by requiring federal agencies to consider the impact of their actions on listed species and to take steps to minimize harm, essentially making the protection of these species a central component of the restoration process.

Reducing Uncertainty of Wading Bird Colony Size Predictions with the Everglades Vulnerability Analysis Tool

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Hydrologic changes resulting from Everglades restoration are expected to support increased wading bird breeding activity and population recovery. Metrics of wading bird nesting activity are assessed to track restoration progress, but these metrics are not directly predicted by the evaluation tools used in the restoration planning process. Rather, restoration planners currently employ existing tools that predict where wading birds might forage during the nesting season. To explicitly address nesting responses to hydrological restoration and better align evaluation efforts with restoration metrics, we are reconstructing an existing submodel within the Everglades Vulnerability Analysis (EVA) tool that predicts the probability of colony size (i.e., number of nesting birds) across the Everglades. EVA's Bayesian modeling framework makes it possible to integrate inputs as they become available and evaluate uncertainty of model outputs. With the current submodel structure, uncertainty is highest for the largest colony size class relevant to restoration goals. To improve predictive accuracy, we are exploring new input variables that represent hydrologic and environmental factors of the nesting habitat. We expect that the addition of presence of water, proximity to historic colonies, and vegetation structure as factors of colony site potential will reduce uncertainty in predictions of colony size. Future work will incorporate predictions of prey biomass and foraging habitat conditions to examine prey availability as an additional predictor of colony size. Finally, we plan to integrate productivity into the submodel to scale up from the colony level and predict population size. With these developments, the wading bird submodel could be used to inform Everglades restoration planning and decision-making by generating spatially and temporally explicit outcomes of colony outcomes and population dynamics from water management projects and restoration scenarios.

Second Periodic CERP Update (SPCU) Modeling Results

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The Comprehensive Everglades Restoration Plan (CERP) is a large-scale effort to restore the Everglades ecosystem. As part of the CERP Programmatic Regulations, the Second Periodic CERP Update (SPCU) is a recurring evaluation that leverages advanced modeling tools and the latest scientific data to assess the plan's progress and inform future decision-making. Building on the 2005 Initial CERP Update and the 2018-2020 Interim Goal and Interim Target (IGIT) effort, the SPCU utilizes the Regional Simulation Model (RSM) to simulate all 68 components of CERP. Recent model development efforts have enhanced RSM's capabilities to accurately represent CERP's foundation projects, including the Kissimmee River Restoration, Water Conservation Areas, Stormwater Treatment Areas, and Lake Okeechobee operations. This presentation will share preliminary results from key model runs, including existing conditions, future without CERP, and future with CERP completion under various operational scenarios and varying levels of aquifer storage and recovery. The results will provide valuable insights into the effectiveness of CERP's restoration objectives, identify areas for improvement, and inform future modeling efforts, which will include simulations of the future with CERP utilizing USACE intermediate sea-level change projections.

Syncing Success: Linking Modeling and Monitoring to Track Restoration Progress in the Greater Everglades

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Authorized by Congress in 2000, the Comprehensive Everglades Restoration Plan (CERP) aims to balance flow characteristics throughout the Florida Everglades by modifying the quantity, quality, timing, and distribution of water. This effort seeks to enhance ecosystem health and improve quality of life in South Florida. REstoration COordination and VERification (RECOVER) is a collaborative, multidisciplinary team involving agencies, tribes, and institutions that organizes and applies scientific and technical information to support CERP restoration goals. RECOVER takes a system-wide approach to planning and implementation, communicating evaluation and assessment results to managers, decision-makers, and the public. RECOVER uses evaluation (modeling) and assessment (real world monitoring) to track progress on CERP success. RECOVER produces a System Status Report every five years, assessing whether CERP goal are being met or are on track to be achieved. In developing the 2024 System Status Report, the RECOVER Greater Everglades team identified areas where evaluation and assessment approaches could be better aligned. The team is actively working on initiatives to improve this alignment. Efforts include (1) increasing the integration of indicators described in the trophic hypothesis using the Everglades Vulnerability Analysis (EVA), a decision support tool that uses modular Bayesian networks to predict ecological outcomes for a subset of Everglades indicators, (2) updating Greater Everglades hydrologic performance measures based on new information gained from lengthening the period of record and target setting, and (3) facilitating discussions focused on updating and developing thresholds, targets, and desired restoration conditions to enhance assessment and evaluation processes and methods. Specific examples of tools and topics will be highlighted to showcase the future direction of the RECOVER Greater Everglades team.

Investigating Seasonal Patterns of Normalized Difference Vegetation Index in a Southwest Florida Cypress Dome

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Climate change is expected to increase the intensity and severity of tropical cyclones such as Hurricane Ian, a category 4 storm that devastated Southwest Florida in September 2022. Cypress domes, which are freshwater forested wetlands dominated by cypress trees, are the most prevalent swamps in the Everglades. They provide critical ecosystem services vital to human health and well-being, but their response to extreme hurricane disturbance is poorly understood. The objective of this research is to investigate interannual and intra-annual cypress phenological patterns, which impact the delivery of services. Drone-based multispectral imagery was collected at the Naples Botanical Garden in the two years following Hurricane Ian, and an orthomosaic was created using PIX4Dmapper. This study investigates the seasonal patterns of cypress dome vegetation phenology and productivity by using Normalized Difference Vegetation Index values computed with ArcGIS Pro. Normalized Difference Vegetation Index values calculated from the red and near-infrared spectral bands serve as a proxy for photosynthetic activity and vegetation productivity. By monitoring Normalized Difference Vegetation Index over time at the same cypress dome site, this research assesses the cypress canopy's resiliency and shifts in phenology following Hurricane Ian's intense winds and flooding. The findings will provide insights into how climate change-amplified hurricane impacts may disrupt the seasonality and productivity of this ecologically and economically important wetland ecosystem in Southwest Florida and the Greater Everglades ecosystem. Understanding cypress system responses can help guide conservation, restoration, and environmental management efforts to sustain their valuable ecosystem services under a changing climate.

Ever-evolving Ecological Monitoring Programs: Evaluating Cape Sable Seaside Sparrow Monitoring in Everglades National Park

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The Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*, hereafter "CSSS") is a short-lived federally endangered species whose nesting success and population numbers are sensitive to water depth, hydroperiod, changes in habitat structure, and fire. CSSS have been monitored in Everglades National Park since 1981, using point count surveys of singing males during nesting season as a measure of relative abundance to estimate the total number of individuals present within the survey area. This monitoring program has been reviewed at several times in the past and has recognized limitations related to the study design and abundance estimation. Additions to field methodology were made, specifically to collect supplemental data that allows calculation of detection probabilities, the probability that an individual present in the sample area at the time of the survey was detected. These methodological changes could allow for a more robust estimation of CSSS abundance, as spatial and temporal variation in bird counts and detection probability due to environmental, biological, or methodological factors may be accounted for within abundance estimation models. Our objective was to complete an evaluation of the existing CSSS monitoring protocol, reviewing field methodology and data analysis techniques to ensure program objectives (i.e., robust abundance estimates of CSSS within their range) are being met, while maintaining the strengths and integrity of the long-term dataset. We evaluated a suite of abundance estimation modeling techniques that incorporate detection probability as alternatives to improve traditional abundance estimation. We also assessed potential sources of bias inherent to the study design, and how these biases may impact resulting abundance estimates using simulation studies. Overall, our evaluation led to recommendations of a variety of changes to the CSSS monitoring protocol which may be tested and incorporated over time.

Mammal Population Changes Across Big Cypress National Preserve

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Big Cypress National Preserve (BICY) encompasses 729,000 acres of the western Everglades ecosystem. This unit of the National Park system is home to a wide variety of native and non-native wildlife including migratory and resident species. The mammals on BICY range from popular game animals to species listed under the Endangered Species Act of 1973. Despite limited monitoring data on mammal populations in this ecosystem, there appear to be obvious declines in several species. Some of the apparent changes can only be described by anecdotes and speculation; however, the future of several medium and large mammal populations seems unclear on BICY. This presentation will review the available information and briefly describe potential trends in rabbits (*Sylvilagus spp.*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), feral pig (*Sus scrofa*), white-tailed deer (*Odocoileus virginianus*), and Florida panther (*Puma concolor coryi*) as well as explain some of the challenges that these species are facing on BICY.

An Early-Warning Forecast Model for Red Tide (*Karenia brevis*) Blooms on the Southwest Florida Coast

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Karenia brevis blooms occur nearly annually along the southwest coast of Florida, and effective mitigation of ecological, public health, and economic impacts requires reliable real-time forecasting. We present two boosted random forest models that predict the weekly maximum *K. brevis* abundance category across the Greater Charlotte Harbor estuaries over one-week and four-week forecast horizons. The feature set was restricted to data available in near-real time, consistent with adoption of the models as decision-support tools. Features include current and lagged *K. brevis* abundance statistics, Loop Current position, sea surface temperature, sea level, and riverine discharges and nitrogen concentrations. During cross-validation, the one-week and four-week forecasts exhibited 73 % and 84 % accuracy, respectively, during the 2010–2023 study period. In addition, we assessed the models' reliability in forecasting the onset of 10 bloom events on time or in advance; the one-week and four-week models anticipated the onset eight times and five times, respectively.

Joan Browder on Shrimp, Water and Marsh-estuarine Management, Southern Louisiana Coastal Marshes and Biscayne Bay

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Dr. Joan Browder influenced many aspects of wetland and estuarine management. She spent several years focusing on the relationships among freshwater delivery to coastal marshes and estuaries, coastal Louisiana marsh loss, and fisheries, especially shrimp. I was working in Southwest Louisiana during this time interval addressing the proper water management methods to reduce marsh loss. Many of Dr Browder's observations influenced my work in both Southwest Louisiana and in the Biscayne Bay. One of the primary objectives of the Biscayne Bay Coastal Restoration Team (BBCRT) was to produce a salinity performance measure or a management target for salinity. Salinity was considered a major aspect of management, which could be controlled by changing freshwater delivery to the Bay. Studies and discussions were conducted to recognize keystone species to utilize as salinity indicators, to determine management success. Dr. Browder suggested shrimp which require estuarine conditions in their life cycle. Soon after that, fossil oyster reefs were discovered at major transverse glade-tidal creek mouths along the western Biscayne Bay coastline, which are also excellent salinity indicators. The target salinity regime was developed by the BBCRT to produce estuarine conditions based upon the shrimp and fossil oyster distribution. Other studies were conducted to establish the volume of freshwater delivery to achieve target salinities. Dr Browder's previous work and her studies in Biscayne Bay influenced me and the BBCRT's thinking which resulted in the establishment of the salinity regime for Biscayne Bay restoration.

Quantifying Spatial Patterns of Woody Vegetation Embedded in Everglades Freshwater Wetland Ecosystems

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Landscapes that are structured as two-phase heterogeneous mosaics of woody vegetation embedded in a matrix dominated by herbaceous vegetation arise from the interaction between biotic and abiotic processes that act and interact at different scales. The spatial distribution and size of vegetation patches can influence water flow, nutrient cycling, soil accretion and the ecosystems response to environmental disturbances. Patch size distributions can be used to provide insight on processes of pattern formation and as an indicator of ecosystem degradation. For example, as a disturbance increases patch size distribution can go from a power law to a truncated power law to an exponential distribution. Everglades National Park (ENP) is characterized by a heterogeneous landscape with varying proportions of woody and herbaceous vegetation. Landscape heterogeneity in ENP has been controlled by physical environmental conditions like microtopography and hydrology, and natural disturbances like fires and drought. However, rapid changes over recent decades due to hydrologic compartmentalization and fire management have altered natural vegetation dynamics. Because woody vegetation affects both microtopography and fire effects, it is important to understand how the distribution and abundance of woody habitats in ENP will be affected by changes in water management, as this will help to assess the success of restoration efforts. We quantified the distribution patterns of four woody vegetation classes and assessed the statistical distribution and geometries of their patch sizes at the regional scale within the eastern ENP, excluding coastal areas. We conducted a multiscale analysis to better understand the differences and similarities of interactions of cypress, hardwood-hammock, and bayhead-dominated communities within their herbaceous wetland and analyzed the spatial distribution and configuration of these freshwater woody vegetation communities. We expect patches of cypress communities to be clumped at the large-scale indicating dispersal limitation. Bayheads and hardwood hammocks will be randomly dispersed at larger scales indicating the influence of environmental heterogeneity. Small trees will be clustered around larger trees indicating local dispersal and tree heights in patches will be smaller in the periphery, especially in cypress domes and tree island heads. We also expect patch size distribution of hardwood hammocks and bayheads to follow a truncated power law distribution at the regional scale indicating scale invariance. At smaller scales, patch size distribution will follow a Gaussian distribution indicating that scale dependent feedbacks drive the spatial pattern. Cypress communities will follow a power law distribution at the landscape scale indicating scale invariance – indicating that endogenous drivers drive the system at the local scale and exogenous drivers at the global scale.

Hydrodynamic and Salinity Modeling in Florida Bay

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Florida Bay is a large and shallow lagoon, characterized by its highly productivity as an estuary and its abundance of seagrass communities which play an important role in supporting economically critical recreational fisheries. This area of approximately 2,200 square kilometers is bounded by the Everglades National Park (ENP) to the north, the Florida Keys to the south and east, and the Gulf of Mexico to the west. Salinities in Florida Bay are highly dependent upon evaporation, direct precipitation and freshwater inputs and flows. This study focuses on developing a hydrodynamic model for Florida Bay. The model will be used to develop a comprehensive understanding of the salinity patterns in Florida Bay. This understanding is critical to water management and hydrologic restoration actions necessary to protect and support this critical ecosystem in terms of quantity, quality, and timing and distribution of freshwater deliveries. There is a significant gap in knowledge when it comes to the connectivity between groundwater and the bay, and the relationship between groundwater and salinity level in Florida Bay. In response to this knowledge gap, the Groundwater Exchange Modeling and Monitoring (GEMM) Plan was created to provide a proposed framework to address the uncertainties associated with landscape-scale flow patterns, surface-groundwater interactions, impacts of seepage eastward on groundwater movements south to Florida Bay, and the influence of water management on the development of hypersalinity (>40 psu) in Central Florida Bay. In support of the GEMM program, the model will serve as a quantitative platform for evaluating various factors in Florida Bay, including the vertical barrier to lateral flow, interactions between vertical and horizontal flows, ecological parameters, current and future water management practices, as well as the impact of sea-level rise on the integrated surface water and groundwater hydrologic systems. Phase I of this study is Model Potential and Capabilities Demonstration. It aims to investigate the functionalities of the Delft3D model, with a primary focus on its hydrodynamic module and the D-Water Quality process library. The objective is to showcase the model's capabilities in supporting the GEMM program and lay the foundation for a future comprehensive study and strategic funding request in future phases. In Phase I, a preliminary and uncalibrated Delft3D-based modeling framework has been developed to simulate hydrodynamics, waves, salinity, temperature, sediment transport and other water quality processes in Florida Bay. The D-Waves (or SWAN, wave module) is online coupled with D-Flow FM (hydrodynamic module). The D-Water Quality processes are integrated in D-Flow FM. The whole year of 2016 is selected to demonstrate model capabilities. This model system could become a potential numerical tool in supporting the GEMM program after model calibration and validation.

Evaluating Apple Snail Responses to Changes in Hydrology: Implications for Snail Kite Recovery and Everglades Restoration Efforts.

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Long-term monitoring of Apple Snails relative to hydrologic histories in Water Conservation Area 3A (WCA3A) can guide water managers determined to include the Snail Kite among the biota targeted for recovery in the Everglades. WCA3A represents a large portion of the Critical Habitat designated by the U.S. Fish and Wildlife Service when the Snail Kite was listed as Endangered in the late 1970s. However, nesting Snail Kites have been rare or absent in WCA3A since the early 2000s. As Darby and others have concluded dating back to at least 2016, above-ground water depths ranging from 10 cm, at which snails begin estivating, to 40-50 cm favor sufficient snail productivity and physical accessibility to support nesting Snail Kites. In addition, there is evidence that such levels followed by relatively rapid recession may be associated with increased snail densities the following spring and early summer, when Snail Kite nesting peaks. We determined that four specific staff gauges in southern WCA3A best reflect the annual changes in water depths in this portion of the conservation area, where nesting Snail Kites were once most numerous. We then compared over 3,400 trap-throws of snail density data collected in the same part of WCA3A from 2017 to 2024 with contemporaneous hydrographs for the specified staff gauges to see how often these recommended depths were attained. In the years immediately following each of the two years in which they were attained, snail densities surpassed the 0.142 snails-per-meter^2 threshold for supporting nesting Snail Kites. By late 2025, we expect to complete a re-analysis of expanded versions of these data sources that will include snail density data collected by Darby from the mid-1990s to 2016. We also hope we will be able to include comparative data for annual Snail Kite nesting effort and success from the UF team's studies that could complement our snail-sampling datasets in assessing the relationships between hydrology and the abundance and availability of the kite's primary prey. Although other factors may influence Apple Snail abundance and availability to Snail Kites (e.g., phosphorus and calcium concentrations, species and spatial extent of emergent vegetation, non-native predatory fish, health of periphyton communities), hydrologic regimes may be a, if not the, critical factor.

Artificial Intelligence Based Smart Traps Increase Effectiveness and Reduce Resources Compared to Traditional Traps

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Invasive species management can be limited due to a lack of sustained resources needed to elicit an effective outcome. Live trapping has proven to be an effective means of detection and removal of certain invasive species such as the Argentine black and white tegu (*Salvator merianae*). However, research has shown that trapping efforts for this species may be most effective when traps are operated for sustained periods of time with high trap saturation in suitable habitats. These requirements pose a challenge for natural resource managers as traditional means of trapping are often labor and time intensive. Yet recent development of an automated smart trapping system, designed by Wild Vision Systems (WVS), that utilizes artificial intelligence (AI) for capture of tegus holds promise for ameliorating many resource concerns. The WVS smart traps can be operated remotely via a software application and the AI software is designed to selectively trap a target species of interest, while excluding capture of bycatch. During May – October 2023, we collaborated with WVS to field test tegu smart traps in St. Lucie County, FL where an incipient population of tegus has established. Specifically, we conducted a comparison study to evaluate the efficacy of smart traps versus traditional (i.e., non-smart) traps for the capture of invasive tegu lizards. We accumulated and average of 89 trap days per trap pair in which both trap types were active. We observed a higher number of tegus captured in smart traps (n = 14) compared to traditional traps (n = 1), as well as a correspondingly higher CPUE for smart traps. We recorded one instance of bycatch in a smart trap versus 19 occurrences of bycatch in traditional traps. In addition, the use of smart traps reduced the need for in-person visits to the study site from 109 days (for traditional traps) to 14 days (for smart traps) reducing personnel costs by 87.2%. These results indicate that use of smart traps may have significant advantages over traditional traps relative to selective trapping of target species and reduced bycatch rates, resulting in a reduction of required resources and increased efficacy of invasive species management.

Multi-Year, High-Frequency Assessment of Water Quality in Biscayne Bay, Florida

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This study presents results from bi-weekly water quality observations collected at 20 stations throughout Northern Biscayne Bay and offshore around the Government Cut inlet gathered by NOAA's Atlantic Oceanographic and Meteorological Laboratory, Miami-Dade's Department of Environmental Resources Management, and the Department of Environmental Protection of Florida since September of 2021 through the present. Water quality measurements include multiparametric sonde profiles, chlorophyll-a concentration, and dissolved inorganic nutrient determinations. The primary goal is to characterize water quality conditions across the study area, identify processes driving nutrient and chlorophyll-a concentrations, and understand how these factors change over time. A Mann-Kendall test analysis at individual stations identified positive trends for silicates and chlorophyll-a, stable for ammonium and negative for phosphates and nitrates at specific stations and seasons of the year, but over the whole North Biscayne Bay, the median phosphates concentrations increased from 0.03 to 0.04 µM from last decade. In addition, the median chlorophyll-a concentrations decreased from 1.4 to 0.5 µg/L but the positive trend remains. The highest level of ammonium and silicate were recorded at inshore stations than those off the shore, reaching up to one order of magnitude higher. A correlation between nitrates and silicates was identified, highlighting that both are essential nutrients for phytoplankton. In general, the highest concentrations were located in shallow waters, near river mouths and the Government Cut Outfall, indicating possible eutrophic conditions in these critical areas. This information is essential for tracking land-based sources of pollution that impact human and ecosystem health. These observations assist in evaluating the effectiveness and impact of management practices aimed at preserving Biscayne Bay's health. The results will support informed decision-making for management initiatives.

Quantifying Biomass Carbon Storage and Soil Elevation Dynamics in Mangrove Forests of Biscayne National Park

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Accelerating sea-level rise is causing uncertainty for carbon storage and resilience in coastal wetlands. Here, we investigate how carbon storage and autochthonous organic production contribute to peat formation, enabling mangrove forests in karstic settings to keep pace with relative rates of sea-level rise. Fringe mangrove forests of Biscayne National Park (Florida, USA) are ideal ecosystems to assess the effects of enhanced marine hydrologic connectivity on mangrove coastal geomorphology and organic production, given their physical restriction from lateral expansion by a levee, rising sea-level rates, and potential to receive restored freshwater sheet flows. Since 2011, the National Park Service Inventory and Monitoring Division has maintained two mangrove sediment elevation table long-term monitoring sites (BISC1, BISC2) to quantify soil geomorphologic trends in fringe mangrove forests. To estimate aboveground carbon storage and net primary productivity in relation to elevation trends, we measured forest structure and above-ground net primary productivity (total annual litterfall) in 20 m × 20 m forest vegetation plots at both sites. A decade of semiannual sampling showed temporal differences between the sites in soil surface elevation change (mean ± error: BISC1 0.86 ± 0.91 mm yr^{-1}; BISC2 2.69 ± 0.92 mm yr^{-1}) and soil vertical accretion rates (BISC1 1.91 ± 0.39 mm yr^{-1}; BISC2 4.49 ± 0.23 mm yr^{-1}). These rates indicate that the sites are unlikely to sustain elevation gains sufficient to counteract contemporary rates of sea-level rise (5.9-9 mm yr^{-1}). Forests characterized by higher density and dominance of *Laguncularia racemosa* showed greater total above-ground biomass storage (BISC1 56.6 ± 1.2 Mg C ha^{-1}; BISC2 79.3 ± 3.1 Mg C ha^{-1}) and total annual litterfall production (BISC1 6.5 ± 0.37 Mg C ha^{-1} yr^{-1}; BISC2 8.0 ± 0.42 Mg C ha^{-1} yr^{-1}). Wet season had greater daily total litterfall production (BISC1 5.5 ± 0.6 g m^2 d^{-1}; BISC2 7.0 ± 0.1 g m^2 d^{-1}) compared to dry season measurements (BISC1 2.4 ± 0.1 g m^2 d^{-1}; BISC2 2.7 ± 0.1 g m^2 d^{-1}) during the 2023 – 2024 sampling period. BISC2 had the highest above-ground biomass, total annual litterfall production, and daily litterfall production in the wet season, which coincided with the highest rates of vertical accretion and soil surface elevation gains. Our results underscore the value of carbon storage and net primary productivity as key indicators of geomorphic stability in karstic-dominated coastal systems constrained by urban development. Preliminary findings suggest that while these mangrove forests are currently highly productive and have high carbon storage potential, they are not maintaining elevation above accelerating sea-level rise. This research will support management and restoration efforts in Biscayne Bay by providing insight into the carbon storage trajectory and ecosystem resilience of valued mangrove ecosystems.

Calibration of a Shallow Coastal Aquifer Density Dependent Transport Model and Preparation for 2050 Sea-Level Rise Model Scenarios, Miami-Dade County, Florida

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Saltwater contamination poses one of the greatest risks to water supply, yet saltwater intrusion remains one of the least understood challenges, marked by significant uncertainties. Key factors driving the inland movement of the saltwater front include increased groundwater pumping due to population growth and rising demand, as well as sea level rise.

In Miami-Dade County, salinity control structures have been constructed along the coast to mitigate saltwater intrusion, particularly in canals traversing low-elevation areas. These canals, located in the Transverse Glades, cut through the higher-elevation Atlantic Coastal Ridge. However, several coastal salinity control structures are already failing during high tides. As sea levels rise, the number of days when gravity-based structures fail is increasing, placing Miami-Dade at a growing risk of saltwater intrusion into its wellfields. If the wellfields become contaminated, alternative water sources will be required—a process that could take over a decade and cost billions of dollars.

To address this challenge, Miami-Dade Water and Sewer Department (WASD) has updated the existing USGS Urban Miami-Dade groundwater model to include density-dependent components for improved predictions of saltwater intrusion. Accurate model calibration is essential to ensure reliable projections, but this process is challenged by the quality and frequency of salinity-related data. Measurements of salinity, total dissolved solids, or chlorides are typically collected monthly or quarterly and can be affected by local conditions, such as rainfall, introducing variability and potential errors.

To improve calibration accuracy, the updated model utilized the saltwater intrusion lines from 2018 and 2022, provided by the USGS, for model layer five (the bottom of the aquifer). Advanced software, PEST, was employed for calibration. The process began with a steady-state model to establish initial conditions, followed by a transient model covering the period from 2018 to 2022. The calibration produced excellent results for both groundwater levels and salinity, indicating the model's readiness for future projections. However, beyond 2040, uncertainties increase exponentially due to unresolved questions about adjustments to the failing salinity control structures.

iModel Application in Central Everglades Planning Project 1.0

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The objective of the Central Everglades Planning Project Increment 1.0 is to develop operational criteria for infrastructure scheduled for completion before 2027 as part of the Central Everglades Planning Project framework. Serving as the first phase of operational planning, Central Everglades Planning Project Increment 1.0 will replace the existing Combined Operational Plan. A key innovation in this process is the incorporation of the iModel, an inverse modeling tool designed to optimize operational strategies based on specific objectives constrained by the plan requirements. Unlike traditional models that predict the system's response based on the given inputs, the iModel calculates the required input needed to achieve a desired response. The iModel helps identify operational strategies that can be integrated into the Regional Simulation Model Glades- Lower East Coast Service Area (RSMGL) for scenario testing. Its domain includes Water Conservation Area 1, Water Conservation Area 2, Water Conservation Area 3 and Everglades National Park. The two primary components of the iModel are the hydrologic model emulators and the optimization framework. The hydrologic model emulator was trained and validated using simulations from a highly stressed RSMGL model, ensuring the hydrologic model emulator can predict behavior under a wide range of conditions. This allows the iModel to test scenarios that have not yet been implemented in practice. The optimization framework for the iModel determines the best combinations of inputs to achieve the desired system responses. A set of hydrologic target timeseries data is used as input across the iModel domain. This allows the inverse process to optimize flows across the full range of variability as opposed to specifying one water level. By testing a range of target combinations and system management concepts the iModel helps to inform the project team of potential viable alternatives for subsequent testing with RSMGL. Together, these components allow the iModel to enhance the operational planning process by providing a flexible and forward-looking approach to water resource management in the Central Everglades.

Testing Low-Cost Control Methods Efficacy on Giant Apple Snails (*Pomacea maculata*) Egg Masses

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The giant apple snail (*Pomacea maculata*), is an invasive, exotic snail that has become a pest, interfering with crop production, clogging crawfish traps, and creating significant biological waste through bycatch. Apple snails are highly fecund, and a cost-effective control method targeting egg clutches that is not toxic to other invertebrates is needed. Giant apple snails were collected and bred in a laboratory experiment to produce egg clutches for treatment with water submersion or vegetable oil application at two different egg developmental stages (Day-1 old, Day-7 old). The hatch rate for each treatment type was estimated and compared to untreated control hatch rates using pairwise Dunn's tests to determine efficacy of the treatments. The results indicated that hatch rate for all treatments were significantly reduced when compared to the control, except for Day-7 clutches treated with oil, which were not significantly different from control hatch rates. These results indicate that oil treatment is only significantly effective at reducing hatch rate for egg clutches that are newly laid (Day-1), and not for clutches halfway through development (Day-7), while water treatments were effective regardless of clutch age.

Assessing Coarse Woody Debris and Mangrove Recruitment in Changing Climates Using GIS and Remote Sensing

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Mangrove forests are vital components of the coastal regions of the Greater Everglades Ecosystem, playing a critical role in resiliency and biodiversity. After disturbances such as hurricanes, the accumulation of coarse woody debris (CWD) can influence mangrove recovery by creating microhabitats and stabilizing sediments, however excessive amounts may negatively impact the species. This study investigates the spatial distribution of CWD and its potential impact on mangrove seedling recruitment in Southwest Florida, specifically Estero Bay.
LiDAR data captured using the viDoc RTK Rover was processed in Pix4D and analyzed in CloudCompare. Drone imagery and spatial tools in ArcGIS were used to map CWD and assess its relationship with mangrove recruitment. Preliminary results of this study indicate that moderate CWD concentrations may support seedling establishment by providing microhabitats and reducing erosion. However, excessive accumulation may result in decreased growth and regeneration.

These findings contribute to understanding how mangrove ecosystems recover as they face changing climate conditions and provide insight into future adaptive restoration strategies that can be used in the Greater Everglades Ecosystem.

Dissolved Organic Matter Cycling in the Everglades Stormwater Treatment Areas

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The Stormwater Treatment Areas (STAs) in South Florida are the largest treatment wetlands in the world and were constructed to decrease the amount of phosphorus (P) discharged to the Everglades. Many drivers can influence STA performance, including land use history, variability in P loading, hydropattern, soil type, and internal P cycling. The majority of P entering the STAs is inorganic P, while the majority of P leaving the STAs is co-dominated by particulate P (PP) and dissolved organic P (DOP). Investigating dissolved organic matter (DOM) dynamics in the STAs can provide insights into this DOP pool, as well as information about the dissolved organic nitrogen (DON) pool, which can influence aquatic primary producers. While DOM has been well studied in much of the Everglades system, less is known regarding DOM biogeochemistry in the STAs. Here, we characterized DOM in the STAs through field observations and experiments to evaluate how leaching, photolysis, and microbial degradation influence DOM and nutrient cycling in these wetlands. A decomposition and leaching study was conducted in the summer of 2022 to evaluate changes in the composition of DOM that leached from fresh to 40-day decomposed litter and floc. Litter and benthic flocculent sediment (floc) material were collected from both emergent aquatic vegetation (EAV; *Typha domingensis*) and submerged aquatic vegetation (SAV; *Chara* spp.) habitats, at an outflow site within STA-3/4. Fresh material was used for the initial timepoint (Day 0; D0) and additional litter and floc were placed in litter/floc bags which were then allowed to decompose *in situ* for 20 (D20; intermediate decomposition) or 40 (D40; late-stage decomposition) days. At the initial, intermediate, and late stages of decomposition, fresh material (D0) or litter/floc bags (D20 and D40) were retrieved, transported to the laboratory, and used as substrate for a leaching experiment. After 48 hours, DOM released from the floc or litter was collected and evaluated for a suite of geochemical parameters and biomarkers to assess DOM composition. DOM leachates were also subject to photochemistry and bioassay experiments to determine their photo- and bioavailability. Here, we will focus on the optical properties (absorbance and fluorescence) of colored dissolved organic matter (CDOM) and the molecular composition (via FT-ICR-MS) of DOM released from the different substrate types. This study was complemented by a transect study that evaluated the composition of CDOM along two STA flow-ways. Overall, we found that EAV and SAV both leach DOM into STA waters and that the chemistries of their leachates differ, with SAV releasing "fresher" DOM when compared to EAV, and litter material leaching more DOM than floc. These findings provide further insights into the internal sources and turnover of DOM in the STAs and their relationship with internal nutrient cycling in these unique treatment wetlands.

Development of Hydrologic Targets to inform the Central Everglades Planning Project Operational Plan (Increment 1)

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The purpose of the Central Everglades Planning Project (CEPP) is to improve the quantity, quality, timing, and distribution of water flows to the northern estuaries, Water Conservation Area (WCA) 3, Everglades National Park (ENP), and Florida Bay while increasing water supply for municipal, industrial, and agricultural users. The purpose of the CEPP Operational Plan (Increment 1) is to provide operating criteria for CEPP infrastructure, while integrating operations of related Comprehensive Everglades Restoration Plan (CERP) and non-CERP projects that contribute towards achieving the goals, purposes, and benefits of CEPP. The CEPP Project Operating Manual will be updated and will change the 2020 Combined Operational Plan Water Control Plan (the current operating plan for the WCAs, ENP, and South Dade Conveyance System). Plan formulation efforts for the CEPP Operational Plan (Increment 1) identified the desire to develop iModel target time series to support alternative development. The iModel emulates the hydrologic response characteristics of the Regional Simulation Model – Glades Lower East Coast Service Area (RSM-GL) and unlike traditional hydrologic models, the iModel is "inverse" in that inputs to the iModel are targets time series (water depths and stage) and outputs are the optimized operations of structures that provide the overall best fit to the hydrologic targets. iModel target time series developed for the CEPP Operational Plan (Increment 1) were either products of: (1) the Natural System Regional Simulation Model (NSRSM); (2) existing condition RSM-GL model runs from current CERP planning projects; and/or (3) a combination of NSRSM and RSM-GL model runs that were site specific or from a current system analog with adjustments for relative differences in microtopography and site conditions (e.g., over drained, ponded, and conserved). The time series were reviewed and modified through interagency discussions in order to meet target water depths for vegetation (e.g., ridge and slough and marl prairie habitat) and wildlife (e.g., wading birds and federally listed species) in WCA 3 and ENP (including Shark River Slough (SRS), Taylor Slough, and Lostmans Slough).

Application of Near-Surface Geophysics in Assessing Spatio-Temporal Variability of Moisture Content in Soils and Trees

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Soil moisture content greatly influences eco-hydrological processes in soils dictating carbon and nutrient pathways. Similarly, trees strongly contribute to and control these processes. As such, effectives ways to image spatial and temporal distribution of moisture in soils and trees are essential to better understanding water availability at the ecosystem level. In recent decades, ground-penetrating radar (GPR) has become an increasingly common and effective approach for estimating and modeling soil moisture beneath the surface. In this study, we use a unique array of GPR measurements that includes: a) transects at the field scale across a variety of soil types in the Luquillo LTER in Puerto Rico to trace spatial (i.e., lateral) and temporal (i.e., seasonal) variability in moisture content across an approximate 2m soil column; 2) soil calibrations at the laboratory scale to generate site-specific relations between moisture and GPR permittivity to be used at the field scale; and 3) measurements along tree trunks to evaluate how soils at the different study sites may influence moisture distribution in trees, particularly during different seasons (i.e., wet vs. dry). While measurements are still ongoing, preliminary results show a clear seasonal control on soil and tree moisture content distribution that is consistent across all sites. This research has implications for assessing ecosystem vulnerability and strengthening ecosystem models particularly in an environment prone to extreme weather events (i.e., tropical storms).

Understanding the Water Quality-Water Quantity Tradeoffs: Can We Find a Balance?

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In many parts of the Everglades, the historic ridge and slough topographic differences have been degraded, such that flow restoration effects, e.g., sediment transport and aeration, are needed to restore the connectivity, function, and ridge and slough patterning of the landscape. However, increased flow increases the supply rate of phosphorus (P), resulting in higher P loading. The Decompartmentalization Physical Model (DPM) Project demonstrated that even when surface water inflow concentrations were ≤10 µg P /L, consistent high flow velocities caused locally elevated loading rates. These high rates caused periphyton community shifts, enriched sediments, and in some cases, a switch to cattail-dominated communities. Therefore, as we implement new projects that transition the Everglades from an impounded to a more flowing ecosystem, it is important for us to consider the potential for both positive and negative ecological responses. During this talk we use data from *in-situ* and modeling studies to discuss how water quality, flow and distribution, and active management strategies could be used to improve ecological conditions. Specific examples of different approaches to reach restoration goals include, setting shallower depth targets, increasing marsh to marsh connectivity, flow distribution features, vegetation management, and incorporating rest/recovery periods in operations. For example, since the inflow structure of the DPM project last operated in March 2022, benthic flocculent sediment TP concentrations in the closest nutrient enriched site have stabilized, while surface water TP decreased. This provides some evidence of recovery and perhaps an opportunity to explore different operational strategies, though more data are needed to support this concept.

The Everglades are not a stationary ecosystem. As different stages of the Comprehensive Everglades Restoration Plan (CERP) are implemented, the Everglades will evolve and so should the restoration targets.

Exploring the Role of Saltwater Intrusion in the Pore Structure of Freshwater Peat Soils Using Laboratory Techniques

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Peatlands are important resources found worldwide that serve as carbon reservoirs and play a critical role in water and biogeochemical cycles. While plant composition of peat soils varies with latitude, physical properties are similar and characterized by high porosity values that result in high water storage capacity and play a role in the accumulation and release of biogenic gases like methane. Previous studies have shown that increases in water conductivity induce a pore dilation effect that may result in changes in physical properties that could have a role in the collapse of the peat matrix. As an increase in saltwater intrusion in freshwater peat soils is expected in the coming years due to sea level rise and storm surges, it is becoming increasingly important to build an understanding of how saline intrusion affects the structural integrity of peat soils. In this study we test an array of peat soils from different latitudes (including the Everglades and boreal systems in Maine) using X-ray CT scans and hydraulic conductivity tests to monitor the changes in pore dilation with different saline exposures. This work aims at exploring the existence of potential salinity thresholds that may induce changes in the structure of the peat matrix and define boundaries where such changes may become permanent and irreversible. Therefore, this work has implications for better understanding how saltwater intrusion may induce physical changes in the peat matrix potentially leading to peat collapse, and what is the role of such salinity threshold for restoration efforts.

Diversity and Distribution of Barnacles on Natural and Artificial Substrates in a Mangrove-Dominated Tidal Creek

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Coastal mangrove ecosystems play a vital role in nutrient filtration, storm surge protection and sustaining local biodiversity. South Florida's Biscayne Bay Coastal Wetlands are home to a series of restoration areas designated as "blocks", dominated by buttonwood trees and red, black and white mangroves. In these estuarine habitats, red mangrove roots attract larvae from multiple epibiont species, including barnacles, mussels and oysters. This study, which was conducted in one of the restoration block's tidal creeks, aimed to: (1) assess variations in the distribution of root epibionts with distance from the tidal creek mouth, and (2) use a molecular systematic approach to identify barnacle species on red mangrove (*Rhizophora mangle*) roots and artificial substrate colonization samplers (ASCSs). Presence-absence data on the tidal creek's red mangrove roots was recorded every 10 meters for *Crassostrea virginica* oysters, *Isognomon* oysters, Mytilidae mussels, and barnacles. ASCSs, each with three suspended pine dowels, were constructed at six locations within and surrounding the tidal creek. After 11 weeks, ASCSs were collected, and barnacle settlement was quantified. Visual identification was difficult due to small size, high diversity and ontogenetic changes. Instead, barnacles were collected from the ASCSs and adjacent red mangrove roots for DNA analysis. A total of 47 barnacles were sampled, 22 from ASCS and 25 from red mangrove roots. Genomic DNAs were extracted, and the cytochrome c oxidase I (COI) gene fragment was amplified and sequenced. Species identifications were made using the BLASTN function in GenBank. Matching sequences with a percent identity of 95% and above were downloaded and aligned to our sequence fragments, and phylogenetic trees were generated. Results of molecular systematic analyses confirmed the presence of five species, including four native species in two genera, namely *Chthamalus fragilis*, *C. proteus*, *C. angustitergum*, and *Amphibalanus eburneus*. One invasive parasitic species, *Parasacculina sp.*, was also identified. Roots exhibited higher barnacle diversity than ASCSs, which were colonized by just two species, *C. fragilis* and *A. eburneus*. ASCSs also displayed lower species evenness, as *C. fragilis* was dominant, accounting for 95% of the samples (21 of 22). Additionally, root survey results showed that oyster and mussel presence did not change significantly with distance from the creek mouth. Barnacle abundance, however, decreased significantly with distance ($p = 0.001$). ASCS barnacle counts generally corroborated these results. Literature suggests this pattern may be a combined result of differential mortality and settlement preferences influenced by tidal flow, current direction, and complex interactions with other epibionts. Both barnacle species diversity and distribution may be affected by current and future changes to the restoration site's freshwater flow.

Long-term Colonial Wading Bird Monitoring in Everglades National Park, a History of Monitoring, Decline and Recovery

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Everglades National Park (ENP), the largest subtropical wilderness in North America, is recognized globally for its ecological significance through designations such as the World Heritage Convention, the Man and the Biosphere (MAB) program, and the Ramsar Convention on Wetlands. As part of our involvement in these international initiatives, we utilize nesting wading birds as key indicators of environmental health in ongoing monitoring, restoration, and management efforts within ENP. Due to their relatively easy monitoring, known habitat and prey requirements, and historical nesting patterns, wading birds are effective indicators—both as a group and at the species level—of the environmental conditions necessary for successful foraging and nesting. In recent years, however, factors such as climate change, sea level rise, invasive species, disease, and habitat alterations from restoration efforts have introduced complexities that may challenge future nesting predictions in the park. Although overall nesting efforts remain below the World Heritage UNESCO Desired State of Conservation, which calls for 50% of all wading bird nests to be located in the southern coastal ecotone region, nesting levels have improved since the lows of the 1990s and early 2000s, when only 2% to 10% of nests were found in this region. While short-term wading bird responses to hydrological conditions are increasingly predictable with advanced monitoring and modeling tools, long-term nesting trends in ENP still show a mix of declines or stagnation for some metrics, with marked improvements in others. Ongoing research and monitoring will continue to shed light on these trends, potentially boosting the recovery of wading bird species in ENP and further supporting nesting success.

Dynamically Resilient Water Resources System in an Environment of a Nonstationary Climate

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Efforts associated with restoration, sustainability, and resilience of large-scale natural ecosystems impacted by human activity, have historically focused on modeling and analysis based on a fundamental assumption of climate stationarity. Given the recent emphasis on climate change, regional- and local-scale water resources planning, and management require a new paradigm based on the emerging concepts of a nonstationary climate. Systematic trends superimposed on natural variability in climate- and related drivers including rainfall patterns, temperature, sea levels, frequency, and magnitude of tropical storms have the potential to challenge the success of long-range plans for multi-sector systems. Regional water budgets, which are fundamental for ensuring water supply for environmental, urban, and agricultural systems may change dynamically outside the envelope of natural variability. Global and Regional Climate Models, applied under various greenhouse gas scenarios, are probably the only way to assess how climatic regimes will evolve in the future. Some important drivers such as sea levels and temperature are already exhibiting increasing trends whereas other important variables such as rainfall do not show statistically significant trend patterns. Future projection of climate is one of Deep Uncertainty due to a variety of factors. The consequences of nonstationarity lead to the notions of sustainability and resilience of large-scale systems with long planning horizons to be dynamic in nature requiring a new paradigm for them in practice. Recent research efforts have led to the development of such a paradigm that includes techniques useful in situations where there is good evidence of significant changes and projected changes. This presentation will focus on the development of nonstationary counterparts to traditional concepts of water resources planning under stationarity. They include new methods for determining return period, risk, reliability, resilience, and the temporal frequency of extreme events in a changing environment. Analytical approaches for dynamic adaptation pathways using the nonstationary counterparts of risks will also be presented.

Efficacy of Targeted Invasive Herpetofaunal Removal in Everglades Tree Islands

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South Florida has the largest number of invasive herpetofauna in the world. Identifying effective methods for controlling these invaders will be crucial to protect the Everglades ecosystem. We tested the efficacy of manually removing invasive amphibians and reptiles on tree islands as a possible management approach. To do this, we conducted 100 person-hours of targeted removals of invasive herpetofauna at four constructed tree islands in the Loxahatchee Impoundment Landscape Assessment (LILA) each year for five years. We then compared the frequency of invasive herpetofauna on removal islands with those on four control islands with no treatment. The effect of targeted removal was then compared with the effect of hydrological management on native and non-native herpetofauna abundance. Removal islands had a lower abundance of invasive herpetofauna than control islands after five years, indicating that targeted removal does decrease invasive abundance. However, hydrological management produces a stronger effect on invasive species abundance than targeted removals. This suggests that managing habitat to favor native species is likely a more effective method of limiting the spread of invasive amphibians and reptiles over targeted removal efforts. Native herpetofauna are favored over invasives in wetter hydrological regimes, so making tree islands wetter is likely one of the best approaches to reducing invasive abundances and preventing their spread.

Invasive Grass Challenges and Solutions for Kissimmee River Restoration

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The Kissimmee River Restoration project was completed in 2020 with previously channelized portions of the river plugged to divert water and force it to follow the historic river channel and provide hydrologic restoration to portions of the river floodplain. Although the restoration is considered completed, a suite of invasive grasses hinders overall restoration efforts to return the floodplain to native plant communities that provide an array of ecological functions and support wildlife. Invasive grasses, such as West Indian marsh grass (*Hymenachne amplexicaulis*), paragrass (*Urochloa mutica*), and torpedograss (*Panicum repens*), complicate efforts to achieve successful ecological restoration in the Kissimmee River floodplain. All three species are listed as a Category I invasive species by the Florida Invasive Species Council due to the negative ecological impact their populations have on native ecosystems and associated ecological processes. West Indian marsh grass is especially problematic in the Kissimmee River where it thrives in portions of the seasonally flooded and disturbed floodplain. This species is a perennial freshwater grass native to the West Indies and Tropical America. Previous small-plot research suggests West Indian marsh grass can be controlled using foliar applications of the herbicides glyphosate and imazapyr. Limited in-situ research has been done to demonstrate effectiveness of long-term control and management of West Indian marsh grass, especially on a large geographic scale in a natural area. This led to the partnership between the University of Florida and the South Florida Water Management District to evaluate the influence of herbicide treatment timing and target vs. native plant densities on the efficacy of treatments and native plant response. Our data suggests that the season influences treatment efficacy, with dry season treatments outperforming wet season treatments. This information will lead to more effective treatments and will aid in developing a long-term management approach, which will continue to be informed by additional research.

Decoding Waterlettuce: Genetic Diversity and Control Strategies for Florida's Invasive Aquatic Menace

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Waterlettuce (*Pistia stratiotes* L.) is a floating aquatic weed with a pan tropical distribution. Historically it has been categorized as an invasive plant in the southeastern United States. Waterlettuce disrupts natural areas by restricting water flow and competing with native plant species. In 1987, the waterlettuce weevil (*Neohydronomus affinis)* was released in the southeastern United States following its successful control of waterlettuce in Australia. As releases were conducted at multiple sites around Florida, it became clear that levels of control differed between waterlettuce populations, and the weevil did not always meet management goals. Past genetic evidence suggested that there were possibly native and non-native waterlettuce populations in Florida, consisting of distinct haplotypes. While seven haplotypes of waterlettuce have been discovered worldwide, only four distinct types are found in Florida: Type A, B, C, and E. The two most prevalent types in Florida were determined to be Type A and Type E, with Type A occurring in southern Florida and the St. John's watershed. It is unlikely that Type A populations are native to Florida. Conversely, the distribution of Type E is widespread around the Caribbean and is hypothesized as native to Florida. These findings have prompted a more detailed analysis of the genetic composition of waterlettuce populations around Florida. A total of 400 samples collected from 20 different waterways (20 samples per site) were dried and sent to the USDA-ARS Invasive Plant Research Laboratory for DNA sequencing. The samples were then amplified, quantitated, cleaned, and analyzed using ddRADseq. The genetic data collected in this study will help elucidate our understanding of waterlettuce populations in Florida, including possible admixtures of genotypes, and could potentially aid in providing more effective implementation of classical biological control for non-native waterlettuce populations infesting Everglades ecosystems.

RECOVER's Scientific and Technical Evaluation of the Second Periodic CERP Update.

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The Everglades ecosystem, including Lake Okeechobee, encompasses a system of diverse wetland landscapes that are hydrologically and ecologically connected across more than 200 miles from north to south and across 18,000 square miles of southern Florida. In 2000, the U.S. Congress authorized the Federal government, in partnership with the State of Florida, to embark upon a multi-decade, multi-billion-dollar Comprehensive Everglades Restoration Plan (CERP) to further protect and restore the remaining Everglades ecosystem while providing for other water-related needs of the region. 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. 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. Since 2000, much progress has been made, including record construction of CERP projects, collection of new data and science through **RE**storation, **CO**ordination, **VE**rification's (RECOVER) Applied Science Strategy, along with new modeling and tool development. The Second Periodic CERP Update (SPCU) is an opportunity to reevaluate whether the goals and purposes of the Plan are being achieved, to ensure that new information is regularly considered and incorporated, and to update the total quantity of water expected to be generated by implementation of the Plan, including the quantity generated for the natural system and the quantity generated for use in the human environment. A periodic CERP Update is not a reformulation or a modification of the authorized CERP. In support of the SPCU, RECOVER conducted a systematic comparison and evaluation of hydrologic parameters across specified Indicator Regions and transects for a set of baselines and alternatives. The baselines examined include the pre-CERP baseline (2000), a snapshot of the system in 2023, and several alternatives to include the future with and without CERP, including alternatives with projected sea level change. RECOVER used a suite of ecological and hydrologic performance measures, ecological planning tools, water supply, flood control, recreation and cultural/archaeological performance metrics to evaluate performance on regional and system-wide scales. The RECOVER Scientific and Technical Evaluation will provide findings and recommendations to the CERP Implementing Agencies to inform decisions regarding areas where adaptive management may be needed to best achieve CERP goals and purposes. This presentation will focus on RECOVER's preliminary findings and recommendations.

Physical and Economic Scalability Analysis of the Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS)

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The Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS) is a research project focused on the development and pilot scale validation of a HAB mitigation capability that physically removes harmful algae, algae-entrained nutrients, and potential algal toxins from freshwater bodies. It incorporates resource recovery methods that support efficient management of the resulting biomass while destroying any potential toxins. The technologies integrated and demonstrated in the HABITATS project include floating weir skimmers for collecting algae-laden water, dissolved air flotation for separating and concentrating the algal biomass from the water, ozonation for destroying potential free cyanotoxins in the clarified water, biomass dewatering processes, and hydrothermal liquefaction for biomass transformation, resource recovery, and cyanotoxin destruction. This presentation will summarize physical and economic analyses based on multiple field pilot demonstration tests and supporting laboratory analyses performed by ERDC and collaborators with a focus on lessons learned and opportunities for improvement. Data incorporated into the analyses include water quality improvement through the treatment system; algae dewatering efficacy with various processes; cyanotoxin removal and destruction; and fuel yields observed in bench and pilot scale studies. Lessons learned from pilot demonstrations at four different field locations, including several demonstrations in Florida, will be shared. A case study for implementation of the HABITATS approach upstream of a spillway and an associated economic scalability analysis will be presented to summarize the estimated costs and to identify opportunities for decreasing costs. Recent laboratory experimental data for in-situ flotation, a potential cost-saving approach that could be used to pre-concentrate algae in the source water and reduce the size of a HABITATS system needed upstream of a spillway, will be presented. The HABITATS research project is funded by the US Army Corps of Engineers through its Aquatic Nuisance Species Research Program and has included collaborators from government, academia, and industry.

Snake Lungworm Alliance and Monitoring (SLAM): Opportunistic Surveillance and Resource Allocation

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The invasive pentastome parasite, *Raillietiella orientalis*, was first detected in a wild native snake in the southeastern United States in 2012. *Raillietiella orientalis* is native to Asia and appeared to have spilled over from the invasive Burmese python population in South Florida. Infections are severe in native snakes, ranging from 1-107 individuals in the lung and can cause lesions of the lung, pneumonia, and sepsis. Mortality associated with *R. orientalis* infection and declines in native snake populations align with the first observations of *R. orientalis* in South and Central Florida, suggesting significant population impacts. Despite this, a lack of coordinated surveillance and minimal research attention leaves many questions about the ecological consequences of *R. orientalis*. To address this deficit, we created the Snake Lungworm Alliance and Monitoring (SLAM) program in 2022 as a nexus of opportunistic sampling for *R. orientalis* infections in native snakes. To date, 18 native snake species and one native lizard species have been observed with *R. orientalis* adult infections across 32 counties, and 18 of these county records were produced by SLAM. Additionally, SLAM collaborators have identified *R. orientalis* adults in five invasive squamates and have documented five captive cases of infection in three snake species and one tortoise species, all associated with mortality. The SLAM initiative involves over 100 collaborators across the southeast who collect fecal samples and cloacal swabs from live snakes or collect road killed snakes. Since our establishment, we have assessed over 700 samples and created a *R. orientalis*-specific PCR assay. We made research and surveillance efforts accessible to the public through a website, social media, and open access publications. The SLAM initiative aims to understand the threat posed by *R. orientalis* to native snake populations, and to inform management strategies.

Application of CFD for the Design of a CEPP-N Restoration Project Flow Distribution Facility

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In large-scale civil engineering projects, the reuse of existing facilities is crucial for cost savings and efficiency. This principle was applied to the Central Everglades Planning Project – North (CEPP-N) north-western Water Conservation Area – 3A (WCA-3A) wetland restoration project, which involved refurbishing and repurposing the existing S-8 pump station with a discharge capacity of up to 4,000 cfs. To achieve this, it was proposed to construct a 1,500-foot-long feeder canal to divert pump discharge water into the expanded L-4 canal. To meet the design requirements of stakeholders and adhere to the South Florida Water Management District (SFWMD) canal design guidelines, a 120-degree abrupt turn of the pump discharge into the feeder canal was unavoidable. This required a comprehensive hydraulic design evaluation using computational fluid dynamics (CFD) models. The primary objectives of the CFD analysis were to ensure effective flow diversion, stable flow distribution of high-velocity discharges at the junction downstream of the pump station, and to reduce stresses on the channel embankments surrounding the junction. The junction is located 300-600 feet downstream of the S-8 pump station. Under the maximum design discharge condition, 75% of the pump discharge is diverted 120 degrees into the expanded L-4 canal via the feeder canal, while the remaining 25% is released through a proposed S-8A spillway structure to the south and into the existing Miami canal. This case study presentation will demonstrate the evolution of the conceptual design of the S-8A junction through CFD model analysis. It will include the interpretation of CFD model results, subsequent design modifications, and a discussion of the hydraulic improvements achieved through these modifications. Additionally, follow-up design improvements for the final design phase will be discussed to ensure project success.

Statistical and State Space Methods Unravel Marsh Stage Response to Rainfall and Water Management

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Marsh water levels are naturally driven by a complex interdependence of rainfall, topography, land cover and hydrogeology. Water management compounds the complexity seeking to regulate marsh water levels by controlling inflows and outflows across Park boundaries, redistributing water levels, seepage barriers and other operational measures. A fundamental question to inform water management planning is: to what extent can one attribute a change in water level to rainfall versus management? We examine this question with conventional statistical and state-of-the-art state space models using empirical dynamic modeling (EDM), a data-driven, model-agnostic tool to unravel complex, nonlinear dependencies. Statistical analysis indicates mean water level maxima observed during the Combined Operational Plan (COP) are improbable under Interim Operational Plan and Everglades Restoration Transition Plan (ISOP/IOP & ERTP) conditions suggesting COP water levels have entered a new state regime. Nonlinear trend and state space analysis agree with the statistical results. State space models relate site-specific stage response to rainfall ($\partial S/\partial R$) consistent with topographic and hydrogeologic site conditions. A two-component dynamic model of Cape Sable Seaside Sparrow subpopulation A stage (gauge: NP-205) driven by Park boundary inflows through the S12A and S12B structures and site rainfall examines relative contributions of rainfall and S12A and S12B flows to NP-205 stage response during two planned, temporary water management deviations for the COP.

Assessing the Risk Factors for Hurricane-Induced Tree Failure in the Naples Urban Forest

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While the coastal ecosystems of the Greater Everglades have long been impacted by hurricanes, recovery may be reduced by their heightened intensity under climate change. There is thus an urgent need to further research on storm damage and recovery, especially in urban forests, which are understudied despite the serious risk posed by tree hazards and their great relevance to the field of restoration ecology. The objective of this research project is to determine whether the probability of hurricane-induced tree failure is impacted by tree, environment, and management factors. A binary logistic regression model was created using tree height, species, utility lines, and their two-way interactions as explanatory variables. The results from this study suggest the probability of hurricane-induced tree failure is impacted by these risk factors. There was a statistically significant interaction between tree failure and tree height and utility lines, tree height and species, and species and utility lines, indicating the direction and magnitude of the effect varies. Given these findings, urban forest managers should consider species-specific responses to hurricanes. It may be advisable to replace less hurricane-resistant species with more hurricane-resistant species, while still maintaining species diversity and ecosystem services. By improving urban forest management practices in the Greater Everglades in line with this research, counties and municipalities may decrease public expenditure, increase public safety, and ultimately enhance coastal resilience in the context of climate change, creating more sustainable communities.

Ecosystem Responses to the Combined Operational Plan (COP): Changes Observed since Implementation

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The Combined Operational Plan (COP) was implemented in September 2020 as a critical component of the Everglades Restoration effort to improve water deliveries (volume, timing, and distribution) into Everglades National Park (ENP) from Water Conservation Area 3 and support ecological habitats while balancing flood control and water supply. This study evaluates the ecosystem responses to the COP, focusing on key hydrologic and ecological indicators since its implementation. By using monitoring data, empirical observations, and hydrologic modeling, we examine the changes in flow regimes, water depths, and hydroperiods and their effects on vegetation patterns, wildlife habitats, and water quality across the Everglades landscape. Key findings indicate both ecosystem improvements and challenges since COP implementation. Hydrologic connectivity has increased, particularly in Shark River Slough and Taylor Slough, resulting in improved water flow and longer hydroperiods in critical marsh areas. Salinity levels in Florida Bay have improved, benefiting seagrass and estuarine habitats. However, unintended trade-offs have been realized, including increased flooding risks in some areas with tree island habitats, especially in southern WCA-3A and Northeast Shark River Slough, and limited improvements in habitat conditions for the Cape Sable seaside sparrow across most subpopulations. These challenges are partially attributed to climatic variability, such as above-average rainfall in certain post-implementation years, which has influenced the effectiveness of COP measures. These results underscore the importance of adaptive management to refine operations and address uncertainties related to climate variability and sea-level rise. Additionally, findings provide valuable insights for the development of the Central Everglades Planning Project (CEPP) operational plan, highlighting the need to account for the relative influence of climatic factors to achieve restoration goals effectively.

FPLOS and Applications in Resilient Florida Flood Vulnerability, Adaptation Planning, and Federal Flood Risk Management Studies

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The Flood Protection Level of Service (FPLOS) program is pivotal in advancing regional flood risk management by utilizing robust modeling tools to address evolving challenges such as extreme rainfall and tropical storms, sea level rise, land development, and population growth. These tools provide a comprehensive understanding of flood dynamics under current conditions and future scenarios, enabling the identification and prioritization of long-term adaptation strategies. Understanding compound flooding, where multiple drivers such as rainfall, storm surge, and groundwater interact, is essential for effective long-term planning.

Recommendations from the FPLOS assessments have been incorporated into the SFWMD 2024 Sea Level Rise and Flood Resiliency Plan, emphasizing the importance of data-driven planning in prioritizing and addressing flood vulnerabilities with the goal of reducing the risks of flooding, sea level rise, and other climate impacts on water resources and increasing community and ecosystem resiliency in South Florida. This planning effort enables the evaluation of selected mitigation measures based on their cost-effectiveness to ensure overall system resilience within dynamic adaptation pathways. These strategies often include a combination of structural, non-structural, and nature-based solutions to reduce flood risks and enhance resilience across the region. Examples are water control structure improvements, canal enhancements, storage areas and operational flexibility, among others. These strategies focus on reducing peak canal stages, overland flooding, and flood durations, and have the potential to help safeguard communities and critical infrastructure.

By integrating regional datasets with advanced Hydrologic and Hydraulic (H&H) modeling, the FPLOS program is the backbone to support decision making for infrastructure investments and funding opportunities. For instance, FPLOS model results have been used in grant funding applications - such as FEMA's Building Resilient Infrastructure and Communities (BRIC) program and Resilient Florida - and guides large-scale flood risk management efforts, including the USACE/SFWMD Central and Southern Florida (C&SF) Section 216 and Section 203 Flood Resiliency Studies in the Southeast Florida.

The application of FPLOS tools into grant proposals as part of SFWMD's Resiliency strategy, has secured $150 million in funding from FEMA BRIC. This success was achieved through collaboration with local and regional partner agencies, ensuring that vulnerability assessments can transition into actionable regional flood risk implementation projects. The foundation of robust and scientific-based tools for understanding flood vulnerabilities and compound flooding under current and future conditions is central to supporting the development of effective flood adaptation measures and build a more resilient South Florida.

A Molecular Platform to Assess the Feasibility of Genetic Biocontrol Approaches for Invasive Burmese Pythons

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The establishment of invasive reptiles in Florida has been documented for decades. Traditional biocontrol methods relying on human detection, such as trapping, require extensive resources and time commitments to be able to mitigate the adverse effects these invaders have on native ecosystems. The need for effective control tools is particularly urgent in the Greater Everglades, an ecosystem of international significance and a designated Ramsar site where restoration efforts are a high domestic priority. Innovative genetic technologies are becoming available that could potentially address some of the limitations ecosystem managers currently face when removing invasive reptiles from the southern Florida landscape. Genetic tools are important to consider, since they have species-specific effects across the landscape, do not rely exclusively on human detection of the targeted invasive species, and can provide more humane methods of control. Due to its complicated nature, genetic biocontrol requires a large degree of community engagement, permitting, safety planning, and regulation. Especially important is a commitment to open science by the researchers and active collaboration and engagement with the affected human communities at all stages of development and implementation. The magnitude and seriousness of the impact of the invasive Burmese python population in southern Florida necessitate the exploration of innovative management techniques. Containment efforts have been ineffective for the invasive population in part due to their low detection and trapping rates (<1%). While we, as USGS scientists aim to remain at the forefront of these efforts, there may be instances where our role is primarily to serve as an advisory board for other researchers advancing control strategies. Preliminary laboratory-based work has focused the development and evaluation of genetic strategies in cultured Burmese python cells. These methods will enable the generation of additional genetic information in an organism that, unlike established laboratory models such as mice and fruit flies, lacks the necessary foundation to explore and implement manipulations related to genetic biocontrol. Ongoing research has demonstrated that nucleic acids can be incorporated into cultured Burmese python cells to express a fluorescent protein with relatively high efficiency (~70%). Similarly, CRISPR-Cas9 complexes were successfully internalized into these cells with high efficiency (~80%). The research was conducted in primary cells obtained from Burmese python tissue which provides an accurate model to evaluate genetic biocontrol methods. Genetic biocontrol technologies developed for Burmese pythons could be translated to address other invasive species as well.

2011-2012 versus 2023-2024: Comparison of the Fishes in the Canals of the A.R.M. Loxahatchee NWR

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The Arthur R. Marshall Loxahatchee National Wildlife Refuge was established in 1951 and protects 145,188 acres of Everglades ecosystems including a mosaic of wet prairies, sawgrass ridges, sloughs, tree islands, cattail communities, and cypress swamp. Also known as Water Conservation Area 1 the Refuge protects the most Northern remnant of the historic Everglades ecosystem. The perimeter canals of the Refuge, 94 Km in length, are inhabited year-round, are used as corridors for movement, and as refuge from desiccation throughout the dry season by several aquatic species. Comprehensive studies on the population structure and dynamics of these fishes and changes over time to populations are limited. In 2011-2012 a study, completed by USFWS, used electrofishing equipment to document the fish in the Refuge's perimeter canals comparing habitat (marsh/levee) and season (wet/dry). In 2023-2024 we repeated the previous study with the goal of completing an updated inventory while comparing the two datasets for changes in species composition and prevalence of nonnative species. The greatest change between the two studies was the shift toward nonnative species and a lack of small bodied native fish. The 2011-2012 study data showed 34 species of which 5 were nonnative, accounting for 14.7% of all species collected. In comparison the 2023-2024 study data shows 32 fish species collected of which 14 were nonnative, accounting for 43.8% of the species collected. Where biomass is concerned, similar discrepancies between studies was seen mainly in the percentage of total biomass that was nonnative fish. In the earlier study (2011-2012) only 5.68% of the total biomass collected was nonnative fish, while in the more recent study (2023-2024) 33.38% of the total biomass was nonnative. This change in species composition is seen mainly in the lack of certain native forage and legacy South Florida marsh species collected. The bluefin killifish (*Lucania goodei*), bluespotted sunfish (*Enneacanthus gloriosus*), Dollar sunfish (*Lepomis marginatus*), Florida flagfish (*Jordanella floridae*), Seminole killifish (*Fundulus seminolis*) were collected in the Refuge canals during 2011-2012 yet were not seen in the more current (2023-2024) study. This large shift in the species composition found in the Refuge canals is of concern, due to the loss of many legacy Everglades forage fish and introduction of new nonnative species. While this is a concern for the aquatic communities of the Refuge this shift in composition also affects the larger predators and avian foragers alike. Animals like the American alligator (*Alligator mississippiensis*) and large wading birds like the great blue heron (*Ardea Herodias*) regularly feed on the fishes noted in this study. This shift in composition is one of a shift from high quality soft bodied forage fish to a community with many low quality boney plated and hard bodied fish.

Sleeper Plant Species in South Florida: History and Patterns and Implications for Restoration

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For at least four decades, scientists and managers have tracked the introduction of new plant species into Florida ecosystems. Most of these plant species are benign in their impacts to native ecosystems. The few plant species that are negatively impactful are typically discovered once their impacts are detected, increasing the costs associated with control efforts. The time lag from introduction to impact can be difficult to estimate, especially when an introduced plant population is overlooked as benign but then changes its growth rate suddenly due to environmental perturbations. These so-called “sleeper species” can have time lags of decades. This research documented twelve cases of sleeper plant species in south Florida dating back to the early 20th century. Each plant species has at least one documented detrimental effect to our environments, cultures, human health, or economies. Likewise, each sleeper plant species has been of management concern in the region in its invasion history in south Florida, where some management action was taken. In multiple cases, a disturbance occurred in the plant community that allowed the sleeper species to expand its range and cause impacts within that community. However, in some cases when habitat restoration was done post-disturbance, the sleeper species did not show invasive tendencies. This pattern of invasion emphasizes the importance of restoring recently disturbed plant communities with abundant or diverse non-native plants species.

Restoration Strategies STA Expansions and Flow Equalization Basins Construction Status Update

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The Everglades Stormwater Treatment Areas (STAs), the largest constructed treatment wetland project in the world, encompass a current treatment area of over 62,000 acres. The STAs are designed to remove phosphorus (P) from agricultural and urban stormwater runoff prior to delivery to the environmentally sensitive Everglades. STA operation is governed by permits and consent orders issued to the South Florida Water Management District (SFWMD) by the Florida Department of Environmental Protection. The permits and consent orders include a stringent water quality-based effluent limit (WQBEL) that must be met by each STA upon completion of all Restoration Strategies Regional Water Quality Plan projects. These projects include expanded STA treatment areas and flow equalization basins (FEBs). FEBs built upstream of the STAs assist in moderating high flows to the STAs during the wet season and providing water in the dry season to maintain minimum stages. The FEBs provide water quality improvement as well, reducing P loading to the STAs. The A-1 FEB with 60,000 acre-feet of storage was completed in 2015 and the L-8 FEB with 45,000 acre-feet of storage was completed in 2017. The C-139 FEB, which will provide 11,000 acre-feet of storage, will begin operation in late 2024-early 2025. STA-1W Expansion #1 consisting of 4,300 acres was completed in 2018, and STA-1W Expansion #2 comprising approximately 1,800 acres was completed in 2024. SFWMD is also completing several STA refurbishment projects as a proactive measure to ensure the facilities are poised to achieve compliance with WQBEL once all the Restoration Strategies projects are complete. An update on the status of the construction of the Restoration Strategies projects and STA refurbishment projects will be presented.

Spatial-Temporal Habitat-Based Variability in Forage Fish Mercury Concentrations in the Florida Everglades

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The Florida Everglades, the largest subtropical wetland in North America, has immense ecological, hydrological, and cultural significance. It supports a unique assemblage of biodiversity and provides essential ecological services to the region. However, the Everglades is also a fragile ecosystem facing numerous threats, including urban development, invasive species, and poor water quality, which may be exacerbated by climate change. Mercury (Hg) is a persistent and globally distributed pollutant, entering the environment from both natural and anthropogenic sources. In the Everglades, unique environmental conditions promote the formation of methylmercury, the most toxic form of Hg, which bioaccumulates in the food web, posing significant threats to both wildlife and human health. Invasive species can influence Hg contamination by disrupting food webs and altering pathways of mercury bioaccumulation. In higher trophic-level species, such as piscivorous fish and wading birds, Hg concentrations can reach levels that impair reproduction and behavior. We examined Hg concentrations across six native and two invasive forage fish species collected from 72 sites across Everglades National Park (ENP) between 2007 and 2018. The over 2,000 fish samples were collected across a range of ENP habitats, including Shark River Slough, marl prairie freshwater marshes, marsh/mangrove coastal zones, and northern and eastern canal boundaries. Our analysis examined Hg concentrations across species to assess the strength and variability of relationships both within and across habitat types. This approach offers valuable insights into the ecological and biogeochemical processes that regulate Hg bioaccumulation within ENP. Exploring these relationships across habitat types will inform a more comprehensive understanding of Hg exposure pathways, environmental influences, food web dynamics, and spatial and temporal patterns. Ultimately, the findings from this analysis will help provide critical information for ecosystem-wide risk assessments.

Engineering for Climate Resilience: The BBSEER Approach

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The U.S. Army Corps of Engineers (USACE) is actively addressing the challenges posed by climate change by developing adaptation strategies and policy updates to enhance the resilience of water resources infrastructure. USACE's climate resilience approach is rooted in collaborative efforts with diverse stakeholders, ensuring that infrastructure and ecosystem projects are designed to perform under all plausible future climate conditions. To integrate climate preparedness and resilience into its projects and operations, USACE continually identifies actionable climate information and develops tools, technical guidance, and best practices. A prime example of USACE's commitment to climate resilience is the Biscayne Bay Southeastern Everglades Ecosystem Restoration (BBSEER) project, which exemplifies how these strategies and tools are applied to address complex environmental challenges in a vulnerable coastal region. Located in southeastern Florida, BBSEER represents a pioneering effort to integrate climate change considerations, particularly sea level change (SLC), into ecosystem restoration planning. As the first Comprehensive Everglades Restoration Plan (CERP) study to incorporate quantitative SLC projections into plan formulation alternatives modeling, BBSEER sets a new standard for climate-resilient ecosystem management. Numerical modeling was performed via Interagency Modeling Center resources (USACE, South Florida Water Management District, and The U.S. Department of the Interior) and external contributors, particularly Florida International University (FIU) and United States Geologic Survey (USGS) regional modeling experts. The project uses the most recent tidal data and applies an offset to develop realistic model boundary conditions based on sea level projections. The project updates the future without project scenarios to include SLC impacts, aligning with USACE's climate change guidance. BBSEER employs a comprehensive numerical modeling approach, using multiple models to assess the impacts of projected SLC across the 50-year planning horizon. These models are used to evaluate inland hydrology and the interaction between freshwater and marine environments based on eight Performance Measures (PMs) representing ecological and hydrological responses. All BBSEER PMs are impacted by precipitation, streamflow, and sea level, and changes in climate conditions will affect their performance. Considering the strong dependence of project performance on climate-change-driven stressors, it is critical for BBSEER to adequately consider climate change to meet immediate and future ecosystem needs. By formulating for the USACE Intermediate SLC curve and stress-testing against High SLC projections, BBSEER ensures robustness and adaptability in its restoration strategies. BBSEER's methodology in incorporating SLC into project planning marks a significant advancement in Everglades restoration, making it a model for climate change resilience.

Consequences of Sulfur Applications on DOM Chemistry Across the Greater Everglades Ecosystem

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Dissolved organic matter (DOM) is a heterogeneous mixture of organic molecules that reflects source materials and environmental transformations. The applications of sulfur to agricultural fields in the Everglades have a cascade of consequences for the chemical composition of DOM. Processes that influence the concentration and composition of DOM have direct and indirect effects on a range of ecological (i.e., photic zone depth) and biogeochemical processes (e.g., carbon cycling, the uptake of toxic mercury in biota). This presentation will present a synthesis of research efforts aimed at quantifying the effect of sulfur applications on the chemistry of DOM across Water Conservation Areas (WCAs) of the Florida Everglades. Over 8 years, water was collected across hydrologic and geochemical gradients of WCA-2A, WCA-3A, and WCA-1 and from agricultural drainage canals that discharge into WCAs. Within wetlands, surface and pore water samples were collected and analyzed for inorganic sulfur species, dissolved organic carbon (DOC) concentration, DOM composition by UV-vis and fluorescence spectroscopy, and DOM was isolated for measurements of elemental composition and molecular and atomic level characterization of organic sulfur. Canals that drain agricultural areas transport water of high DOC concentration and DOM that is highly aromatic and elevated in inorganic sulfate. In the WCA wetlands, DOC aromaticity decreases from the location of canal inputs along surface water flow paths, reflecting the combined influence of DOM mineralization and autochthonous DOM production. In wetland sediments, sulfate was reduced to inorganic sulfide and incorporated into DOM predominantly as reduced sulfur species, with a three-fold enrichment in DOM reduced sulfur group content between locations with low versus high sulfate inputs. Sulfur-enriched DOM in sediment pore waters exchanged with overlying surface waters and was transported down-gradient in the marshes. Using a laboratory study, we show that the reduced sulfur species in DOM are recalcitrant under dark oxic conditions but rapidly oxidize to inorganic sulfate in the presence of sunlight. These observations are discussed in the context of land and water management actions and water quality implications in the freshwater Everglades and provide a foundation to consider the effects of marine sulfate on DOM chemistry in coastal Everglades wetlands.

Phosphorus Retention within STA Ecotopes

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The Everglades Stormwater Treatment Areas (STAs) are wetlands constructed to reduce phosphorus (P) in stormwater and urban runoff prior to discharge to the Everglades Protection Area. The STAs are required to meet a water quality-based effluent limit as measured by a flow-weighted mean (FWM) total phosphorus (TP) concentration. Plant communities within the STAs affect P concentrations directly through assimilation and indirectly though their influence on P loading and retention mechanisms in the water column and soil. This study evaluates the effect that wetland ecotopes (i.e., contiguous homogenous vegetation communities) have on the FWM TP concentration. Research at the ecotope scale captures the influence of these communities on water quality that are not observed at a larger landscape scale maintaining key ecological features not included in finer scale mesocosm research. Four different ecotopes in the outflow regions of STA-3/4 Central Flow-way were monitored for water quality, physico-chemical properties, and soil characteristics for two years. The four ecotopes monitored were a dominant *Chara* spp. ecotope, a dominant *Typha domingensis* ecotope, a codominant *Najas guadalupensis* and *Chara* spp. ecotope, and an open-water/bare ecotope. The vast majority of STA discharge typically occurs during the wet season, 87% during this study's period of record. Therefore, P concentrations during the wet season are of the greatest importance as they are most heavily weighted in the calculation of the FWM. When compared using Conover's all-pairs comparison test the *Chara* ecotope tied for lowest wet season mean outflow TP in year one of the study ($p > 0.05$) and had the lowest outflow TP in the second year of the study ($p > 0.05$). Consistent differences were not detected between the other three ecotopes. Differences between ecotopes were small, typically less than 3 µg L^{-1}, and smaller than the effects from season, water depth, or flow. However, an increase of over 5 $^{-}$µg L^{-1} occurred in the mixed ecotope during the second year of the study when SAV coverage declined during the wet season accentuating the importance of SAV resilience and coverage during the wet season.

The Everglades Multi-Species Biological Assessment – A Programmatic Endangered Species Act Consultation

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The Everglades Multi-Species Biological Assessment (EMSBA) is a proposed programmatic consultation with the U.S. Fish and Wildlife Service (FWS) to assess impacts on Threatened and Endangered Species under Section 7 of the Endangered Species Act (ESA) from aquatic ecosystem restoration projects, flood risk management projects, and regulatory projects that the U.S. Army Corps of Engineers is assessing in south Florida. The goal of the programmatic consultation is to streamline future Comprehensive Everglades Restoration Plan (CERP) and South Florida Ecosystem Restoration (SFER) project ESA consultations. The EMSBA will encompass both formal and informal consultations for over 70 threatened or endangered species throughout southern Florida. Regional Simulation Model results from the Second Periodic CERP Update (SPCU) will provide the basis for the assessment. The SPCU provides a potential look at the end state of CERP and includes modeling for sea level rise. The creation of the EMSBA also requires analysis of previous consultations, breaking down completed projects into their main components and assigning impacts to species based on these components. Data gathered from this analysis can show generalized impacts to species based on component through all previous CERP projects. This gives resource agencies insight into how restoration components generally affect species and can even show if there are components that are wholly beneficial to a species. Having this information condensed and easily accessible will be a great resource not just for efficient consultation, but also for future project planning efforts by reducing the time needed for ESA consultation.

From Roots to Leaves: Understanding Multi-Scale Trait Variation in Freshwater Wetlands

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Abiotic and biotic drivers influence plant community structure and function, including functional traits, differently depending on spatial scale (from fine plot-level to broad landscape level) processes and patterns. These community-level patterns arise from the assembly of species whose functional traits collectively determine ecosystem processes, with traits serving as a link between community composition and the ecological strategies that underpin community dynamics. This study investigates how abiotic and biotic factors shape the functional traits of herbaceous wetland plants across spatial scales in the Everglades National Park, a landscape shaped by hydrological and nutrient gradients. Sampling was conducted at 42 sites spanning the marl prairies and the ridge & sloughs, representing short, transitional, and long hydroperiod communities. Plant composition and trait data were collected from three replicate 1 m^2 plots per site. Aboveground traits, including specific leaf area (SLA), leaf dry matter content (LDMC), and nutrient content, along with belowground traits such as specific root length (SRL) and diameter, and nutrient composition, were measured. Environmental variables like hydrology and soil nutrient levels were recorded to assess their relationship with functional traits and diversity. Functional diversity was evaluated using indices such as functional richness and Rao's quadratic entropy to explore community assembly processes. Our results suggest that abiotic factors, particularly hydrology, drive functional trait variation at broader spatial scales through environmental filtering, which narrows trait ranges and promotes functional convergence. For example, sawgrass (*Cladium jamaicense*) showed significant plasticity, with root traits like SRL and root diameter adapting to wet conditions, indicating flexible resource acquisition strategies. In contrast, muhly grass (*Muhlenbergia capillaris ssp. filipes*) exhibited limited trait variation, reflecting lower plasticity and a narrower ecological niche. This study highlights the importance of multi-scale analyses to understand how environmental drivers and biotic interactions shape functional trait patterns in wetlands. Abiotic stressors like hydrology dominate at broad scales, while biotic processes play a larger role at finer scales, contributing to the complex assembly of wetland plant communities. These findings provide critical insights into wetland ecosystem responses to environmental changes, such as altered hydrologic regimes or nutrient inputs, and underscore the importance of functional trait variation for ecosystem resilience.

Transport and Salinity Budget of Florida Bay

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The Florida Bay is home to a wide range of habitats and organisms that have faced increasing pressure associated with anthropogenic and climatic change stressors in recent decades (e.g. warming, changing evaporation, sea level rise, etc.). These are known to cause cascading effects that can disrupt natural balances associated with both biotic and abiotic parameters. One such parameter is salinity, which has been shown to be an important factor to seagrass health and growth. In the Central-Northern Bay (CNB), flows are generally stagnant due to restrictive mudbanks and bathymetry, and little freshwater input from the Everglades. As a result, hypersalinity events occur frequently in this area. At the same time, strong cyanobacteria blooms also frequently take place here, usually from the summer through the fall seasons. Nevertheless, the transport and connectivity of this area with other parts of the bay, including their salinity budget, have not been well quantified. To address this need, a high-resolution (~500 m) hydrodynamic model was developed and nested within a regional model. A two-year (2011-2012) study has been conducted and calibrated with available data. Model results align closely with historical observations of tides, salinities, water levels, and transports within the bay. Transport across the bay channels were computed and seasonal salinity budgets for the bay as a whole and its 4 subregions were constructed. The results indicate that tidal and winds-driven transport are weak throughout the bay except in the western and southern regions where exchanges with the west Florida shelf and the Florida Straits are significant. The residual transport forms a semi-enclosed clockwise pattern in the western bay, consistent with previous observations. In the CNB the salinity balance is dominated by evaporation year-round at around 0.15 PSU/day, with precipitation offsetting the flux to restore the salinity during the late summer and early fall periods. Evaporation being the only driver in the spring and summer leads to hypersalinity in early summer 2011 (max. salinity ~43). In spring 2012, significant rainfalls and river runoffs took place and as a result, salinity was lower than 40. Further modeling efforts and analyses are needed to understand how these changing conditions might have significant effects on the nutrient transport and phytoplankton blooms of the Florida Bay.

Tools to Evaluate the Effects of Climate Change in CERP

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Climate change effects such as changes in temperature and precipitation and an increase in sea-level is having a profound impact on south Florida and Everglades ecosystems. Therefore, successful restoration of the Everglades requires the incorporation of robust climate projections to plan for and adaptively manage projects and the system as a whole to meet desired ecological outcomes. The National Academies' 2024 biennial review by the Committee on Independent Scientific Review of Everglades Restoration Progress recommended more rigorous use of modeling tools and available data to improve restoration planning and management in the face of climate change. The increasing availability of climate change projections as well as models and empirical data on ecosystem responses provides opportunities to build upon current and ongoing efforts in CERP planning. The report outlined five key opportunities to better incorporate information about certain aspects of climate change and associated tools into the CERP: (1) using a curated set of temperature and precipitation scenarios consistently across all components of restoration planning and implementation; (2) use of dynamic sediment accretion modeling informed by empirical data to consider the effects of sea-level rise; (3) improved use of ecological models and wildlife indicators including consideration of climate change; (4) an integration of ecological and physical modeling and monitoring that draws together existing data, models, and efforts to understand and mitigate the effects of climate change; and (5) regular revisions to the System Operating Manuals and other operational plans to incorporate the evolving understanding of climate variability and change, including extreme events, to ensure anticipation of and planning for a wide range of conditions.

Valuing Nature for Decision-Making and Policy

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Ecosystem services provide benefits to people that are not bought or sold in commercial markets, such as water quality, wildlife habitat, and many others. These nonmarket benefits are increasingly accounted for in government decision-making, such as in benefit-cost analyses; willingness to pay for programmatic management of public natural resources; and the design of landowner incentive programs. This presentation summarizes recent projects that applied ecosystem service values to inform decision-making and policy within the Greater Everglades Ecosystem through three different approaches.

Willingness to Pay for Enhanced Waterway Access in Miami-Dade County: In an economic analysis of recreational access to Miami-Dade County waterways, a study of preferences for waterway access and associated amenities and infrastructure found that Miami-Dade residents have a WTP of approximately $29 million/year for high levels of natural resource quality in Miami-Dade's waterways and waterfronts, second only to reduced congestion at access points. Findings provide an indication of public support for natural resource management and importance of waterway and natural resource health. The results further highlight the need for local investments in waterway access points to encourage responsible natural resource use and protection within the Greater Everglades Ecosystem.

Benefit-Cost Analysis of Natural Resource-Based Adaptation strategies in the Florida Keys: The Florida Keys, a chain of barrier islands in Monroe County, are home to unique ecosystems currently experiencing impacts from sea level rise. Monroe County identified natural resource adaptation strategies for future planning efforts in a recent Vulnerability Assessment (VA), and a BCA of five nature-based strategies found that they are cost-effective in many, but not all, sites. Findings validate the VA strategy recommendations and underscore the public value of natural resource-based strategy implementation in the Keys.

Optimizing Payments for Ecosystem Services in the Florida Wildlife Corridor: In the face of continued high development pressures within ecologically sensitive areas near the headwaters of the Everglades, innovative land conservation approaches like PES provide another tool in the land conservation toolbox for consideration by policymakers. PES programs can provide near-term natural resource protection, compensate landowners for provision of ecosystem services, and support community economic development. A PES program for private landowners at the headwaters of the Everglades was designed to protect critical linkages in the Florida Wildlife Corridor. The research team developed a PES program framework, market-based estimates of opportunity costs based on actual property transactions, and upper and lower bounds for realistic PES revenue streams. A Technical Advisory Committee of key landowners provided critical input, and pilot transactions with initial funding are pending.

Chronic Stress Impacts on Mangrove Mortality and Recovery Following Hurricanes in Southwest Florida

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Mangrove forests in southwest Florida experience acute stress in hurricanes from high-speed winds and wave energy, but they must also cope with chronic stress from standing water, sulfide toxicity, and sediment burial months after a hurricane has passed. Mangrove forests suffering from stress before or after hurricanes can experience delayed mortality or delayed recovery following the storm. Long-term monitoring data were collected in seven plots in mangrove forests in the Ten Thousand Islands from 2017 to 2024, following Hurricanes Irma and Ian, and in eight plots in Charlotte Harbor mangrove forests from 2022 to present, encompassing impacts from Hurricanes Ian, Helene, and Milton. Monitoring metrics included canopy cover, recent tree mortality, trunk impacts, branch loss, sapling and seedling density, storm surge deposit thickness, soil shear strength, fine root density, soil density, and porewater sulfide concentration. Water level loggers were also installed at selected sites to study inundation and depth. Delayed tree mortality was observed at all Charlotte Harbor mangrove plots up to 16 months following Hurricane Ian. Multiple plots showed signs of recovery in the form of increasing canopy cover and understory growth. However, plots that were chronically stressed by standing water, storm surge deposits, and/or high sulfide concentrations in porewater (up to 200 pm) exhibited 100% tree mortality and low root density 16 months after Ian. Some mangrove forests in the Ten Thousand Islands that had similarly high tree mortality following Hurricane Irma hosted abundant sapling growth five years after the storm, highlighting the importance of long-term monitoring in forests that show delayed recovery following disturbances.

Machine Learning Models for Water, Energy and Greenhouse Gas Fluxes Measured from a Dwarf Cypress Wetland Within the Greater Everglades

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Globally, wetlands are considered sinks for atmospheric carbon dioxide (CO_2) and sources for water vapor and methane (CH_4) emissions, including forested and non-forested wetlands within the Greater Everglades. In this study, the magnitude and seasonality of CO_2 uptake, water vapor (ET), and CH_4 emission were defined using ensembles of machine learning models combined with a unique decadal record of water, energy, and biogeochemical cycling measured from one eddy-covariance (EC) flux station located in an area of dwarf cypress and sawgrass wetlands. Dwarf cypress and sawgrass are spatially extensive plant communities within the Greater Everglades. The EC station recorded latent heat flux (the energy equivalent of evapotranspiration), sensible heat flux, net ecosystem exchange (NEE) of carbon dioxide, net radiation, soil temperature, air temperature, relative humidity, hydroperiod, and CH_4 emission. Ensembles of machine learning models learned and forecasted clear seasonality in latent heat, NEE, and CH_4, including a substantial decline in latent heat at the onset of the rainy season likely due to cloud cover reducing the solar radiation that drives evaporation and photosynthesis. Furthermore, ensemble forecasts of NEE increased during the driest time of year, which is generally characterized with water-levels below land surface, dry soils, and thus enhanced oxidation of organic peat soils. Seasonality in cypress photosynthesis due to leaf growth and dormancy was also apparent within forecasts of NEE. Additional experiments with machine learning are planned for this unique decadal record of water, energy, and biogeochemical cycling in the Greater Everglades.

Coupled Physical-Biogeochemical Modeling to Understand Cyanobacterial Bloom Dynamics in St. Lucie Estuary

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The Saint Lucie Estuary (SLE) on Florida's east coast is vital for diverse aquatic life and local communities, but its health is threatened by water quality deterioration and harmful algal blooms. In the last decades, this estuary has seen frequent and severe cyanobacteria blooms. These blooms may deteriorate water quality by reducing dissolved oxygen and increasing turbidity. Primary nutrient sources in this estuary include watershed freshwater discharges, sediment inputs, coastal ocean water exchanges, and Lake Okeechobee water via the C-44 canal. It is hypothesized that Lake Okeechobee waters not only supply nutrients but also phytoplankton to this estuary. Moreover, some phytoplankton species, including *Microcystis aeruginosa*, a freshwater cyanobacteria, produce harmful toxins, posing risks to both marine life and human health in this area. However, despite extensive field research and monitoring efforts, the factors and processes driving cyanobacteria blooms in the SLE have yet to be incorporated into a comprehensive predictive model. To better understand the cyanobacterial bloom dynamics, a coupled hydrodynamic-biogeochemical model has been developed. The physical model is based on the Regional Ocean Modeling System (ROMS). The biogeochemical model simulates nitrogen and phosphorus cycles and key processes for phytoplankton blooms including photosynthesis and nutrient uptake, zooplankton grazing, and microbial loop, among others. One year (2018) simulation has been completed and calibrated with available observational data. Model result shows significant phytoplankton blooms during summer when freshwater discharges were strongest, consistent with available data. Nitrogen is identified as the primary limiting nutrient, aligning well with observational data and underscore its importance in bloom dynamics. To further understand the bloom dynamics, several numerical experiments have been conducted to examine the importance of various factors that might drive cyanobacterial bloom, including the N/P ratios from watershed and sediment inputs, cyanobacteria and other phytoplankton inputs from Lake Okeechobee, and residence time in the upper estuary. Results from these experiments will be presented to understand the key drivers and processes influencing cyanobacteria blooms in this estuary.

Investigating Deep Learning Models for Water Level Prediction in the Everglades National Park

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The Everglades National Park plays a critical role in flood and drought prevention, sustainable water resource planning, and ecosystem management. Traditional methods for water level prediction, including physics-based hydrological models and statistical techniques, face challenges, such as high computational overheads and limited adaptability to diverse scenarios. Recent advancements in deep learning have shown the potential to overcome these limitations. For example, large foundation models, represented by large language models, have shown great success in time series modeling. However, the application of these methods to environmental systems like the Everglades National Park remains underexplored. In this work, we evaluate the performance of several state-of-the-art deep learning models in predicting water levels 7, 14, 21, and 28 days ahead and report their mean absolute errors and root mean squared errors. Specifically, our study focuses on three categories of deep learning models: Transformer-based models, linear models, and large foundation models. The study area encompasses the South Florida Everglades, characterized by heterogeneous environmental variables such as rainfall, evapotranspiration, gate flow, and water levels. Preliminary results indicate that most deep learning models achieve promising predictive accuracy. Among them, the linear models, **NBeats and NLinear**, excel in long-term predictions (14, 21, 28 days ahead), while the Transformer-based model ***PatchTST*** performs the best in short-term predictions (7 days ahead). This suggests that the model selection should be carefully tailored to the specific tasks. Our ongoing research includes the experiments on large foundation models to assess their potential in this domain.

Applying Indigenous Knowledge in the Comprehensive Everglades Restoration Plan (CERP)

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The lands and waters of the Everglades are the geographic and spiritual home of the Miccosukee and Seminole peoples. The health and well-being of the Everglades is synonymous with that of the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida. Therefore, the Tribes have a wealth of knowledge about the South Florida ecosystem based on their intimate reciprocal relationship with the biophysical environment that has been developed through lived experience and passed down through generations. In 2021, the Executive Office of the President released a memorandum and guidance on Indigenous Knowledge and its role in federal research, policies, and decision making. In this presentation we summarize and synthesize some established best practices in response to a request from CERP agencies for advice on how Indigenous Knowledge could be better included in CERP planning and management. The following conclusions and recommendations are discussed:

- Indigenous Knowledge, like western science, is a body of observations, oral and written knowledge, innovations, practices, and beliefs about the natural world that has much to offer Everglades restoration.
- The recently developed Miccosukee internal peer-review process is an important step toward facilitating consideration of Indigenous Knowledge in Everglades restoration processes and provides a potential model for others throughout the nation.
- RECOVER and other CERP staff should implement (or continue to implement) best practices to engage meaningfully with Tribes and apply Indigenous Knowledge in Everglades restoration planning, operations, monitoring, and adaptive management. Some best practices include:
  - Recognize that Tribes are autonomous nations and interact with Indigenous partners as such, not as stakeholder groups.
  - Involve Tribal members in planning, research, and monitoring efforts, with funding where necessary, to foster co-stewardship and co-production of knowledge to support restoration and priorities of value to the Tribes.
  - Provide opportunities for the Miccosukee and Seminole Tribes to engage in CERP processes and share knowledge in meaningful and culturally sensitive ways, recognizing that independent internal discussions among Tribal members may be necessary to provide input to the decision-making process.
  - Include Tribal members in meetings in thoughtful ways that avoid unintentional tokenism and encourage participation by Tribal members in planning meeting agendas.
  - Create data-sharing agreements that center Indigenous data sovereignty and governance and support the culturally sensitive integration of Indigenous Knowledge into reports and agency actions while protecting sensitive Tribal cultural information from public disclosure.
  - Build, support, and maintain an inclusive agency and CERP culture that establishes high expectations for meaningful engagement and incorporation of Indigenous Knowledge throughout agency hierarchy and operations.

Linking the Movement and Trophic Ecology of Consumers to Enhance Our Understanding of How Fisheries Respond to Hydroclimatic Variation

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Understanding how hydroclimatic variation shapes the movement and foraging ecology of organisms is vital for understanding responses to restoration and managing ecosystems facing global change. Here, we used Common Snook (*Centropomus undecimalis*) as a model species to understand how higher order consumers and also valuable recreational fisheries, track and respond to varying environmental conditions in a coastal riverscape, Shark River, Everglades National Park.

We first examine the foraging ecology of Common Snook, focusing on the interplay between temperature, hydrology, and body size, assessing their effects on snook diet and energy needs. We then examined individual variability in the space use of snook across the riverscape, investigated how hydrological conditions, seasonal resource pulses, and prey availability influenced snook movement patterns and trophic niche dynamics over a decade. We combined acoustic telemetry and stable isotope analysis with long-term diet data, energetic models, and predation simulations.

Our findings show how warming temperatures and fluctuating hydrological conditions influence prey quality and predator energy requirements. Specifically, they underscore that warming exacerbates the metabolic costs of predation, compelling snook to shift toward lower-quality prey, which can lead to ecosystem-level implications for trophic dynamics and resilience. For movement, we found that snook exhibited lower space use specialization during the dry season, when prey subsidies from adjacent marsh habitats were abundant. However, increasing hydrological variability due to climate change and water management has disrupted these subsidies, leading to greater specialization in snook space use and a contraction of their trophic niche over time.

These findings highlight the critical role of resource predictability and habitat connectivity in shaping consumer behavior and population-level trophic dynamics. Together, our studies illuminate the intricate links between resource dynamics, consumer behavior, and ecosystem function in riverscapes. They demonstrate the necessity of integrating movement and dietary analyses to forecast the impacts of global change on predator-prey dynamics and to inform adaptive management strategies for hydrological conditions. The findings advocate for preserving habitat connectivity, maintaining resource heterogeneity, and incorporating long-term monitoring to sustain ecosystem resilience in the face of anthropogenic and climatic stressors.

Quantifying Marsh Aboveground Net Primary Productivity Along Shifting Freshwater-to-Saltwater Gradients

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Hydrology is a master variable of wetland ecosystem development. Sea-level rise is changing hydrological variables such as water depth and freshwater availability, while human activities have reduced or altered water flows in wetlands worldwide. Restoration efforts in the Florida Everglades aim to mitigate hydrological impacts, yet how changing hydrology interacts with other variables to impact primary productivity remains uncertain. Quantifying changes in long-term primary productivity can provide critical insights for predicting ecosystem trajectories. From 2006-2022, we quantified *Cladium jamaicense* (sawgrass) aboveground primary net productivity (ANPP), foliar total phosphorus (TP), and water depths in Taylor Slough/Panhandle (TS/Ph) and Shark River Slough (SRS) in Everglades National Park (Florida, USA). Both basins span gradients of freshwater-to-saltwater that are transforming with freshwater restoration upstream and saltwater intrusion from sea-level rise downstream. To capture these gradients, we selected freshwater and brackish water sites spanning from restoration-affected areas to downstream brackish water ecotones. ANPP was measured using phenometric methods in triplicate plots, and water depth was recorded hourly using pressure water level loggers. Over time, sawgrass ANPP in SRS increased at the most upstream site but decreased at all other sites, while in TS/Ph, ANPP decreased at all sites except the brackish water ecotone, where it increased. Mean ANPP was lower in TS/Ph (190.0 ± 7.2 g C m^{-2} yr^{-1}) than SRS (491.4 ± 16.6 g C m^{-2} yr^{-1}) across all years and sites. Increasing water depths decreased productivity at most sites, except at the most upstream freshwater site in SRS. Increases in ANPP were explained by higher water depth increases in marshes that frequently dried-down from water management (upstream SRS) and marshes that are receiving higher brackish water P subsidies (ecotone TS/Ph). Foliar TP varied over time but did not increase at sites where ANPP increased, indicating that sawgrass may be utilizing P more efficiently. Our results highlight the dynamic responses of sawgrass along freshwater-to-salinity gradients in the Everglades and underscore the need to understand these interactions to predict ecosystem development trajectories under shifting hydrologic conditions. Disturbance legacies (e.g., drought and saltwater intrusion) and changing amounts of fresh and marine water interact to affect marsh ANPP differently in coastal wetlands. Given the increasing exposure of freshwater systems to changing hydrology, quantifying long-term responses is critical for understanding how ecosystems will adapt to future changes under a warming climate.

Spatiotemporal Patterns of Tidal Creek Expansion and Riparian Mangroves in the Southern Everglades

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Sea-level rise is driving significant landward expansion of tidal creeks in low-relief coastal plains, altering hydrologic connectivity of saline and brackish water flows, shifting salinity gradients, and facilitating the encroachment of halophytic communities into freshwater marshes. This study focuses on the Shark-Harney River system located in the Western coastal plain of South Florida Everglades National Park and is part of the Florida Coastal Everglades Long Term Ecological Research (FCE LTER) domain. The objectives of this research were to quantify the spatiotemporal landward expansion of the Shark-Harney River creek system and develop a methodology for modeling and quantifying spatiotemporal change in creek width, and riparian mangrove cover as a function of distance from the coast. Tidal creek expansion was mapped through progressive segmentation of the current extent of the creek system, as referenced by historic aerial stereo and ortho photography (AP) mosaics. The segmentation was performed utilizing the DAT/EM Stereo Plotter, and ArcGIS Pro clipping tool, across six-time intervals from 1952 to 2018. Creek branching expansion was quantified using a spatial line density analysis and modeled as a function of distance to the coast using generalized additive models (GAMS) for each time interval. Changes in creek width and riparian mangrove cover were assessed by generating 1-km transects along visible creeks and segmented as reference from 1999 and 2021 aerial photography. The proportional change in creek width and riparian mangrove as a function of distance from the coastline was modeled using a linear model (LM). Preliminary results revealed that the tidal creek system expanded landward by a total of 118 kilometers of branching and lengthening since 1960. A progressive increase in creek density was observed at intermediate and long distances from the coast between 1952 and 1984. This trend is followed by a reduced rate of branching and overall expansion after 1984. Results indicate a decreasing trend in creek width by 8.4% per kilometer away from the coast between 1999 and 2021, while riparian mangrove cover increased by 8.2 m per kilometer inland over the same period. These findings highlight the dynamic interplay between hydrologic processes, vegetation succession, and geomorphic changes driven by sea-level rise and saltwater intrusion. The transect methodology used for the assessment of creek width and riparian mangrove change, proved more effective for mangrove cover change analysis than creek width change due to limitations in image resolution and the obstruction of visible creek shores by mangrove canopies.

40 years of Increased Phosphorous Availability Impact Seagrasses in Biscayne Bay, Implications for Water Quality Management and Biscayne Bay Southeast Everglades Restoration (BBSEER) Project

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Seagrasses provide essential habitat for a variety of marine species in the shallow coastal environments found throughout the estuaries of South Florida and can only proliferate and survive in places with low nutrient availability. In Biscayne Bay, the availability of phosphorus (P) is the likely driver that controls the abundance, productivity and species composition of seagrasses (Millette et al. 2019), as it has historically evolved as an oligotrophic system, where the addition of nutrients changes the balance and impairs ecosystem function.

Analysis of recently aggregated data from several sources collected over a 40-year period reveals a significant change of the original benthic community described by Milano in 1983. The most notable are changes along the northern and central coasts and the increase in growth and in some cases steady state of seagrass cover in the southern Bay, especially near the safety valve. Miami-Dade County's benthic cover map of Biscayne Bay was converted from shoot counts to a percent cover format and digitized for the years 1979-1989 and were compared to data collected during 2020-2023 exposing considerable shifts in seagrass species composition, cover and abundance throughout the northern and central Bay, with the most dramatic changes occurring along the coast. The offshore areas that have received less total P (TP) inputs have achieved a steady state-state seagrass condition, while nearshore areas experienced significant change in speciation, cover and abundance likely driven by TP concentrations increasing along the coast. Abnormally high P concentrations correlate with seagrass loss and precipitate shifts in nearshore ecology. Continuous additions of TP to an oligotrophic ecosystem initially fertilizes seagrass beds, creating denser seagrass meadows, however, P accumulation is cumulative and permanent and continued P-loading leads to replacement of the seagrasses by macroalgae ultimately resulting in loss of seagrass cover. Changes in the extent of seagrass beds and macroalgae accumulation in nearshore areas are consistent with this pattern of nutrient-driven habitat succession. We have explored major sources of TP and have isolated some hotspots that should be a focus for restoration efforts.

The state of Florida uses numeric nutrient criteria (NNC) that average surface water samples across a polygon (WIBID) that includes both offshore and nearshore areas which masks P-levels, which are higher in the nearshore and in groundwater. Biscayne Bay has never had a P-violation, yet this is the likely limiting nutrient which is driving the seagrass loss in the bay. In addition, the Biscayne-focused Everglades Restoration project BBSEER does not consider reduction in nutrients as a goal, but only a constraint. A greater focus must be paid to reducing and eliminating P inputs if we are to restore or preserve the benthic communities of Biscayne Bay.

Using GIS to Enhance Efficacy and Efficiency of Drone Imagery Analysis

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Drones, or unmanned aerial vehicles/systems (UAV/UAS), can be used as a method of imagery acquisition similar to manned aircraft or satellites. One may opt to utilize drones to obtain data depending on factors such as required frequency and resolution, weather, accessibility, among others. During this talk, we'll discuss things to consider when choosing whether or not to pursue the acquisition of imagery using drones and weigh pros and cons. Additionally, by using geographic information systems (GIS) software, we're able to seize opportunities to go above and beyond simply looking at drone data by creating web apps, maps, and mobile-friendly products that help enhance our analyses and improve efficiency. The South Florida Water Management District (SFWMD) drone program currently has around 30 pilots from a variety of different bureaus and backgrounds, covering projects related to wildlife, emergency management, invasive species, infrastructure, and more. We'll take a quick look at the agency's program and discuss how GIS can be used to support an end-to-end process from drone mission planning all the way through the use and analysis of the data. We will also review several case studies of real-world situations where drones have been deployed to collect data and how GIS software is leveraged to bring these projects to the next level.

Over the River and Through the Woods: Next Steps in Florida Panther Recovery

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Conservation efforts to ensure survival of the Florida panther have included habitat preservation, improved habitat management, installation of wildlife crossings, and notably, genetic restoration. The panther population has since grown over the past 30 years because of higher survival and increased reproductive success. The population continues to face ongoing and novel challenges, however, and it is crucial to expand the breeding population beyond south Florida. Fostering relationships with private landowners is critical not only for maintaining the current population but also for promoting range expansion and recovery.

Identifying Nutrient Sources Driving Algal Blooms in Florida Bay: A Causal Modelling and Stable Isotope Analysis Approach

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Over the past century, Florida Bay has experienced a number of disturbances, both presses and pulses, which have significantly altered ecosystem structure, function and the provisioning of services. These major anthropogenic and natural disturbances include the chronic reduction of freshwater inputs from water management practices, large-scale seagrass die-offs, and a number of hurricanes and tropical storms. The loss of seagrass coupled with strong storms has led to s shift from a clear water state to one dominated by sediment plumes and algal blooms. The bloom we are presently experiencing has increased in size and intensity each year after the 2015 seagrass die-off and have been hypothesized to be driven by a combination of factors such as rainfall and a shift in water chemistry. However, the sources of nutrients causing these blooms have yet to be identified. Using Empirical Dynamic Modelling (EDM) and stable isotope analysis, our research aims to determine the cause of the northcentral Florida Bay algal blooms by leveraging long-term data collected in northcentral Florida Bay along with 1 year of new data collection (water and sediment stable isotope and nutrient data along with algal identification). The results of this research will provide managers and policy makers with crucial information on the cause of algal blooms in Florida Bay with the goal of reducing blooms in the future.

Enhancing Invasive Plant Management Through Multi-Scale Monitoring in the A.R.M. Loxahatchee National Wildlife Refuge

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Water Conservation Area 1, part of the A.R.M. Loxahatchee National Wildlife Refuge, is a 57,324 ha wetland landscape, characterized by sawgrass marshes, sloughs, wet prairies, and tree islands. This unique component of the Everglades is the subject of ongoing inter-agency efforts to control two highly invasive species: melaleuca (*Melaleuca quinquenervia*) and Old World climbing fern (*Lygodium microphyllum*). Management efforts have utilized various monitoring methodologies, including systematic reconnaissance flights for landscape-scale assessments, rapid assessments to support ground-based herbicide applications, and detailed mapping of invasions within large, inaccessible tree islands. This multifaceted monitoring approach has provided critical data for decision-making processes, enabling strategic control efforts that optimize resource allocation and protection of priority ecological assets. This presentation will provide an overview of the current invasive plant monitoring framework employed at the Refuge, highlighting recent changes in the landscape-level distribution and abundance of melaleuca and Old World climbing fern.

Management Approaches and the Importance of Working with Land Managers to Recover Imperiled Species

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In response to the drastic decline of the Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), conservation partners implemented a multi-pronged recovery program. Since loss of native habitat is one of the reasons for the decline, habitat restoration and management is integral to the recovery program and should take an adaptive approach guided by ongoing research. Critical to the success of the conservation breeding and release program, release sites must have unoccupied and suitable habitat available. Therefore, land managers are key conservation partners during all phases of the recovery effort. Three Lakes Wildlife Management Area, located in Osceola County Florida, is home to the largest known remaining Florida grasshopper sparrow breeding aggregation. As we detected population declines, land managers identified potential sparrow habitat within their historical footprint on this property. Some of the identified habitat was degraded by hardwood encroachment due to fire suppression and changes in hydrology. Since sparrows occupy open dry prairie, restoration included the removal of canopy trees, such as oaks and cabbage palms. After restoration, the habitat continues to be managed through short-rotation prescribed fire, mechanical treatments to reduce hardwood and saw palmetto cover, and chemical treatment of invasive vegetation. These efforts increased available open dry prairie habitat for the release of conservation-bred sparrows and intrinsic growth of the aggregation. Since multiple imperiled species inhabit dry prairie, land managers conduct management at the landscape level for populations instead of individuals. Three Lakes Wildlife Management Area is one example of habitat restoration and management supporting the recovery of the sparrow throughout the subspecies range. Recovery of imperiled species requires protection and management of suitable habitat at the landscape level, and therefore, different land use types should be considered in the context of conservation. Habitat restoration and management varies depending on land use practices and land managers from multiple sectors should be included in conservation planning. The development of long-term management plans is also key to maintaining the continued persistence of species on the landscape.

Balancing Ecological Outcomes in Everglades Restoration and Water Management

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The U.S. Geological Survey (USGS) is collaborating with the U.S. Army Corps of Engineers to develop a web-based decision support tool that gives stakeholders the opportunity to evaluate potential ecological responses to water management and restoration scenarios in the Everglades. Our goal is to provide users the ability to explore hydrologic scenarios that may benefit a suite of ecological communities, potentially at a cost to others. The Joint Ecosystem Modeling (JEM) team housed at the USGS has previously developed predictive models for a suite of species and ecological communities. Example models include alligator (*Alligator mississippiensis)* breeding potential, native apple snail (*Pomacea paludosa*) population size, multi-species wading bird occupancy, and Cape Sable seaside sparrow (*Ammospiza maritima mirabilis*) presence. These ecological models are routinely run using short- and long-term hydrologic forecasts and scenarios. While many JEM models share similar ecological inputs, taxonomic groups exhibit distinct responses. The development of this web-based dashboard provides users with the ability to simultaneously evaluate multiple ecological responses to future hydrologic conditions across the Everglades in a single tool. Users would have the ability to interact with a range of hydrologic futures such as planned restoration outcomes with a multi-decadal hydrologic outlook, short-term hydrologic forecasts with a six-month outlook, and projections of saltwater intrusion in the coastal Everglades. In this poster, we present feedback from stakeholders on information and visualization needs for this new tool, planned next steps, and longer term aims.

Chemical-Free Harmful Algal Bloom Control: Nanobubbles-To Be, or Not to Be

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Nanobubble technology presents an innovative alternative for mitigating harmful algal blooms (HABs), particularly in environments where traditional methods are ineffective. This 18-month study assessed the effects of oxygen and ozone nanobubbles on water quality, nutrient dynamics, and algal community composition in Pahokee Marina, Florida. Four dock-mounted Moleaer Clear generators injected nanobubbles into recirculated marina water. Continuous monitoring was conducted using In-Situ sondes equipped with sensors for temperature, conductivity, ORP, pH, dissolved oxygen, and phycocyanin. These sondes were deployed at treatment and control sites, with cloud-connected telemetry for real-time data collection. Monthly discrete samples were also collected for laboratory analysis. Nutrient concentrations (nitrate, nitrite, ortho-phosphate, total phosphorus) were measured by a NELAC-accredited lab, while Florida Gulf Coast University analyzed algal populations and cyanotoxins (microcystins, cylindrospermopsin, saxitoxin, anatoxin-a). The treatment spanned two bloom-prone warm seasons, allowing insight into seasonal water quality trends and potential treatment impacts. Phycocyanin (PC) levels tended to be lower in treated areas, but sonde calibration uncertainties limited insight on algal biomass. ORP remained stable across all sites, indicating ozone application did not negatively affect oxidative balance. Dissolved oxygen was slightly higher and more stable in treated zones, suggesting a positive influence on aquatic conditions. Nutrient trends were consistent across all sites, making it difficult to isolate treatment effects from natural variability. Total phosphorus appeared uncorrelated with nitrogen compounds, hinting at distinct nutrient sources. Algal data showed no statistically significant differences in dominant taxa, *Microcystis* colony structure, or cyanotoxin levels between treatment and control areas, suggesting limited ecological disruption from nanobubble use. While some encouraging trends emerged, a lack of understanding of treatment dispersion limited the ability to draw firm conclusions. Variability in nanobubble dosing—due to equipment efficiency or hydrodynamic factors—may have led to misclassification of control/treatment sampling zones. As such, the efficacy of nanobubble technology in this application remains inconclusive. Future research should improve spatial delineation of treatment areas and further investigate interactions between nanobubbles, nutrients, and specific algal taxa to better evaluate this technology for HAB control.

Mangrove Transgression into Everglades Marshes: A Process to Be Accepted, Resisted, or Directed?

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Sea-level rise is commonly understood as a critical agent of change in low-lying coastal ecosystems in south Florida. Apparent acceleration in the rate of increase – from 3.0 $mm \cdot yr^{-1}$ during 1940-1994, to 4.4 $mm \cdot yr^{-1}$ during 1994-2016, to 9.6 mm yr^{-1} during 2016-2023 - suggest that rising seas may pose a significant challenge to the Comprehensive Everglades Restoration Plan (CERP) goal of restoring the historical diversity and abundance of native plants and animals in the coastal Everglades. The Resist-Accept-Direct (RAD) concept advanced by the National Park Service and several other federal agencies provides a framework by which to approach this challenge. RAD would direct planners to consider the *ecological, societal, and financial feasibility* (costs and benefits) of resisting, accepting, or directing mangrove encroachment into Everglades freshwater marshes. In 1994, we initiated a study of ecosystem dynamics in the southeastern panhandle of ENP. This portion of the Southeast Saline Everglades (SESE) is characterized by a prominent "white zone", a sparsely vegetated band that effectively separates tidally influenced mangrove swamp from freshwater sawgrass marsh. Our study demonstrated that since 1940 this transitional zone had advanced furthest inland in areas cut off from upstream water sources, thereby identifying freshwater delivery along with sea-level rise as important elements in recent coastal dynamics. The implications were not lost on CERP planners, whose broad objective was to restore the pre-development Everglades landscape by re-allocating freshwater, or "making the water right". In the coastal zone, this purpose could be sought by increasing freshwater delivery from upstream canals, with the re-establishment of glycophytic plant species and reversal of mangrove advance serving as measures of success. With ENP support, we returned to the area in 2016. During the 22-year period between studies, the landscape experienced a tangible wave of mangrove advance, a loss of habitat diversity, and a change in invertebrate fauna from a freshwater assemblage to one characteristic of brackish water environments. Faced with a further acceleration in the rate of sea-level rise, restoring the coastal Everglades of 1900 seems an unimaginably difficult task. Our experience throughout the SESE wetlands suggests that a strategy based exclusively on historical landmarks and resistance to rising seas should be replaced by a longer-term vision that balances all three RAD elements. In developing this vision, management should continue to *Resist* mangrove encroachment in productive marshes distant from the coast, *Accept* that mangroves will play an expanded role in the coastal Everglades of the future, and *Direct* change such that healthy mangrove forests will serve as hydrological and biological connectors between major Everglades flow-ways and downstream estuaries that will be adequately supplied with freshwater.

Spatio-temporal Dynamics of Vegetation Species Abundance in Response to Hydrologic Changes in the Ridge and Slough Landscape of Everglades Ecosystem

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The Florida Everglades features a mosaic of sawgrass ridges, sloughs, and tree islands, essential for its ecological and cultural functions. Unfortunately, the ecosystem faces historical threats from human activities, invasive species, climate change, and fire. Restoration efforts under the Comprehensive Everglades Restoration Plan (CERP) aim to mitigate these issues and restore the Everglades ecosystem, including ridge and slough landscape. While past research has explored surface landscape patterning and species dynamics within the R&S landscape, a broader understanding of ecosystem-wide relationships between hydrology, notably water depth and spatiotemporal changes in vegetation composition and species abundances in relation to hydrologic changes resulted from restoration activities, remains limited.

We conducted comprehensive vegetation monitoring within R&S landscape across the Greater Everglades Ecosystem, which includes Everglades National Park, Water Conservation Areas, and the Loxahatchee National Wildlife Refuge (LNWR). This study occurred in two phases: from 2009 to 2015 and 2015 to 2020. We sampled vegetation species composition in fifty-eight permanent sampling units (PSUs), each measuring 2×5 km and containing up to 135 1×1 m quadrats. In this study, we measured the importance value of all sampled plant species and tracked how water depth (WD) and the abundance (Importance Value, IV) of the major plant species changed over time. We also explored any correlation between changes in WD and plant abundance.

Mean water depth during the 2nd cycle was significantly higher than the 1st cycle throughout the study area. However, it was much more evident in WCA3B and ENP, primarily due to the result of increased water deliveries associated with restoration efforts under Combined Operation Plan (COP) and others. Our results indicated that there was a shift in species composition and an increase in the relative abundance of several major species, that are indicators of relatively wet conditions. However, it was surprising that an increase in WD did not correlate with temporal changes in abundance of water lily, a species that is common in sloughs, in those two regions. This suggests that the magnitude of change in WD was insufficient to influence changes in abundance of species that is key indicator of sloughs. Our study sheds more light on the importance of understanding the landscape-level drivers of species abundance in ecosystems of global importance. This information is valuable for detecting changes/trends in the landscape system patterns due to water management operations and restoration initiatives.

The Influence of Florida Bay in Structuring Nearshore Coral Reef Communities in the Florida Keys

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Florida Bay and Greater Everglades are unique ecosystems that play an important role in structuring nearshore coral reef communities in the Florida Keys. The term ‘‘inimical’’ refers to a number of water quality parameters (e.g., turbidity, high salinity, and high temperatures) believed to be detrimental to coral survival and has long been hypothesized as a major control limiting reef development adjacent to tidal passes in the Florida Keys exiting from Florida Bay. Additionally, due to the shallow geomorphology of Florida Bay and the subtropical location of South Florida, intrusions of artic air masses can rapidly plummet seawater temperatures below the survival threshold of many tropical organisms and conversely, during periods of prolonged heating and drought, only corals that are more thermally tolerant may persist in these areas. In the case of the latter, numerous changes over the past century to upstream water management and land use of the Greater Everglades have likely exacerbated conditions because of reduced water flow entering into Florida Bay. Over the course of several climatic events during the las two decades (the 2010 polar vortex and the 2023 heatwave), FWC coral monitoring programs have documented differences in coral survival across the Florida Keys with some of the lowest survival rates occurring adjacent to tidal passes bordering Florida Bay. This presentation will provide a summary of these differences and if additional water flow could help mitigate against the most severe of the hot water induced disturbances in the future.

Evaluating the Effects of Lake Guard® Oxy on Phytoplankton Communities in the Caloosahatchee River

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The Caloosahatchee River is subject to harmful algal blooms (HABs) as a result of nutrient loading largely from agricultural runoff. These blooms, which are often dominated by cyanobacteria, result in negative consequences to the local ecosystem and adverse health effects to local residents. Bloom death, which occurs during overcast weather or when the blooms are large enough to self-shade, can result in low dissolved oxygen in the local environment, increasing the amounts of fish kills. Previous studies have shown hydrogen peroxide can reduce cyanobacteria communities, which are more sensitive to oxidative stress than other aquatic organisms, suggesting that this treatment is minimally harmful to the ecosystem as a whole.

The study was conducted at the S-77 structure in Moore Haven in June and July of 2024 over three tests and involved the application of Lake Guard® Oxy to a site upstream of the dam, with a goal of cyanobacteria mitigation. Phytoplankton were counted under the microscope and DNA was sequenced in order to calculate the total counts of the phytoplankton groups and determine the community composition of the algal bloom.

Research is still ongoing, but preliminary results characterize the bloom as one that is cyanobacteria dominant. This kind of data may be crucial to understanding how best to address HABs moving forward.

Vegetation Dynamics on Tree Islands within the Ridge and Slough Landscape in the Southern Everglades

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In the Everglades tree islands, plant communities are primarily arranged along a hydrologic gradient. Temporal change in hydrologic regime may cause shifts in species composition, affecting the structure and boundaries of these communities. However, the direction and magnitude of such a change are determined by the extent of hydrologic alterations, with prolonged and extreme wet events even resulting in loss of upland woody vegetation. We examined the vegetation changes over a 24-year period, between 1999/2000 and 2023/2024 on tree islands in Shark River Slough, Everglades National Park (ENP). In the rarely flooded hardwood hammocks of these islands, vegetation was surveyed in 1999/2000 and then annually since 2006/2007, whereas in the seasonally flooded hydric portion (bayhead and bayhead swamps) of a subset of these islands, vegetation was surveyed three to four times over the study period. We quantified the changes in relative abundance of flood-tolerant and intolerant tree species, and then using a suite of multivariate techniques, we examined the magnitude and direction of vegetation change over time by quantifying the displacement of sites in relation to the hydrologic gradient in ordination space. Plant communities in the hydric portions of studied tree islands primarily responded to the changes in hydrologic conditions. In contrast, communities in the hardwood hammocks responded to changes in both hydrologic conditions and the periodic disturbances such as tropical storms. Our results also show that periodic fluxes in the hydrologic regime, resulting in below average water levels and shorter hydroperiods over a period as short as one decade, promote the establishment and growth of moderately flood-tolerant woody species within the hydric portions of tree islands. Conversely, increased wetness in recent years has led to an increase in mortality of flood-intolerant species in hardwood hammocks, while increasing the relative abundance of some flood-tolerant species, like pond apple (*Annona glabra*) in the tree layer of bayhead and bayhead swamp forests. In summary, community dynamics in the hardwood hammock portions of the study islands are primarily influenced by the long-term interaction between hydrology and tropical storms. However, recent incremental rise in water levels resulting from activities under the Comprehensive Everglades Restoration Plan (CERP) to increase the water delivery to ENP, has also influenced tree island plant community composition in both hardwood hammock as well as bayhead and bayhead swamps. Depending on the magnitude of increase in water delivery into the ENP, the balance between flood-tolerant and flood-intolerant woody and herbaceous vegetation on these tree islands will change. This may result in shifts in boundaries between plant communities on the islands as well as between tree islands and marshes in this part of ENP.

Water, Carbon, and Nutrient Balance on Ranchlands in the Everglades Headwaters

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The Headwaters of the Everglades is a ~1.1-million-hectare watershed with ranchland as the dominant land use. These ranchlands are recognized as valuable not only for food production, but also for biodiversity, carbon, and water services. There are concerns about environmental impacts on water quality and greenhouse gas emissions, however there are opportunities to reduce impacts through management interventions and restoration. Here we synthesize research conducted at Archbold's Buck Island Ranch, a 4,249 ha representative working cow-calf ranch. Research included field data collection, high resolution sensor networks, life cycle analyses, and ecosystem modeling. Our research objectives were to understand water, carbon, and nutrient balance across pasture and ranch spatial scales. Based on measurements from a 405 ha catchment at Buck Island Ranch, precipitation and evapotranspiration were the largest components of water inputs and outputs, respectively, surface water runoff was quantified at 92 ± 24 mm/year, and percolation estimated at 460 ±349 mm/year. Regarding nutrients, we focused on phosphorus since this is a nutrient of concern in the watershed. P balance of ranchlands was found to be nearly balanced, and P outputs from the ranch were primarily from sold animals. Imported animal feed was the single largest source of P imported to ranches and fertilizer inputs were significantly reduced from earlier years. However, there is a large amount of P stored in the soil in the spodic horizon which contains high concentrations of Al and Fe that retain P but may continuously leach P to surface waters. Even though nutrient loads from cattle pastures are low relative to other land uses on a per ha basis, the large area of ranches in the watershed make them a significant nonpoint source contributor to overall nutrient loads at a landscape scale. Finally, utilizing eddy covariance, we found that ranch grasslands and wetlands vary in their carbon sink strength. At the ranch scale, life cycle analysis estimated annual average emissions as 11,293 Mg CO2 eq. An ecosystem model, validated with eddy covariance, estimated annual soil organic carbon sequestration as 12,390 Mg CO2 eq/year. Therefore, sequestration offset annual emissions by 1,097 Mg CO2 eq for this typical ranch. Understanding the dynamics of water, nutrients, and carbon cycles within ranchland landscapes, the largest landuse in the Everglades Headwaters, is essential for more efficient and sustainable watershed management. Management interventions to mitigate water quality impacts include water retention, hay harvest, and overseeding legumes. Future research will focus on understanding how a fluctuating water table interacts with spodic soils to affect surface water quality and nutrient loss from ranchlands. Management levers being investigated for ecosystem methane include dominant grasses, soil type, and soil amendments, and feed amendments for cattle emissions.

Invasive Burmese Python Movement and Management Implications

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Understanding the spatial ecology of an invasive species is critical for assessing potential routes of range expansion and designing effective control programs. The range expansion of invasive species can be heavily influenced by patterns of movement and behavior of individuals. Dispersal behavior (i.e., the unidirectional movements of individuals from their birth site to their breeding site) plays a prominent role in defining invasion dynamics. In South Florida, invasive Burmese pythons (*Python bivittatus*) are a wide-ranging, cryptic species that disrupts native ecosystems and have the potential to expand their range beyond Florida. Control of invasive python populations is hindered by limited information on dispersal behavior and habitat associations, especially within the younger age classes. Movement data for invasive pythons have primarily been used to investigate the size of home range and habitat associations. However, there is limited information on how management practices for native habitats, such as prescribed fire, impacts the movement ecology and health of invasive pythons. Here, we analyzed spatial data collected using radiotelemetry to characterize the movement, dispersal behavior, and response to prescribed fire of adult and juvenile pythons in Big Cypress National Preserve. Preliminary results indicate the dispersal behavior of juvenile pythons in our two study sites in Big Cypress (Turner Block and Loop Rd) consists of random and unidirectional movements indicating that hatchling pythons from a single nest can disperse in all directions. Analyses of space use in adult pythons revealed seasonal differences (breeding vs non-breeding seasons) in home range size across years, as well as variation between sexes, giving insight into potential dispersal patterns over time. We found little evidence of changes in movement patterns of adult pythons during or after prescribed burns, whereas juveniles appeared to increase movement activity either during or after prescribed burns. Of note, we obtained several observations of adult and juvenile pythons in burn areas with superficial burns to their skin or recent scarring, but no direct mortality. Together, these analyses fill important gaps in understanding the spatial ecology of invasive pythons in Florida.

Assessment of Nektonic Communities' Spatiotemporal Patterns in the Everglades Coastal Lakes Using a Fisheries-independent Monitoring Approach

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Nektonic and forage fish communities are vital for the functioning of estuary ecosystems (e.g., energy transfer across food webs and nutrient transport). Recognizing this essential contribution, monitoring programs, such as the Florida Fisheries Independent Monitoring Program (FIM), have been established to assess and understand the dynamics of nektonic communities as a function of environmental conditions and disturbances. The Everglades coastal lakes region bordering Florida Bay is one region with conditions to support high nektonic species biomass that fisheries monitoring programs have historically overlooked. To fill this knowledge gap in the region, we adopted an FIM protocol to assess the nektonic communities' responses to unique changes in freshwater inflows, salinity, and nutrient regimes in two coastal lake systems, the Alligator Creek (ACS) and McCormick Creek sub estuaries (MCS) system. Over four years (2016–2020), over 500 seine hauls across MCS and ACS revealed that species abundance, biomass, and richness were driven by spatial factors, particularly north-to-south zonation of the ACS and MCS lakes, and by environmental conditions such as salinity, submerged aquatic vegetation (SAV), and sediment depth. The ACS system exhibited higher biomass but lower evenness, primarily driven by Hardhead Catfish dominance, while richness peaked in downstream bays of the systems. Species richness increased from upstream to downstream zones, with distinct community structures observed in specific lakes like ACS' Cuthbert Lake. Despite spatial variability, seasonal differences were limited. Our findings underscore the importance of these ecosystems for supporting diverse nektonic communities that serve as prey energy sources for recreational fishery species subject to changing climatic and hydrological conditions.

Application of the Blue Shanty Flowway Model to Achieve CEPP Restorative Flow Targets

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The Central Everglades Planning Project-South (CEPP-S) was designed to hydrologically reconnect Water Conservation Area (WCA) 3A and WCA-3B with Everglades National Park (ENP), via the Blue Shanty Flowway (BSF). The BSF aimed to deliver water as sheetflow from WCA-3B to ENP; however, original designs lacked backfilling of the L-67C Canal that crosses the BSF, spanning 8 miles northeast to southwest. The landscape-scale, Adaptive Management experiment known as the DECOMP Physical Model (DPM) demonstrated that left unfilled, the L-67C Canal would reroute sheetflow as canal flow and create localized extreme velocities (>0.1 ft/s) downstream of the adjacent degraded L-67C levee. The combination of canal flow, which mobilizes P-rich canal sediments, and extreme velocities, which lead to algal shifts that generate P-rich sediments, together result in ecological damage and replacement of ridges and sloughs by cattail. Extrapolating DPM results to the BSF-scale suggested that some flow through the BSF could be captured and rerouted as canal flow that would in turn generate excessive hydraulic loads and transport P-rich canal sediments from the degraded L-67C Levee near its southwest terminus into the L-29 Canal and then into ENP. The objective of the Blue Shanty Flowway Model (BSFM) was to assess the extent to which alternative canal plug configurations could minimize harmful canal flows (>20 cfs) and extreme velocities (>0.1 ft/s) in the BSF. The BSFM uses HEC-RAS 2D software to simulate unsteady flow within WCA-3B, with boundary conditions (inflows, seepage, boundary stages) provided by the Regional Simulation Model–Glades LECSA (RSM-GL). The BSFM demonstrated the ability to match stages and flows observed in DPM and from RSM-GL. BSFM generated future scenarios of completed CEPP-S buildouts, including a baseline (no plugs) and varying plug lengths and spacings, to assess optimal configurations that meet DPM-based canal and marsh flow targets. Overall, scenarios demonstrated that combining numerous (31) mini-plugs (60-ft length) with four moderate length (500-ft) plugs was most cost-effective in achieving most flow targets. This scenario performed better than other scenarios with four longer (1000-ft) plugs or nine small (300-ft) plugs. Notably, the best performing scenarios utilized intermediate volumes of fill, confirming the importance of location of fill placement over total fill used. Additional refinements further improved performance near outflows to ENP. By integrating large-scale hydrological models and landscape-scale observations in an Adaptive Management framework, the BSFM provides a novel tool to forecast fine-scale (and observable) ecological metrics. More broadly, it is a blueprint for optimizing other large-scale flow restoration projects.

Changes in Soil Phosphorus Over Fifteen Years in the Historically Oligotrophic Everglades National Park

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Everglades National Park (ENP) in Florida, USA has been experiencing threats of increasing eutrophication from runoff from upstream agricultural and urban areas. The Everglades is naturally an oligotrophic and therefore low-phosphorus (P) system, and consequently, increasing P enrichment is threatening local vegetative communities and altering native food web dynamics. Changes in hydrology upstream of the study site have occurred within the past several years that may have led to downstream changes in hydroperiod as well as soil TP. In order to look at long-term changes over time, soil collection and analysis have been conducted at a series of transects in the Taylor Slough area of ENP in 2012, 2018, and 2023. The most recent analysis from October 2023 has yielded some surprising results with average soil total phosphorus concentrations shifting from no significant differences from 2012-2018 to decreasing by 22% from 2012 to 2023. At first glance, this appears to be a positive shift in eutrophication reduction. However, the inorganic fraction of soil phosphorus has increased significantly by 33% from 2012 after no significant differences were found between 2012-2018. This indicates a loss of organic phosphorus that has accompanied a loss of organic matter of 5% since 2012 and 13% since 2018. Therefore, it becomes apparent that when sampling an area for changes in P due to eutrophication, total P might not be enough to understand the total picture of P cycling within a system for making future management and restoration decisions.

Historical Perspectives on Faunal Abnormalities and Contaminants in Biscayne Bay

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Dr. Joan Browder was instrumental in spearheading early studies related to the health of Biscayne Bay. Most importantly she was a key bridge between public observations of abnormalities in fauna in the Bay and appropriate scientists. These must be some of the earliest examples of what we now refer to as “Citizen Science” in the nearshore environments of South Florida. The studies described here were driven by Joan’s passion for following these leads and her refusal to take no for an answer when marshalling resources to better understand the problems facing Biscayne Bay and neighboring habitats. We conducted surveys from 1991 thru 1994 to determine the nature and distribution of abnormalities and diseases in fish and blue crabs from sites throughout Biscayne Bay. These studies, funded by the South Florida Water Management District, demonstrated significant differences in the prevalence of abnormalities between sites. Missing or deformed dorsal fin rays were the most common abnormalities observed in gray snapper (*Lutjanus griseus*). Scale disorientations were most common in pinfish (*Lagodon rhomboides*) while sea bream *(Archosargus rhomboidalis*) exhibited both types of abnormalities. The highest prevalence rates of abnormalities in these three species were found at Sunset Harbor Marina and at Miami Beach Marina. The prevalence of abnormalities for all fish species combined was correlated with historical concentrations of total and aromatic hydrocarbons in sediment samples from sites within 2 km of the faunal survey sites. Laboratory studies were also conducted to investigate the etiology of scale disorientations (SD) that were commonly seen in *L. rhomboides*. Scales from SD areas exhibited both abnormal orientation and morphology with larger average focus diameter, smaller size, more elongate shape and fewer radii relative to normal scales. Affected fish demonstrated a proportional growth of SD areas such that the percentage of body surface affected did not change as fish grew. Experimental removal of scales demonstrated that normal scales regrew in normal orientation and morphology while those from SD areas regrew in abnormal orientations and morphologies. Experiments in which fish were exposed to acute and chronic injuries indicated that these physical traumas were insufficient to directly induce formation of scale disorientations typical of those seen in the wild. Observations of pinfish in the laboratory revealed that SD areas can appear spontaneously in grossly normal juvenile and adult fish. These new SD areas developed relatively rapidly, did not require prior scale loss and remained stable in size after first appearance. Although the etiology of SD remains unknown, the significant difference in prevalence of this syndrome between regions of Biscayne Bay having different historical levels of sediment contaminants suggests that environmental factors may be important in development of SD.

Building Capacity for Resilience on Florida's Coral Reef through Coral Rescue and Propagation

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In response to Stony Coral Tissue Loss Disease (SCTLD) 20 coral species were collected along Florida's Coral Reef by the Florida Coral Rescue Project for live gene banking to prevent infection, preserve genetic diversity, and propagate offspring for use in future restoration. Over 2,500 coral colonies have been collected over six years and have been expertly cared for in land-based facilities across the USA. Most species have never been held under human care before and the rescue project has provided a unique opportunity to learn husbandry needs, develop treatment options, and advance spawning and settlement techniques for each species. Now, after the creation of novel genetic markers, breeding and propagation plans are being developed to guide spawning activities to increase genetic diversity and build resiliency within Florida coral populations to provide a sustainable source of corals for outplanting. The use of "rescue" offspring will be a focus of outplanting for species enhancement on Florida's Coral Reef. Resource and communication pathways are being developed to connect rescue partners conducting spawning and propagation with Florida restoration practitioners for grow-out and outplanting. Completing the circle from colony rescue to the outplanting of offspring will dramatically assist in scaling up restoration efforts and promoting the recovery of Florida's Coral Reef.

Current Restoration Indicators for Florida Bay, Everglades National Park, and Challenges for Assessing Restoration Success

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Everglades restoration is modifying marine and estuarine environments of Everglades National Park through increased freshwater flows, longer upstream hydroperiods, and reduced salinity. The desired State of Conservation for Florida Bay involves more natural salinity regimes, seasonal timing of freshwater flows, and reduced nutrient inputs. A restored Florida Bay system would be characterized by clean water, less frequent algal blooms, healthy mixed-seagrass beds, and robust mixed-hardbottom communities. These habitats would support diverse faunal communities including forage fish, sport fish, wading birds, and American crocodiles. To assess restoration progress and success, a suite of indicators such as salinity levels, algal bloom occurrences, seagrass coverage and composition, and catch rates of coastal fisheries species have been used. The most recent report indicated that increased rainfall led to extended periods of mesohaline conditions during the wet season and less extreme hypersalinity events compared to previous years. However, salinity regimes are still a concern as they do not yet meet the desired conditions. Additionally, the frequency and severity of algal blooms has decreased overall, but algal blooms continue to occur regularly in certain areas. Seagrass habitats appear to be recovering from past die-off events and catch rates of estuarine fish appear to indicate generally good conditions. Ongoing Everglades restoration efforts necessitate continuous monitoring and critical evaluation of these indicators to gauge the status of the Florida Bay ecosystem. This adaptive management approach is becoming increasingly vital as we document the impacts of climate change and rising sea levels, ensuring that restoration strategies remain effective in the face of evolving environmental challenges.

Development and Implementation of a Conservation Breeding Program: One of Many Tools in the Recovery Toolbelt

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Conservation breeding programs are an important tool to assist in maintaining and growing small wild populations. Initiated in 2016, United States Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission, and various stakeholders established a successful conservation breeding program for Florida grasshopper sparrow, *Ammodramus savannarum floridanus*. Releases of Florida grasshopper sparrow were initiated in 2019 and since that time 1,188 Florida grasshopper sparrows have been produced from three conservation breeding facilities and released into three release locations. Integral to program efficacy was utilization of a One Plan Approach, allowing strong communication and collaboration between all in situ and ex situ subpopulation managers. Additional key strategies include the utilization of a model species to establish husbandry techniques, effective assessment and management of disease risk, implementation of holding facilities for pre-release or non-releasable FGSP, and a managed care approach mimicking the species natural history. We've shown that an initially poorly understood and secretive *Ammodramus* sparrow can be successfully bred in managed care to support small remnant populations in conjunction within a suite of other recovery actions. The FGSP conservation breeding program may serve as a model for similar endangered species.

Traits that Facilitate Invasion of Natural Habitat

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South Florida is home to more established non-native species than any other continental region in the world. Many of these non-native species are confined to human-altered habitats, and only a subset make inroads into natural habitats where they are more likely to impact native species. While there have been many analyses of traits associated with non-native species establishment and geographic spread, there has been little examination of the traits associated with penetration of natural habitat. To investigate this question, we downloaded ~1.2 million locality records covering all non-marine vertebrates and vascular plants in South Florida. Using a high-resolution land cover layer, we then determined the fraction of each species' locality records that were from natural vs. human-altered habitat. For the 134 most abundant South Florida non-natives, we then collected data on 15 functional traits of each species that have previously been tied to invasive species establishment or spread. Using a model selection approach, we determined which of these traits are most associated with penetration of native habitat. The top model included two traits: wetland tolerance and year of introduction, with wetland species and those introduced longer ago having greater penetration of native habitat. As 92% of South Florida's remaining natural habitat is wetland, this suggests that pre-adaptation to the predominant habitat type is key to invasive species spread. We also examined which properties of natural habitat patches best predict the degree to which they have been invaded. We found habitat type to be the sole significant predictor (not patch area or proximity to human-altered habitat), with a gradient from upland habitats being this most invaded to wetland habitats being the least. Collectively, these results argue that preserving South Florida's wetlands is the best defense against the spread of the majority of non-native species.

Collaborating with the Remarkable Ecologist, Dr. Joan Arrington Browder

Joe Serafy
NOAA

I had the privilege of working with Joan Browder over the last two decades of her long, storied professional career. She was a fixture at the Miami Lab of the NMFS Southeast Fisheries Science Center, long before I arrived there in 2001. Behind her gentle, stereotypical “little old lady” appearance was a driven, insightful, politically savvy researcher who cared deeply about the natural resource problems that crossed her path. Best known to the scientific community for her work in wetlands conservation and restoration, she was also a force in seabird biology and ecology, bycatch reduction, conceptual and quantitative ecological modeling, and understanding how pelagic fishes (swordfish and tunas) relate to their dynamic, thermal environments. In my presentation, I’ll focus on her enduring influence on shaping and maintaining the Biscayne Bay Ecological Assessment and Monitoring (IBBEAM) program, which continues to operate today by virtue of funds from US Army Corps of Engineers and South Florida Water Management District. A fierce supporter of her research team, Joan’s combination of experience, optimism, thoughtfulness, and grace made her a role model for those of us who had the good fortune of collaborating with her.

Integrated Modeling System for the Loxahatchee River and Estuary Watershed to Address Environmental Challenges

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Over the past several decades, the Loxahatchee River and Estuary, a vital ecological system containing a federally designated Wild and Scenic River, has faced significant environmental challenges from anthropogenic activities. Population growth, urbanization, agricultural expansion, and drainage activities have disrupted the natural hydrologic regime, leading to a pronounced encroachment of saltwater-tolerant, mangrove-dominated communities into freshwater, bald cypress-dominated floodplains. Effective management and restoration of the Northwest Fork of the Loxahatchee River and Estuary require predictive models to simulate long-term freshwater inflows and salinity dynamics.

This study presents an integrated modeling approach using the WaSh (Watershed water quality model) model to address these challenges. The WaSh model restructures the Hydrologic Simulation Program – Fortran (HSPF) into a cell-based system enhanced by a groundwater model and a fully dynamic channel routing component. This advanced modeling system is designed to simulate hydrology in South Florida's unique landscape, characterized by high groundwater tables and dense drainage networks. The WaSh model was calibrated and validated using long-term flow data from multiple stations, including Lainhart Dam, S-46, G160, C-18, and Kitching Creek. The model performance measure parameters such as the coefficient of determination (R^2) and Nash-Sutcliffe efficiency (NS) consistently exceeded 0.6, confirming the model's reliability in simulating daily freshwater flows.

Simulated outputs support the re-evaluation of Minimum Flows and Levels (MFLs) and offer insights into the impacts of climate and land use changes on coastal ecosystems. This integrated modeling system shows its potential as a decision-support tool for sustainable water resource management, enabling the formulation and evaluation of adaptive strategies to restore and protect the Loxahatchee River and Estuary's ecosystem.

Understanding and Managing Local-to-Landscape Resilience for Everglades Periphyton

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Resilience, the ability of a system to maintain itself despite disturbances, is a crucial component of ecosystem stability and environmental policy, especially in the face of climate change. But how does resilience work, and how resilient is the FL Everglades? In this presentation we review the mechanisms by which ecosystem resilience operates at small to large spatial scales, such as functional redundancy, synchrony, and species dispersal. Then, in this context, we present quantitative analyses of the relative importance of different ecological dimensions (space, time, abiotic conditions, and biotic interactions) as landscape-scale drivers of change for the benthic algae (periphyton) of the Everglades. This analysis uses data from the world's largest ecosystem restoration project, the Comprehensive Everglades Restoration Program (CERP). From the CERP analyses we draw conclusions about how ecosystem management may boost the resilience of the Everglades' benthic algae: we find that factors including species dispersal and biotic interactions play an important role in landscape-scale regulation of benthic algae. These results show that management tactics like increased landscape connectivity and holistic species management are likely important components of a resilient future Everglades.

Development of a Sponge Restoration Strategy for Florida Bay

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The South Florida watershed is a complex and highly altered ecosystem composed of a diverse mosaic of upland, wetland, and estuarine habitats that culminate downstream in Florida Bay and, ultimately, Florida's Coral Reef. Decades of alterations to the hydrology of the South Florida watershed have resulted in a cascade of ecological perturbations in Florida Bay. One of the most conspicuous drivers of Florida Bay's altered ecosystem function has been the repeated occurrence of cyanobacteria blooms that have been associated with mortality of sponges in the Bay. First documented in the early 1990s, these blooms have resulted in the loss of sponge communities over large areas of Florida Bay. In one well-studied event, a bloom resulted in the loss of ~98% of the sponge biomass in one semi-isolated basin in the central Bay. Sponges historically dominated the heterotrophic biomass of Florida Bay's hard-bottom habitat, and the ecological services they provided have long been recognized. Large structure-forming sponges provide shelter for the juveniles of coral reef-associated species of fishes and invertebrates. The loss of the sponge communities and the ecological services they provide inspired efforts to restore Florida Bay's sponge communities. For more than a decade, the foundational components of a sponge restoration strategy, grounded in basic ecological tenants, have been developed. Underpinning this effort has been the development of sponge propagation methods and the establishment of in-water nurseries, mirroring coral restoration efforts in South Florida and elsewhere. Our present efforts are focused on refining this process such that assisted sponge restoration in Florida Bay can be conducted at an ecologically relevant scale. Collectively, these advances in our understanding of sponge ecology will support a sponge restoration strategy to guide local resource managers implementing large-scale sponge restoration in Florida Bay. This strategy designed to maximize the potential for positive restoration outcomes, even under the potential of continued cyanobacterial blooms. This strategy will outline the composition and spatial distribution of sponges derived from historical data, the location, duration, and intensity of historic cyanobacterial blooms *via* satellite imagery, and cost estimates of sponge restoration based on present efforts. By integrating continuous research designed to refine restoration activities, we are optimistic that implementing this strategy will result in the restoration of the ecosystem services provided by sponges in the presently degraded hardbottom habitat of Florida Bay.

Ecological Thresholds and How They Inform Potential Tradeoffs

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Threshold concepts are used to detect and manage shifts in ecosystems and are employed in restoration ecology and ecosystem management. The utility of threshold-based decisions inevitably depends on the socio-ecological context that determines their ecological relevance and capacity for management control. To improve understanding of where and when threshold concepts may be useful for science, policy, or management, a matrix of Everglades examples explore the dynamics of resilience, stability and hysteresis on the application of thresholds to ecosystem restoration and management in the context of two questions: 1) how can hydrology and water quality attributes constrain or facilitate the application of ecological thresholds, and 2) how can scientists, restoration practitioners, and environmental stakeholders navigate socio-ecological complexity together to achieve ecological goals?

For Question 1, there are four basic, ecological concepts of thresholds applied in the Greater Everglades that are the framework for understanding tradeoffs. 1) Hydrological Operational Thresholds are derived from WCA Regulation Schedules, which were originally designed for water supply and flood control and are now being adjusted to manage for the restoration of the Ridge-Slough-Tree Island landscape patterns. 2) Compliance Thresholds are derived from socio-ecological investigations to constrain ecosystem degradation by creating legal mandates, such as the Everglades Forever Act. 3) Protective Thresholds are derived from understanding how an ecosystem with relatively high resilience and stability can be replaced by an alternative state, as has been observed for tree islands. 4) Recovery Thresholds are a situation when the qualitative aspects of resilience and hysteresis are equivalent.

For Question 2, attributes of our socio-ecological system can constrain or facilitate our implementation of thresholds and trade-offs. These attributes tend to be scale dependent. Long-term data are needed to discern patterns that indicate whether a perceived change in the ecosystem is transient and recoverable, or directional, indicating that a threshold has been permanently crossed. However, long ecological timescales do not match the faster-paced social and political timescales. Large spatial scales increase the complexity of socio-ecological systems as stakeholders, higher costs and a wider range of ecosystems can introduce competing structures and targets. Tradeoffs are expected in complex socio-ecological systems. Restoration success can potentially be increased by stakeholder engagement, adaptive management, use of long-term baselines, the acceptance of multiple ecological states, and quantifying specific ecological functions. Static concepts of ecosystems in their present condition are insufficient proxies for dynamic systems.

South Florida Water Management District – Lake Okeechobee Watershed Restoration Project, Aquifer Storage and Recovery Wells: A Project Overview

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The Lake Okeechobee Watershed Restoration Project (LOWRP) is part of the Comprehensive Everglades Restoration Plan (CERP) planning effort, the largest hydrologic restoration project in U.S. history. Designed to improve water levels and water quality in Lake Okeechobee, LOWRP also will improve the quantity and timing of discharges to the St. Lucie and Caloosahatchee estuaries, increase the size and functionality of wetlands, and improve water supply for existing legal water users. Aquifer storage and recovery (ASR) well technology will be utilized to collect excess flows from the nearby surface water source during the wet season, treating the collected surface water to US EPA primary and secondary drinking water standards before recharging the aquifer via an ASR well. The treated water will then be stored until recovered during the dry season. A total of 55 ASR wells are planned for the program, and each ASR well is designed to recharge and recover approximately 5 MGD, with a combined ASR wellfield capacity of 275 MGD of treated surface water to help fortify South Florida's ecology and surface water systems.

An in-depth feasibility assessment led to the selection of two separate storage zones: Upper Floridan aquifer (UFA) and the Avon Park permeable zone (APPZ). Based on the results of the site investigations, ASR test well designs were developed and bid documents were prepared. In conjunction with the development of ASR well design, continuous core holes were advanced at select locations. Data from these core holes were used to refine design criteria and provided preliminary hydrogeologic data. Data interpretations from a series of five, 5-day aquifer performance tests (APTs) at each site will aid in determining aquifer hydraulics and evaluate for leakance between aquifers. APT data will be input into a groundwater model to determine adequate well spacing between future ASR well pairs. As construction and testing of ASR well pairs progress, construction of a 10 MGD Demonstration Surface Water Treatment Plant (WTP) will facilitate future cycle testing. Once cycle testing is successfully completed, the treatment plant will be expanded to a 50-MGD and permitting for operation can begin.

Establishing a Protective Phosphorus Target for the WERP region of Big Cypress National Preserve: Experiment

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Big Cypress National Preserve (BICY) has been designated by the Florida Department of Environmental Protection as an "Outstanding Florida Water," which mandates the highest level of state protection. However, some wetlands in northern BICY have shown signs of degradation, which may be linked to canal water inputs containing runoff from fertilized lands upstream. This runoff can contribute to increased water column phosphorus (P) concentrations. In the Everglades, persistent above-ambient P exposure has been linked to the degradation of periphyton communities, which is known to be associated with cascading consequences leading to impaired ecosystem states. As the upcoming Western Everglades Restoration Project (WERP) increases water flow to BICY, it will be crucial to protect these wetlands from further degradation by ensuring that inflowing water does not exceed critical P-driven ecological transition thresholds. While previous experimental and long-term studies have provided a defensible basis for establishing a protective P criterion for Everglades Protection Areas (EPA), BICY has not received similar attention. Therefore, the central objective of this study is to quantify a protective P target for the WERP region of BICY. Periphyton-based attributes will be used as the primary indicator for determining the P threshold, given that periphyton is a key indicator of P change in the greater Everglades. A first phase of our study demonstrated that algal periphyton assemblages in BICY and EPA are similar, dominated by taxa indicating low P conditions, and strongly influenced by P gradients. Building on these findings, our experimental approach utilizes a flow-through flume design to assess periphyton response to P additions. Four flumes will be positioned along a wetland transect in BICY, constructed within the footprint of the Environmental Protection Agency's 2023 Regional Environmental Monitoring and Assessment Program (REMAP) sampling of BICY. Each flume will consist of four 10-m channels—one control channel and three treatment channels. We will add P to increase total P concentrations in experimental channels by 5, 10, and 15 ppb (0.17, 0.34, and 0.51 μM) above ambient concentrations. We will sample periphyton and other major ecosystem components (water biogeochemistry, floc, soil, macrophytes, and fauna) in the flumes prior to P additions, and sampling will continue for 2.5 years of P additions. We expect our findings to align with previous Everglades studies, showing that all levels of P addition will cause significant change in periphyton-based attributes in a time dependent sequence. We anticipate the effect rates to be dose-dependent, but that total P concentrations in periphyton and floc will be the first parameters to change. Ultimately, our results will help establish P thresholds that prevent ecological imbalances, supporting ecosystem health in BICY as restoration efforts increase water flow to the region.

Modeling the Effect of Salinity and Sea Level Rise on Alligator Production

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Salinity is an important factor within coastal Everglades ecosystems, yet many predictive ecological models used to inform Everglades restoration do not incorporate this variable because there are no spatially explicit predictive salinity models. For example, the Alligator Production Suitability Index (APSI) model has been used since 2015 to assess the potential effects of different restoration scenarios on annual productivity of American alligators (*Alligator mississippiensis*). The APSI was developed using the expert opinion of Everglades alligator scientists and established a suite of mathematical relationships between hydrology, salinity, landscape configuration, and alligator productivity. Due to a lack of salinity information available at the temporal and spatial scale needed for the model, salinity has been held as a constant of 0 parts per thousand across the system during modeling exercises. Without incorporating salinity, the resulting predictions of alligator production suitability have likely been overestimated in previous modeling efforts. The Biscayne and Southern Everglades Coastal Transport (BISECT) model produces salinity estimates from 1996 – 2016 for a portion of the southern Everglades coast under various sea level scenarios. We examined the APSI under a baseline sea level scenario with and without salinity inputs from BISECT, to compare model outcomes and quantify how salinity impacts alligator production suitability within Everglades National Park. In addition, we modeled effects of two potential sea level rise scenarios on salinity intrusion for an average, dry, and wet year to explore how the interaction of sea level rise and salinity could be used in future modeling efforts. This work is an important first step towards incorporating salinity and effects of saltwater intrusion within a predictive ecological model for an important indicator of Everglades ecosystem health.

Mapping Kissimmee River Floodplain Vegetation: A New Approach Using Machine Learning Algorithms

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At South Florida Water Management District, we have begun applying machine learning (ML) algorithms combined with Object-based Image Analysis (OBIA) methods to the mapping of wetland vegetation as part of the Kissimmee River Restoration Project. This restoration, which involves filling parts of a large flood control canal and re-opening flow to quiescent river channels and to a wide floodplain was started in 1999 and completed in 2020. The only restoration piece remaining is a permanent change to the hydrologic regime for the river called Headwaters Revitalization Schedule (HRS). HRS will change the managed hydrology of lakes upstream and of the river itself to allow for continuous flow in the river channel. This change will be implemented in a staged process over several years and marks the final stage of the river restoration. To track wetland community response to restoration, vegetation maps produced through photo interpretation of aerial photo surveys have been generated periodically since 1996. The resulting maps have been used to measure the distributions and relative abundances of wetland vegetation types of interest. Comparisons are made to *a priori* expectations to determine if the restoration is proceeding according to plan. This year, I completed a mapping effort using a workflow combining ML and OBIA algorithms developed through both commercial and open-source software products. The benefit of using these methods is a quick turnaround and lower funding requirements, compared to traditional methods using private mapping contractors. Results from the current mapping effort using 2020 imagery shows that the restoration is proceeding, but with mixed results. Wetland vegetation comprises about 82% of the Kissimmee Floodplain in the Phase I area (the oldest of four restoration phases) which meets one of the restoration expectations. However, specific expectations related to native wetland vegetation are not being fulfilled. Anecdotally, native wetlands have appeared to be under pressure from exotic and invasive wetland species (including West Indian marsh grass and Carolina willow); these mapping results seem to bear this out as both Broadleaf Marsh (BLM), a deep-water wetland class and one of our focal native wetland types, and native wet prairie (WP) grass species appear in this map to have reduced areal coverage, while invasives have expanded, when compared to the most recent past map of floodplain vegetation. It is expected that once the hydrologic changes to be implemented by HRS are on-line, native habitats will be favored by continuous river flow at higher stages, but vegetation management options including the use of fire, herbicides and other measures are currently being studied for use on the floodplain. In my presentation, I'll offer further details on mapping processes, along with a discussion of the mapping results and management options for dealing with current issues.

Trends of Phosphorus Storage in Well- vs Under-performing Everglades Stormwater Treatment Wetlands

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Constructed wetlands (CW) have been applied all over the world to reduce excess phosphorus (P) from nonpoint source nutrient pollution. However, the relationship between the function of CWs and the forms and trends of soil P being stored has not been widely studied. This study seeks to better understand the relationship between P storage trends and P removal efficiency in a study of six Everglades Stormwater Treatment Area (STA) CWs representing a range of water chemistries, soil and vegetation types, and performance designations (i.e., well- vs under-performing). Accreted soil (i.e., floc and recently accreted soil layers) P fractionation data from STA-1E EFW, STA-1E CFW, STA-2 FW3, STA-2 FW4, STA-3/4 CFW, and STA-5/6 FW1 was utilized to observe trends of accreted soil P storage as a function of distance and performance. The results of this study found that well-performing flow-ways (FWs) had no consistent trend of accreted soil P storage as a function of distance but stored the majority of P in reactive (i.e., acid-extractable inorganic P) and non-reactive (i.e., residual P) P forms. Accreted soil P storage in under-performing FWs increased with distance from the inflow and stored the majority of P in highly reactive (i.e., bicarbonate-extractable inorganic and organic P, microbial biomass P) and reactive (i.e., acid-extractable organic P, alkali-extractable organic P) P forms. The results of this study point to various management strategies to improve P removal efficiency and P storage trends, such as submerged aquatic vegetation management.

Mangrove Resiliency and a Changing Coastline on Jim Foot Key, Florida Bay, Everglades National Park

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Mangroves play an imperative role in shoreline preservation in south Florida coastal ecosystems by acting as a natural buffer to storms. Because climate models predict increased temperatures, sea level rise, and increased storm intensity and frequency in the future, resource managers need to better understand how south Florida coastal areas will respond to these changes. To address this need, we are investigating mangrove and coastal resiliency on Jim Foot Key (JFK), a mangrove-ringed island in Florida Bay. Two mangrove plots have been established on JFK: Plot A, on the eastern berm (established 9/2021) and Plot B, further inland on the southeast side (established 3/2022). Each plot has a center stake and a 5 m radius. Within our monitoring plots, two mangrove species are present: red mangroves (*Rhizophora mangle*) and black mangroves (*Avicennia germinans*). In Plot A, the number of live *Avicennia* >1.4 m in height has remained stable and *Rhizophora* >1.4 m in height have increased slightly during our monitoring period of September 2021 to April 2024. In that same time frame, live *Rhizophora* saplings and seedlings (<1.4 m in height) decreased in number by 50%. Between September 2021 to March 2022, recruitment of live *Avicennia* saplings more than doubled; however, by April 2023, numbers had returned to the initial count, then declined by an additional 50% by April 2024. Because of the location of Plot A, we also measure the distance of live adult mangroves to the edge of the berm to record changes in the width of the berm. Although Plot B has been monitored for a shorter time, substantial changes have occurred. No live adult *Avicennia* are in this plot and the number of live adult *Rhizophora* increased slightly from March 2022 to April 2024. During this same period, live *Rhizophora* and *Avicennia* saplings decreased by 91% and 100% respectively. As we continue to assess growth rates, density, recruitment, and die-off of mangrove taxa over time in these designated plots, we hope to have a clearer picture of mangrove resilience on JFK. Each mangrove plot is located near a surface elevation table (SET). We have established 8 SET plots on JFK, 4 on the eastern side of the island and 4 on the southeastern corner of the island, to measure change in the surface elevation and to understand where sediment is accumulating versus eroding. Each SET plot has 3 feldspar marker horizon pads to measure sediment accretion. A time-lapse camera facing the eastern berm and Plot A is deployed in the interior of the island. It takes 3 photographs per day to observe storm impact and daily water level changes. The mangrove ecosystem in south Florida provides coastal protection, shoreline stability, carbon sequestration, and biodiversity support. As south Florida coastlines face increasing threats due to climate change, we hope to better understand impacts of storms and sea level rise on the mangrove coastal ecosystem and its resiliency using these monitoring techniques.

Examining the Phenology of Flowering, Fruiting, and Fruit Maturation in Saw Palmetto (*Serenoa repens*)

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The saw palmetto (*Serenoa repens*) is a key component of a number of habitat types throughout the southeastern United States. As a dominant fruit-bearing understory plant, it provides both cover and forage for a variety of wildlife. The fruit (a drupe) has been consumed by humans for millennia to stave off starvation and for medicinal purposes. The demand for palmetto "berry" extracts to produce commercially available herbal supplements has led to unprecedented levels of harvest of palmetto crops. Often illegally harvested, whether from private, public, or Tribal lands, the State of Florida instituted stiff penalties for the illegal harvest of and the purchase of illegally harvested berries in 2024. The Seminole Tribe of Florida has its own harvesting permit process regulating commercial harvesting by Tribal members. Despite being such an important resource for wildlife, humans, and commercial markets, not enough is known about factors that influence reproductive phenology and fruit production in wild populations from year to year. Furthermore, the south Florida climate, hydrology, and soils, are unique within the range of the species, warranting long-term examination of palmetto fruit production. We monitored stands of saw palmettos for 3 years, recording timing of flowing and fruiting, the development of fertile fruit over the summer, and the amount of mature harvestable crop. We present an examination of interannual variation in palmetto berry production over the course of the monitoring period.

Largemouth Bass and Relationships with Submersed Aquatic Vegetation

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Florida Largemouth Bass and submersed aquatic vegetation on Lake Okeechobee have strong correlations to recruitment and survival of juvenile Florida Largemouth Bass. Florida Fish and Wildlife Conservation Commission collects standardized electrofishing population data on Florida Largemouth Bass in the spring and the fall each year as part of the Long-Term Monitoring project on Lake Okeechobee. Fall Long-Term Monitoring lends insight to recruitment of Florida Largemouth Bass into the population and spring monitoring gauges the survival of juvenile Florida Largemouth Bass. Spring of 2024 produced an insignificant amount of juvenile Florida Largemouth Bass, and the fall of 2023 produced the lowest number of juvenile Florida Largemouth Bass on record. Submersed aquatic plant communities' abundance and densities have been variable throughout the lake related to multiple environmental stressors. Water regulation schedules on Lake Okeechobee impact submersed aquatic plants greatly depending on lake stage and duration of the event. The normal Lake Okeechobee Ecological Envelope defines desired lake stages to maintain lake ecology and the recover ecological envelope defines lake stages that recover lake ecology. The Ecological Envelope provides a daily point system that grades water managers performance ecologically on Lake Okeechobee. Until the submersed aquatic plant community recovers to the target acreage, Florida Largemouth Bass recruitment and survival will continue to be poor.

Spatial and Temporal Patterns in Ecosystem Responses to Management, Restoration, and Disturbance in Florida Bay

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Florida Bay is an estuary in the southern Everglades where seagrass and other submerged aquatic vegetation support high productivity. It is uniquely shallow (~1m average depth) and mudbanks throughout compartmentalize the bay into sub-basins based on circulation and physical characteristics. This morphology can prove challenging to understanding ecological conditions but also allows data from multiple long-term monitoring programs across the bay to be examined across basin, regional, and baywide spatial scales. Over time, Florida Bay has experienced numerous disturbances such as drought, large-scale seagrass die-offs (1987 and 2015), tropical cyclones, severe cold and heat, and periodic algal phytoplankton blooms.

Using data from three long-term monitoring datasets across multiple spatial scales, we examined phytoplankton trends from 2000-2024 and before and after the 2015 seagrass die-off. Baywide annual patterns in chlorophyll a (chl-a), indicative of phytoplankton, emerged with “high” or “low” clusters using K-means cluster analysis. The six years with “high” chl-a had average concentrations 2.5x greater than “low” years and followed disturbance events including cyclones, hypersalinity, and the 2015 seagrass die-off. Finer-resolution basin-level analysis revealed spatially distinct patterns in chl-a. Most basins shifted from “low” to “high” chl-a in 2006 following three hurricanes in 2005 (2-6x greater). Basins in central Florida Bay spatially coinciding with the 2015 seagrass die-off shifted to “high” chl-a in 2016. Baywide, most basins had “high” chl-a concentrations after Hurricane Irma in 2017. However, following the storm, basins with highest chl-a were those previously affected by die-off, reaching up to 60 ug/l compared to ≤30 elsewhere. Notably, greater resilience (i.e., return to a “low” chl-a state) after Irma was observed in basins that were not affected by the seagrass die-off. In the past several years, areas in the central Bay have periodically experienced elevated chl-a, indicating intermittent algal blooms. Multidimensional space-time cluster analysis revealed two spatial clusters with a higher chl-a cluster in the central bay. No temporal trend in chl-a for the two clusters was observed before the 2015 seagrass die-off, but an additional high chl-a cluster appeared after the die-off coinciding with the spatial extent of the affected area. Together, these findings underscore the influence of the 2015 seagrass die-off in long-term spatial and temporal bay ecology.

USACE Project Integration in Southeast Florida

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The complex nature of resilience challenges faced by communities in Southeast Florida and the way the U. S. Army Corps of Engineers (USACE) Civil Works support building long term resilience, which requires the involvement of multiple USACE missions. Projects focused on Aquatic Ecosystem Restoration (AER), Coastal Storm Risk Management (CSRM), Flood Risk Management (FRM), Navigation (NAV) and Continuing Authority Program (CAP) are ongoing within the region. Due to the complexity of these projects, with different missions, in various phases of implementation, integration of USACE projects is needed to ensure that the projects planning objectives across multiple these multiple missions are met. This poster presents on an overview of the USACE Civil Works phases of project development including the Feasibility, Preconstruction Engineering and Design, Construction, and Operation and Maintenance (O&M) and how integration is being approached. The USACE integration effort focuses on collaboration through active and frequent communication with stakeholders, sponsors, project team leads, other federal agencies, local governments, and Tribes; technical coordination with multidisciplinary teams; and coordination with USACE policy advisors to identify and assess impacts, risk, constraints, connections, dependencies, timing, sequencing, future changing conditions including climate and sea level change, and benefits of the existing and future projects in the area.

Phosphorus in Big Cypress National Preserve – Data Synthesis from the 2023 Regional Environmental Monitoring and Assessment Program Sampling

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Eastern Big Cypress National Preserve (BICY) is within the U.S. Army Corps of Engineers' Western Everglades Restoration Project (WERP) boundary. This Project aims to deliver new water into BICY through Mullet Slough and improve hydrology and water quality for areas within the WERP footprint. In October 2023, the U.S. Environmental Protection Agency completed a multimedia (i.e., surface water, sediment, macrophyte, and periphyton) sampling campaign within the WERP boundary. Samples were analyzed for chemical and physical properties providing a synoptic picture of the ecosystem status. Here, we evaluate the spatial sampling results with a focus on total phosphorus (TP). Across the sample domain, median and interquartile ranges were as follows: surface water TP 12 and 5 mg L^{-1}; surface water conductivity 300 and 60 mS cm^{-1}; surface water chloride 11 and 6 mg L^{-1}; water depth 1.30 and 1.23 ft; and sediment TP 237 and 278 mg kg^{-1}. Thirty-one percent of the sampled area had TP concentrations ≤10 mg L^{-1} (Everglades long-term TP protective standard). Surface water TP concentrations had a strong correlation with latitude, declining on a north to south gradient through the Preserve (Spearman's r = 0.81, $p < 0.05$). Spatially, sediment (0 - 10 cm) TP concentrations were consistent. Water depth (r = -0.35, $p < 0.05$) and chloride (r = -0.36, $p < 0.05$) had weak negative correlations with latitude. Cluster analysis (eclust R package; hclust function with Kendall dissimilarity determination) using surface water TP, conductivity, chloride, water depth, and sediment TP resulted in four clusters. Cluster 1 was generally indicative of lower conductivity and chloride and deeper water. Cluster 2 had lower median water depths and higher surface water TP, while Cluster 3 had higher chloride and lower surface water TP. Cluster 4 was near the median for each parameter. Most BICY Mullet Slough stations were part of Clusters 2 and 3. Higher TP concentrations in surface water were generally observed in the northern portion of the Slough, just downstream of farming activity or adjacent to the L28I canal. Where waters were deeper in the Slough and throughout BICY, TP levels tended to be lower, with deeper waters and lowest TP concentrations observed in the southernmost reach where Cluster 4 stations concentrated. For new water delivered to BICY, where TP concentrations are presently highest, WERP is dependent on additional Florida State efforts to implement phosphorus load reduction measures in the watershed to protect downstream ecosystems. The data provided in this synoptic survey will be useful in assessing WERP effects, especially in sensitive areas of BICY like Mullet Slough.

Biscayne Bay Reasonable Assurance Plan: The Path to Restoring Water Quality and Habitat

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As of the 2022-2024 biennial water quality assessment performed by the Florida Department of Environmental Protection (DEP) to confirm attainment of water quality standards, two-thirds of Biscayne Bay's waterbody segments were designated impaired for nutrients and/or chlorophyll-a. The State of Florida is delegated the authority to implement the federal Clean Water Act and biennial assessments are conducted to evaluate attainment of state water quality standards. The state then establishes whether or not a waterbody is impaired or requires additional study for a determination. Once designated impaired, the state is required to develop a Total Maximum Daily Load allocation and a Basin Management Action Plan to enact load reductions. However, there is an alternative to this state-driven plan which is referred to as a Reasonable Assurance Plan or colloquially as a "RAP". Development of a RAP is stakeholder driven. Miami-Dade County, through the support of the Mayor, Biscayne Bay Watershed Management Advisory Board, and Board of County Commissioners, has endeavored to collaborate with stakeholders as well as fund the necessary technical components required to develop an approvable RAP. The RAP will focus on nutrient reduction as a path to significantly improve Biscayne Bay water quality and habitat and will describe both existing conditions that resulted in the impairment as well as conditions required to meet Biscayne Bay's applicable nutrient criteria. To meet the RAP goal of providing allocations to individual entities that are nutrient sources to Biscayne Bay, assignment of estimated nutrient nitrogen and phosphorus loadings to these entities, will be required. Loadings from non-point nutrient sources will also be assigned. The RAP will include a delineation of the Bay's watershed, a current list of water quality impairments, identification of the causes of the impairments, estimation of existing pollutant loads, and derivation of water quality and ecological targets representing healthier conditions. In addition to defining the pollutant load reduction necessary to attain healthy conditions, the RAP will identify projects needed to reduce or maintain loads and estimate the technical and financial resources needed to implement the projects. The RAP will also describe stakeholder outreach efforts and provide a detailed monitoring program to evaluate restoration progress and plan effectiveness. Approved RAPs are adopted by Final Order of the DEP Secretary and must provide "reasonable assurance" that the proposed pollution control mechanisms will effectively address the documented impairment. The development of the Biscayne Bay RAP will require surface and groundwater modeling, pollutant loading model estimates, a project prioritization matrix, and peer review of model outputs.

Zooplankton Monitoring in Lake Okeechobee's Pelagic Zone

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Planktonic organisms are the base of the pelagic trophic web in Lake Okeechobee. Phytoplankton function as the ecosystem's primary producers, and zooplankton serve as both a regulator of phytoplankton dynamics and an energy link between phytoplankton and higher trophic levels, such as macroinvertebrates and planktivorous fish. Presented here are two years of zooplankton data collected from the open-water habitats of Lake Okeechobee. These data examined how the lake's zooplankton communities vary both spatially and temporally. We also investigated how other measured variables, such as nutrient and phytoplankton parameters, relate to zooplankton trends and communities, placing results into the context of water quality and trophic ecology. Results showed that, while different groups of zooplankton reacted differently, as a whole, zooplankton in Lake Okeechobee increased through the spring and declined through the summer. Additionally, sites in deeper areas of the lake had more similar zooplankton communities than shallow areas. Microzooplankton were found to dominate total zooplankton abundances while macrozooplankton had a heavier influence on total zooplankton biomass. Finally, this project found that the relationship between planktonic communities was driven more by changes in phytoplankton than zooplankton, suggesting base-level trophic forces could be affecting this energy linkage and its efficiency more than zooplankton grazing, consistent with earlier studies. This monitoring effort will continue to provide essential information on the lowest trophic levels of the ecosystem, furthering scientists' understanding of lake ecology and whether the new Lake Okeechobee System Operating Manual will affect these communities. The information gleaned from this project may help inform adaptive management decisions for operations in Lake Okeechobee and the South Florida Environment.

Comparing Carbon Stocks and the Physical Environment of Created and Natural South Florida Mangrove Forests

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Interest in mangrove restoration has increased with the growing recognition of the importance of mangrove ecosystem services, including carbon sequestration. However, the long-term functionality of these created estuarine habitats is rarely assessed. This study examines above and belowground carbon stocks at natural and decades-old, restored mangrove forests in central and south Florida. The restored mangrove forests, created between 1982 and 2004, were compared with adjacent natural mangrove forests. The calculated aboveground biomass and carbon stocks were compared to elevation, water level, and water quality data to identify aspects that potentially impact carbon sequestration and its functional ecology. Mangrove restoration sites created more than 30 years ago contained aboveground carbon stocks similar to natural mangrove forests, while the 19-year-old site had younger mangroves and significantly lower aboveground carbon stocks. Restored sites in South Florida (Naples and Rookery Bay) had significantly higher carbon stocks than Central Florida (Tampa Bay). Peat was found to extend to greater depths in South Florida, in the natural forests, and in older restoration sites compared to the younger sites. Water level data indicates highly variable inundation frequency, and South Florida water levels were notably influenced by channelized freshwater flow. Future work will include further comparison of environmental variables with carbon stocks and soil accretion rates.

Assess for Success: Science Supporting CERP Restoration in Lake Okeechobee and the Northern Estuaries

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REstoration, COordination, and VERification (RECOVER) is an interdisciplinary collaboration of agencies, tribes, and institutions that conducts scientific and technical evaluations and assessments to improve the ability of the Comprehensive Everglades Restoration Plan (CERP) to restore, preserve, and protect the south Florida ecosystem while providing for the region's other water-related needs. RECOVER has a two-step process to track progress towards goals: assessment (observed monitoring criteria) and evaluation (predictive modeling criteria). RECOVER's Monitoring & Assessment Plan (MAP) includes a suite of ecological indicators that are monitored to determine realized benefits of constructed CERP projects, known as RECOVER assessment. The 2024 System Status Report (SSR) assessed the status of ecological indicators between different time periods, to determine progress toward expected restoration goals based on CERP project implementation. Stepwise targets are defined in RECOVER's Interim Goals and Interim Targets (IGIT) 2020 report, in which numeric models of indicator metrics are used to predict expected restoration responses to improved hydrology, known as RECOVER evaluation. The IGIT report provided results from modeling various CERP futures of incremental project implementation for 2026 and 2032. For the 2024 SSR, assessments of MAP data were compared to evaluations of 2026 Interim Goals (IGs), and system-wide, RECOVER identified areas in which assessment and evaluation criteria differ. For the Lake Okeechobee (LO) and Northern Estuaries (NE) regional modules, all ecological indicators have an evaluation-assessment disconnect. Both regional modules lack modeling tools for evaluating responses of submerged aquatic vegetation (SAV) to expected hydrological change, thus no evaluation criteria currently exist. In other cases, monitoring assessment criteria and modeled evaluation criteria may share metrics but are not yet fully aligned. For example, NE IGs for eastern oysters utilize acreage of suitable habitat, whereas monitoring collects organismal and population-level metrics of oyster health, in addition to acoustic mapping. Currently, the only evaluation-assessment linkage available for this indicator is modeled acreage of suitable habitat compared to acoustic mapping of existing oyster reef acreage, but since these criteria differ in categorization of oyster habitat direct comparisons are difficult. To help bolster the evaluation potential of both modules, RECOVER is reexamining desired restoration conditions of ecological indicators, exploring ways to leverage years of monitoring data, and identifying information and skillsets needed to develop predictive models. These efforts will help bridge the gap between RECOVER assessment and evaluation, allowing the LO and NE regions to better track restoration progress, improving their ability to report in future SSRs, and fulfill RECOVER's mission to support the goals and objectives of CERP.

Effects of Salinity on Methylmercury Production and Microbial Community Composition in Everglades Coastal Mangroves

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The delivery of mercury (Hg) via precipitation to the Everglades has been persistent over decades and is a concern to the region due to biogeochemical transformations Hg undergoes after deposition to aquatic environments. Once deposited, microorganisms carrying the hgcAB gene pair mediate the transformation of inorganic Hg(II) to neurotoxic methylmercury (MeHg), which enables rapid bioaccumulation and biomagnification in the food web. MeHg formation in the Everglades is characterized by several key biogeochemical factors, including (1) dissolved organic carbon (DOC), which influences Hg transport and bioavailability, (2) sulfate (SO_4^{2-}), which can stimulate SO_4^{2-} reducing bacteria and shift overall microbial structures, and (3) redox conditions in sediments, which regulate the activity of anaerobic microorganisms. While these biogeochemical controls on MeHg formation are well-characterized for freshwater regions, sea-level rise poses an additional risk to coastal wetlands in Everglades National Park (ENP) by altering aqueous geochemistry and microbial communities that impact Hg cycling. We hypothesize that inundation of coastal mangrove soils will create hotspots of MeHg formation at oligohaline salinity regimes (0.5 – 5 parts per thousand (ppt)) due to the stimulation of SO_4^{2-} reducing bacteria from marine SO_4^{2-} inputs and syntrophy between microorganisms. To test this hypothesis, we sampled surface water, porewater, and sediments biannually across a transect of the Shark River in ENP that spans freshwater to tidally influenced regions. Salinity measurements quantified the extent of marine water influence along the transect, ranging from freshwater (< 0.5 ppt) to marine (> 18 ppt). Measurements of sulfide, DOC, inorganic anions, and MeHg concentrations were used to evaluate the salinity impacts on Hg distribution and speciation. To examine salinity effects on microbial communities, shotgun metagenomic sequencing was conducted on DNA extracted from sediments across the transect. Preliminary results show increases in porewater sulfide concentrations in the oligohaline salinity zone (17.5 ± 7.8 mg/L), indicative of active SO_4^{2-} reduction from marine SO_4^{2-} inputs. Porewater in the sulfidic region also contained moderately elevated concentrations of aromatic DOC compared to freshwater regions, suggesting higher Hg(II) bioavailability for methylation. Similarly, MeHg concentrations were low in freshwater conditions (0.09 ± 0.09 ng/L), increased to a maximum at the oligohaline region (0.40 ± 0.14 ng/L), then declined at locations with higher salinities (0.11 ± 0.25 ng/L). Assembled metagenomes will be used in combination with water chemistry and hydrologic data to examine the abundance and metabolic capabilities of hgcAB-carrying microorganisms and identify the dominant microbial metabolic pathways contributing to MeHg formation across salinity gradients and hydrologic conditions.

Incorporating Climate Change Scenarios and Interactive Stressors into a Seagrass Model for Florida Bay

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Multiple stressors will define how seagrasses will respond to climate change. Florida Bay seagrasses will simultaneously respond to climate change and Everglades Restoration activities increasing freshwater flow to the bay. We modified a well-established seagrass ecosystem model (SEACOM) that has been applied to management of seagrasses in Florida Bay to examine responses to multiple stressors under various scenarios of climate change. Specifically, we incorporate the relationship between multiple stressors related to climate change drivers (temperature, sea level rise, salinity, precipitation) that lead to low internal tissue oxygen and facilitates sulfide intrusion, the dominant factor thought to cause large-scale seagrass mortality events in Florida Bay. Stressors were modified using sensitivity analysis to examine seagrass response to single versus multiple interactive stressors. Sensitivity analyses were conducted under optimal conditions and climate IPCC 8.5 worst-case scenario. The model is being run for the dominant habitat-forming tropical species in Florida Bay, *Thalassia testudinum,* to examine the frequency of mortality events and above ground biomass under the two climate scenarios of 2060 and 2100.

Investigating Mercury Bioaccumulation and Risk in Invasive Reptiles in the Florida Everglades

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Mercury (Hg) bioaccumulation is a persistent threat in the Florida Everglades, and elevated Hg concentrations have been observed in both native and invasive species. While numerous studies have focused on fish and avian Hg exposure, relatively little is known about Hg contamination for reptiles as it pertains to spatial variation, dietary controls, and internal detoxification mechanisms. While snakes and reptiles have been proposed as bioindicators of Hg risk for other protected or more difficult to collect species, we have been unable to assess their utility in the Everglades due to the pre-existing data gaps. In this study, we examined Hg concentrations in comparison to dietary tracers (carbon and nitrogen isotopes), capture location, and body condition within two invasive reptiles, Black and White tegus (*Salvator merianae*) and juvenile Burmese pythons (*Python bivittatus*) from data collected by USGS between 2022 and 2024. Mercury concentrations in muscle tissues of tegus ranged from 4.1 to 1200 ng g^{-1} while juvenile pythons ranged from 3.0 to 2400 ng g^{-1}. These ranges are highly variable but, on average, notably lower than Hg measurements in adult pythons and other native species, such as alligators (640 ng g^{-1}). Additional matrices such as livers and blood were measured for both tegus (n = 29) and pythons (n = 36) to examine internal Hg detoxification. For tegus, it was observed that liver tissues (182 ± 224 ng g^{-1}) were substantially higher than paired muscle tissues (50 ± 81 ng g^{-1}) indicating the ability to detoxify Hg, and that females have higher Hg concentrations in their livers compared to males or undetermined sex (primarily sexually immature juveniles). Spatial analysis of tegu data also identified a gradient of concentrations based on capture location. No correlations were observed between carbon and nitrogen isotope values, respective proxies of dietary carbon sources and approximate trophic level, and total Hg concentrations. Overall, these results show that tegus exhibit spatial patterns in bioaccumulation and the ability to detoxify Hg, which makes them potential bioindicators to explore Hg risk in reptiles in the future. In contrast, juvenile python Hg content could not be tied to nesting location or other body metrics. Juvenile pythons did not show significant differences between average liver and muscle tissue concentrations, however juveniles with higher Hg concentrations in muscle were associated with higher blood concentrations in the muscle tissue of the mother. This suggests that maternal transfer is the controlling factor on Hg burdens in juvenile Burmese pythons. These observations for juvenile pythons make it difficult to resolve potential factors impacting bioaccumulation within adult pythons as well as other species. Follow-up work will expand upon spatial comparisons and internal cycling dynamics for Hg in both species to further inform factors driving bioaccumulation in reptiles from the Florida Everglades.

Effects of Stage Ascension and Recession on Dissolved Oxygen Concentrations in the Kissimmee River and its Floodplain

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Understanding the connections between river channel dynamics and ecological parameters is not only a key to restoration efforts, but also to watershed management. Dissolved oxygen concentrations (DO) in the Kissimmee River are most likely to drop to anoxic levels during high flow, floodplain-inundating events that occur in the wet season. The combined action of the S-65A (inflow) and S-65D (outflow) structures controls the ascension and recession of river stage, which in turn affects river channel and floodplain water depths, floodplain inundation, and flow velocity. Ascension and recession rates during high flow events are found to correlate with DO rates of change. Increased river depth can limit photosynthesis and exposes higher sections of the riverbank to water flow, causing erosion and suspension of organic particles. Loose organic matter from floodplain inundation may be released, and as river flow is increased, suspended sediment transport may also increase. Our investigations suggest the end results are stimulated aquatic respiration and corresponding reductions in DO.

Evaluating Population Dynamics of the Everglades Crayfish Within Marl Prairies of Big Cypress National Preserve

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The Everglades crayfish (*Procambarus alleni*) is an annual burrowing crayfish species that occupies seasonally flooded marl prairie habitats and that is an important prey item for nesting White Ibis (*Eudocimus albus*) in the southern Everglades. Everglades crayfish construct burrows in the sediments in the dry season when the water recedes belowground, but the mechanisms by which water depth variation produces high densities aboveground are not well studied because most aquatic animal monitoring has focused on prey production in longer hydroperiod sloughs. Therefore, it is critical to identify the hydrologic conditions in marl prairie habitats that maximize Everglades crayfish population sizes and aboveground biomasses. Drainage in the 20th century resulted in wetlands with shortened hydroperiods, but *P. alleni* lives in temporary wetlands, making the concept of hydrologic stress unclear when applied to their populations. Hydrologic stress limiting population size might be substantiated by lower biomasses when all sites are flooded, reduced emergence rates from burrows or slower growth rates in shorter hydroperiod wetlands. To look for patterns that could indicate with population limitation by hydrologic stress we selected six sites near Loop Road in BCNP across a hydroperiod gradient with three short hydroperiod sites (average 3-5 mo.) and three medium hydroperiod sites (7-9 mo.). At each site we quantified *P. alleni* aboveground density, biomass and size structure, with replicated 1-m^2 throw traps up to three seasons per year (2022-2024) whenever water depths were > 5 cm. To address any potential differences in wetland suitability for individual growth we conducted an *in-situ* enclosure experiment to quantify the summer growth rates of juvenile crayfish (8-9 mm carapace length) at each site. Results from the throw-trap sampling indicated that populations at all sites were juvenile-dominated with the highest densities of small juveniles timed to the summer re-flooding of the marsh surface. Dry conditions forced crayfish belowground (0 aboveground biomass) in 4 of our seven sample seasons at the short hydroperiod sites, respectively. Medium hydroperiod sites had significantly more aboveground biomass than short hydroperiod sites in July of 2023 ($p = 0.01$) when two of the short hydroperiod sites were dry, but not in October 2023 or July 2024 when all sites were flooded ($p > 0.1$). Results from the *in-situ* experiment indicated no significant differences among sites in juvenile crayfish growth ($p = 0.12$). *Procambarus alleni* populations are capable of persisting in temporary wetlands with hydroperiods as short as 3 months and we have little evidence, thus far, for population limitation by hydrologic stress (i.e., hydroperiods < 7 months). Nevertheless, wetland hydroperiods will determine whether crayfish biomass is available (aboveground) for foraging wading birds in the spring.

A Closer Look at Native Apple Snail Hydrology in Water Conservation Area 3A

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The hydrology of Water Conservation Area 3A (WCA3A) is critical to its role in providing optimal water levels in different seasons to a range of flora and fauna. One of the more hydrologically sensitive animals in this water storage area is the native Apple Snail, *Pomacea paludosa*. Due to its short life span and single major reproductive effort per year, the native Apple Snail requires a very specific range of water depths to produce a strong cohort the following year. In 2010, the USFWS produced a Multi-Species Transition Strategy (MSTS) report for WCA3A that cited recommendations (P. Darby) for seasonal water depths and recession rates during the native Apple Snail's breeding season that would be most likely to result in adequate snail populations and, thus, adequate prey availability for the federally endangered Snail Kite during the succeeding year(s). In this paper, we compare snail population density data collected by Darby (1995 to 2016) and the Avian Research and Conservation Institute (ARCI) (2017-2024) with hydrograph depth data collected at WCA3A's most relevant staff gauges by historic sources and the more recent Everglades Depth Estimation Network (EDEN) from 1995 to 2023. We also compare snail density and hydrologic data for WCA3A with Snail Kite nesting effort and success in WCA3A for those years in which the UF Snail Kite research team has reported such data. Our results provide guidance needed by water managers to achieve the best balance of hydrologic conditions in WCA3A for Apple Snails and Snail Kites.

Investigating Adaptive Capacity to Climate-Related Shocks and Stressors in Southeast Florida

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Southeast Florida environments are exposed to multiple types of climate-related shocks and stressors. In coastal wetlands, a unique combination of environmental conditions, including subtropical wet-dry season extremes, periodic salt exposure, occasional extreme temperatures, and an underlying rapid change in climate (e.g. sea-level rise, SLR) and disturbance (e.g., coastal storms) regimes regulate biological structure and function. Wetland plant species have important foundational roles in maintaining and enhancing ecosystem resilience to disturbance by stabilizing and building soil and retaining nutrients. In our experimental work on coastal peat marshes in the Everglades, we have found that increased salinity reduces plant productivity, and availability of the limiting nutrient, phosphorus, offsets the stressful impacts of salinity on a moderately salt-tolerant freshwater species, sawgrass (*Cladium jamaicense*). Our long-term monitoring data have also shown that sawgrass can persist in continuously saline conditions at higher marsh elevations. In urban environments, we also strive to improve adaptive capacity to flooding in low-lying areas while protecting and improving water quality and human well-being. New collaborative, interdisciplinary studies will seek to identify flood adaptation strategies that promote flood risk reduction and improve water quality and natural habitat.

In order for Southeast Florida natural and urban environments to adapt to the impacts of climate-related shocks and stressors of increasing frequency and severity, more holistic approaches are needed. Adaptive capacity is an informative tool for promoting more resilient trajectories across natural and human systems. For instance, in coastal wetlands, marsh and mangrove species must maintain productivity levels that enable the rate of soil elevation change to increase at a greater rate than SL (e.g., wetland adaptive capacity). Thus, we are exploring dynamics in vegetation and geomorphic gradients to test the overarching hypothesis that productivity and sediment availability modulate adaptive capacity in Everglades coastal marshes and urban mangroves. New experimental work will investigate phosphorus availability and sediment elevation as drivers of adaptive capacity in a marl-forming coastal marsh. To enhance adaptive capacity in urban environments, new work aims to identify nature-based solutions that can be evaluated and integrated for flood protection and wildlife habitat benefits together with a diverse set of stakeholders to improve coastal watershed resilience planning and resilience outcomes in Miami-Dade County. Enhancing the adaptive capacity of both natural and urban environments to climate-related shocks and stressors can promote more integrated regional strategies with multiple benefits across Southeast Florida.

Post-restoration Monitoring of the Picayune Strand Restoration Project

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The Picayune Strand Restoration Project (PSRP) encompasses an area of sensitive natural land in southwestern Collier County, Florida and is part of the Comprehensive Everglades Restoration Plan. PSRP is located southwest of Florida Panther National Wildlife Refuge, north of Ten Thousand Islands National Wildlife Refuge, east of the South Belle Meade State Conservation and Recreation Lands project, west of Fakahatchee Strand Preserve State Park, and northeast of Collier-Seminole State Park. The central location of the project among established wildlife areas and nature preserves echoes its importance to ecosystem connectivity of the entire region. The 55,000-acre restoration project will restore close to a total of 100,000 acres, including adjacent and downstream state and federal conservation lands. This will reestablish hydrologic and fire regimes, plant communities, and wildlife habitats in a critical area of the Greater Everglades. Pre-restoration monitoring data collected in the mid-2000s provides a basis for documenting changes occurring post-restoration from PSRP implementation. Ecological monitoring of the project plays a key role in measuring changes in ecological conditions, assessing the effectiveness of restoration efforts, and long-term sustainability. Performance metrics and targets have been developed for plant communities, aquatic fauna, and hydrology, to ensure restored hydrological conditions align with restoration goals. Post-project monitoring includes additional fish and wildlife, e.g., West Indian manatee, Florida panther and their prey, wood storks and wading birds, and estuarine oysters and benthic substrate. Monitoring data will be utilized to determine if the anticipated hydrologic, vegetative, wildlife, and estuarine benefits of the project are being achieved as a result of project implementation and to support the adaptive management process.

Water Quality in the Peace River Watershed: An Analysis of Current Conditions and Mitigation Strategies

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The Peace River Watershed (PRW), encompassing 2,350 square miles in southwest Florida, provides a critical source of water supply, agriculture, phosphate mining, and recreation while sustaining vital ecosystem services for the community. The PRW drains to Charlotte Harbor and its excess nutrient load threatens the harbor's ecosystem, fueling harmful algae blooms and red tides. Evaluating water quality and implementing targeted mitigation measures are critical to protecting these freshwater resources.

The study employed the Watershed Assessment Model (WAM) to evaluate the nutrient loading and potential mitigation measures within the PRW. The WAM model leverages ArcGIS for spatial inputs of land use, soil type, rain, and wastewater utility zones to create unique cells for detailed simulations. Daily loads and flows from unique cells were generated based on field-scale sub-models tailored to well-drained and high-water table soils, wetlands, and mining areas. The predicted daily outputs from each cell were routed to receiving water bodies using an overland routing model in WAM. Estimated daily flows and nutrient concentrations were calibrated and validated using data from USGS and FDEP. The current condition hotspots simulated by WAM were identified using multi-criteria spatial analysis. To improve the water quality abatement strategies, seven scenarios targeted urban, agricultural and septic land uses were simulated using WAM.

Results showed an annual average discharge of 1.88 cubic kilometers of water to Charlotte Harbor, along with 2,303 tons of nitrogen (N) and 981 tons of phosphorus (P). Spatially, annual N and P loads varied considerably, ranging from near zero to 103 and 34 pounds per acre, respectively. Elevated N levels were observed in agricultural areas (farmlands, nurseries, citrus groves) that lacked best management practices (BMPs) and in urban areas reliant on septic systems. Elevated P loads were estimated in reclaimed phosphate mining lands and agricultural regions with intensive fertilization practices (nurseries, row crops). Scenario simulations indicated that enrolling all agricultural land in BMPs would result in about a 10% reduction in total nitrogen (TN) and a 13% reduction in total phosphorus (TP) entering the harbor. Implementing fertility and retention BMPs in urban areas reduced TN by 19% and TP by 20%, while converting septic systems to sewer with external treatment reduced TN by 26%. Furthermore, targeting areas with the highest nutrient loads (the upper 95th percentile) for N, the limiting nutrient in the watershed, resulted in load reductions of 4%, 3.1%, and 7.7% for priority agricultural areas, priority urban BMPs, and priority septic-to-sewer conversions, respectively. The model and scenario-based hotspot analysis provide a cost-effective way to assess water quality mitigation measures, helping water engineers and stakeholders make proactive decisions for watershed development.

Lake Guard Oxy Treatments for Cyanobacterial Blooms at a Lake Okeechobee Outflow Structure

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Lake Okeechobee is the largest inland lake in Florida and serves as a critical hub connecting the St. Lucie River to the East and the Caloosahatchee River to the West. These warm tropical/subtropical waters undergo harmful algal blooms (HAB), and cyanobacterial biomass could flow populated downstream areas via canals. *Microcystis aeruginosa* is the most frequent and persistent toxic cyanobacterium, and the mitigation of this species has become a greater focus for water managers of the region over the last several years. To address this issue, the South Florida Water Management District (SFWMD) developed the 2022 Blue Green Algae Monitoring, Mitigation and Control Plan (BGA MMCP), which involves preventative and targeted treatments using Lake Guard® Oxy, a U.S. EPA-approved and certified algaecide that contains sodium percarbonate, which releases hydrogen peroxide when it comes into contact with water. While Lake Guard® Oxy has demonstrated efficacy in stagnant systems like marinas and small lakes, its performance in flowing waters remains largely underexplored. Short-term mesocosm and field studies along the C-43 Canal (Caloosahatchee River) conducted by Florida Gulf Coast University suggest that higher concentrations of Lake Guard® Oxy may be required to effectively treat cyanobacterial scums and water column communities in flowing systems. Therefore, evaluating treatment efficacy at outflow structures and canals is crucial for the SFWMD and the U.S. Army Corps of Engineers to prevent cyanobacterial HAB. This study should help both agencies to further optimize HAB treatments and operations at major Lake Okeechobee outflow structures. This project will generate important data regarding the efficacy of Lake Guard® Oxy algaecide treatments, which will guide future use of this technology in Florida and among interested parties in other aquatic systems nationwide. We hypothesize that we need a higher concentration of Lake Guard® Oxy when it is applied for canals than the regular applications. Monitoring hydrogen peroxide concentrations post-treatment will provide insights into its effectiveness. The results from this project could be used in modeling efforts that aid in future decision-making regarding treatments. These results may be applicable to various water resource development projects or federally constructed reservoirs, facilitating the scaling up of treatments in future applications. In this presentation, we will discuss the background, progress, and preliminary results of this ongoing project.

Role of Vegetation on Local Water Column Phosphorus Dynamics in the Everglades STAs

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The Stormwater Treatment Area (STA) wetlands south of Lake Okeechobee were constructed to remove total phosphorus (TP) from runoff prior to discharge to the Everglades Protection Area. The STAs are comprised of flow-ways divided by interior levees which are often a combination of cells in series. The ability of these wetlands to achieve low TP concentrations at the outflows is influenced by many factors including treatment area size, phosphorus (P) loading rates, inflow concentration, and vegetation condition. It can be difficult to distinguish which of these factors affects a given flow-way based on inflow-outflow monitoring data alone. Internal monitoring of water quality coupled with vegetation surveys can provide more detailed information on the variation of STA performance and support remediation measures. Recently within a larger study that used this coupled monitoring and survey approach, two case studies highlighted the interactions between vegetation and water quality in the STAs. In the first case study, sampling events were conducted before and after an extensive loss of submerged aquatic vegetation (SAV) in the outflow region of STA-2 Flow-way 3. TP removal performance was much lower after the loss of SAV. In the second case study, in STA-1E Eastern Flow-way, a region of dense SAV on the east side of the outflow cell produced much lower water column TP concentrations than an area of lower vegetation coverage on the west side of the cell during a high-flow event. By contrast, the outflow concentrations were similar in both regions during a lower-flow event. Based on the results from these two events in STA-1E Eastern Flow-way, the effects of vegetation density on outflow TP concentrations during flowing conditions are important under high flow scenarios. These case studies support the hypothesis that SAV density is important for water column TP removal in the STAs. The 24 coupled internal water quality and vegetation survey events conducted during the larger study collectively found that TP removal patterns during flowing conditions were largely related to patterns of vegetation-driven removal of soluble reactive P. Additionally, during periods of no-flow conditions, particulate P accumulation was lower in vegetated regions. It is well-known that aquatic vegetation provides many of the processes and conditions for nutrient removal in treatment wetlands, but the observations from this study 1) support the critical role of vegetation for P removal, 2) illustrate the value of vegetation monitoring to diagnose changes in P treatment performance and 3) illuminate several potential mechanisms by which vegetation influences water column P concentrations, speciation, and overall STA P removal performance.

A Symphony of Sound: Examining Ecological Resilience in the Picayune Strand Using Bioacoustics

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The growing environmental threats stemming from climate change place increased strain on the Greater Everglades Ecosystems and the biodiversity found within. Severe deviations in the frequency and intensity of wildfires and hurricanes outside of historical norms challenges the resilience of the Everglades as a system. To better protect these systems and inform future management, it is crucial to develop methods and metrics that can rapidly observe species responses to these disturbance events. The Acoustic Monitoring Project (AMP) involves filling a critical gap in resilience research by using bioacoustics to measure wildlife activity in response to fires, droughts, and hurricanes in the Picayune Strand Restoration Project (PSRP). AMP's objectives are to (1) establish a database and baseline of wildlife community sounds in the Picayune Strand, (2) investigate differences in soundscapes between habitats varying in restoration progress, and (3) discern the resilience of the wildlife community using the recovery time of biophonic activity. This study uses continuous, high-resolution audio sampling stations to record biophonic communities before, during, and after natural disturbance events. Eight stations are currently installed in the Picayune Strand across restored and unrestored habitats. Baseline biophonic activity was established in May of 2024 and has continuously documented wildlife sound recovery from wildfire, the wet to dry season shift, and the 2024 Atlantic hurricane season. Initial results suggest discernable differences in soundscapes across sites affected by disturbances, primarily driven by frog and insect communities. Results also indicate an increase in biophonic activity in parallel with the wet season shift. This study is ongoing and will deploy audio recording stations in the Florida Panther National Wildlife Refuge to compare Picayune Strand soundscapes to historical reference areas. This project is on the cutting-edge of resilience science and may be extremely informative for questions surrounding the adaptability of the Everglades to future stress.

Seagrass Changes Associated with Long-Term Algae Blooms in Biscayne Bay

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Initiated in 1985 with 10 fixed survey transects, the Miami-Dade County Benthic Habitat Monitoring Program (BBBHMP), expanded when 101 stratified random stations were added in 1999 covering Biscayne Bay from the Rickenbacker Basin to Little Card Sound. Additionally, twelve stations covering the north area of Barnes Sound were incorporated in 2018 and another area in Manatee Bay and Barnes Sound, previously monitored in partnership with the South Florida Water Management District, added 24 stations to this monitoring program in 2020. Increases in macroalgae blooms and seagrass die-off events impacting benthic habitats led to additional expansions through annual assessments. Currently, more than 400 stations are assessed by Braun Blanquet Cover Abundance and Percent Cover methods through these three monitoring levels (fixed transects, stratified random stations, and special assessments) across the Biscayne Bay area on an annual basis.

The BBBHMP has identified three areas, almost 100 km^2 combined, as impacted by multi-year macroalgae and phytoplankton blooms. Between 2005 and 2009, after the impacts of three hurricanes and an ecosystem disturbance associated with US1 road construction, the southern area of Manatee Bay and Barnes Sound experienced a phytoplankton bloom which caused a nearly a 50% decrease in seagrass coverage. Record elevated salinities in 2015 and 2016 followed by another hurricane event in 2017 further impacted this area, with additional seagrass declines and a shift to a green macroalgae dominated habitat by 2020. Secondly, two multi-year macroalgae blooms with different dynamics and development commenced around 2004 and 2018 in Central and North Bay, respectively. Each resulted in shifts of the benthic communities' structure from seagrass to macroalgae. In the north central inshore area of Biscayne Bay, the *Anadyomene* bloom, caused a nearly 75% of *Thalassia* loss over a 10-year period by overgrowing the seagrass canopy. Following the bloom recession in 2016, seagrass coverage remained low while species of the genera *Digenea*, *Laurencia,* and *Halimeda* increased their presence and coverage in the area. A resurgence of *Anadyomene* spp. initiated in 2020 has contributed to steadily increased green macroalgae coverage back to bloom levels. Thirdly, in North Bay, seagrass declines became apparent around 2013 and peaked in 2016-2017 resulting in a die-off event affecting nearly 90% of the seagrass beds in the area followed by a rapid colonization of green algae of the *Halimeda* genera. This algae complex has maintained nearly 30% annual coverage across the area since 2018, while other green algae -primarily *Caulerpa* spp.- have recently increased in abundance and to date appear to be persisting. Seagrass has steadily recovered from an overall coverage value of 4% in 2018 to nearly 26% in 2023, particularly in the Julia Tuttle basin, where *Syringodium* became dominant again in 2023, demonstrating natural recruitment success.

Tree Island Structure and Composition in Water Conservation Area 3

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The disruption of the Everglades' natural hydrology has led to the degradation of many components of Everglades ecology, including tree islands. Tree islands are a major ecological feature across the Everglades landscape that act as biodiversity hotspots, providing scarce terrestrial and semi-terrestrial habitat during seasonal high-water conditions. The loss of tree islands, both in number and areal coverage, within the Everglades Water Conservation Areas (WCAs) has been largely attributed to water management-related high-water levels. In response, the Central Everglades Planning Project (CEPP) was developed to restore hydrologic connectivity between the WCAs and alleviate deep water conditions in the wet season. These hydrologic restoration efforts are expected to improve conditions for the tree islands, but negative impacts from changes in water level are also possible. Therefore, a critical component of CEPP is evaluating how the hydrologic restoration efforts will impact the vegetative communities of the Everglades tree islands. The Tree Island Assessment project is part of a long-term effort to support tree island restoration as part of CEPP. The objective of this project is to establish baseline conditions of the forest structure on tree islands in WCA-3 and detect changes in the tree island communities in response to restoration activities. A total of 86 permanent 10-meter x 10-meter monitoring plots have been established on 30 islands since the inception of the project in 2021. Tree height, DBH, basal area, sapling density, herbaceous species composition and percent cover, water depth, elevation, and annual inundation days were evaluated for each plot. Overall, there are large variations in canopy species density, diversity, and structure, and each island has its own unique characteristics that will influence how the vegetative community may respond to hydrologic restoration efforts. Continued long-term monitoring of these islands will provide crucial data to better understand the effects of the restoration on these vital Everglades communities.

Assumptions for a Projected CERP in the Second Periodic CERP Update

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The Everglades ecosystem is a diverse south Florida landscape with unique hydrologic and ecological characteristics, making this region in south Florida one of the most valuable ecosystems in the world. For this reason, in 2000, the U.S. Congress authorized the U.S. Army Corp of Engineers and the South Florida Water Management District to pursue the protection and restoration of the Everglades ecosystem through the Comprehensive Everglades Restoration Plan (CERP). CERP focuses on the restoration of the quantity, quality, timing, and distribution of water flow critical to re-establish and conserve the historic ecosystem functionality of the Everglades while integrating the evolving water-related needs in the region. This restoration is projected to be accomplished by constructing, implementing, and operating a series of components in the landscape to promote hydrologic connectivity, resulting in a healthy wetland landscape. Since 2000, the concept of those components has evolved as portions are constructed, and new science, technology, and data are gathered. All this new information is periodically translated into assumptions aiming to simulate the projected implementation of CERP through computer modeling. This periodic CERP Update is not a reformulation or a modification of the authorized CERP, but an effort to evaluate that the goals and purposes of the authorized CERP are being achieved, to ensure new information is regularly incorporated, and to update the quantity of water expected to be generated through CERP implementation for the natural systems and the human environment. The most recent version of this effort will be the Second Periodic CERP Update (SPCU), a robust technical evaluation of the Plan performance at the projected implementation of CERP. This presentation provides a synopsis of the assumptions included in the SPCU using the information available today to evaluate the CERP performance towards achieving its restoration goals.

Advancing Predictive and Assessment Tools in the Everglades' Southern Coastal Systems

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REstoration, COordination, and VERification (RECOVER) is an interdisciplinary collaboration of agencies, tribes, and institutions that conducts scientific and technical evaluations and assessments to improve the ability of the Comprehensive Everglades Restoration Plan (CERP) to restore, preserve, and protect the south Florida ecosystem while providing for the region's other water-related needs. Ecosystem restoration at the spatial scale undertaken by CERP requires extensive field assessments of a diverse set of indicators to determine their status, establish restoration goals, and understand the causal linkages related to CERP implementation and changes in water management activities. Assessments also inform the development of predictive models and tools to evaluate project planning alternatives by anticipating outcomes from project implementation. RECOVER is designed to support CERP goals and objectives by maintaining a system-wide and integrative perspective through predictive modeling (evaluations) and monitoring and synthesis of ecological and hydrological indicators (assessments) to inform managers, decision-makers, and the public. The RECOVER Southern Coastal Systems (SCS) team coordinates these efforts in four sub-regions within the SCS: Florida Bay, Biscayne Bay, southwest coast, and the freshwater to marine transition zone. The coastal habitats extending from mangrove and coastal wetlands to open water in these sub-regions have been damaged by changes in timing, quality, quantity, and distribution of freshwater. Previous tool development by the SCS team primarily focused on Florida Bay where responses to CERP implementation were anticipated to occur first. The SCS team recently initiated efforts to update existing tools and develop new tools to integrate new science and ecosystem knowledge that also consider sea-level rise and invasive species. The SCS team collaboratively integrates new biologic and hydrologic data and models to advance the Florida Bay Salinity performance measure using the EFDC model and the Estuarine Prey Fish Biomass Ecotool using the BISECT model. Additionally, many of the SCS indicators described in the 2024 RECOVER SSR highlight the need for improved capabilities to evaluate and assess our indicators. To start addressing these needs, the SCS team is developing and updating (1) submerged aquatic vegetation restoration targets, predictive models, and assessment tools the region and (2) predictive models and assessment tools for fish habitat suitability in the estuaries of the southwest coast. Not only will these tool updates equip the SCS team to better describe desired restoration conditions, develop restoration targets, and inform the establishment of meaningful ecological thresholds, but also identify gaps in monitoring and knowledge that limit our ability to understand indicator status and trends.

Pre-Restoration Mangrove Cover Change in the Cutler Wetlands and Functional Trait Response

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Areas of low mangrove cover in the Cutler Wetlands component of the Biscayne Bay Coastal Wetlands have been observed. The objective of this work was to determine if vegetation cover is still currently decreasing in these areas and if soil conditions demonstrate signs of structural change suggestive of peat collapse or ponding in comparison to high vegetation cover areas. In addition, leaf functional traits of the dominant species Rhizophora mangle (red mangrove) were measured to determine if there is a detectable signal of stress in low cover and transitional areas. Transects capturing a gradient of low to high mangrove cover were selected based on present day satellite imagery. High resolution aerial imagery was used to determine trends of vegetation cover change in three 10 x 10 meter plots aligned along transects that extended 50 meters in an interiorward direction, representing relatively low, moderate, and high mangrove cover in 2023. In a subset of these transects, depth to bedrock, surface soil structure, and leaf trait characteristics were measured. Along each transect, mangrove cover in low cover plots ranged from 5.53 to 53.69 m2 in 2023 in comparison to an average of 72.06 m2 in moderate cover plots, and 96.88 m2 in high cover plots. Areas of low cover were not associated with underlying bedrock depressions. Soil organic matter in low cover plots was lower than in high cover plots within each transect but northern transects also transitioned from marl to peat surface soils. Among leaf traits, specific leaf area (ratio of leaf area to dry mass) was lower in low cover relative to high cover areas, while leaf digital chlorophyll readings showed higher values in low cover areas. High cover plots demonstrated increasing vegetation cover from 2010 to 2023. Vegetation change was less consistent in southern transects, which showed a decline in cover in 2017 with a slight increase to or near 2010 values by 2023 in some plots, but a continued decrease in others. In the northern transects low and moderate cover plots increased in cover between 2010 and 2023 (ranging from 21-53.9% cover). Mangrove cover in low cover plots remained near or below 54%, and most of these plots had lower organic matter content compared to high cover plots. Soil bulk density values were reflective of soil compositional change and along with organic matter content did not provide an effective metric to determine the presence or absence of peat collapse. As sea-level and water management continue to influence mangrove coastlines, analysis of aerial imagery can be effective in tracking directions and rates of vegetation change.

High-Resolution 2D HEC-RAS Modeling in Support of Region 2 Western Everglades Restoration Project

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This ongoing study aims to develop, calibrate, validate, and apply a high-resolution hydraulic and hydrologic model to evaluate the effects of proposed features in the Western Everglades Restoration Project (WERP). The primary objective is to restore natural overland flow while mitigating flood risks in the region. To achieve this, a 2D hydrodynamic model was implemented using the Army Corps of Engineers' (USACE's) Hydraulic Engineering Center's River Analysis System (HEC-RAS). Extensive data collection efforts supported model development, including rainfall records, LiDAR-based topography, field surveys – including canal bathymetry and detailed structure information, surface water monitoring data, and land use characteristics. The model was developed and calibrated using Hurricane Irma (2017) and validated with Hurricane Ian (2022), incorporating key adjustments to parameters such as Manning's roughness values, infiltration rates, and initial conditions. Results demonstrated the model's effectiveness in simulating regional hydrology and hydraulics, accurately predicting water stages and flows at critical structures. The calibrated model will guide the assessment of potential WERP modifications, including the creation of flow ways, canal modifications, and new embankments, while ensuring flood protection for areas outside the restoration zone. Stakeholder engagement will play a crucial role in the process, with input guiding the planned testing of alternative scenarios. This collaborative approach aims to balance restoration goals with community needs.

Drops for Dollars: Estimating the Economic Value of Recreational Fishing and Water Management in Lake Okeechobee, Florida

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Ecosystem service valuation is the process of quantifying the economic and societal impacts of the provisioning, regulating, cultural, and supporting services provided by natural systems. One such ecosystem service is recreation, which involves direct use of a natural system from which humans derive wellbeing or enjoyment. As an added economic bonus, communities situated near recreational areas experience economic benefits from visitation. The State of Florida enjoys significant value-added from outdoor recreation, with $145 billion in total contribution to the state economy. In the Greater Everglades Ecosystem, recreational ecosystem service valuation efforts have focused on the economic benefits of functioning coastal ecosystems as well as the economic costs of chronic water quality and delivery problems. While Everglades ecosystem service valuation efforts are expanding, updated estimates of the ecosystem services provided by Lake Okeechobee, the historic and future lifeblood of the wetland, remain largely neglected. Lake Okeechobee is also of particular interest due to its myriad chronic water quality issues and future restoration projects.

This study seeks to update ecosystem service valuation efforts in Lake Okeechobee with an estimate of the economic impact of recreational fishing expenditure in Lake Okeechobee and estimates of economic losses associated with harmful algae bloom scenarios in the lake. Methods included a combination of original angler survey data, Florida Department of Environmental Protection recreational expenditure data, stochastic input-output analysis, and Monte Carlo sensitivity analysis. Algae bloom scenarios were created to reflect four conditions ranging from "less severe" to "extreme," aligned with seasonality of tourism and peak harmful algae bloom conditions by month. Results estimated economic impact of recreational fishing in Lake Okeechobee to include $368 million in economic output, $121 million in earnings, $238 million in value-added to the economy, and employment for 2,700 individuals. The "extreme" harmful algae bloom scenario was estimated to reduce economic output in the region by 44%, presenting profound economic impacts for counties surrounding Lake Okeechobee. Monte Carlo simulations revealed a range of economic impacts across all four scenarios. This study contributes to global efforts to estimate the economic connections between natural systems and recreational activity. More importantly, this study urges consideration of the economic impacts of chronic water quality management problems which lead to often-unpredictable HABs in Lake Okeechobee and freshwater lakes across the globe.

Karenia brevis Cell and Brevetoxin Mitigation Using EPA FIFRA-exempt Natural Products

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While natural algicidal products show promise to be an environmentally friendly approach to short-term Harmful Algal Bloom (HAB) control in laboratory experiments, acquiring permits for *in situ* testing is a complicated, extended process due to federal and state regulations. To accelerate the permitting process, we investigated the mitigation potential of ingredients listed as exempt from EPA regulation under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Based on an extensive literature review conducted to determine any prior research on the compounds' algicidal, antibacterial, antifungal, antiviral, and antiparasitic properties, cinnamon, garlic, flaxseed, clove, eugenol, and thyme were selected and tested for efficacy in mitigating cells and toxins of *Karenia brevis* culture. Cinnamon, in both oil and powder form, was most effective of the compounds tested, reducing cell concentration by 98% within 2 hours compared with the control (no addition), followed by eugenol at 89%. Within 24 hours, all flaxseed oil and clove oil reduced cell concentrations by >79.5%. These data suggest that FIFRA-exempt natural products hold potential for successful *in situ* mitigation both *K. brevis* and other HAB species in Florida freshwater, estuarine and marine waters.

A Comprehensive Overview of the Lake Okeechobee C-HAB Management Strategies and Selected Mitigation Projects

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Eutrophication and climate change have been recognized as primary drivers of harmful algal blooms (HABs) in aquatic systems around the world. They are considered harmful due to their vast socio-economic and ecological impacts, and ability to generate toxins, and taste and odor compounds that can pose serious threats to humans and animals. Their global expansion and spontaneous occurrence have made HAB prevention, control and mitigation measures a cumbersome task.

Lake Okeechobee has long been affected by harmful cyanobacterial blooms (C-HABs) as a result of man-induced hydrologic and land use modifications over the past several decades. To reduce their impacts, the South Florida Water Management District (the District) developed a comprehensive C-HAB management program that focuses on reducing HAB incidence and extent (prevention), stopping or containing blooms at priority locations (control), and minimizing their impacts (mitigation). Information on C-HAB occurrence, extent and severity obtained from the water quality monitoring network, satellite remote sensing imagery, 3–5-day forecasts, and daily response teams' visual bloom assessments at the priority locations are used to make the "go" vs. "no-go" bloom treatment decisions. Out of 941 observations made at ten priority lake locations between 2023-2024, visible algae were detected 31% of the time with a bloom index of ≥3 reported in 58% of those cases. Algaecide treatments were done in 23% of the cases with visible algae.

Additionally, the District conducted several highly successful bloom mitigation studies at the Pahokee Marina and the C-43 Canal during the 2021 bloom season, and a new peroxide-based Lake Guard® Oxy algaecide treatments efficacy study at the S-77/C-43 site was initiated in 2024. In 2021, the Pahokee Marina's interlocking sheet pile storm protection segments trapped large amounts of the lake and in-situ cyano-scum, which over time decomposed and released microcystin toxins (max. 860 µg/L) and odorous substances (geosmin). A comprehensive mitigation strategy that included excess scum and sheet pile segments removal, deployment of circulators, aerators and ultrasonic devices, and application of algaecides resulted in a significant reduction of cyano-toxins (<0.2 µg/L) and phytoplankton biomass (<40 µg/L) and increase in their species diversity over two months. Successful Lake Guard® Oxy algaecide treatments (112 treatments over 15 days) were also conducted along the C-43 canal. In June-July 2024, three Lake Guard® Oxy treatment tests conducted under 500 and 1000 cfs daily average flows at the S-77/C-43 location showed that the standard treatment procedures used for this product in stagnant waters may not be suitable to successfully treat C-HABs and their toxins in lotic canal systems. Six additional tests are planned for the 2025 bloom season to optimize the timing and dose of the algaecide applications to further reduce the risk of transporting blooms to downstream ecosystems.

Hydrographic Connections of Inland Water to Diseased Corals and Water Quality Sites on Florida's Coral Reef

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Over a century of replumbing the Everglades has altered its historic water flows and led to large scale ecosystem changes in south Florida. Florida's Coral Reef resides downstream of the Everglades flow and has experienced significant declines in the last 50 years, including the loss of over 25% live coral cover. Most of the coral losses were attributed to various extreme temperate and disease events beginning in the late 1970's and becoming more frequent over time, culminating with the emergence of stony coral tissue loss disease (SCTLD) in 2014, which continues to decimate populations.

Corals typically thrive in nutrient-poor environments through symbiosis and high nutrients are linked to increased disease prevalence. Global coral disease prevalence has tripled since the 1990s, along with rising temperatures and decreasing water quality. Spatiotemporal patterns of coral diseases in the Florida Keys have been difficult to discern due to the complex array of environmental, anthropogenic and host-specific factors that affect the pathogen virulence and host susceptibility. Southeast Florida reefs present a unique opportunity to understand connections to inland waters because of their proximity to significant anthropogenic sources in Biscayne Bay.

Monthly disease on large coral colonies varies temporally, with the highest in the warmer, wetter months. Analyses explained 63.1% of the variation in coral disease incidence and 66.2% of disease prevalence over a three-year study period using a suite of environmental predictors related to historic heat stress, terrestrial rainfall, and inlet outflow. Inlet flow, rainfall, and wind predictors also explained 79% of the model variation of orthophosphates and 55% of nitrates of monthly water samples collected on the reefs over the same temporal period. These results suggest that excess nutrients or another covariate not measured in this study from inland sources seasonally exacerbated SCTLD.

Hydrographic modeling of nutrient dispersal from four major inlets utilizing DBHydro flow data in a multiscale ocean model identified Government Cut as the largest source, with a notable impact both north and south of the inlet. Backtracking the model from the time of lesions found that Government Cut was the most probable source of inland water compared with the other inlets.

Identifying disease drivers is key to designing effective local mitigation strategies, prioritizing disease intervention resources, and identifying areas suitable for reef restoration. The exact cause (e.g. nitrate, phosphorus, heavy metals, sewage) of the measured effect is unknown and deserves significant research attention as it could be an important indicator of the potential sources and causes of SCTLD. Expanding the geographic scope and temporal range of this modeling to include the entire reef tract will help in identifying hotspots of terrestrial sources and a more complete picture of their impacts.

Simulating Water & Phosphorus Balances of Everglades Stormwater Treatment Areas & Water Conservation Areas

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This presentation describes applications of the Dynamic Model for Stormwater Treatment Areas (DMSTA, Walker & Kadlec, 2005) to the Stormwater Treatment Areas (STAs) and Water Conservation Areas (WCAs). DMSTA has been used extensively in several regional water projects for designing STAs to meet target outflow concentrations. Simulations cover the entire periods of record for the STAs (2000-2024) and the WCAs (1979-2024).

The model is driven by daily time series of rainfall, evapotranspiration, inflow volumes, inflow TP concentrations. Predicted variables include, water depths, outflow volumes, outflow TP loads, and outflow TP concentrations.

DMSTA was originally calibrated to the data available as of 2005. Those data were derived from relatively small treatment cells and experimental platforms. Separate calibrations were developed for emergent vegetation (EMG), submerged aquatic vegetation (SAV), periphyton, and reservoirs. The 2006-2024 data provide independent datasets for testing and refining the model using data from full-scale systems.

The 2000-2024 STA simulations use the same calibration parameters developed in 2005. Average yearly observed and predicted water depths and outflow variables are compared at yearly intervals and on a long-term basis. The focus is on model predictions of the total outflow volumes, loads, and concentrations from each STA a whole using the Restoration Strategies design parameters for each treatment cell. While outflow concentrations from STA-56 are over-predicted, there is reasonable agreement between observed and predicted values for the other STAs. Additional testing is based on predictions of the same variables in each treatment cell. Results indicate that TP removals in emergent cells have been higher than predicted using the original calibrations. Testing at a monthly time step indicates that seasonal factors could be added to improve the P cycling model used in DMSTA. While this enhancement is likely to improve monthly simulations, STAs have been designed to achieve long-term average concentration targets.

The 1979-2024 WCA simulations are based upon new calibrations developed for each WCA. Data from 2012-2024 are used for calibrations and data 1979-2011are used for testing. The datasets compiled to support these simulations describe responses of WCA annual outflow concentrations and loads to significant variations in inflow phosphorus loads resulting from changes in regional water management, implementation of Best Management Practices (BMPs), and construction of the STAs.

Improving Wetland Methane Flux Estimates to Meet User Needs

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Wetlands are a major natural source of methane emissions, accounting for up to a third of global emissions from all sources, and there is room to improve the representation of these fluxes in greenhouse gas (GHG) inventories. Such GHG inventories provide transparency into how management actions impact wetland GHG emissions in larger contexts (e.g., states, nations, whole economies). It has been well-documented that GHG emissions from these ecosystems respond to both climatic drivers and human action, including land management of wetlands themselves (e.g. drainage or restoration). Where direct monitoring is not practical, such as at large spatial scales and at high frequency over long time periods, we must rely on modeled estimates for information on the dynamic GHG responses of wetlands. The LPJ-EOSIM (Lund-Potsdam-Jena Earth Observation Simulator) dynamic vegetation model currently provides publicly accessible global daily estimates of natural emissions of GHGs from wetlands at 0.5 degree resolution every two months with uncertainty estimates driven by multiple input datasets. We illustrate current use cases for this low-latency data, such as regional atmospheric inversions and the Global Methane Budget, and those driving planned improvements such as subseasonal-to-seasonal emission forecasts, additional uncertainty quantification and high-resolution (1 km) estimates for the coterminous United States. Using the Everglades as a case study, we will discuss the potential for these improvements to leverage existing data to provide model based estimates of CO_2 and CH_4 emissions at management relevant scales for inventory and planning, and also refine targeting for satellite, airborne and ground resources for direct monitoring.

Collection of Digital Imagery to Support Carbon Cycling Research in the Greater Everglades

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Wetlands represent areas of important biogeochemical cycling, acting as globally significant carbon sinks and natural sources of methane gas. The greater Everglades ecosystem consists of expansive wetlands experiencing continual variability in hydrology because of altered precipitation, climate, and waterflow, influencing the functional health and diversity of its habitats. Long-term observations of the Everglades wetlands represent an important source of information in understanding changing conditions and provide the opportunity to predict future trends. Comprehending the current response of the Everglade's wetlands to environmental change will be crucial to continued effective management efforts and resource usage. In this study, we installed a five-band multispectral camera, equipped for high-quality, high-resolution images and normalized difference vegetation index (NDVI) sensing, overlooking a dwarf cypress wetland in Big Cypress National Preserve. Visible spectrum, infrared, and NDVI-standardized images were collected multiple times daily from February 2021 to November 2024, observing variation of the dwarf cypress wetland in response to seasonal and interannual changes to the environment; in total, approximately 2300 images were collected from the site. NDVI provides an optical indicator of vegetation growth and quality and can be applied to identify and observe trends of photosynthesis, biomass production, and community composition. Association of visual trends with coinciding data from a USGS eddy-covariance (EC) flux station allow for determination of the dwarf cypress wetland's role in key processes of water and carbon cycling in the greater Everglades ecosystem of South Florida.

REMAP Big Cypress 2023 Results: A Baseline for WERP

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The Everglades Regional Environmental Monitoring and Assessment Program (REMAP) has provided environmental data for various sub-areas of the Everglades ecosystem at 5- to 10-year intervals since 1995. As part of the fifth cycle of the Everglades REMAP, EPA collected water, soil, sawgrass, mosquitofish and periphyton samples at 38 sites in marsh habitat within the eastern portion of the Big Cypress National Preserve in 2023. From those data, spatial and statistical patterns can lend insight into the environmental context within Big Cypress and potential relationships between various environmental analytes in the area. 2023 data indicate that for most analytes, there is no significant north to south spatial gradient in concentration throughout Big Cypress, though notable exceptions are surface water chlorides and total phosphorus and sediment pH and bulk density. In comparison to Big Cypress data collected in the 1995-1996 REMAP cycle, the 2023 data indicate higher surface water total organic carbon and conductivity and lower surface water total nitrogen. In addition to the general patterns in the observed 2023 REMAP data, statistical analyses can be informative of how different analytes are interacting. Soil type varies throughout the study area. When results are expressed by mass (i.e., mg/kg), many analytes had significant and strong correlations. When results are expressed by volume (i.e., mg/cc) there were fewer strong correlations. Organic matter in sediments, expressed as ash-free dry matter (AFDM) concentrations were moderately correlated with sediment total nitrogen and total mercury concentrations in the 2023 samples (Spearman's ρ = 0.42 and 0.52, respectively, $p < 0.05$). Both correlations were direct. AFDM had a negative and moderate correlation with bulk density and pH. Sites with the highest values of AFDM observed in 2023 largely coincided with freshwater marsh habitat, as opposed to freshwater prairie habitat. This difference suggests that habitats with more surface water may allow for increased rates of detrital decomposition to organic matter within Big Cypress, compared to prairie habitats with less water that dry out more often. Correlations between AFDM and water depth support this hypothesis, with the two variables being nearly statistically significant at the alpha = 0.05 level and showing a direct correlation (Spearman's ρ = 0.33, p = 0.053). These preliminary analyses can lend insight into the environmental conditions in Big Cypress and may help inform effective management of the area via the planned Western Everglades Restoration Project by shedding light on the current conditions.

On the Cusp of LOSOM – Considering Environmental Events and Ecological Changes Under LORS08

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Lake Okeechobee opened a new chapter in its regulation schedule history with the implementation of LOSOM in August of 2024; its fourth set of operational criteria adopted in the last 25 years. Over that same time period, many historically significant events occurred that warrant a review: there were at least four major hurricane seasons that dramatically affected water levels, water quality, and habitat; both the lowest and the 2nd highest loads of total phosphorus into the lake were recorded; water levels fell to the lowest level on record… twice; there was a loss, then gain, and then loss again of roughly 50,000 acres of submerged aquatic vegetation; and there was a gain and then loss of roughly 25,000 acres of littoral marsh extent. When LORS08 was adopted roughly 17 years ago, it was the lowest regulation schedule ever implemented, and the lake was in the middle of a record drought and still reeling from multiple hurricanes. The fishery had severely declined, the littoral marshes had been dried for 14 months, there were novel changes in even the base of the food chain (plankton communities), and endangered snail kites were in a severe population decline, teetering on extinction and no longer nesting on the lake. Today, less than a year into LOSOM, the situation is much different; there are concerns about impacts from lingering high-water levels and we are beginning a wetter regulation schedule. The marsh extent has receded to a near 20-year low; coverage of submerged aquatic vegetation has dwindled to the lowest five-year average on record; there are concerns about fish recruitment and wading bird activity; yet less concern anymore about snail kites; and water quality remains as critical an issue as ever. Reviewing the past 10-25 years of lake history provides context to the issues being discussed today, as we settle into a new regulation era.

Linking Burmese Python Ecology with Removal Efforts in the Everglades

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The invasive Burmese python (*Python bivittatus*) is established across southern Florida and is implicated in negative impacts to native wildlife. For over a decade, scientists and natural resource managers have investigated python ecology to develop targeted removal and control tools. However, due to their crypsis, pythons have proven extremely difficult to assess, and no tractable abundance estimates have been made. Several successful python removal programs and tracking efforts have been implemented across South Florida. With few exceptions, these programs are focused in accessible areas or high ground habitats containing a mix of hardwood hammock, pinelands, prairie, cypress swamps, and estuaries that constitute only a portion of South Florida wildlands. In addition, most pythons removed from the region are captured while crossing roads or levees transecting vast wild habitats that may be flooded year-round. As such, there is an informational gap regarding python ecology and removal efficacy in the eastern Everglades region, where landscapes primarily consist of sawgrass marsh interspersed with sloughs and tree islands. To address this need, we initiated a collaborative multi-year study to integrate radio-telemetry field techniques and advanced modelling approaches to estimate population-level metrics to inform python removal efforts within the eastern Everglades. Additionally, we initiated a scout snake program, where adult pythons are tracked during the breeding season to lead researchers to mating aggregations, to increase the ability to detect and remove pythons and provide critical information on movements, behaviors, and demographic rates (i.e., survival and reproduction). We present a preliminary assessment of our telemetry dataset, including a dynamic Brownian bridge movement model analysis to assess python spatial ecology and to identify potential temporal and spatial movement pathways. Knowledge of python spatial ecology in the eastern Everglades can inform targeted removal efforts, allowing for more effective management strategies while reducing resources necessary for python control.

Hydrology and Water Quality in Everglades National Park

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The Comprehensive Everglades Restoration Plan (CERP) aims to restore the hydrology and water quality of the Greater Everglades Ecosystem and Everglades National Park (ENP) by delivering the right amount of water, of the right quality, to the right places at the right times. This presentation reviews considerable progress toward the Desired State of Conservation by evaluating key indicators, including water volume, distribution, flow patterns, and water quality. Recent data reveal increased water flows and a beneficial shift toward historic eastward pathways in Northeast Shark River Slough, resulting in deeper water levels and longer hydroperiods within ENP. While water quality remains stable at some inflow structures, rising phosphorus levels at others pose a threat to sensitive freshwater marshes. In Florida Bay, reductions in chlorophyll-a levels and algal blooms suggest recovery from past disturbances, though hypersalinity persists in the central region. Key restoration projects, such as Tamiami Trail Next Steps (TTNS), Western Everglades Restoration Plan (WERP), and Central Everglades Planning Project (CEPP) with the Everglades Agricultural Area Reservoir (EAA-R), offer promising solutions to address these issues and enhance ecosystem resilience.

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

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The Comprehensive Everglades Restoration Plan (CERP) was approved by Congress in 2000 to restore, preserve, and protect the Florida Everglades while providing for other economic and cultural water-related needs of the region by improving the quantity, quality, timing, and distribution of water throughout the system. The Everglades is an expansive mosaic of natural communities with complex ecological interactions driven primarily by seasonal hydrologic variation. This complexity produces a considerable amount of uncertainty related to ecological responses to hydrologic restoration. Recognizing that uncertainties exist within our knowledge of Everglades ecology, 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 project design and implementation, as necessary, to increase the likelihood of restoration success. REstoration, COordination, and VERification (RECOVER) is an interdisciplinary collaboration of agencies, tribes, and institutions that conducts scientific and technical evaluations and assessments to improve the CERP. To facilitate the integration of new science and information between restoration project delivery teams and improve CERP implementation, RECOVER developed the CERP Adaptive Management Strategy, CERP Adaptive Management Integration Guide, and CERP Programmatic Adaptive Management Plan. 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. Lessons learned from adaptive management efforts are informing updates to the CERP adaptive management framework that will be used to continue to improve restoration success and address project uncertainties within CERP. In recent years, efforts to address programmatic uncertainties resulted in adaptive management recommendations to CERP projects, for example, Decompartmentalization Physical Model findings were used to make recommendations to the Central Everglades Planning Project-South for increased marsh connectivity and reduced ecological impacts of future construction. Additional examples of successful CERP project design refinements and implementation will be highlighted to showcase the application of the CERP adaptive management framework.

Historical Salinity and Flow in Biscayne Bay – The Pathway to Performance Measures

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One of the goals of the Biscayne Bay Southeast Everglades Restoration (BBSEER) project is restoration of a more natural salinity regime in the nearshore region of Biscayne Bay to sustain healthy ecosystems there, and throughout central and southern Biscayne Bay. For several decades the USGS, NOAA, NPS, University of Miami, Florida International University (FIU), and others have conducted research and gathered historical documents to address the question – what was the natural salinity regime prior to canal construction and land-use alterations? This information is necessary to set performance measures to achieve the desired outcomes of increasing indicator taxa and natural habitats. Historical maps, aerial photos, and documents provide some insights to past habitats along the shoreline; however, since regular water monitoring did not begin until the latter half of the 20th century, the primary source of information on pre-alteration salinity are analyses of salinity proxies from sediment cores. The USGS has examined cores from six locations in central and southern Biscayne Bay. Four locations show definitive increases in salinity throughout the time of deposition (~5000 to 300 years ago). The gradual trend of increasing salinity prior to the 20th century can be attributed to sea level rise in the region; however, this rate accelerates in the 20th century. In addition, over the last 100 years core assemblages show increasing dissimilarities in both molluscan (USGS) and diatom (FIU) data, indicative of alteration of their ecological niches. The decline and/or loss of freshwater and low salinity mollusks in the nearshore areas strongly suggests that reduction in freshwater flow was a significant driver of these changes. Similar studies of molluscan core assemblages in Florida Bay have used paleo-salinity estimates to adjust the Natural System Regional Simulation Model (NSRSM; Everglades hydrologic model). The paleo-adjusted output from the NSRSM was inserted in linear regression models that link current stage and flow in the wetlands to salinity in Florida Bay. The results indicate that flow through Shark River at the beginning of the 20th century was approximately 2 times greater than it is today, and Taylor Slough was 3.2 to 3.7 times greater. Unfortunately, this tool cannot be applied to Biscayne Bay because the NSRSM does not accurately predict salinity in Biscayne Bay and the long-term water monitoring data needed are lacking. However, the flow values through the wetlands can be used as a model for regional flow, and the resulting values for Taylor Slough are particularly relevant to the southeast saline marshes of southern Biscayne Bay. The analysis of geohistorical information strongly indicates the existence of mesohaline conditions in nearshore Biscayne Bay prior to water management and provide a reference point for establishing performance measures that reflect natural conditions.

Lygodium microphyllum Presence and Prevalence in WCA-3

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Lygodium microphyllum (Old World Climbing Fern) is an invasive exotic climbing fern that poses a significant threat to tree island health and community diversity. Since 2002, the South Florida Water Management District has supported surveys of *L. microphyllum* in Water Conservation Area (WCA) 3. These surveys have served multiple purposes including the identification and subsequent removal of *L. microphyllum* populations and the collection of growth characteristics and ecological data, including post-treatment surveys to assess treatment efficacy. In 2023, 129 previously documented *L. microphyllum* populations were re-surveyed on nine different islands in WCA-3B. Varying rates of treatment success were observed across the landscape. Treatment efficacy was found to be negatively correlated to tree island head elevation, i.e., treatment was more effective at lower-elevation islands. This is not unexpected given that previous studies have shown that *L. microphyllum* prefers to grow in wet but not permanently inundated conditions. However, *L. microphyllum* populations were found to have a broad hydrologic tolerance range and to frequently root on elevated substrates such as fern mounds, making island elevation alone a poor indicator of *L. microphyllum* presence and prevalence. Findings indicate that hydrology, soil microtopography, vegetation community type and canopy cover may explain the presence of *L. microphyllum* on the tree islands; however, further investigation is ongoing.

Enhancing Detection of Invasive Tegus in the Everglades with Scent Lures and Camera Traps

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Invasive species pose significant threats to biodiversity and ecosystem health, underscoring the urgent need for effective monitoring and management strategies. Among these invaders, the Argentine black and white tegu (*Salvator merianae*) has established populations across Florida, particularly in southern Florida, where it threatens to encroach into Everglades National Park. These large-bodied, omnivorous lizards disrupt native wildlife through predation and competition, compounding ecological imbalances caused by other invasive species such as the Burmese python (Python bivittatus). This study investigated whether commercial scent lures could enhance tegu detection rates in the field, using trail cameras as a non-invasive monitoring tool. Over a 10-week period, 24 sites were surveyed across control and treatment phases, testing two lure types—mouse oil and blueberry oil—against a non-scented control. Detection data, along with environmental covariates, were analyzed using generalized linear mixed models with a negative binomial distribution. Results showed a marginal increase in detection rates with the mouse oil lure compared to other treatments, suggesting its potential as an effective tool for improving detection efficiency. These findings highlight the value of targeted lures in optimizing monitoring efforts for invasive species, providing insights to support more precise and impactful management strategies aimed at mitigating their ecological impacts.

Spatiotemporal Dynamics of Surface and Groundwater in South Florida: Long-Term Trends and Implications for Water Management

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Groundwater dynamics in South Florida play an important role in shaping the region's hydrologic and ecosystem balance, particularly in Florida Bay and surrounding marshes. This study investigated long-term trends in groundwater elevation, surface water stages, and their interactions across water conservation areas, Everglades National Park, coastal watersheds, and Florida Bay. Time series decomposition of long-term groundwater elevation data (1990–2022) was used to identify trends, seasonal patterns, and anomalies. Analysis of groundwater elevation revealed distinct phases of depletion (2005–2016) and recovery (2016–2022) driven by changes in rainfall patterns and water management practices. While overall changes in groundwater elevation have increased in recent years, groundwater elevation in upstream areas was more strongly associated with aggregated flow, whereas coastal areas were more strongly correlated with cumulative changes in sea level. This distinction suggests separate mechanisms for the observed trends: upstream recharge likely dominates in freshwater marshes, whereas coastal areas are associated with sea level variability. The increasing saturation in coastal areas highlights a shift associated with external factors such as sea level rise, especially during dry periods. The seasonal patterns indicated mild temporal variability and a delayed response to rainfall, whereas short-duration deficits during historical drought years reflected a reduction in short-term groundwater elevation, which lasted up to 15 months. Spatial autocorrelation analyses revealed significant clustering and coherent spatial patterns between groundwater elevation and surface water stages, highlighting the interconnected nature of hydrologic systems in the region. The relationships between surface water stages and groundwater elevation in the study area followed a linear pattern, whereas coastal regions, parts of the northern water conservation areas and northern parts of the Taylor Slough showed nonlinear patterns. In Florida Bay, sea level variability has emerged as the dominant driver of surface water variability, overshadowing the influence of canal discharge and creek flow. These findings suggest the need for adaptive management strategies that address upstream recharge dynamics, coastal sea level impacts, and the localized nonlinear nature of surface water–groundwater interactions. Holistic approaches that integrate climate variability, water management, and ecosystem restoration are suggested for ensuring effective restoration efforts in this ecologically sensitive region.

Blue Shanty Flowway Restoration HECRAS Model Study

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The Central Everglades Planning Process-South (CEPP-S) aims to restore hydrological connectivity and ecological balance across the Water Conservation Areas (WCAs) and Everglades National Park (ENP). A key challenge involves addressing unintended hydrodynamic impacts of canal flows, such as altered flow patterns and habitat disruption, as observed during the DECOMP Physical Model (DPM) study. To address these issues, the Blue Shanty Flowway Model (BSFM) was developed to evaluate and optimize canal plug configurations and swale performance in the L-67C canal. This Phase I study prioritized rigorous validation of the BSFM to ensure its reliability for hydrological restoration planning. By replicating observed hydrodynamic conditions with high accuracy, the model demonstrated its capacity to capture complex interactions between water stages, flow velocities, and discharge patterns across ridges, sloughs, and canals. Simulations using HEC-RAS 2D achieved stage variations within approximately 0.15 feet of observed data and accurately captured flow fields, providing confidence in the model's ability to reflect real-world conditions. The validation process, which included iterative adjustments to seepage rates, boundary conditions, and flow resistance coefficients, was critical for minimizing uncertainty and establishing the BSFM as a dependable tool for evaluating restoration strategies. Following its validation as a reliable tool, the BSFM is now being used to support future evaluations of canal plug designs and swale performance. These efforts aim to enhance distributed sheet flow and restore natural flow regimes within the sensitive ecosystems of the Everglades. This study underscores the importance of rigorous model validation in hydrological restoration. By integrating high-resolution modeling with empirical data, the BSFM provides a reliable platform for evaluating restoration initiatives under CEPP-S and the broader goals of the Comprehensive Everglades Restoration Plan (CERP).

Applying Remote Sensing to Map Subsurface Electrical Conductivity in the Everglades

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Geophysical field measured subsurface Electrical Conductivity (EC) can indicate peat soil stability in the coastal Everglades, but application of such field approaches is challenging to reveal soil vulnerability to sea level rise at larger scales. Linking field measurements with remote sensing observations may have the potential to map and monitor Everglades' peat stability and identify the most vulnerable zones at a larger scale. We explored modern Artificial Intelligence (AI) based upscaling techniques and the capacity of fine resolution airborne and spaceborne remote sensor products for mapping soil stability at an experimental site in the Everglades. The preliminary results are encouraging. Remote sensing observations can explain over 70% variance of field measured EC at this site.

Flood Protection Level of Service Program: A Systematic Approach to Vulnerability Assessment and Mitigation Planning

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The Flood Protection Level of Service (FPLOS) program is a key element of the South Florida Water Management District's (SFWMD) mission to enhance resilience against increasing challenges in flood risks. Managing over 2,200 miles of canals and 1,380 water control structures, the SFWMD oversees a vast and intricate water infrastructure system. This system faces growing challenges from aged structures, sea-level rise, extreme rainfall, intensifying hurricanes, and future development. The FPLOS program employs a systematic and data-driven approach to assess infrastructure performance, prioritize long-term needs, and identify adaptation strategies to protect communities and ecosystems. Leveraging advanced hydrological and hydraulic models such as MIKE SHE and MIKE HYDRO River, FPLOS evaluates vulnerabilities based on performance metrics like flood depth, duration, and structural flow capacities. These insights inform both local projects—such as stormwater system upgrades—and regional-scale adaptations, including forward pumps, tieback levees, and distributed storage solutions. The systematic approach also encompasses economic assessments and adaptation pathway planning, ensuring that the proposed strategies are both economically viable and that the implementation plan is optimized and adaptable to future conditions. This systematic approach has been adopted to conduct vulnerability assessments across various counties in the South Florida region and to develop mitigation and adaptation plans for the C8 and C9 basins. Importantly, the model tools developed under the FPLOS Phase I studies support critical initiatives like FEMA's Building Resilient Infrastructure and Communities (BRIC) funding applications and U.S. Army Corps of Engineers (USACE) Flood Risk Management (FRM) studies. The program's collaborative framework encourages collaboration with local governments and stakeholders, ensuring a comprehensive, basin-wide approach to mitigating flood risks. By integrating nature-based solutions with regional infrastructure strategies, FPLOS advances sustainable adaptation practices.

Marsh and Canal Flow Connectivity Approximations to Explore Influence of Marsh on Constituent Transport

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High phosphorus loading has affected water quality and ecological health of Everglades National Park. Determining phosphorus transport mechanisms and pathways are critical to implement effective water quality improvement strategies and restoration activities. Direct contributions through L-67A canal and indirect contributions through legacy phosphorus stored in the Water Conservation Area-3A marsh system have been suggested as potential sources. Limited availability of data on water exchange between marshes and canals impedes our understanding of phosphorus flux pathways. This study aims to address these gaps by investigating water exchange between WCA-3A marsh and L-67A and L-29 canals and estimating total phosphorus (TP) loads based on currently available data and models. Daily water exchange for the period 2019–2023 was calculated using the weir discharge equation from the Regional Simulation Model (RSM). Observed water level data from EDEN and DBHYDRO were used to represent marsh and canals levels, respectively. TP loads were then estimated by combining calculated water exchange volume with TP concentrations. Results indicate an average daily water discharge of 151,595 cfs from L-67A canal to WCA-3A and 17,138 cfs from WCA-3A to L-29 canal during the period of analysis. When integrated with TP concentration data, the average daily TP load was calculated as 4,581 kg/day from L-67A canal to WCA-3A and 224 kg/day from WCA-3A to L-29 canal. These preliminary findings indicate that L-67A canal serves as a primary phosphorus transport pathway. However, substantial discrepancies between the different models used highlight the limitations of the coarse-scale resolution of these models in accurately capturing local variability of water exchange and TP transport. These uncertainties are amplified by challenges such as a lack of fine-scale monitoring and insufficient spatial resolution of water quality data. These findings call for the need to develop a local-scale model with a finer resolution to accurately reflect marsh and canal interactions along with an expanded monitoring network. These improvements are essential for informing effective water management strategies and supporting restoration efforts to achieve water quality targets in the Everglades.

The Everglades Wasn't Built in a Day: Micro and Major Transitions in Restoration

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The historic Everglades was built over millennia by dynamic fluvial processes that created patterns on both micro and macro scales. Lake Okeechobee and the Kissimmee Chain of Lakes were originally connected to the Everglades by rivers from the south shore of Lake Okeechobee and were a consistent source of water. As a result of significant drainage occurring in the 1880's in the Kissimmee/Okeechobee basin, the hydrology of the Everglades was affected long before the canals began to directly drain this large, patterned wetland. Compared to the timescale for creation, degradation of landscape pattern and microtopography is accelerated and it is likely that even the earliest explorers during the late 1800's were not describing the original Everglades. These changes in hydrology and landscape connectivity upstream and within the Everglades have created a dynamically degraded landscape that has different restoration needs regionally, compounded further by spatially variable changes in microtopography within the ridge and slough habitat (elevation of ridge above slough equals: 0-20 cm current vs. >50 cm historically). The Decompartmentalization Physical Model has provided new information and ideas about how the natural landscape formed, substantially advancing and refining ideas formed twenty years ago (CERP, yellow book). We believe that it is time to consider the tradeoffs between static and dynamic thinking (i.e., ideas that change over time to adapt to new information and synthesis) for restoration success and our ability to reflect these ideas onto infrastructure and the built landscape. Not only will tradeoffs be necessary between static and dynamic thinking, but also between our perception of what restoration looks like in different regions and which goals are achievable. This process will be greatly facilitated by new ideas about natural transitions that occurred to build the natural Everglades, including a reduced emphasis on sheetflow and increased evidence for a new hypothesis: that the Everglades developed as a flowing system similar to a delta with preferential flow paths and large-scale movement of flowpaths around the landscape.