SOCIETY of WETLAND SCIENTISTS
Wetland Restoration Section

# 2022 Symposia

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***Improving Wetland Restoration Outcomes: Revisiting Monitoring and Adaptive Management***

***May 19th, 2022***

Wetland restoration projects require clear goals and objectives that are linked to measurable performance standards. After project implementation, restoration sites must be monitored to measure their response to the actions taken and compliance with the performance standards. Monitoring also provides feedback to inform the need for modifications to the site being monitored and/or to improve future restoration projects (i.e. adaptive management). Too often, monitoring is simply not conducted or is inadequate to provide the feedback needed to effectively facilitate meeting the desired outcomes. Monitoring and subsequent site management requires substantial time, money, and skilled technicians, all of which may not be available to all restoration projects. Even for projects that have ample resources or specific obligations per regulations (e.g. Clean Water Act in the USA), there usually is a designated and often arbitrary endpoint in terms of staffing, funding, or regulatory requirements. Are the commonly used monitoring approaches adequate to indicate that wetland restoration sites are self-sustaining and returning key ecological processes? Are there smarter ways to monitor sites that would result in more appropriate adaptive management actions and ultimately more favorable outcomes? This symposium will discuss how the implementation-monitoring-adaptive management feedback loop can be improved and will use case studies to illustrate specific examples.

*Speakers and Abstracts:*

**Feasibility of Stem-Area-at-Groundline to Assess Woody Vegetation Development in Mitigated Wetlands**

*Jessica Bryzek, West Virginia University*
*Christopher T. Rota, West Virginia University*
*Elizabeth Byers, West Virginia Department of Environmental Protection*
*Walter Veselka, West Virginia University*
*James T. Anderson, Clemson University*

As a long-term inhabitant of restored ecosystems, woody vegetation has the potential to be useful for assessing restoration trajectory in mitigated wetlands. Identifying data driven functional attributes are necessary to select performance standards that cumulatively evaluate restored wetland characteristics. Previous research suggests Stem-Area-at-Groundline (SAG) to be indicative of woody vegetation functions such as biomass accumulation. SAG is defined as the morphological measurement of the cross-sectional area where the stem enters the ground. This study assesses the feasibility of SAG to be useful as a performance standard. We apply existing woody vegetation protocols adopted in Virginia, USA to mitigated wetlands in West Virginia, USA. Using a chronosequence approach, 40 mitigated wetland sites ranging from 1 to 29 years following creation were assessed. Circular plots with a 5.6 m diameter were randomly generated within each national wetland inventory habitat type. All woody vegetation within each plot were identified to the species level and SAG measured. Preliminary results suggest SAG responds to site age, following an increasing trend as time since restoration increases, which suggests potential to be used as a performance standard. While the dominant species sampled included Alnus serrulata, Hypericum densiflorum, Cornus amomum, Salix nigra, and Platanus occidentalis, some study sites exhibited higher species diversity and unique species due to the quantity and type of planted stock. Overall, woody vegetation community composition and development is dependent upon site specific characteristics and implementation techniques. Results of this study will be useful for incorporating woody vegetation characteristics into effective, science-driven performance standards.

**Synergies and Trade-offs Among Ecosystem Functions and Services of Lake-edge Wetlands**

*Audréanne Loiselle, Université de Montréal*
*Stéphanie Pellerin, Université de Montréal*
*Raphaël Proulx, Université du Québec à Trois-Rivières*
*Marie Larocque, Université du Québec à Montréal*

"Wetlands are valuable providers of ecosystem functions and services (EFS). However, quantifying EFS is complex, time- and resource-consuming and requires extensive datasets. Consequently, studies generally settle for simpler and fewer metrics. For instance, EFS with broad spectrums, such as biodiversity, are often reduced to a single indicator. While EFS quantification and wetland classification rely on similar methods, differences between wetland types are mostly ignored, as they are grouped together into one category in most EFS studies. Ecosystem multifunctionality is also often overlooked. However, accounting for synergies and trade-offs among EFS allows for more efficient landscape planning. It represents a powerful tool to compare the consequences of different conservation scenarios and avoid undesirable trade-offs.
Our project addresses these issues by proposing a method centered on synergies and trade-offs assessment of different types of lake-edge wetlands. The main objective was to identify similarities and differences in EFS provisioning in three types of wetlands: peatlands, alder swamps, and ash swamps. Using both field-collected and geomatic data, we quantified 25 indicators for 8 EFS, with a vast array of metrics related to biodiversity. We evaluated their interactions using multivariate ordination and cosine similarities. We found significant differences between wetlands types, as peatlands and ash swamps appeared to be mirror opposites. Biodiversity indicators showed diverging patterns, with each wetland type supporting different aspects of biodiversity. Our results suggest that wetland typology influences EFS provisioning and that simplification of some metrics can lead to undetected trade-offs. These differences should be considered in wetland conservation and restoration.

**Modular Monitoring Framework to Assess Performance of Coastal Wetland Management**

*Janet Walker, Southern California Coastal Water Research Project,*
*Eric Stein, Southern California Coastal Water Research Project*
*Kevin O'Connor, Moss Landing Marine Labs*

Our inability to answer basic questions about the effectiveness of coastal wetland restoration and management result from highly fragmented, uncoordinated, and inefficient monitoring approaches that lack mechanisms for effective data sharing and leveraging of resources. We attempt to remedy these deficiencies through the creation of a modular, function-based assessment program that can be customized to specific sites, yet still be synthesized across large geographic areas. We developed a multi-layer monitoring framework, which leverages existing regional monitoring organizations, universities, NGOs, and indigenous communities. A key aspect of this program is a focus on ecological functions versus a single type of flora or fauna. This focus allows the framework to accommodate different estuary types and assimilate data from diverse existing monitoring programs, while maintaining an underlying data comparability. In service of assessing functional performance, we developed standard protocols to assess key estuarine features, coupled with standard data templates and guidance on analysis, synthesis, and reporting. The program focuses on four guiding principles – flexibility, comparability, interpretability, and practicality. Currently, our team is testing the monitoring framework across three geographic regions and fifteen estuaries. This framework provides an opportunity to assess general condition and trends of coastal wetlands that can be used as baselines for regional assessments, proposed restoration projects, and the development of bioassessment tools, as well as help the state assess its large investment in coastal wetland protection, enhancement, and restoration.

**Using Plant Functional Traits and Environmental Conditions to Measure the Value of Native and Non-native Plants to Ecosystem Services**

*Tara Mazurczyk, The Pennsylvania State University*
*Trevor Birkenholtz, The Pennsylvania State University*
*Denice Wardrop, The Pennsylvania State University*

Biodiversity and ecosystem function are central to understanding how species and ecosystems in general, respond to environmental change and how declines in diversity may influence ecosystem services, particularly those that society values most. Considerable evidence now points to the idea that the diversity of functional traits in an ecosystem is more relevant to ecosystem functioning than species diversity alone. Using a trait-based approach, plant functional groups were devised to capture the level of ecosystem functionality in different wetland types for six ecosystem services. A modifier-based approach was also developed to identify major environmental stimuli that influence trait response using machine learning methodologies. These approaches were combined to create an ecosystem service functional score that measures the value of individual plant species, plant functional groups, and entire wetland sites to ecosystem services. Results show that species are not equally important in their contribution to ecosystem processes, where a few key species may account for the majority of ecosystem functioning. Certain invasive plant species do contribute to ecosystem service provisioning, but the degree of ecological function depends on the level of functional redundancy and disturbance. Functional groups that consisted of invasive plant species coincided with native species more tolerant of disturbance. Overall, restoration initiatives must be vigilant with the plant species they eradicate from a given system as removal of an undesirable plant species could result in the reduction of ecosystem functionality in certain contexts and under varying degrees of disturbance.

**Practical Approaches to Improve Wetland Restoration Site Monitoring and Project Outcomes**

*Andy M Herb, Owner, AlpineEco*
*Joy Zedler, University of Wisconsin – Madison*

Monitoring (measuring a site's response to restoration) is essential to understand project outcomes. Because ecosystems are dynamic, there is not likely to be a linear progression toward the expected performance standards and overall project "success" (a term that can be misleading and confusing, and that warrants clear definition). The monitoring method, period, and frequency must be adequate to assess whether a site is self-sustaining. It also must provide the data needed to inform any actions necessary to improve the outcome of the site and other future restoration efforts (i.e. adaptive management). This new-age monitoring and associated feedback requires substantial financial and technical resources, and is recommended for all projects. Restoration projects should begin with agreement on what constitutes “success” (What are the metrics? Must each be met? On what timeline?). Then, cost-effective and efficient monitoring programs must be created that extend beyond the typical monitoring period and frequency, and provide data that are easily translated into on-the-ground adaptive management actions. The benefits of appropriate monitoring and feedback will be improved restoration projects and practices. Recent wetland restoration examples will illustrate practical solutions.

**Monitoring in Management: Restoration Results with Realistic Resources**

*Anna Puchkoff, Yosemite National Park*
*Erin Dickman, Yosemite National Park*

When not required by regulatory obligations, it is difficult to set aside funds and time for restoration monitoring. At Yosemite National Park, wetland and riverbank restoration projects are primarily soft-funded, with limited resources assigned for intensive follow up monitoring in subsequent years. To assess site recovery given these limitations, we use a hybrid approach of quantitative and qualitative methods for monitoring. We present results from a riverbank restoration project, where an engineered log jam was installed along a 130-meter reach narrow a widening river through floodplain sediment deposition. We collected species composition data using line-point intercept for rapid site assessment in conjunction with cross-sectional geomorphological surveys to highlight process-based recovery of 5-year post-restoration habitat. Through photo point monitoring, we capture a qualitative assessment of habitat quality and intervene when necessary to encourage desired native vegetation. We highlight the cost-effective timeline and approaches for improvement, which promote efficacy in understanding shortcomings. By using core methods, we reduce monitoring effort which can be utilized efficiently across a spatially interconnected landscape.

**The role of governance in setting goals and pathways for wetland restoration: lessons from Loktak, a Ramsar site in northeastern India**

*Ritesh Kumar, Wetlands International South Asia*
*C. Max Finlayson, Charles Sturt University*

Institutions and governance arrangements play a critical role in steering wetland restoration towards clearly defined goals and pathways, also enabling the incorporation of diverse stakeholder views and knowledge systems in the process. Persistent mismatches of governance arrangements with the functioning of the wetland social ecological system may position these ecosystems in a ‘social-ecological systems trap’ wherein piecemeal and incremental changes fail to deliver the restoration outcomes aligned with the overarching goal. Loktak, the largest of the Manipur River floodplain wetland complex, and with characteristic mats of floating vegetation (locally called phumdi) forming the habitat of globally endangered ungulate Rucervus eldi, was designated as a Ramsar Site in 1990. Construction of the Ithai barrage downstream of Loktak in 1984 for hydropower generation converted a naturally fluctuating wetland into a reservoir leading to inundation of peripheral areas, loss of migratory fisheries, reduction and degradation of national park habitat, and decline in water quality, ultimately culminating in the Ramsar Site being placed in Montreux Record in 1992. The Government of Manipur constituted the Loktak Development Authority in 1986 as a nodal agency for the conservation and management of the Ramsar Site. Despite the availability of a science-base to guide restoration goal setting, and the expenditure of nearly US$ 90 million to implement management plans, the restoration is far from being effective and complete, primarily due to lack of adaptability within the Authority to respond to changes in wetland social-ecological systems, and effective use of monitoring mechanisms to decide on optimal pathways.

## Hydrologic Performance Standards for Wetland Restoration

*Jeremy Sueltenfuss, Dr., Colorado State University*

Post-restoration wetland monitoring is meant to determine whether restoration goals were met, and whether any adaptive management is required to achieve those goals. However, many restoration projects perform no monitoring, particularly outside of a regulatory context, and the monitoring that is conducted is often not able to determine the mechanisms leading to performance. While plant communities in some contexts can tell us a lot, the lack of hydrologic monitoring, and lack of specific hydrologic goals, limits our ability to restore specific wetland types, and to determine whether those wetland types were created or not. Similar plant communities can be found across different wetland types, but each wetland type has a very specific hydrologic regime. Achieving a particular plant community does not necessarily mean the correct wetland type has been restored. Conversely, if the target wetland plant community does not develop, but the correct hydrologic regime is restored, that system has realistically been set on a trajectory to maintain itself and develop over time. This presentation is meant to provide a framework to establish hydrologic performance standards from one or many reference wetland sites, and provides case study data from existing wetland mitigation projects showing the framework's utility. Hydrologic monitoring and comparisons to reference sites allows us to determine hydrologic performance, and provides a mechanistic understanding of what specific adjustments must take place to achieve the desired hydrologic outcome when the restored site differs from the reference site.

## A practical approach to setting achievable restoration goals in South Africa

*Nancy Job, South African National Biodiversity Institute*
*Damian Walters, Endangered Wildlife Trust*

A key challenge of most restoration programmes is to ensure that efforts are as effective as possible. Effective restoration is strongly influenced by the ability to diagnose ecosystem damage, and then to set effective and realistic restorative goals for the ecosystem in question. When assessing a wetland ecosystem for restoration, it would be useful to be able to identify the presence of impediments to restoration and to develop an understanding of the degraded state, in order to better predict what would be required to restore the system, and what the most appropriate restorative level may be. If a system is shown to have too many impediments, it may be prohibitively expensive or difficult to restore the system, while a less degraded system with superior restoration potential may be a better candidate. The purpose of our research was to develop a framework for identifying potential impediments to restoration, assessing their significance to the restoration potential of the wetland, as well as how these could be practically incorporated into restorative project planning. We present a scaffolded framework that provides guidance for systematically constructing a conceptual model of wetland dynamics, investigating the presence of impediments to restoration and finally setting effective and realistic restoration objectives.

## Application of an integrated monitoring and evaluation framework for resilient wetland restoration to selected case studies in South Africa

*Nancy Job, South African National Biodiversity Institute*
*Damian Walters, Endangered Wildlife Trust*

Evaluation of ecological restoration project success is a vital component of the restoration project cycle, to deepen reflection and demonstrate the value of restoration within natural resource management, support continued development of best practice, and enhance the sustainability of the restoration project. However, evaluation is often informal, and poorly, if at all, documented, and emphasis remains largely on the ecological outcomes of restoration, with little focus on socio-economic outcomes. In response to a growing need for sharing lessons on wetland restoration best practice, the South African National Biodiversity Institute Freshwater Biodiversity Programme, together with the South African Working for Wetlands Programme, solicited evaluations of independent wetland restoration case studies using a prescribed set of criteria to evaluate restoration project outcomes and capture lessons being learnt in the private sector. The criteria were part of a newly developed monitoring and evaluation framework for South Africa which integrates the social, economic and ecological aspects of wetland restoration, and includes a specific focus on evaluating resilience of the post-restoration ecosystem. Four case studies were commissioned across a diversity of wetland types, issues and management contexts in South Africa. The resilience of the wetland restoration projects was reviewed through application of the monitoring and evaluation framework, while simultaneously testing the applicability of the framework, and enabling a further synthesis of lessons.

**Expanding the evidence base for wetland restoration in South Africa: Hard lessons from a strategic infrastructure project**

*Ian Bredin, Institute of Natural Resources*

The Spring Grove Dam development resulted in the loss of 4.62km2 of wetlands. The securing and restoration of selected wetlands were required to mitigate the loss of wetlands resulting from this strategic infrastructure project. A Participatory Action Research approach was adopted for the case study, and the WET-RehabEvaluate framework was used to evaluate the programmatic approach to the wetland offsite mitigation for the Spring Grove Dam development. The case study found that while significant progress was made to overcome the challenges of setting ecosystem-specific targets at a landscape scale, little progress was made in resolving the complex governance issues surrounding wetland offsite mitigation. As such, the securing and restoration of wetlands for the Spring Grove Dam development continues to unfold years after the completion of the development. However, given the evaluation and the stakeholder-focused reflection undertaken for the case study, important opportunities for improving the practice and process of securing and restoring wetlands offsite were identified.

**Monitoring, Research and Social Learning Contributing to the Adaptive Management of Environmental Flows in a Regulated River in Australia**

*Robyn J. Watts, Charles Sturt University; Catherine Allan, Charles Sturt University; Nick Bond, La Trobe University; Bruce Campbell, Department of Agriculture, Water & the Environment; Paul Childs, NSW Department of Planning, Industry and Environment; James Dyer, NSW Department of Planning, Industry and Environment; Sascha Healy, Murray-Darling Wetlands Working Group; Xiaoying Liu, Charles Sturt University; Nicole McCasker, Charles Sturt University; Damian McRae, Department of Agriculture, Water & the Environment; Ebony Mullin, Department of Agriculture, Water & the Environment; Katherine Reid, Department of Agriculture, Water & the Environment; Andre Siebers, La Trobe University; Jason Thiem, NSW Department of Primary Industries; John Trethewie, Charles Sturt University*

Environmental flows are increasingly part of many river restoration programs. In Australia, the Murray-Darling Basin (MDB) Plan aims to protect and restore water dependent ecosystems that have been altered by river regulation. The Plan includes the voluntary purchase of water entitlements from irrigators, with this water allocated to the environment. Monitoring and evaluation of the outcomes of environmental flows in the MDB has been undertaken since 2010, initially through annual monitoring projects, then by the Long-Term Intervention Monitoring program (LTIM, 2014-2019) that has been succeeded by the Monitoring, Evaluation and Research project (Flow-MER, 2019-2023). This paper focusses on the monitoring and research program in one of the areas in the MDB; the Edward/Kolety-Wakool river system, and describes how this program has contributed to the adaptive management of environmental water. This river system has considerable biophysical and institutional complexity, high species diversity, a rich Indigenous history, and supports a productive agricultural community. Since 2010 the system has experienced floods, hypoxic blackwater events, algal blooms and periods of low flows, so the monitoring program has needed to be flexible. The interdisciplinary core monitoring program (established in 2014) has been complemented by targeted research projects and additional short-term monitoring during key flow events. Over time the monitoring and research has shifted from being undertaken entirely by scientific experts, to increased collaboration with a range of local stakeholders. The outcomes have contributed to social learning, informed decision making, the adaptive management of environmental water, and improved environmental outcomes in this system.

**Using hydrogeomorphic characteristics to predict tree species distribution and resulting ecosystem functions**

*Matthew Shockey, The University of Alabama*
*Charles Jones, Univerisity of Alabama*
*Carla L. Atkinson, University of Alabama*
*Lisa Davis, The Univeristy of Alabama*
*Christina Staudhammer, The University of Alabama*

Floodplain forests are an important and integrated component of river corridors. They reduce downstream flooding, store carbon, and are hotspots for biodiversity. While contemporary restoration and management efforts often aim to restore and enhance these critical ecosystem functions, key uncertainties associated with feedbacks between inundation regime and ecosystem function limit those efforts. In this study, we are beginning to address this challenge by examining the relationships between the abundance and distribution of tree species, inundation regimes, and cascading ecosystem functions. We characterized tree species abundance and distribution by establishing 50-0.04 ha experimental plots, where we identified tree species and hydrogeomorphic characteristics. We then characterized inundation regimes using a raster-based inundation model paired with 93 years of streamflow data from an adjacent USGS gage. Finally, to characterize ecosystem function, we used the TRY Plant Trait Database to collect physiological traits such as Leaf Mass per Area (LMA) and leaf Nitrogen-Phosphorus ratio (N/P ratio), which are commonly associated with ecosystem function. Our results highlight strong linkages between hydrogeomorphic characteristics, species distribution, and resulting ecosystem function. We found that both inundation duration and height above nearest drainage (HAND) were good predictors of species distribution ($p=0.001$, $p=0.002$ respectively). Similarly, we found both inundation duration and HAND were strongly associated with LMA and N/P ratios. Although more research on the predictive powers of HAND is needed, this study suggests it could be an effective metric that can improve current and future floodplain restoration projects.

**Combining Field-Based Approaches With Remote Sensing and Ecogenomics To Monitor Wetland Change in Canada's Oil Sands Region**

*Danielle Cobbaert, Alberta Environment and Parks; Craig Mahoney, Alberta Environment and Parks; Stephanie Connor, Alberta Environment and Parks; Joshua Montgomery, Alberta Environment and Parks; Wendy A. Monk, PhD, Environment and Climate Change Canada @ Canadian Rivers Institute, University of New Brunswick; Daniel Peters, Environment and Climate Change Canada; Donald J. Baird, Environment & Climate Change Canada*

"Boreal wetlands represent less than 3% of Earth's surface area and 20 to 30% of the total terrestrial carbon, underlining their importance in climate regulation.  Situated in the boreal, the Oil Sands Region (OSR) is the

world's third largest oil reserve, located in a wetland-dominated landscape of 142,000 km2. Wetlands in the OSR risk degradation from oil sands development associated with land disturbances, contaminants and hydrologic alterations including groundwater and surface water withdrawals. A long-term monitoring program to determine the effects of oil sands development on wetlands focuses on monitoring wetland indicators predicted to respond to oil sands development activities that include changes in hydrology, water quality, and biota. Key challenges for the program include the vast extent of and remoteness of much of the OSR, they underlying natural variability of wetland ecosystems and lack of long-term wetland monitoring data.

Our approach has employed remote sensing and ecogenomics to overcome these challenges and that is complemented with traditional field-based wetland monitoring observations, and thus support adaptive management. Bi-temporal lidar data collected circa 2008 to 2018 that was used to compared changes in wetland vegetation heights adjacent to oil sands mining activities, identifying hot spots of change across wetland classes. This approach was augmented with photogrammetry to assess long-term hydrological changes (i.e. open water) associated with stream diversions from oil sands mining. Finally, eDNA metabarcoding, coupled with multispecies occupancy models supported analysis of responses for a broad range of taxa, allowing influences of climate (temperature and water level variation) to be separated from natural variability in biota composition

**Did it work? A case study on a 13 yr old peatland restoration**

*Valerie J. Brady, Natural Resource Research Inst., University of Minnesota Duluth; Kelly O. Beaster, Lake Superior Research Institute, University of Wisconsin Superior; Kari Hansen, Natural Resources Research Inst., University of Minnesota Duluth; Katya Kovalenko, Natural Resources Research Institute, University of Minnesota Duluth; Robert Hell, Natural Resource Research Inst., University of Minnesota Duluth; Holly Ann Alfreda Wellard Kelly, UMD/NRRI; Zachary Wagner, Natural Resources Research Inst., University of Minnesota Duluth; Jerry Henneck, Natural Resource Research Inst., University of Minnesota Duluth*

In 2002 the Natural Resources Research Institute received regulatory approval to restore 525 acres of a one-time peatland with the goal of creating a peatland wetland bank. The original peatland formed on the bed of the ancient glacial Lake Upham in northern Minnesota. In the 1950’s the land was drained for vegetable farming. Over the decades other land use activities included peat and sod harvesting, agricultural experimentation, and peat research. Restoration followed the “Canadian approach” of using plant material from a nearby “donor” bog to help revegetate the site. Restoration was completed in phases, ending in 2009. The various wetland bank areas were monitored through 2013 and wetland credits were approved in 2014.

In 2019, the opportunity arose for NRRI researchers to more closely evaluate the success of the restoration. The original water table monitoring wells were still intact and are again being monitored, and we have re-established the original vegetation assessment plots across the site. Shortly after restoration efforts were completed (~2010), dominant vegetation species in plots were largely weedy, pioneering graminoids and annual forbs. By 2021, these had largely disappeared and plots were dominated by a diverse community of shrubs and perennial gramminoids and forbs. Vegetation indicative of peatlands increased greatly over the years. Future assessment will include insect, small mammal and bird usage of the site, and site water chemistry. These ecosystem components will be compared in future years to nearby unrestored and least disturbed areas to advance our understanding of functional restoration of peatlands

**Vegetation Composition Assessment and Trend Analysis of Forested Mitigation Wetlands in Marquette *Michigan, USA***

*Emma M. Waatti, Northern Michigan University Student; Matthew J. Van Grinsven, Northern Michigan University; Katy Robinson, U.S. Department of Agriculture Natural Resource Conservation Service; Connor O'Loughlin, Northern Michigan University Student; Madeline O'Donnell, Marquette County Conservation District Field Coordinator*

The purpose of this study was to assess vegetation composition and examine vegetation community trends across a several year period of monitoring to evaluate the condition of five forested mitigation wetlands in Marquette, MI USA. All five wetlands were constructed by the City of Marquette and the Marquette County Conservation District to fulfill Michigan Department of Environmental, Great Lakes, and Energy Division Permits to restore 4.74 acres of forested wetlands. In addition to extensive broadcast application of sedge (Carex spp.) and rush (Juncus spp.) planting, several woody tree and shrub species including red maple (Acer rubrum L.), white spruce (Picea glauca, Moench Voss), highbush cranberry (Viburnum trilobum Marsh.), and red osier dogwood (Cornus stonilifera Michaux) were planted in these wetlands between 2012 - 2018. Repeat quadrat sampling locations were established on both hummocks and hollows along one transect where plant species were identified and their percent cover were monitored annually in each wetland.  Non-native species management procedures were also repeatedly used to control species such as narrowleaf cattail (Typha angustifolia L.) and Butterbur (Petasites hybridus L.).   Native plant percent plant cover, percent bare ground, non-native plant percent cover, wetland indicator status, and native species richness were summarized for each year within each wetland, and linear regression methods were used to evaluate vegetation composition trends for all study sites since 2012.  Preliminary results suggest that non-native species management procedures were effective, and that native plant percent cover significantly increased, native species richness significantly increased, and percent bare-ground significantly decreased since 2012.

**Investigating the Hydrological Connectivity of Forested Mitigation Wetlands Between 2019 - 2021 in Marquette Michigan, USA**

*Emma M. Waatti, Northern Michigan University Student*
*Matthew J. Van Grinsven, Northern Michigan University*
*Katy Robinson, U.S. Department of Agriculture Natural Resource Conservation Service*
*Connor O'Loughlin, Northern Michigan University Student*
*Madeline O'Donnell, Marquette County Conservation District Field Coordinator*

In 2011, the City of Marquette and Marquette County Conservation District began a mitigation project to fulfill a Michigan Department of Environment, Great Lakes, and Energy permit to restore 2.1 acres of forested palustrine wetlands. A major objective of this study was to characterize the hydrologic conditions of these three mitigated wetlands in Marquette, Michigan by examining hydrological connectivity between the atmosphere, Lake Superior, the surrounding groundwater and the mitigated wetlands. Wetland water level observations were recorded using data loggers in three mitigated wetlands during the 2019, 2020 and 2021 growing seasons, and these data were compared to meteorological observations from a local weather station, Lake Superior water levels, and upland groundwater levels. Wetland, groundwater and Lake Superior Water level (AMSL) fluctuations and wetland water level responses to precipitation events and to potential evapotranspiration (PET) were analyzed to the examine the hydrological connectivity between wetland study sites, groundwater, Lake Superior, and the atmosphere. Preliminary results suggest wetland water levels are both sensitive and responsive to PET losses and precipitation additions during the growing season where the largest daily PET estimates corresponded with the greatest daily water level drawdown rates. Whereas the smallest daily drawdown rates were detected during periods with low daily PET estimates.  Water table responses to precipitation events were also most pronounced when wetland water tables were at their lowest

levels during the growing season, and Lake Superior water level fluctuations did not appear to immediately influence wetland water levels.

**Establishment of Wetland Reference Sites in Alabama using Aquatic Assemblages**

*Brian S. Helms, Troy University*
*David Laurencio, Auburn University*
*Khalil Carson, Troy University*
*Jonathan Armbruster, Auburn University*
*Alfred Schotz, Alabama Natural Heritage Program*

Freshwater wetlands harbor high levels of biodiversity and are pivotal to many physical and biogeochemical processes critical to functioning waterways. Despite their recognized benefits, over 50% of the historically 8 million acres of wetlands in Alabama have been lost and/or converted. Further, there is increasing emphasis to identify reference wetland condition as a basis for management and restoration efforts. Thus, the objective of this study was to characterize the representative faunal conditions in 3 replicates each of 7 different types of freshwater wetlands across the state of Alabama. Each wetland type was initially characterized based on floristic surveys and the Cowardin classification system. Following classification, fishes were collected with seines, amphibians were collected with timed searches, turtles collected with traps and macroinvertabrates were semi-quantitatively collected with D-nets during spring and summer seasons 2020-2021. Suspected habitat and hydrologic correlates were also quantified. Fish were collected at nearly half of the field sites and, along with permanency, appear to strongly influence community structure. Taxa richness and overall abundance of amphibians and macroinvertebrates were markedly higher in wetlands that did not contain fish and had a high degree of permanency. Preliminary results suggest that, although many sites show high faunal diversity and characteristic wetland assemblages, there are not strong faunal groupings associated with individual wetland categories. These results allow for the determination of baseline faunal conditions in various types of freshwater wetlands and provide fundamental information to managers and practitioners tasked with managing and or restoring these resources.

**Drone Photography vs Traditional Plot Based Monitoring in Tidal Wetlands**

*Metthea Yepsen, Research Scientist, New Jersey Department of Environmental Protection*
*Terresa M. Doss, Meadowlands Research and Restoration Institute*
*William M. Smith, New Jersey Department of Environmental Protection*
*Elizabeth G. Muntean, The Nature Conservancy*
*Ildiko C. Pechmann, Meadowlands Research and Restoration Institute*
*Adrianna N. Zito-Livingston, The Nature Conservancy*
*Steven M. Jacobus, New Jersey Department of Environmental Protection*

Plant cover and species composition are common metrics used to evaluate wetland condition and restoration project success. Vegetation is assessed on foot in plots as part of regional monitoring programs as well as mitigation and voluntary restoration projects, but depending on where plots are located, this method can easily misrepresent the general condition of the wetland and can be resource intensive. Drone-based monitoring of natural areas and restoration projects are discussed. In the Meadowlands of New Jersey, drones are used to monitor changes in vegetation patterns and distribution, shoreline erosion, change in marsh surface elevation, and to assess plant health at disturbed and reconstructed wetlands. In Southern New Jersey, traditional plot-based monitoring of vegetation was compared with assessments conducted using drone imagery at three tidal wetland elevation enhancement projects. Preliminary analysis suggests that using image-based classification of orthorectified drone photos in ArcPro to delineate areas that were vegetated and unvegetated was very similar to plot-based assessments of the percentage of the sites that were vegetated or unvegetated. The equipment used and analysis conducted with drones gave a higher estimate of plant cover than plot-based monitoring, but both methods tracked the same trends in increases and decreases in cover. In addition, species composition was not able to be determined during the drone analysis. Classification results may be improved using drones equipped with RTK units and multi-spectral cameras.

**Mitigating A Mitigation: Addressing Failure in Wetland Design and Maintenance**

*Will J. Downey, Impact7G, Inc.*

Compensatory wetland mitigation and stormwater wetland sites can require substantial time and cost investment for design, construction, monitoring, and maintenance. These costs can be further exacerbated when wetland sites decline into a state of failure. Three wetland sites have been highlighted to discuss the problems and eventual solutions needed for success.

Site A is as permittee responsible wetland mitigation site with significant setbacks including fatality of tree plantings, hydrology incompatible with the mitigation objectives, invasive species, and structural failures due to an extreme precipitation event. Troubleshooting these issues required close collaboration with the permittee, monitoring to provide preventative correction, and persistent maintenance.

Site B is a stormwater wetland design which was constructed, planted, and then ignored during the remaining construction of the surrounding development. This lack of monitoring and maintenance resulted in a significant fatality of the vegetation, erosion, and loss of 330 cubic yards of storage capacity due to sedimentation. The absence of knowledgeable oversight and monitoring during the establishment of the site resulted in expensive setbacks to the project.

Site C is a wetland mitigation bank which is situated in the floodplain of the Iowa River. This site was carefully designed with potential failure in mind, utilizing a natural system to provide adequate soils, vegetation, and hydrology to create a functioning wetland. Building a resilient system with oversight of wetland professionals through the process of design, construction, and maintenance has resulted in the successful establishment of the site