4-28-2021

Socio-ecological context matters for wetland project outcomes

Sydney VanWinkle
srv7357@rit.edu

R I T

Socio-ecological context matters for wetland project outcomes

by

Sydney VanWinkle

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Environmental Science

Thomas H. Gosnell School of Life Sciences
College of Science

Rochester Institute of Technology
Rochester, NY
April 28, 2021

Committee Approval

Anna Christina Tyler, PhD — Date
Committee Member, Thesis Advisor

Evelyn Brister, PhD — Date
Committee Member

Kristoffer Whitney, PhD — Date
Committee Member

Table of Contents

Acknowledgements

I would like to extend a heartfelt thanks to my advisor, Dr. Christy Tyler, and my committee members, Dr. Evelyn Brister and Dr. Kristoffer Whitney, who showed me what true interdisciplinary collaboration in science looks like. Their willingness to work as a team and understand multiple perspectives has ignited my curiosity and passion for science time and time again. I would also like to extend special appreciation and gratitude to Dr. Christy Tyler, who kept me under her wing since my early years at RIT. She has allowed me to explore all of my interests with unwavering guidance. Her belief in me has led me to believe in myself, and for that I am forever grateful.

I would like to thank RIT's College of Science for granting me the Emerson Fellowship as an undergraduate, Sea Grant for funding the Shipbuilders Creek Restoration project and Waste Management for funding my many years working at High Acres Nature Area (HANA) and Mill Seat Landfill. Additionally, thank you to all of the organizations and people who took the time to help me build my site lists, show me sites in person and help me gather site documents. This type of support was crucial to the development and completion of my research. Thank you to the many students who helped me on this project and throughout my RIT experiences, including Ben Hamilton, Delanie Spangler, Evan Squier, Briana Stringer, Mike McGowan, Liam McGraw, Avery Miller and so many more. The many summers at HANA and the long days spent gathering my last wetland data during a global pandemic will always be in my memory - I truly do not know where I would be today without all of you.

Lastly, I would like to thank my friends and family at home - who have supported my decisions, pushed me to go further and encouraged my true love of wetlands, even when I came home covered in muck. Thanks for the endless time spent discussing my research, aspirations, worries, passions and future plans.

I have been very lucky to be a part of the RIT community and to have many amazing people support me in my endeavors. Thank you all so much!

List of Tables and Figures

ABSTRACT

Restoration or creation of wetlands is used to counteract wetland loss in the United States. However, projects often fail to meet functional equivalence with natural wetlands, and the shortcomings increase with time since construction. Many restoration projects are located in suburban or urban areas and are highly influenced by human impacts. Lack of understanding of how human communities influence restoration outcomes, in ways both positive and negative, hinders the ability of restoration managers to produce favorable long-term outcomes. This thesis investigates relationships among ecological metrics of success and the biotic, abiotic and social context for 38 created and restored wetlands in New York State. Measures of ecological function include invasive species and hydrological regimes, among others, and socio-ecological factors include public access, proximity to residential areas or roads, management strategies, volunteer participation, ownership characteristics, and the initial motivation for the project. Plant diversity, floristic quality index, and metrics developed using the New York Rapid Assessment Method (RAM) for wetlands were used as response variables for ecological quality. Potential predictor variables were evaluated using both univariate and multivariate analyses. I further assessed the role of stakeholders at two sites using semi-structured interviews. These qualitative results were used to evaluate reciprocal interactions between restoration outcomes and stakeholder communities. I found that the social context associated with management, public use/awareness, volunteer participation, and ownership of a site impacted ecological outcomes, suggesting that these factors likely influenced the abiotic and biotic relationships that are key to wetland function. These are leverage points that drive ecological success and delivery of ecosystem services, and thus integrating them into projects at the outset may improve management and planning and long-term positive outcomes. I present a new framework for wetland management based on these results to improve long-term engagement and ensure future wetland health.

INTRODUCTION

Anthropogenic degradation of natural habitats decreases ecosystem services and is the leading cause of extinction and decline in biodiversity worldwide (Millennium Ecosystem Assessment 2005). Wetlands, with an estimated value of $140,000 per hectare per year - more value than most other ecosystems (Costanza et al. 2014) – provide crucial ecosystem services to humans, including water purification and detoxification of waste, and they are critical to mitigating climate change impacts related to flooding and aquifer recharge (Millennium Ecosystem Assessment 2005). The world has lost 50% of its wetlands, with inland wetlands having larger and faster losses than coastal wetlands (Davidson 2014, Van Meter & Basu 2015). Wetland creation and restoration, both voluntary and regulatory, are therefore important for reclaiming lost ecological value (Clean Water Act, Lewis 1990, USEPA ND). The practice of wetland restoration is increasingly important as urbanization accelerates and recognition of the importance of functional ecosystems grows (Race 1985, Race & Fonseca 1996, Gwin et al. 1999, Zedler & Callaway 1999, Brown & Venemen 2001, Bernhardt & Palmer 2007, Matthews & Endress 2008, Fennessy et al. 2008, Reiss et al. 2009, McKinney & Charpentier 2009, Moreno-Mateos et al. 2012, Baldwin et al. 2019).

Voluntary Restoration, Mitigation and Storm Water Wetlands

Modern wetland protection in the US largely began with the Clean Water Act of 1972 Section 404 permit program when mitigation became a required consequence of unavoidable impacts to an existing wetland (History of the Clean Water Act ND, Clean Water Act 1972). Over the next two decades, a number of key regulations were issued to provide better guidance. The current approach to wetland mitigation was established in a 1978 regulation issued by the Council on Environmental Quality (CEQ) that aimed to illuminate the importance of functional replacements for filled or degraded wetlands (CEQ 1978, Hough & Robertson 2008), and was then further clarified in 1990 through coordination of the multiple parallel regulatory structures. Current wetland impact regulations follow a hierarchy of avoidance, minimization and compensation that was largely determined in the period prior to 2000 (Corps & EPA 1990, Hough & Robertson 2008).

Compensatory Mitigation can occur by three pathways: Mitigation Banking (MB), In-Lieu Fee Programs (ILF), and Permittee-Responsible Mitigation (PRM), each of which has different mechanisms to achieve required mitigation for wetland loss. Under PRM, the permittee is held responsible for the construction and success of the mitigation site (USEPA ND). In contrast, MB and ILF Mitigation are considered "third-party" means of compensation (USEPA ND, USACE 2008). The major difference between MB and ILF Mitigation is timing: MB project implementation begins before impacts occur, while ILF project implementation does not begin until afterward. MB thus carries less risk, as wetlands are constructed and fully funded before damages occur. Timing of mitigation efforts is crucial to consider in project planning and could impact initial construction efforts as well as long-term monitoring. While both regulatory and voluntary restoration efforts play a major role in implementation of the Clean Water Act, voluntary restoration initiatives are more often part of local collaborations among governments, nonprofits and private organizations (USEPA 2018).

While the definition of "*good*" restoration has been long debated (Higgs 1997, Kellert et al. 2000, Palmer et al. 2005, Stryszowska-Hill et al. 2019), identifying target goals is key in order to consistently plan, execute and evaluate project outcomes. In wetland mitigation, the evaluation of individual projects may be as simple as permit compliance (Holland & Kentula 1992, Robb 2002, Reiss et al. 2009) or permit compliance with field indicators of success (Brown & Veneman 2001, Sudol & Ambrose 2002, Hoeltje & Cole 2007). Relative to some more ambitious standards of restoration success, compliance standards are easier to meet. Wetland mitigation sites that successfully meet the standard of permit compliance may yet fail to achieve a higher standard of ecological functionality long-term (Race 1985, Race & Fonseca 1996, Wilson & Mitsch 1996, Gwin et al. 1999, Zedler & Callaway 1999, Brown & Venemen 2001, Turner et al. 2001, Matthews & Endress 2008, Fennessy et al. 2008, Reiss et al. 2009, Moreno-Mateos et al. 2012, Baldwin et al. 2019, Moreno-Mateos et al. 2020). Many mitigation projects are initially successful, accomplishing short-term targets for vegetation cover or hydrological standards. However, once permitted mitigation requirements are met for wetland sites, no further monitoring or maintenance is mandated (Sudol & Ambrose 2002) and prolonged maintenance is considered voluntary, may be costly, and is therefore not often undertaken (Turner et al. 2001, Gittman et al. 2019). This leads to a discrepancy between (short-term) regulatory compliance and long-term ecological outcomes. Regardless of progress in wetland mitigation practice, "no net loss” is not being achieved in terms of functional replacement of lost natural systems (NRC 2001, Marton et al. 2014). The mechanisms for failure are complex, likely involving factors such as geographic location, climate change, ownership, management, stakeholder engagement and learning over time. It is possible that management of these ecosystems may need to be considered alongside high-level policy change.

Constructed stormwater wetlands (CSW; hereafter SWW) are wetlands constructed for ecosystem services related to filtering and regulating pollutants and runoff from suburban and urban areas (Lucas et al. 2014, Al-Rubaei et al. 2017). SWW are evaluated in terms of hydrology and pollutant removal, corresponding to why most SWW research focuses on these criteria for success (Moore & Hunt 2012). Though SWW are regulated in the US under the National Pollutant Discharge Elimination System (NPDES) stormwater program, the permitting and approval process differs from wetland mitigation (USEPA 2021). Similar to wetland mitigation practices, NPDES policies and standards developed over time, with an updated practical guidebook publication in 2009 (USEPA 2009). SWWs contribute to biodiversity (Greenway 2010, Woodcock et al. 2010), connect diverse stakeholder groups through education and learning (Welker et al. 2010) and provide habitats to species impacted by fragmentation due to urbanization (Holtmann et al. 2017, Holtmann et al. 2018). There may be an opportunity to gain beneficial information from SWWs that are managed under different regulatory regimes and evaluation methods, in order to identify those that correlate with long-term maintenance of high ecosystem function. Understanding the ecological status, socio-ecological context and how these systems fit into wetland science as whole is a critical connection in need of further development.

Drivers of Aquatic Ecosystem Structure and Restoration Outcomes

Successful restoration requires an understanding of the drivers of ecosystem function and of how these can be leveraged to contribute to the rapid development of desired restoration outcomes (Moreno-Mateos et al. 2020). Wetland structure is determined by abiotic and biotic drivers that are both intrinsic and extrinsic. Some factors, such as hydrology, nutrient availability, herbivory, invasive species, adjacent land-use and historic land use are well studied. Others, and especially those related to the socio-ecological context of sites, such as proximity to neighborhoods, trails, volunteers and land ownership, are less well studied in terms of how they correlate with desired restoration outcomes. There may be significant interaction among any of these drivers that can lead to variable ecological outcomes. Understanding the importance of each driver and evaluating variability in drivers across sites can give insight into control of emergent ecosystem functions in created wetlands.

Hydrology is the defining characteristic of wetlands and is critical for successful restoration. Hydrological regimes interact with landscape features to drive plant community structure (Carter 1996, Pollock et al. 1998, Grabas & Rokitnicki-Wojcik 2015). Unfortunately, projects often fail to replicate these conditions accurately, leaving sites too wet or too dry, which is further exacerbated by variable rainfall and the unpredictability inherent in climate change (Zedler 2000). When hydrological regimes are open, wetlands may develop ecological structure through self-design, while wetlands designed with de-watering methods often see higher invasive species cover (Mitsch & Wilson 1996, Ehrenfeld et al. 2003). These regimes thus influence other drivers such as biogeochemical cycling, nutrient removal and herbivory in wetlands (Carter 1996, Newman et al. 1996). For example, permanent flooding limits vegetation growth and denitrification (Toogood & Joyce 2009, Hernandez & Mitsch 2007), which can lead to invasive plant colonization and may promote overgrazing by migratory waterfowl (Lauridsen et al. 1993, Perrow et al. 1997, Chaichana et al. 2011, Lodge & Tyler 2020).

Nutrient availability is correlated to the health and growth of plants in both terrestrial and aquatic ecosystems (e.g., Bedford et al. 1999, Elser et al. 2000, Ballantine et al. 2014), and it interacts with hydrology, plant cover, and herbivory with cascading impacts on ecosystem functions such as nitrogen removal (Hanson et al. 1994, Newman et al. 1996, Hernandez & Mitsch 2007, Lodge & Tyler 2020). The disturbance of restoration activities combined with high nutrient availability sometimes makes new systems more vulnerable to invasion by non-native plants, leading to further degradation of desired functions (Zedler & Kercher 2005). Agriculture as a previous land use legacy may provide unintended vegetation establishment due to historic seed banks (Middleton 2003), contain undesirably high or low nutrients from previous farming practices (Compton et al. 1998, Richter & Roelcke 2000), and include physically altered landscape micro-topographies, impacting hydrological regimes and soil characteristics (Bruland & Richardson 2005). Nutrient inputs are also strongly influenced by current or legacy use of surrounding land (Castelle et al. 1994, Kuusemets & Mander 2002, Houlahan & Findlay 2004) and those downstream of agricultural or urban areas are therefore vulnerable to aggressive non-native species invasion (Zedler & Kercher 2005). When such drivers are understood, restoration strategies may be selected to promote or hinder their action. For instance, buffer areas are used to reduce the negative impacts of species invasion (Castelle et al. 1994, Houlahan & Findlay 2004, The Nature Conservancy 2015). Additionally, strategically placing wetland projects near similar habitats, and keeping the ratio of wetland perimeter to area (P:A) low may help hydrological regimes develop and provide protection against surrounding land use effects (Van Meter & Basu 2015). An understanding of the importance of these key environmental drivers is typically the overarching guide for restoration planning, but the potential role of social drivers is less well studied.

Social Drivers of Restoration Outcomes

Recognition of the complex but critical link between human involvement and restoration success has prompted evaluation of stakeholder components in restoration (Ehrenfeld 2000, Ehrenfeld 2001, Palmer et al. 2005, Jähnig et al. 2011, Druschke & Hychka 2015, Le Roy et al. 2018). The main arguments for stakeholder involvement in conservation activities revolve around political aims to increase social equity and democratic participation (Reed 2008). However, there are also some reasons to believe that stakeholder involvement is pragmatic, as it may improve the ecological success of restoration projects (Sterling et al. 2017). The pragmatic value of stakeholder components may enter a project in several ways. First, stakeholders may be a resource for project planning, increasing the range of options and building a broader base of support (Sultana & Abeyasekera 2008). Second, they may positively contribute to management interventions in ways that reduce costs of project implementation (Richards et al. 2004). Finally, they may be a resource for longer term maintenance and monitoring. In addition, depending on how projects are structured and their success, the involvement of stakeholders may change over longer periods of time, potentially affecting the priority that the broader society gives to wetland protection.

People that live or work near restoration projects have potential, direct and indirect, impacts that are not well understood. Neighborhoods, major roadways, or agricultural fields that are near restoration projects may influence the nutrient inputs, often in a negative way, but they may also drive awareness of the value of wetlands and produce recreational opportunities for these communities and that, in turn, may increase the ecological care for the area (Wu & Cai 2006). Community stakeholder participation in restoration efforts is potentially valuable in all stages, from planning through implementation and for long-term monitoring. For instance, in some cases natural wetlands in urbanizing areas have higher Floristic Quality Indices (Houlahan et al. 2006, Chu & Molano-Flores 2012). It may happen that developers place value on larger wetlands due to their scenic value, which provides an opportunity for the ecosystem to thrive (Chu & Molano-Flores 2012). This illustrates one mechanism whereby community involvement supports the conditions that develop more robust ecosystems. Community stakeholders may also have relevant site knowledge to assist with project planning, along with community connections that allow project managers to draw in other supportive stakeholders and to defuse controversy and conflict among stakeholders.

Stakeholders may be an asset in project implementation, too (Richards et al. 2004). Many regulatory wetlands utilize professional experts as consultants to carry out wetland construction and monitoring, and community participation in restoration by voluntary stewards is typically limited. However, there may be overlooked disadvantages to reliance on professionals and overlooked benefits of utilizing volunteers (Miles et al. 1998). There is the potential that professional experts use a cookbook, standardized approach to restoration, while those with local knowledge may be more sensitive to the specificities of individual sites.

Moreover, stakeholders who volunteer their labor may have the potential to carry on monitoring and maintenance past original project scopes. Although long-term success may not be a regulatory requirement, developing community investment in a project may make long-term ecological success an obtainable and affordable goal. While it follows that human valuation derived from awareness and proximity will promote long-term ecological protection for a site, the connections between all these drivers are not fully understood. There is a clear need to understand how community involvement helps achieve performance criteria in the long term.

Beyond the immediate goals of wetland restoration, there are broader goals that may generate stronger support for future environmental projects, beyond stakeholder's personal values and motivations (DiEnno & Thompson 2013, Bennett et al. 2018). Project owners have the ability to influence stakeholder perceptions of the project, provide resources to encourage their involvement, or directly facilitate stakeholder learning through education (Rissman & Sayre 2012, Trimble et al. 2014, Medeiros et al. 2014, Bennett et al. 2018, Dawson et al. 2021). Further, policies that govern how or why owners carry out projects may have cascading impacts on stakeholder involvement and long-term ecosystem management (Dawson et al. 2021). When these broader socio-ecological considerations are identified in the original project scope, opportunities for social learning and long-term community support may arise (Blackstock et al. 2007).

<u>Wetland Management</u>

There is a great deal of uncertainty in the management of wetland restoration projects (Mitsch et al. 1998, Millennium Ecosystem Assessment 2005), making it perfect for adaptive management techniques (Williams et al. 2009, Pahl-Wostl 2009, Fabricius & Cundill 2014, Murray & Marmorek 2003). Adaptive management was first described by Walters and Hilborn in 1978 and has been discussed as a part of ecosystem management thereafter. On a large scale “adaptive planning and management” was recommended by the National Research Council’s Committee on Restoration of Aquatic Ecosystem Science in 1992. Adaptive management techniques are also noted as beneficial to utilize in climate change mitigation (Pahl-Wostl 2006, Biesbroek et al. 2010, Porter et al. 2015). Adaptive management is “a systematic approach for improving resource management by learning from management outcomes” (Williams et al. 2009) and is representative of holistic, community-based environmental management (Norton & Steinemann 2001). A key component of adaptive management is the iterative learning process, undertaken in conjunction with improving ecological systems and building stakeholder engagement (Elliot et al. 2004, Palmer et al. 2005, Pahl-Wostl 2006, Pahl-Wostl 2009, Williams et al. 2009, Fabricius & Cundill 2014). Learning is also recognized as a key component in climate change adaptations (Vinke-de Kruijf & Pahl-Wost 2016). The most beneficial use of adaptive management recognizes *learning* as a double loop process, versus a single loop process. Single loop use of adaptive management utilizes learning that leads to improvements in existing practices, but due to its lack of reflectivity and innovation can be limited (Fabricius & Cundill 2014, Tosey et al. 2012). In contrast, double loop learning is a type of knowledge building that leads to reflection and exploration of new creative approaches, sometimes by challenging known best practices (Fabricius & Cundill 2014, Tosey et al. 2012). It has also been noted through systematic review of adaptive management studies that use of both single and double loop learning in adaptive management may be most beneficial (Fabricius & Cundill 2014). One example of single loop learning in managing ecosystems may be in the control of invasive species. Managers often take actions to reduce invasive plant populations and if the results do not reduce population sizes, they adjust their actions and continue on in their endeavors of control. For the double loop process to occur in this given scenario, managers would have to reflect on their initial actions which did not reduce the invasive population size, create predictions or assumptions for various future management option outcomes and then base their new actions on the predicted outcomes of various scenarios. This scenario also illustrates how single and double loop learning can occur simultaneously. Predictions may arise based on single loop learning history; however, innovation and nuances may arise as well. The use of adaptive management should thus be considered as a potential technique to leverage in restoration planning and implementation.

This study aimed to improve long-term wetland restoration outcomes by understanding how socio-ecological context impacts outcome. We hypothesized that long-term outcomes are driven by a combination of environmental and social factors, with sites that have greater stakeholder engagement exhibiting greater long-term success. We used a multivariate approach to assess a variety of potential ecological and social drivers (Table 4) at 38 inland freshwater wetlands (Figure 1) through permit analysis, rapid assessment of ecological state in the field, and geospatial landscape analysis. Two sites were used as intensive case studies to determine the role that stakeholders play in project processes.

METHODS

Site Selection

Local municipalities, New York State agencies, and environmental consultants provided information to build a potential site list. Individual stakeholders were contacted to gain access permission and arrange scoping site visits. Sites were then confirmed based on location and ability to obtain official site access permissions, including highway work permits and temporary revocable permits when applicable. A total of 38 sites were selected encompassing a range of wetland age, type, size, location, ownership, and motivation for restoration (Table 1, Figure 1). The final set of sites ranged in age (as time since the completion of construction) from 2-27 yr, and 0.2 – 12.2 ha. For each site, various features representing legal characteristics and permit details, management, internal and external landscape features, and ecological integrity were recorded.

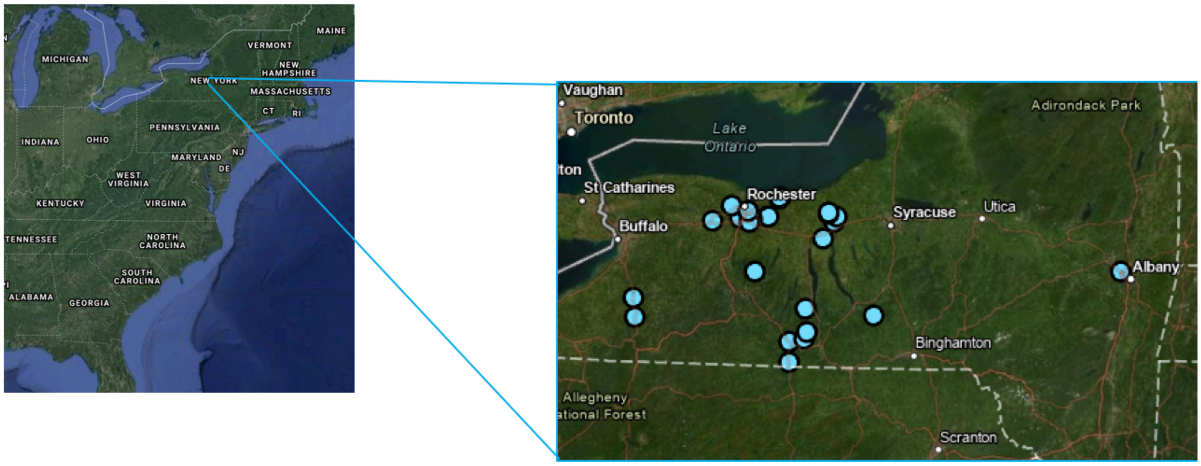


Figure 1: Locations of wetland sites

Site Characterization

Permit documents, mitigation reports, and miscellaneous data were obtained from consulting companies, municipalities, non-profit organizations, and town/county engineers. Where documents were not readily available, I completed a Freedom of Information Request to obtain the data. I reviewed permit documents and land ownership agreements to characterize each project according to a set of predictor variables. Ownership of the land was based on current ownership and classified as private, government, municipality, or non-profit (Own; Table 2). The motivation for the project was classified as in lieu fee mitigation (ILF), permittee responsible mitigation (PRM), stormwater wetland (SWW) or voluntary (PrjctTyp; Table 2). From site documents, I also extracted the intended wetland type, whether the project was *de novo* creation or restoration of a degraded wetland site (Crt/Rst), if there were multiple wetlands embedded within a single project (MultiW), and whether phasing of the project into different steps was planned (Phas). I also evaluated the use of the term “Adaptive Management” (AdptM), and indication of specific invasive species control criteria in planning documents (InvCC; Table 2). I evaluated the differences between current ecological structure in terms of diversity and floristic quality in light of the socio-ecological context derived in the section below.

Table 1: Site characteristics ordered by site age. See Table 2 for further variable description

Sites	Owner	Public Use	Size (ha)	Age	County	RAM	DI	FQI
Preemption ILF 3	4	2	0.7	2	Schuyler	41	1.7	8.0
Preemption ILF 2	4	2	1.4	2	Schuyler	45	1.6	9.4
Mill Seat	1	1	4.1	3	Monroe	46	1.3	7.8
Brickyard Trail	2	1	0.3	4	Monroe	74	1.1	6.1
Honeoye Inlet	3	1	2.6	4	Ontario	36	1.5	11.9
A3B 2019	1	1	1	7	Monroe	36	2.5	18.3
Rapp Road	2	2	0.9	9	Albany	34	1.7	10.8
Warder Marsh	3	1	4.4	9	Seneca	51	1.4	8.7
BOCES	5	1	0.2	9	Steuben	49	1.5	10.6
SR 414 Beaver Dams	4	1	1.5	9	Chemung	72	1.9	14.8
Seneca Meadows 1	1	1	2.0	10	Seneca	43	1.2	14.1
Seneca Meadows 2	1	1	1.4	10	Seneca	40	1.0	13.6
Flat Iron: Roadside	4	1	0.3	10	Tompkins	42	2.2	16.5
Flat Iron: Lower	4	1	1.0	10	Tompkins	42	2.4	15.4
Post Creek Site	4	2	0.8	10	Steuben	45	2.2	19.0
A1N	1	1	1.9	11	Monroe	51	0.7	6.4
A2N	1	1	1.3	11	Monroe	42	2.4	13.4
Mitigation Marsh	3	1	10.5	11	Seneca	33	1.1	8.5
Deep Muck Marsh	3	1	12.2	11	Seneca	34	1.4	10.6
South Butler Unit	3	1	8.3	12	Seneca	37	2.0	12.9
RIT	1	1	1.1	13	Monroe	61	1.6	10.4
Flat Iron: Pipeline 1	4	1	6.1	13	Tompkins	33	2.2	14.1
Flat Iron: Pipeline 2	4	1	0.6	13	Tompkins	35	2.7	11.7
Lindley Road Site	3	1	2.5	13	Steuben	64	1.0	8.7
Hinman Valley 1	3	1	2.7	13	Cattaraugus	46	1.4	10.1
Hinman Valley 2	3	1	2.3	13	Cattaraugus	23	1.8	12.4
Peters Road	3	2	0.7	13	Erie	46	2.4	16.2
Mulligan	3	1	9.1	18	Seneca	45	1.0	5.3
Kensington Park	2	1	0.4	19	Monroe	74	2.4	11.4
Delancey Court	2	2	0.6	20	Monroe	85	0.9	12.3
Rt104 WMA 1	3	1	0.9	23	Ontario	67	2.3	14.0
Rt104 WMA 3	3	1	0.6	23	Ontario	68	2.2	12.8
Rt104 WMA 4	3	1	1.8	23	Ontario	58	0.5	8.1
Rt104 WMA 6	3	1	1.6	23	Ontario	51	2.5	7.9
Tinker	2	1	0.3	25	Monroe	75	0.8	4.0
Frost Hill	3	1	9.4	25	Seneca	22	0.7	9.5
Chatham Woods	2	2	0.6	27	Monroe	101	1.3	10.4
Rt531 D	3	2	1.7	27	Monroe	81	1.2	3.8

The current management of each site was determined through discussion with land owners and classified as actively managed, moderately managed, and "hands-off" management (Mgmt; Table 2). Hands-off management indicates sites that are dominated by natural processes to regulate wetland state, moderately managed sites may have species and/or water level monitoring as well as occasional changes such as invasive species removal, and actively managed sites have routine monitoring, maintenance and plantings. Sites were classified as either open or closed to the public (PubUse), and managers were asked to indicate whether or not community-based volunteers were active at the site (Vol; Table 2).

Using ArcGIS analysis, I classified, digitized and extracted landscape features, including the most recent historic previous land use (PrvLU), the wetland perimeter to area ratio (P:A) and placement among wetland landscape features (PlcWet) as determined by the National Wetlands Inventory database in conjunction with up to date aerial imagery to identify streams or rivers. PrvLU was determined from site documents, inspection of Google Earth aerial imagery, and conversations with land owners. All human-altered habitats, including agriculture, mining, or residential were grouped into the altered category, while largely undeveloped, abandoned or marginal areas were grouped into the undeveloped category. It is important to note that there may have been multiple land uses that existed at each location prior to this categorization of recent land use history. The proximity (in km) to the closest roadway of three size classes was based on NYS DOT ArcGIS layers, with primary roads (PrxPR) as interstate highways expressways and state routes, secondary roads (PrxSR) as county routes and main urban roads, and tertiary roads (PrxTR) as residential or privately-owned roads (Table 2). A similar process was used to estimate the distance (in km, $\log_{10}$ transformed) to NYS DEC snowmobile trails using the DEC 2018-2019 ArcGIS layer. Nearby school districts were identified by using NCES ArcGIS layers, identifying each district near a site, compiling addresses and importing them as a layer into ArcGIS Pro to determine distance to each wetland (in km). Actual school building addresses or district offices were used based on district websites. Through ArcGIS analyses, variables such as: perimeter to area ratio, placement among wetland landscape features, proximity to roadways; trails or schools were collected by using the most update to date imagery/data layers available. Additional landscape features were derived from the rapid assessment methods described below.

Metrics of Ecological Health

I used the New York State Rapid Assessment Method (NYRAM) Version 5 protocol, developed by the New York Natural Heritage Program (NYNHP) to evaluate functional health for each site (Shappell & Howard 2018). Rapid assessment methods are a commonly used tool across ecosystem types to quickly assess ecological structure and threats (Stryszowska-Hill et al. 2019), and are typically designed as a tiered system with increasing depth at each level. While wetland RAMs vary geographically depending on climate and wetland type, assessment models are transferable to other locations as long as the wetland type evaluated aligns with the specific RAM used (e.g., NYRAM was developed from the Ohio Rapid Assessment Method; Stryszowska-Hill et al. 2019).

I selected a representative primary Sample Area (SA) at each site using ArcGIS in conjunction with site visits and discussion with land managers. SA selection also limits the area of water ≥1 m and the non-target wetland class to <10% of the total SA (Shappell & Howard 2018). NYRAM has not been used in the past for created or restored wetlands and some modifications were made to accommodate the smaller wetland size (all <13 ha). The SA size was reduced from the prescribed 40-m radius (0.5 ha) plot to a 20 m x 50 m (0.1 ha) non-standard plot. A field buffer of 100 m was established outside of the SA, and assessments of the adjacent areas were completed through field buffer plots per the NYRAM protocol (Shappell & Howard 2018). Where adjacent roads or privately-owned land prevent establishment of a full buffer plot, remote observations were made from within the site. Because of this limitation, I did not use the AOI in the final analysis.

Figure 2: Schematic of manual NYRAM Part A showing the 50 m x 50 m grid overlay and digitized roads/trails used to determine LULC and Fragmenting Features scores.

NYRAM Part A consists of an onscreen GIS assessment including a Land Use Land Cover (LULC) and Fragmenting Features (Frag) Assessment to calculate a Part A score of the 500 m buffer (Figure 2; Shappell & Howard 2018). I used a manual method to complete Part A, where a grid layover guides the assessment visually, so various road, trail and utility layers were collected and used to improve accuracy (Figure 2; Shappell & Howard 2018). First, the LULC within the 500 m buffer was completed by tallying the number of cells comprised of impervious surface, land that is intensely managed, actively managed, lightly managed, or natural following the NYRAM protocol (Shappell & Howard 2018). Percentages were converted into "type scores" by using the multiplier provided in the NYRAM protocol. Per the protocol the type scores were summed and divided by 10 to produce the total LULC score. Equation B-2 (Appendix B) was used to calculate each Part A score which was used later in the final NYRAM (RAM) score (Shappell & Howard 2018). LULC and Frag were also retained as separate variables for comparison against DI and FQI.

Part B of NYRAM includes on-site completion of field stressor checklists within the SA and within the field buffer (Figure 3). Ecological stressors such as vegetation modifications (VM), hydro-period modifications, microtopography, eutrophication and sediment transport were noted based on a visual assessment, following the NYRAM protocol within the 20 m X 50 m macro-plot. Scores from these checklists were included in the Part B score and combined with the Part A score using Equation B-2 (see Appendix B) to determine the final NYRAM score.

The Level 3 assessment is modeled after the Carolina Vegetation Survey (Peet et al. 1998). This was completed at the time of the Level 2 monitoring. The same 20 m x 50 m macro-plot was divided into ten 10 m x 10 m subplots (Shappell & Howard 2018). Vegetation strata and percent cover for each plant species was measured in four-10 m x 10 m plots within the SA. Complete species lists and DBH for tree stems greater than or equal to 10 cm was recorded for each plot (Shappell & Howard 2018). The Shannon Diversity Index was calculated using the raw percent cover for each species.

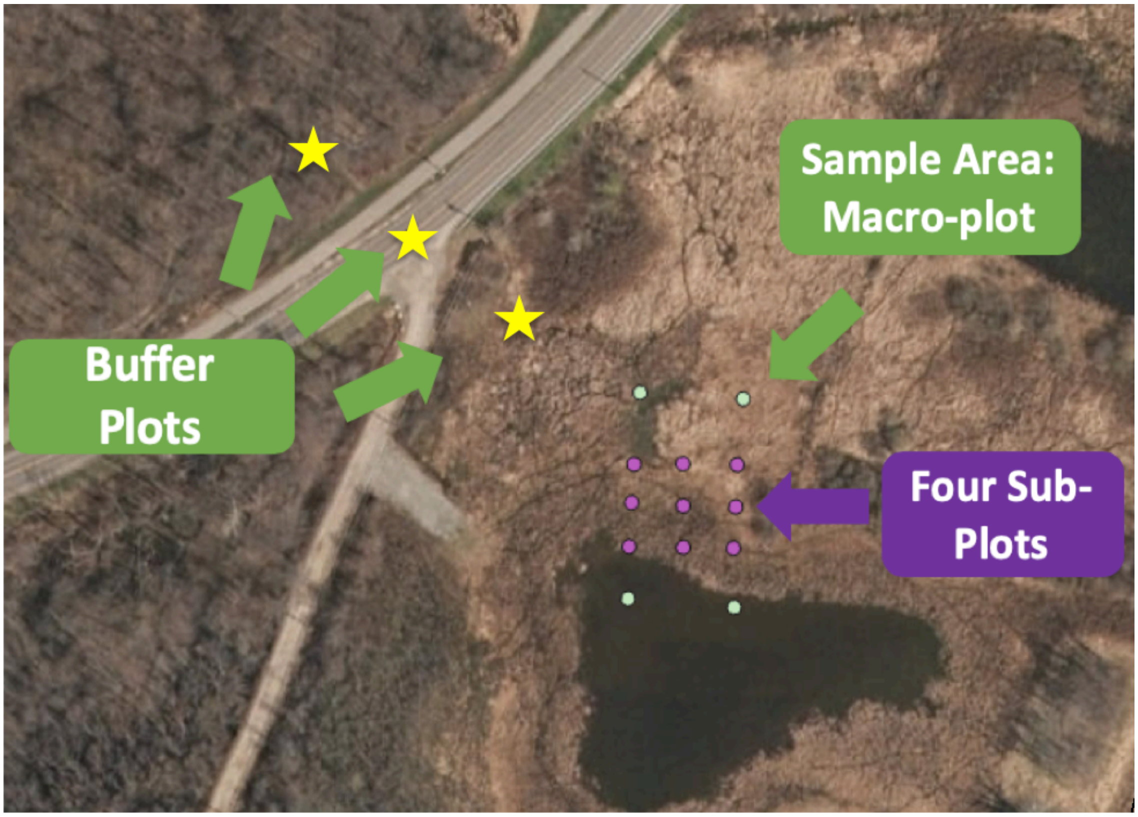


Figure 3: Map of NYRAM Part B macro-plot (green points indicate plot corners), bufferplots (whole plots indicated by yellow stars) and sub-plots (purple points indicate plot corners) at the RIT wetland site. All sites utilized this layout

Response variables: The plant Diversity Index (DI), Floristic Quality Index (FQI) and overall degradation (RAM) were chosen to indicate ecological health at each site. The vegetation data collected during the Level 3 assessment described above served as the main input for the response variables FQI and DI.

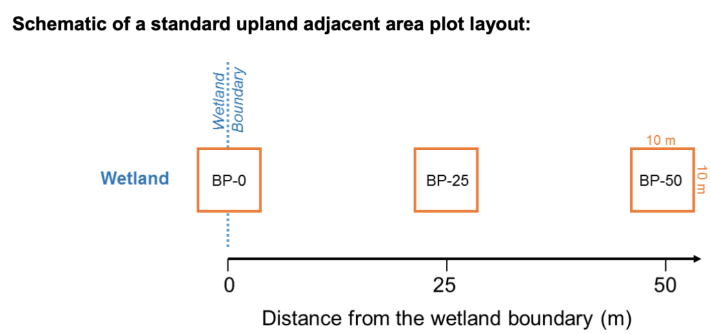


Figure 4: Schematic of standard upland buffer plot layout (Shappell & Howard 2018)

FQI was calculated using the mean native coefficient of conservatism (specific to the northeast ecoregions) multiplied by the square root of the total number of native species (Herman et al. 2001, Bried et al. 2011). DI was calculated using the Shannon

Diversity Index formula and using percent cover for each species (Ortiz-Burgos 2016). Wetlands in “good” condition wetlands have RAM scores <38, (Shappell & Howard 2018). DI <1.5 is considered low, while 3.5 and above is considered high; similarly, FQI between 1-19 is considered low and high is >20 (Ortiz-Burgos 2016, US Fish & Wildlife Services 2019).

Table 2: Final independent variables tested in univariate comparisons

Code	Variable	Type	Attributes	Model
Own	Ownership (Priv, Muni, Govt, NP)	Nominal	2020 ownership: (1) Private Company; (2) Municipality; (3) Dept of Government; (4) Non-Profit	FQI, DI, RAM
Age	Wetland Age	Continuous	Years from completion of construction	DI, FQI, RAM
PrvLU	Previous Land Use	Nominal	Most recent previous land use (1) Human Altered Landscape; (2) Undeveloped	FQI, DI, RAM
PrjctTyp	Project Type	Nominal	(1)ILF, (2) PRM, (3) SWW or (4)Voluntary	FQI, DI, RAM
MultiW	Multiple Wetlands in Project	Binary	More than one wetland was part of the overall project for each site (0)No, (1)Yes	FQI, DI, RAM
PlcWet	Wetland Landscape	Binary	Site placed among other wetland features in landscape (0)No; (1)Yes	FQI, DI, RAM
Crt/Rst	Created	Nominal	Site were either (1) Created (2) Restored	FQI, DI, RAM
LULC	Land Use Land Cover Score	Continuous	Score derived from the NYRAM Part A 'On Screen Assessment' Protocol.	FQI, DI
P:A	Perimeter: Area	Continuous	Calculation of the ratio of perimeter and area (m/m^2)	DI, FQI, RAM
Fr	Fragmentation	Continuous	Score of fragmenting features within a 500m buffer.	FQI, DI
PrxST	Snowmobile Trails	Continuous	Distance (km) to DEC Snowmobile Trails.	
PrxPS	Proximity to Public Schools	Continuous	Distance (km) to the closest Public School District.	
PrxPR, PrxSR, PrxTR	Proximity to Roads	Continuous	Proximity (in km) to Primary (PrxPR), Secondary (PrxSR), and Tertiary (PrxTR) Roads.	
Mgmt	Management (HO, Mod Mgmt, Act Mgmt)	Nominal	Management level in 2020: (0) Hands off; (1) Moderately managed; (2) Actively managed	FQI, DI, RAM
AdptM	Adaptive Management	Binary	"Adaptive management" in site documents: (0) No; (1) Yes	FQI, DI, RAM
VM	Vegetation Modifications	Nominal	NYRAM Part B Protocol coded as: (0) absent in SA and FB, (1) present in FB	
Phas	Phased Implementation	Binary	Project phasing described in site documents: (0) No; (1) Yes	FQI, DI, RAM
InvCC	Invasive Control Criteria	Nominal	Invasive plant control criteria in site documents. (0) absent; (1) present	
PubUse	Public Use	Nominal	(1) Open to public uses (education, recreation, permitted hunting) or (2) Closed	FQI, DI, RAM
Vol	Volunteers (Vols, No Vols)	Binary	(1) Volunteers active at site, or (2) No volunteers	FQI, DI, RAM

Data Analysis

Univariate relationships between predictors and the three response variables (RAM, FQI and DI) were tested. Variables that were included in the calculation of RAM were not compared against the composite RAM score. These ranges were used to assess the overall condition of each wetland. For normally distributed categorical data, a one-way analysis of variance (ANOVA) was used, with Tukey Kramer HSD post hoc testing when significant relationships were identified among three or more categories ($p<0.05$). For non-normally distributed data, univariate relationships were tested with Wilcoxon/Kruskal-Wallis Tests (Rank Sums). Nonparametric comparisons for each pair using the Wilcoxon Method was used as the post hoc test when the Chi-square approximation was found to be significant ($p<0.05$). Linear regressions using best fit lines were used for continuous data comparisons ($p<0.05$). All regressions used normal distributions.

Multiple iterations were used to create three models (one for each response variable) with varying inputs. Response variables were tested and scaled (when applicable) for normality prior to regression analyses and distributions were accounted for in each regression and noted in final summaries. Final inputs were guided based on known variables that impact wetland creation and restoration projects (PlcWet, P:A, Age, LULC, PrvLU, Crt/Rst, etc.), combined with hypothesized variables that may directly impact project outcomes or have a combination effect with known variables (Vol, Phas, Own, PubUse, etc; Table 2). Dummy variables were created manually by categorizing each nominal or binary variable as true (1) or false (0) for use in regression modeling. For each dummy variable set, "k-1" was used when inputting variables into the model to avoid redundancy. The final models identified only main effects; though interaction effects were explored. Akaike's Information Criterion (AIC) was used to compare the quality of each model and determine the best model based on the lowest AIC_c value (Anderson 2008). Estimates from each regression were used to identify the redundant dummy variables in each model. To detect collinearity Variance Inflation Factors (VIFs) were calculated to show how much the standard error of the coefficient/estimate is inflated due to multicollinearity. Final models were chosen based on the lowest AICc validation in conjunction with the highest R-square value and least overall noise from highly correlated or dependent predictor variables.

Interviews:

I analyzed the perspective of stakeholders at two of the 38 wetland sites and related this to the success of the restoration project using the ecological assessment described above (Appendix D). Interviews were conducted to provide insight into human perception about project values to local communities, motivation to stakeholder involvement and the value of stakeholder input. Two stream and two wetland projects were originally used as intensive case studies, but due to COVID-19 limitations, fewer interviews were conducted and stream site interviews are not being used for interpretation (for more information see Appendix D). RIT's Internal Review Board Process was completed prior to interviewing and surveying the public. See Appendix D for further description on the use of interviews for this study.

I completed three interviews for the RIT wetlands and five for the High Acres Nature Area wetlands (A1N, A2N, A3B). Assessing data saturation in qualitative research is a debated topic (Guest et al. 2006, Weller et al. 2018) but is typically determined based on the individual study. The interview questions were designed to assess stakeholder perception of each wetland project and thus may be considered phenomenological, requiring fewer interviews (5 or more) to meet data saturation (Morse 1994, Creswell 1998). To build my participant list I used purposive sampling and selected stakeholders that played some role in each restoration project (Palinkas et al. 2015). The roles included: project planning, execution, or being an active community member who had input into the project due to its location, visibility or impact. From this initial group, I used a snowball sampling technique to continue to build the final participant list (Davenport et al. 2010). Each interview was audio recorded along with note taking during the session. Interviews were semi-structured without set time constraints and ranged from 13-47 min.

I used open coding techniques to analyze interviews and to allow categories and themes to emerge from the data (Emerson et al. 1995). This technique enabled me to recognize when no new categories were in the data and when theoretical saturation had been met. Each interview was coded by hand and then compared to find common broad categories. Original coding was noted so that each category could be described. Final categories were compared across sites and conclusions were drawn based on the responses.

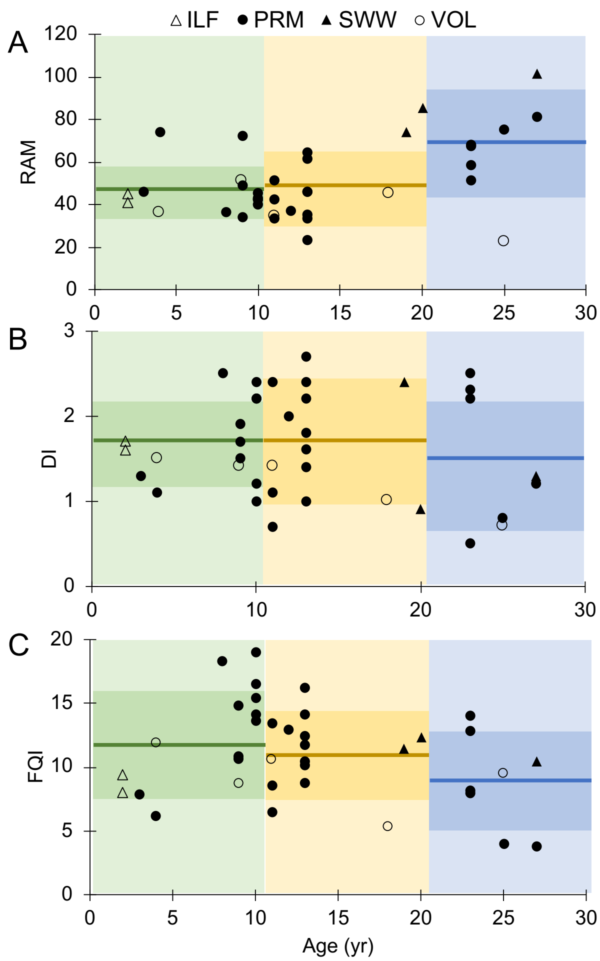


Figure 5: Scatterplot matrix of response variables by age. Lines represent the response mean for each colored (10 yr) age group. Shading represents standard deviations. Note that higher FQI and DI indicate better ecological states while higher RAM indicates more potentially degraded ecosystem states.

RESULTS

Overall indicators of wetland health suggest that created and restored wetlands in this study were of relatively poor quality (Ortiz-Burgos 2016, Shappell & Howard 2018, US Fish & Wildlife Services 2019). RAM scores ranged from 22-101 with a mean of 51±18 (error estimates are standard deviation in all cases; median = 45). Mean DI was 1.6±0.6 (range 0.5-2.7; median=1.6) and FQI was 11±3.7 (range 3.8-19.0; median= 10.7). Individual site scores are in Table 1. Rapid Assessment Method Scores (RAM) were negatively correlated with Floristic Quality and Diversity ($p=<0.0001$, $r^2=0.08$).

Univariate Relationships

Wetland age was positively related to RAM score (p=0.002; Table 4; Figure 5A), but was not correlated with DI or FQI (Figure 5B, 5C). The size of the wetland relative to the perimeter (P:A) was also positively correlated with RAM (p=0.03; Table 4). The relationships among DI or FQI and the continuous variables Fr and LULC, that are part of the buffer assessment of RAM, were not significant (Table 4). However, DI and FQI were significantly negatively correlated with proximity to Public DEC Snowmobile Trails (p=0.004 and 0.05, respectively; Table 4), but not with any other proximity category.

Similarly, there were few significant categorical predictors (binary and nominal) for DI, FQI, and RAM (Table 4). However, sites owned by municipalities had (>50%) increase in RAM scores (74±22) relative to all other types (<48; $p=0.03$). SWW had substantially higher RAM scores than ILF, PRM or voluntary sites ($p=0.004$), due to high scores for impacts in the buffer areas. DI was higher for active (2.0±0.4) and hands-off management (mean=1.7±0.7), than for moderate management (1.3±0.5; $p=0.018$); there were no differences for FQI or RAM. Restored wetlands (43±14) had lower RAM scores than created wetlands (57±19; $p=0.02$), as did wetlands that were placed within a wet area (49±17 versus 67±18; $p=0.05$). Wetlands in a wet landscape also had higher plant diversity ($p=0.05$). Mention of the words "adaptive management" in site documents ($p=0.02$) along with having multiple wetlands in a project scope (mean=46±15) is correlated with approximately 25% lower RAM scores ($p=0.02$ and $p=0.06$, respectively), but were unrelated to FQI and DI. Sites with an established invasive species threshold had higher FQI ($p= 0.02$) and lower RAM ($p= 0.01$). Modification of vegetation (VM) in the 100 m buffer led to roughly 30% lower diversity in the SA ($p=0.03$; Table 4).

<u>*Relationships among predictors*</u>

Most (87%) of the data was from sites that were legally required either for mitigation or stormwater management. Whether a site was created or restored, varied as a function of projects being legally required or voluntary, with restoration more common in voluntary sites ($p=0.008$; Fishers Exact Test). Most sites (80%) offered public use, which varied slightly by ownership ($p=0.06$; Pearson). Of the 20% of sites that didn't, 50% were owned by a municipality (city/town), 12% were owned by a department of the government (DOT/DEC), and 37.5% were owned by a non-profit. All sites owned by a private company allowed some level of public use. The probability of having volunteers was greater for sites that offered public uses ($p<0.05$; Fishers exact), with all sites closed to public lacking volunteers, relative to 58% of sites open to public use (permitted hunting, walking trails, education, etc). Use of the words adaptive management appeared more in documents from younger sites ($p=0.0005$). The earliest mention of adaptive management in our data is in 2008, although 16 sites constructed after 2007 did not mention adaptive management in available site documents. The use of phasing during project implementation also occurred more in younger sites ($p=0.0091$).

Multivariate Models

The significant main effects in the DI and FQI models were similar, while the RAM model varied (Table 2 & Table 5). SWW, sites that were restored, owned by non-profits or actively managed fueled better DI ($p<0.05$) and FQI ($p<0.05$). Interestingly, PRM was an additional positive indicator of FQI ($p=0.01$) while SWW and PRM were positive indicators of RAM ($p<0.0001$ & $p=0.07$; respectively). Voluntary sites or sites owned by municipalities fueled worse DI ($p<0.05$) and FQI ($p<0.05$), however voluntary sites produced lower RAM scores ($p<0.0001$). The presence of volunteers was an additional positive main effect in the DI model ($p<0.01$), phasing ($p=0.02$) was an additional main effect in the FQI model and placement in a wet landscape was for RAM ($p<0.0001$).

When data was sub evaluated by only wetland mitigation sites, main effects for FQI and RAM remained the same, however, project types (ILF, PRM) were no longer significant. The DI model remained the same except for the significance of project types (ILF, PRM) and the presence/absence of volunteers.

Table 3: Summary of means ± standard deviation for each univariate test. Post-hoc connecting letters are noted as subscripts.

Parameter	Category	DI	FQI	RAM
Own	Private	1.5 ± 0.7	12 ± 4.1	**46 ± 8**$_{b}$
	Municipality	1.4 ± 0.6	9.2 ± 3.3	**74 ± 22**$_{a}$
	Govt Dept	1.5 ± 0.6	10.1 ± 3.1	**48 ± 16**$_{b}$
	Non-Profit	2.1 ± 0.4	13.6 ± 3.7	**44 ± 12**$_{b}$
PrvLU	Altered	1.6 ± 0.6	11.1 ± 3.7	49 ± 19
	Undeveloped	1.8 ± 0.8	11.0 ± 3.7	57 ± 14
PrjctTyp	ILF	1.7 ± 0.1	8.7 ± 1.0	**40 ± 3**$_{b}$
	PRM	1.7 ± 0.6	11.5 ± 4.0	**50 ± 15**$_{b}$
	SWW	1.5 ± 0.8	11.4 ± 1.0	**79 ± 14**$_{a}$
	Voluntary	1.2 ± 0.3	9.2 ± 2.5	**40 ± 11**$_{b}$
MultiW	One	1.5 ± 0.6	10.3 ± 3.4	**59 ± 21**
	Multiple	1.7 ± 0.6	11.4 ± 3.8	**46 ± 15**
PlcWet	No	1.4 ± 0.5	**7.7 ± 5.1**	**67 ± 18**
	Yes	1.7 ± 0.6	**11.5 ± 3.3**	**49 ± 17**
Phas	No	1.6 ± 0.6	10.5 ± 3.4	54 ± 20
	Yes	1.6 ± 0.6	12.8 ± 4.2	42 ± 5
CrtRst	Created	1.6 ± 0.6	10.3 ± 3.5	**57 ± 19**
	Restored	1.6 ± 0.6	12.0 ± 3.8	**43 ± 14**
AdptM	No	1.6 ± 0.7	10.5 ± 3.6	**56 ± 20**
	Yes	1.7 ± 0.5	12.3 ± 3.6	**40 ± 4**
Mgmt	Hands off	**1.7 ± 0.7**$_{ab}$	10.7 ± 4.1	54 ± 17
	Moderate	**1.3 ± 0.5**$_{b}$	10.3 ± 2.8	51 ± 23
	Active	**2.0 ± 0.4**$_{a}$	12.7 ± 3.9	44 ± 11
VM	Absent	**2.2 ± 0.4**	12.9 ± 1.9	- ± -
	FB	**1.5 ± 0.6**	10.8 ± 3.8	- ± -
InvCC	No Criteria	1.4 ± 0.7	**9.3 ± 3.1**	**61 ± 21**
	Criteria	1.8 ± 0.6	**12.2 ± 3.6**	**44 ± 12**
PubUse	Open	1.6 ± 0.6	11.0 ± 3.4	48 ± 15
	Closed	1.6 ± 0.5	11.2 ± 4.7	60 ± 25
Vol	No	1.7 ± 0.6	11.2 ± 3.7	54 ± 19
	Yes	1.5 ± 0.7	10.7 ± 3.8	45 ± 15

Table 4: Summary of univariate results for response variables. Bolded p-values indicate siginificance at 0.05. DI was transformed for Vol; RAM for MultiW, PrjctTyp, PrvLU, Own, Crt/Rst, PubUse and InvCC. "*" indicates a non-parametric Chi-Square test was used.

	DI				FQI				RAM			
Parameter	**df**	**F**	***p***	**R^2**	**df**	**F**	***p***	**R^2**	**df**	**F**	***p***	**R^2**
Own	3	2.6	0.07	-	3	2.7	0.06	-	3	3.5	**0.03**	-
Age	1	-	0.40	0.02	1	-	0.16	0.06	1	-	**0.002**	0.23
PrvLU	1	0.001	0.97	-	1	0.60	0.44	-	1	1.7	0.21	-
PrjctTyp	3	1.0	0.40	-	3	3.1*	0.38	-	3	5.4	**0.004**	-
MultiW	1	1.3	0.26	-	1	0.7	0.40	-	1	3.9	**0.06**	-
PlcWet	1	0.6	0.45	-	1	4.1	**0.05**	-	1	4.1	**0.05**	-
Crt/Rst	1	0.0	0.99	-	1	2.1	0.16	-	1	6.3	**0.02**	-
LULC	1	-	0.97	<0.001	1	-	0.98	<0.001	-	-	-	-
P:A	1	-	0.29	0.03	1	-	0.73	0.003	1	-	**0.03**	0.13
Fr	1	-	0.87	<0.001	1	-	0.61	0.01	-	-	-	-
PrxST	1	-	**0.004**	0.21	1	-	**0.05**	0.1	-	-	-	-
PrxPS	1	-	0.30	0.03	1	-	0.20	0.05	-	-	-	-
PrxSR	1	-	0.79	0.002	1	-	0.85	<0.001	-	-	-	-
PrxTR	1	-	0.88	<0.001	1	-	0.93	<0.001	-	-	-	-
PrxPR	1	-	0.09	0.08	1	-	0.34	0.03	-	-	-	-
Mgmt	2	4.4	**0.02**	-	2	1.3	0.26	-	2	2.3*	0.31	-
AdptM	1	0.1	0.82	-	1	2.2	0.15	-	1	6.7	**0.02**	-
VM	1	4.9	**0.033**	-	1	1.4	0.24	-	-	-	-	-
Phas	1	0.0	0.94	-	1	2.8	0.10	-	1	3.4	0.08	-
InvCC	1	3.3	0.07	-	1	6.5	**0.02**	-	1	7.0	**0.01**	-
PubUse	1	0.0	0.99	-	1	0.03	0.87	-	1	1.9	0.18	-
Vol	1	1.7	0.21	-	1	0.2	0.67	-	1	2.3	0.14	-

Table 5: Multivariate model summary for all response variables. Note that RAM was log10 transformed to achieve normality. "*" = significance at 0.05; "**" = significance at 0.01. See Table 2 for parameter abbreviations.

Response Variable	BIC	AICc	R-sq.	+ Correlation	- Correlation
DI	73.7	66.0	0.43	Act Mgmt**, Restored*, SWW**, Vols**, NP Own*	Mod Mgmt**, Created*, Voluntary**, No Vols**, Muni Own*
FQI	205.2	197.1	0.54	Act Mgmt**, Restored**, PRM**, SWW**, NP Own**, Phased**	Mod Mgmt**, Created**, Voluntary**, Muni Own**, Not Phased**
RAM Score	-46.9	-54.0	0.57	PRM, SWW**, PrvLU Undeveloped**, Not Plc Wet**	Voluntary**, PrvLU Altered**, Plc Wet**

Interviews

Analysis of the interviews indicated social barriers were the key factors and challenges during planning (communication among stakeholders, recruiting and retaining stewards) and implementation of projects. Interviews exemplified the importance of stakeholder involvement and identified a need for best practices for integrating local human communities into projects. For more information on results of all interviews, including from the two stream restoration sites, see Appendix D.

DISCUSSION

Wetland project management can be viewed from two different perspectives. First, management can be considered on a project-by-project basis, with regard for how practitioners handle day-to-day or month-to-month ecosystem management. These project-level techniques are important to illuminate as they are site specific tools for practitioners to consider during planning and implementation. The second perspective considers project connectedness across ownership, project type, location, etc. This second perspective takes a systems approach to wetland management and illuminates ways to ensure long-term ecosystem health is prioritized at all wetland sites.

General Trends in Ecological Condition

Though we found potentially encouraging differences between worse low-quality wetlands and better low-quality wetlands, our findings corroborate the long-standing idea that most wetland projects are still not achieving functional equivalency with natural wetlands (e.g., Race 1985, Race & Fonseca 1996, Gwin et al. 1999, Zedler & Callaway 1999, Brown & Venemen 2001, Matthews & Endress 2008, Fennessy et al. 2008, Reiss et al. 2009, Moreno-Mateos et al. 2012, Baldwin et al. 2019). Most created and restored wetlands are of relatively low quality with respect to all three of the response metrics: low diversity, low floristic quality, and low overall condition (Table 1). Interestingly, there was not a negative impact specifically driven by proximity to roads or human development on DI or FQI, but these factors may be influencing the overall health of the wetland as determined by RAM.

Results also confirmed the idea that restoration leads to better outcomes than *de novo* wetland creation (Table 3 and 5) (Hammer 1996, Mitsch et al .1998, Kentula 1999). For created wetlands, success is correlated with hydrological conditions, since placement in a generally "wet" area increased FQI ($p=0.004$ for PlcWet of created sites only) and lowered RAM for all sites ($p<0.0001$). Created wetlands develop faster when hydrological regimes are open and self-design can more easily be sustained (Mitsch et al. 1998). For projects with rigid timelines and low stakeholder input, it remains important to strongly consider the surrounding hydrologic landscape (Ehrenfeld 2000, Ehrenfeld et al. 2003).

In general, older wetlands were of poorer quality than moderately-aged wetlands (Figure 5). We found that for completed projects only, as time passed, ecological integrity declined substantially (FQI: $p=0.03$; RAM: $p=0.0009$). Additionally, intended and observed wetland type (based on Cowardin et al. 1979 classification) showed that only four sites had mismatched wetland states. Three out of four of these sites were completed mitigation wetlands with ages ranging from 10 to 23 years, indicating that completed sites may be at risk of reverting to undesirable wetland types. Our data may indicate that regulatory structures and guidance in combination with regulatory stakeholder involvement (i.e., consultants) produce projects with lower degradation scores and higher quality species present (usually incomplete but established, or 5-15 years old). Sites that are very newly established (1-5 years old) show degradation and low-quality plant colonization. This is expected, since they are not fully established. It is after the 15-year mark where most older sites (that are mostly completed sites with very minimal required or voluntary stakeholder involvement) trend toward degradation and decreasing plant quality in comparison to the middle-aged sites (Figure 5).

This change over time could be the result of two potential drivers: (1) lack of active management of older sites, or (2) restoration practices that have improved over time so that newer sites are and will be better. Most of the older sites have hands-off or moderate management, with several being mostly left alone since project completion. The management category is a function of age: with hands-off and moderately managed sites being older than new, actively managed (and under permit requirements) sites. These older sites likely have less stakeholder involvement, potentially due to dwindling public interest and financial resources (Turner et al. 2001, Sutton-Grier et al. 2018, Gittman et al. 2019). This may indicate that there is an opportunity to adjust long-term management practices for these sites to ensure that after the bulk of regulatory stakeholder involvement is completed, other stakeholder groups are integrated to ensure sustainability. Lack of management combined with shifting environmental drivers (i.e., rainfall, droughts, species range shifts) due to climate change may be compounding to increase degradation of older sites. The one exception to this trend is a site that is open to public use, owned by a government agency that is environmentally driven and placed in a wet landscape. This exceptional site has more potential for stakeholder involvement – dedicated managers and an involved public - indicating this may be important to consider to sustain ecosystem health over the long term. This exemplifies the importance for long-term stakeholder involvement, due to changing environmental drivers and the known importance of long-term wetland management.

Sites completed from 1990-2005 may have had less guidance and information on best practices since that was a pivotal time in wetland regulation development. As noted above, the regulatory time period leading up to the 2000s may be a cause of the advancements in wetland ecosystem management from 2000 to now, showing an evolution of best and acceptable practices. From the original Clean Water Act passed in 1972, when protection of wetland ecosystems was mandated, through the multiple updates and more in-depth guidance issued in 1990, it becomes clear that practitioners were likely experiencing a trial-and-error period even into early 2000s.The learning gained through implementation and experience, guided by regulatory advice and standards should be recognized as a key component in the formula for success.

From 1972 to the 1990s government agencies clarified wetland projects' procedural definitions, management expectations and overall guidance in how to protect or compensate for impacts to wetland ecosystems. From 1980 into the 1990s the wetland 'compensation' aspect of mitigation became a primary component of policy development, with production of numerous guidance documents and memoranda (e.g., EPA 1980, FWS 1981, FWS 1983, Corps & EPA 1990, Hough & Robertson 2008). Clarifications to policy and new regulations are usually introduced when practitioners have asked for guidance because uncertainty exists, making it hard for them to carry out duties, sometimes leading to unfavorable project outcomes. Reviewing the time period before 2000, it is apparent that as time passed from the initial Clean Water Act, there was a clear need to connect regulations and clarify guidelines for better wetland project implementation (Hough & Robertson 2008). Into the 1990s, final justifications and explicit connections were made, like the 1990 Memorandum of Agreement between the EPA and USACE that created a final connection between the 1978 rule and the 1980 EPA guidelines (Corps and EPA 1990). In addition, by 2000 all three mitigation mechanisms, ILF, MB and PRM, had been established, defined and put into practice (Corps et al. 1995, Zirschky et al. ND). Though many of these final justifications and rules would be improved upon in the 2000s, the basic ground rules, clarifications and connections had been set by then.

Policy and formal regulation are key for broad implementation across many jurisdictions (Mazmanian & Sabatier 1989). At the same time that significant developments were being made in mitigation policy, scientific researchers were concerned with the shortcomings of the practice (Erwin 1991, NRC 1992). This shows the importance of wetland mitigation to multiple stakeholder groups and shows the influence they may have on each other. It is likely that progress in clarifying wetland guidance was due to the developments and research happening in wetland science, thus exemplifying the importance in continuing to evaluate the ecological integrity of these ecosystems. By the early 2000s the EPA and USACE created actionable "checklists" to ensure proper ecosystem maintenance (Corps & EPA 2003). When grouped based on this regulatory development timeline, projects completed from 1990-2005 had higher average RAM scores than projects completed from 2005-2020 ($p=0.007$). As time progressed there was a deeper understanding of the standards required by mitigation practices, but there was an acknowledgement by practitioners of struggles and inconsistencies which still exist today. Well into the 2000s projects failed to meet functional equivalence with natural counterparts (Turner et al. 2001, Brown & Venemen 2001, NRC 2001, Matthews & Endress 2008, Fennessy et al. 2008, Reiss et al. 2009, Moreno-Mateos et al. 2012, Marton et al. 2014, Baldwin et al. 2019, Gittman et al. 2019). Though our data also supports this, there are also successes worth recognizing.

Ecosystem Management

On local levels, a known leverage point that is commonly used to promote ecological outcomes, is to identify criteria for successful wetland projects *a priori* (Ehrenfeld 2000, Cole & Shafer 2002, Jähnig et al. 2011). We found evidence to support this: sites with specified targets for invasive species (such as a maximum acceptable percent cover) had higher FQI and lower RAM scores. Setting specific benchmarks and documenting them well is important for wetland success and for historical evaluation (Cole & Shafer 2002).

Construction completion year was also associated with mention of adaptive management in planning documents. Generally, adaptive management was most common for the younger projects completed between 2010-2020 that have higher ecological integrity in terms of DI, FQI and RAM, suggesting an improvement in management techniques over time. Additionally, the relatively new process of adaptive management has been more actively implemented only recently in conservation (Elliot et al. 2004, New York State Invasive Species 2011). The use of adaptive management increased with the degree of management, appearing in only 12% of hands-off project documents, 33% in moderately managed project documents and 60% in actively managed site documents. This increase is likely related to age.

Adaptive management that utilizes uncertainty through a double-loop learning process is currently not the widely used form in conservation (Williams et al. 2009, Pahl-Wostl 2009, Fabricius & Cundill 2014) and is likely not what is used in the projects analyzed here. Timelines for wetland activities are short and must end once sites reach certain criteria. If the sites revert to undesirable states and there are not long-term management plans, then the adaptive management process has ended. Thus, better understanding and integration of adaptive management could be an important step moving forward in wetland ecosystem management.

The relationship between utilization of phasing in project implementation and higher FQI suggests that these phases act as “experimental treatments”, allowing subsequent phases to adopt treatment conditions that were beneficial to overall goals (Zedler 2005). This type of approach is considered a form of “adaptive restoration” and begins to illustrate how human “learning while doing" may be important in producing robust project outcomes (Zedler 2005, Doremus 2007). Phasing is an opportunity for stakeholder learning, achieved through site-specific trial and error.

Learning (Elliot et al. 2004, Pahl-Wostl 2006, Pahl-Wostl 2009, Williams et al. 2009, Fabricius & Cundill 2014) and active stakeholder engagement (Williams et al. 2009) are key components of adaptive management. I suspect that projects using adaptive management were using a form of iterative management where data is used to indicate if changes need to be made (i.e., invasive species cover, water level fluctuations, etc.) and is thus a reactive process used to fix shortcomings rather than a truly iterative double-loop process. However, this could indicate that even a basic use of adaptive management may lead to better ecological results.

Community Integration for Long-Term Success

Although site selection was a function of regional site availability, and the distribution of ownership and other characteristics may be partially related to this availability, I suggest that site ownership may lead to specific management efforts and outcomes. For example, government agencies were the exclusive owners of voluntary sites. This suggests that ownership is tied to interests, values and funding that promote ecological outcomes. These sites may also have multiple interested parties who oversee or are invested in the project, with positive long-term outcomes. However, voluntary sites drove lower DI and FQI indicating there may be a need for better integrated long-term management efforts. Voluntary sites had less degradation overall, however, which may mean they have potential to be improved over time. For mandatory projects, ownership was more diverse across projects. All government-owned projects were dominated by the DOT, who must maintain traffic routes and thus inherently will have more regulatory sites. Non-profit-owned projects had the highest FQI at their regulatory sites, suggesting a commitment to quality habitat enhancement and the potential to engage diverse stakeholder groups via conservation easements, management practices, public outreach and coordinated project efforts (Rissman & Sayre 2012, Bennett et al. 2018) that may be less prevalent for municipalities and private companies. It is also possible that certain non-profits buy or are gifted land that already contains these characteristics; however, non-profits in our data are environmentally mission driven, which may suggest owner motivation plays a role in ecological outcomes. These indirect outcomes of land ownership or completion of regulatory mitigation on behalf of another entity may result in in partnerships and land agreements between government, private and non-profit organizations where regulatory projects can be overseen by more diverse stakeholder groups.

Socio-ecological systems have been defined as “systems that involve both natural/ecological and human/social components that interact to affect system dynamics” (Koontz et al. 2015). Broadly, ecological restoration projects have been shown to encompass exactly this (Aronson et al. 2020), and the wetlands in this study are no exception. Direct management decisions (i.e., implementation techniques, guidelines for ecological states) impact human awareness (i.e., stakeholders who care about or invest in the site), and public support ultimately impacts ecological outcomes (i.e., diversity or degradation). Results can be improved through learning experiences (Uphoff 1996), which we also found. By increasing learning opportunities and the number of engaged stakeholders, improved ecological outcomes will follow.

There is evidence that stakeholder involvement is important in ecosystem restoration, but to what extent and of what type is highly debated (Palmer et al. 2005, Jähnig et al. 2011, Le Roy et al. 2018). Required stakeholders may be organizations contracted to complete wetland construction and monitoring in order to meet regulatory requirements or project owners required to compensate for impacted wetlands. In both cases required stakeholders represent people who have agendas and tight limitations on their investments. Voluntary stewards may have deeper interests and value associated with the site if they are willing to volunteer their free time to ecological efforts, and so, the involvement of voluntary stewards may counteract dwindling effort by required stakeholders over longer time frames.

The lack of impact of public use on any response metric suggests that, at the very least, public involvement does no harm and that, at best, integration of public value may prevent degradation over time. No volunteers had a negative effect on DI. There were 82% of created sites with *no* volunteers while restored sites had 56% *with* volunteers which may suggest that created sites would benefit from gaining volunteers. Community assets and governance determine if and how a potential steward will act toward a restoration project (Bennett et al. 2018), and my results suggest that volunteers may be more attracted to restoration than creation, which is perhaps driven by the governance or ownership of the site. Though there is still much to be learned, it is clear that there is a human community component that should be better integrated into every project in order to ensure long-term stability (Jähnig et al. 2011, Le Roy et al. 2018).

"Learning while doing" during phased project implementation (Zedler 2005), the learning facilitated by adaptive management processes (Walters & Hilborn 1978, Fabricius & Cundill 2014), obtaining volunteer interest in a site, and owners with environmental missions, stand out in the context of wetland projects due to stakeholder engagement. Through interviews, stakeholders were identified as both important and the largest challenge in wetland projects. Overall, volunteer input during site establishment was seen as critical for improvement of both scientific knowledge and development of the site as a community resource. Volunteer respondents indicated clearly that the role of the site owner in engaging the community and creating a synergistic partnership was key:

"… [the public relations representative] was interested in getting community involvement so…we brought our birding org over... so that's where it … started…"

"…it's really this kind of working partnership **[between volunteers and site owners]***…"*

and

"There's nothing that's, my success… its everybody that's been involved"

Further, during several interviews the importance of the multiple roles and levels of stakeholders was emphasized, where regulatory guidance must be the base of wetland projects and learning and adaptation then occurs through stakeholder involvement:

"one of the most limiting factors of mitigation is how willing your client is to take your recommendations and go with them" – Wetland Consultant

and

"the partnership between **[land owner, universities and volunteers]** *would continue and help to ensure that … once these areas are established that they're sustained." – Site Engineer*

However, funding was also identified as a key component of involvement, and is often the limiting or complex factor in many wetland projects (Gittman et al. 2019). Ultimately, the idea of learning, stakeholder engagement, and being able to work through management as a collaborative process was one of the largest take-aways from the interviews. This information directly shows diverse stakeholder groups are integral to the longevity of wetland ecosystem maintenance. Further, all of the learning and development that comes from wetland projects that utilize diverse stakeholder groups should be applied to other sites, if possible. Overall, our data show that there are leverage points available to increase the ecological success of wetland projects. Stakeholder input underscores several of these leverage points, such as ownership, management and volunteering. Learning processes and stakeholder input are key themes to integrate into any implementation technique to produce higher quality wetlands.

"whatever you learn out here you can always project that onto mitigations elsewhere…that has probably been the biggest success we've had…"

<u>*Socio-ecological Wetland Management*</u>

Our data suggest that techniques that inherently require more engagement (such as phasing, active management, or determining success criteria) produce better ecological states. Adaptive management that engages multiple stakeholders has the ability to be a mechanism that allows for many techniques to be leveraged at various types of wetland sites, while integrating the highest level of stakeholder involvement.

When adaptive management is used as a reaction to "undesirable impacts of change", as it may be in our sample, it is less effective than if it was implemented in a manner that allows for an increase in the ability of the whole system (wetland ecosystem projects) to respond to change (Pahl-Wostl 2006). Adaptive management as a *system mechanism,* rather than simply a reactive site by site prescription, would capture the beneficial underlying characteristics, including stakeholder input and learning of identified leverage points such as phasing and success criteria. Better use of adaptive management is, thus, a relatively new idea in ecology, meaning that there is an opportunity to better implement it now.

The process of sharing knowledge in a broad way (NRC recommending adaptive techniques), as opposed to an operational way (DOI technical guide for practitioners: Williams et al. 2009), is important because it shows *learning*. As operational uses have improved over time and adaptive management came to be implemented more accurately, we began to see steady improvements to wetland restoration. While adaptive management is not a clear solution, it can encompass the main characteristics of wetland projects (uncertainty, learning, stakeholder engagement) and has the potential to be better integrated. Thus, the combination of effects that are inherent to "wicked problems" like ecological restoration (Rittel & Webber 1973, Giest &

Galatowitsch 1999) can be addressed by an adaptive management mechanism if implemented on a wide scale.

The basic regulatory tenets that drive wetland ecosystem projects have been set in place for the last 25 years. When considering how to manage conservation efforts, learning in terms of theories, pragmatic approaches and adaptation have been discussed (Blackmore 2007, Elliot et al. 2004, Fabricius & Cundill 2014, Koontz et al. 2015, Pahl-Wostl 2006, Pahl- Wostl 2009, Plummer et al. 2012, Vinke-de Kruijf & Pahl-Wostl 2016, Williams et al. 2009, Murray & Marmorek 2003). The connection between learning and adaptive management (or adaptive strategies) becomes an obvious consideration for wetland projects where uncertainty is high, but whole ecosystem outcomes are extremely important (Mitsch et al. 1998, Blackmore 2007, Williams et al. 2009, Elliot et al. 2004, Fabricius & Cundill 2014). Learning itself can be used as a tool in implementation of human climate change adaptations (Vinke-de Kruijf & Pahl-Wostl 2016), making it an even stronger component to consider for wetland ecosystems due to their important role in climate mitigation in terms of buffering floods and recharging aquifers (Millenium Ecosystem Assessment 2005).

Learning is currently facilitated through numerous work groups that are specific to wetland ecosystems and operated on various levels (from regional to national). Additionally, there are groups like the Interagency Ecological Restoration Quality Committee or the Great Lakes Commission which operate over a large scope to tackle projects related to invasive species, water quality and infrastructure. These groups are important starting points to integrate broad scale management of wetlands and provide important connections to integrate stakeholders, and make learning a priority by synthesizing data and management techniques from many smaller projects. They also facilitate learning through conferences, publications and workshops. Partnerships are fundamental to their work and is the type of framework that should be emphasized.

An Integrated Framework for Wetland Ecosystem Management

I recommend a new framework to leverage both social and ecological drivers of healthy wetland ecosystems (Figure 6). This framework is a mechanism to move information through, facilitating stakeholder engagement and allowing projects to operate on local levels while contributing to knowledge on national levels. Local leverage points must be facilitated to feed into large scale learning, or there is a risk that dissemination of this information will be slow and limited, thus negatively impacting the forward progression of wetland projects nationally.

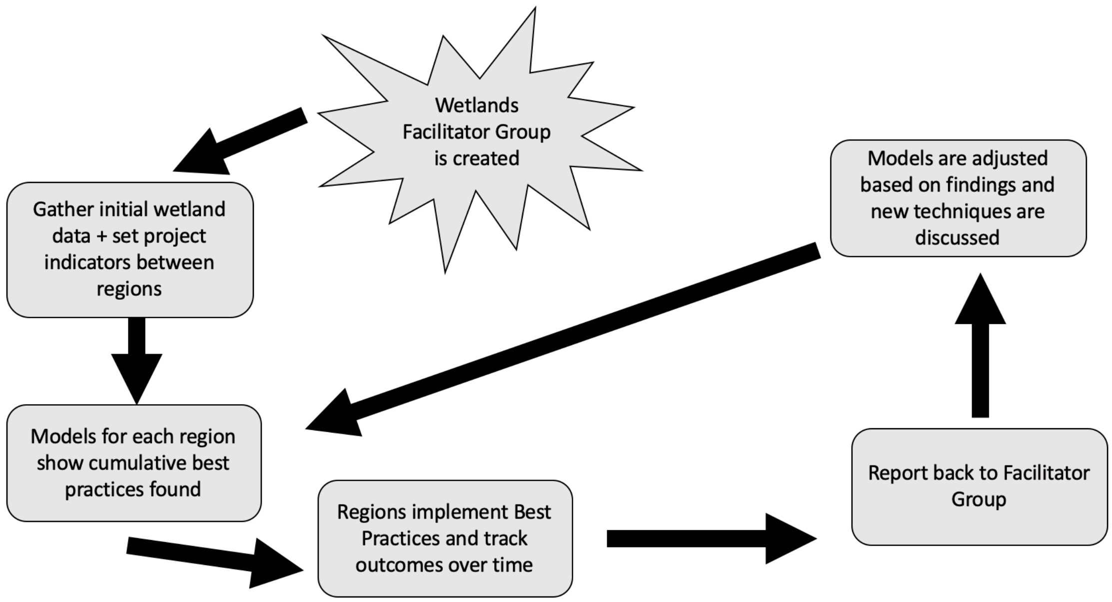


Figure 6: Systems framework for national wetland facilitator.

Based on the knowledge gained through this study, a broader and arguably better system for holistic management and learning is necessary to move wetland projects forward in terms of ecosystem states and functions. A wetlands management facilitator, at a national scale, could suffice as a mechanism for holistic management that facilitates learning and increases stakeholder engagement (Aronson et al. 2020, Cooke et al. 2019). Overarching working groups are not new to wetland ecosystem management (Interagency Coastal Wetland Work Group, Chesapeake Bay Wetland Work Group, White House Wetland Work Group, Wildlife Society Wetland Work Group, Biological Assessment of Wetland Work Group, California Wetland Work Group), but groups have disbanded (White House Wetlands Workgroup, Biological Assessment of Wetlands Work Group), some are discussions only (Wildlife Society Wetland Work Group) while others do use data driven approaches to assess management (Interagency Coastal Wetland Work Group, Chesapeake Bay Wetland Work Group, California Wetland Work Group). The difference between all of the groups mentioned so far, and this national facilitator is that the facilitator has a potential to bring these groups together, along with practitioners and researchers from other sectors, to disseminate broader findings on a larger scale (i.e. setting forth new technical guidelines based on model iterations as they occur).

A national wetland facilitating group is needed to gather data from regional working groups, wetland consultants, and government agencies on best practices and techniques, with hierarchy's dependent on location and wetland type. The facilitator group will then synthesize the data and disseminate back to working groups, land owners and consultants as best practices. Using data, a predictive model at a large scale may be generated to identify efficient and effective practices. Stakeholders from across the US would then be involved in an open forum where predictions and inputs in the final model were discussed- and non-feasible options were removed. The open forum, or public comment period, could be structured by region or wetland type, allowing for those interested in specific management styles to focus their interests. This will enable adoption of new techniques in light of the desired outcomes especially for projects that have already secured funding and have the abilities to take on new recommendations. Iterative data-driven reflection is integral to the double-loop process (Fabricus & Cundill 2014) and fosters discussions and learning among stakeholders to assess new operational changes and facilitate a true double loop process.

One example of this type of holistic ecosystem management process is the United States National Estuary Program (NEP). This program protects 28 nationally significant estuaries and is largely overseen by the EPA, but integrates many types of stakeholder groups (USEPA 2019). Due to the consensus-building approach used in this program, collaboration between the multiple stakeholder groups is prioritized. Comprehensive Conservation Management Plans (CCMPs) are created for each estuary to address long-term management goals and techniques. Management Conferences (MC) are used to review CCMPs in a collaborative setting to ensure unique estuarine characteristics are considered while prioritizing local needs of managers (USEPA 2019). This program was made possible through the support of the EPA (to provide funding and guidance to each project) and through formal legislation (USEPA 2019).

The European Union's Marine Strategy Framework Directive (MSFD) is also an example to consider. This directive uses an ecosystem approach in their framework, where human activities are considered alongside species indicators of marine health (European Commission ND). To make the directive manageable, European marine areas are divided into regions and sub-regions, with "member states" in each region that must report their management strategies and data every 6 years to follow an iterative adaptive management approach (European Commission ND). This type of dynamic is discussed as a socio-ecosystem approach and has been compared to species approaches and ecosystem approaches where the synergy between each one is described as complementary (Boudouresque et al. 2020). Further, these approaches cannot exist in isolation and they must feed into each other for effective projects to occur (Boudouresque et al. 2020).

Overall, a wetlands facilitator group would need to have support from federal entities such as the EPA or the Department of Interior. This would become especially crucial for funding and performance reporting components of the process. Similar to NEP, new legislation or amendments to current legislation (such as the Clean Water Act) may need to occur before the facilitator can be created. Large wetland projects in the US could be entered into the system at the onset, however, over time all wetlands would need to be a mandatory participant in this process. If regions, like in the MSFD, were created and utilized for data collection this process may become more manageable. The Clean Water Act could be amended to include participation in the facilitator group and mitigation could proceed as a normal process with the caveat that data be reported to the facilitator group and incorporated into CCMPs for each site. CCMPs could be created on a site by site basis or by stakeholder groups that oversee many sites that have similarities (i.e. if a consulting firm has several emergent wetlands with similar defining characteristics, in a similar geographical area they could create a CCMP based on best practices for all of those wetlands). This type of integrated national management would improve coordination between wetland projects and bolster the compensatory mitigation system that exists today in the US.

Recognition of complex socio-ecological systems also means recognizing and considering new ways to approach large scale management (Ostrom 2009). Though adaptive processes for large scale management is new, wetlands are a good pilot ecosystem, since indicator species are well studied and human components are becoming more evident. It is important to ensure "not all involved are consumed by the complexity of the larger picture, nor focused on a purely local achievement" (Aronson et al. 2020). A hierarchical data sharing, synthesizing, and dissemination process, whereby wetland consultants and owners would work on local achievements while inputting data to fulfill large picture achievements on a national scale, takes this approach.

Better large-scale management for wetlands would combine practitioners (managers) and researchers (scientists) to identify new ways to meet project objectives by predicting the potential outcomes (Murray & Marmorek 2003) through collaboration of regional and national groups. Currently, wetland stakeholders interact to the extent necessary to meet interests and accomplish local wetland goals. They iteratively manage and, in some cases, adaptively learn best practices that are shared over time. However, if an organizational mechanism was implemented to unite all wetlands across the US, learning would be bolstered and more sites may reap the benefits.

Most projects that use adaptive processes cite management improvements or conflict resolutions as outcomes (Plummer et al. 2012, Fabricius & Cundill 2014). These improvements are needed in the complex socio-ecological context of wetland restoration (Koontz et al. 2015). Regulatory structures to support participation in the adaptive management working group through incentives or trading have been recommended to drive the radical change needed in restoration science (Aronson et al. 2020). By utilizing a facilitator group, regulatory structures could ensure that legally "completed" sites (i.e., sites that were constructed and followed normal mitigation protocols) that show potential for improvements, are re-visited by allowing a transfer of credits to entities that will take on re-managing them. This would be able to occur because the facilitator group would maintain a database with project information for wetlands across ownerships, regions, legality, etc. This overall process would likely result in an original burden of cost in setting up the working group, collecting the first round of data and creating an initial model, but when the system is in place we should see a few much better wetland projects with requisite long-term stakeholder engagement, instead of many low-quality projects that are considered "complete" and therefore abandoned. Since this facilitator group would not replace any of the current wetland policies in the United States, no net loss which is based on acreage, would still be achievable through normal mitigation processes. These projects would ultimately feed into a larger system and have the opportunity to be improved over time or projects may begin to be implemented better requiring less effort to revisit them later. This would effectively link socio-ecological context into project planning, implementation and management by integrating stakeholders on various levels.

Conclusions

I present this framework and specific management techniques that are aligned with stakeholder engagement and learning as a pathway to bolster project outcomes. Social context associated with management, project type, public use/awareness, volunteers and ownership of a site impacts the ecological state of wetlands and should be considered alongside the well-known abiotic and biotic drivers of ecological outcome. At each step of the overall project process, learning should be leveraged and best practices iteratively optimized. Within the framework I present, governments would have an opportunity to incentivize the public to contribute to wetland projects even after their original timelines are complete, encouraging long-term management. With restoration ramping up as one of the most important tools humans have to respond to the degradation humans have caused (Aronson et al. 2020, Cooke et al. 2019) it is a poignant time to integrate this process for wetland ecosystems.

References

Anderson, D.R. 2008. Akaike's information criterion. In: Model Based Inference in the Life Sciences: A Primer on Evidence. Springer 55–60.

Aronson, J., Goodwin, N., Orlando, L., Eisenberg, C., & Cross, A. T. 2020. A world of possibilities: Six restoration strategies to support the United Nation's Decade on Ecosystem Restoration. Restoration Ecology *28*(4):730-736. https://doi.org/10.1111/rec.13170

Al-Rubaei, A.M., Engström, M., Viklander, M. et al. 2017. Effectiveness of a 19-Year Old Combined Pond-Wetland System in Removing Particulate and Dissolved Pollutants. Wetlands 37: 485–496 https://doi.org/10.1007/s13157-017-0884-6

Baldwin, A. H., Hammerschlag, R. S., & Cahoon, D. R. 2019. Chapter 25 -Evaluating Restored Tidal Freshwater Wetlands. Coastal Wetlands, 889-912. https://doi.org/10.1016/B978-0-444-63893-9.00025-3

Ballantine, K. a., Groffman, P. M., Lehmann, J., & Schneider, R. L. 2014. Stimulating nitrate removal processes of restored wetlands. Environmental Science and Technology 48: 7365–7373. doi:10.1021/es500799v

Bedford, B. L., Walbridge, M. R., & Aldous, A. 1999. Patterns in nutrient availability and plant diversity of temperate North American wetlands. Ecology 80(7): 2151–2169. doi:10.1890/0012-9658(1999)080[2151:PINAAP]2.0.CO;2

Bennett, N. J., Whitty, T. S., Finkbeiner, E., Pittman, J., Bassett, H., Gelcich, S., & Allison, E. H. 2018. Environmental Stewardship: A Conceptual Review and Analytical Framework. Environmental Management 61(4):597-614. https://doi.org/10.1007/s00267-017-0993-2

Bernhardt, E. S., & Palmer, M. A. 2007. Restoring streams in an urbanizing world. Freshwater Biology *52*(4):738-751. https://doi.org/10.1111/j.1365-2427.2006.01718.x

Biesbroek, G. R., Swart, R. J., Carter, T. R., Cowan, C., Henrichs, T., Mela, H., Morecroft, M. D., & Rey, D. 2010. Europe adapts to climate change: Comparing National Adaptation Strategies. Global Environmental Change *20*(3):440-450. https://doi.org/10.1016/j.gloenvcha.2010.03.005

Blackmore, C. 2007. What kinds of knowledge, knowing and learning are required for addressing resource dilemmas?: A theoretical overview. Environmental Science & Policy 10(6):512-525. https://doi.org/10.1016/j.envsci.2007.02.007

Blackstock, K.L., Kelly, G.J., & Horsey, B.L. 2007. Developing and applying a framework to evaluate participatory research for sustainability. Ecological Economics 60(4):726-742. https://doi.org/10.1016/j.ecolecon.2006.05.014

Boudouresque C.F. et al. 2020. The Management of Mediterranean Coastal Habitats: A Plea for a Socio-ecosystem-Based Approach. In: Ceccaldi HJ., Hénocque Y., Komatsu T., Prouzet P., Sautour B., Yoshida J. (eds) Evolution of Marine Coastal Ecosystems under the Pressure of Global Changes. Springer, Cham. https://doi.org/10.1007/978-3-030-43484-7_20

Bried, J. T., Strout, K. L., & Portante, T. 2011. Northeast Regional Floristic Quality Assessment Final Report. https://neiwpcc.org/wp-content/uploads/2020/08/EPA-OW-OWOW-08-05FinalReport-1.pdf

Brown, S. C., & Veneman, P. L.M. 2001. Effectiveness of compensatory wetland mitigation in Massachusetts, USA. Wetlands 21(2):508-518.

Bruland, G. L., & Richardson, C. J. 2005. Hydrologic, Edaphic, and Vegetative Responses to Microtopographic Reestablishment in a Restored Wetland. Restoration Ecology 13(3):515-523 https://doi.org/10.1111/j.1526-100X.2005.00064.x

Castelle A.J., Johnson A.W. and Conolly C. 1994. Wetland and stream buffer size requirements: A review. Journal of Environmental Quality 23:878–882.

Carter, V. 1996. Wetland hydrology, water quality, and associated functions. National Water Summary on Wetland Resources, 40-48.

CEQ [Council on Environmental Quality]. 1978. National environmental policy act—regulations: implementation of procedural provisions. Federal Register 43:55977–56007

Chaichana, R., Leah, R., & Moss, B. 2011. Seasonal impact of waterfowl on communities of macrophytes in a shallow lake. Aquatic Botany 95(1):39–44.

Chu, S., & Molano-Flores, B. 2012. Impacts of agricultural to urban land-use change on floristic quality assessment indicators in Northeastern Illinois wetlands. Urban Ecosystems 16(2):235-246. https://doi.org/10.1007/s11252-012-0236-5

Clean Water Act, 33 U.S.C. § 1251 (Supp. 1972).

Cooke, S. J., Bennett, J. R., & Jones, H. P. 2019. We have a long way to go if we want to realize the promise of the "Decade on Ecosystem Restoration." Conservation Science and Practice 1(12):1-5 https://doi.org/10.1111/csp2.129

Cole, C. A., & Shafer, D. 2002. Section 404 Wetland Mitigation and Permit Success Criteria in Pennsylvania, USA, 1986–1999. Environmental Management 30(4):508-515. https://doi.org/10.1007/s00267-002-2717-4

Compton, J., Boone, R., Motzkin, G. et al. 1998 Soil carbon and nitrogen in a pine-oak sand plain in central Massachusetts: Role of vegetation and land-use history. Oecologia 116: 536–542. https://doi.org/10.1007/s004420050619

Corps [US Army Corps of Engineers] & EPA [US Environmental Protection Agency]. 1990. Memorandum of Agreement Between The Department of the Army and The Environmental Protection Agency: The Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines. Signed 6 February 1990, Washington DC

Corps [US Army Corps of Engineers] & EPA [US Environmental Protection Agency]. 2003. Multi-agency compensatory mitigation plan checklist. http://www.mitigationactionplan.gov/ checklist.pdf.

Costanza, R., Groot, R. D., & et al. 2014. Changes in global value of ecosystem services. Global Environmental Change *26*:152-158. http://dx.doi.org/10.1016/j.gloenvcha.2014.04.002

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biological Services, Fish and Wildlife Service, U.S. Dept. of Interior, Washington, D.C.

Creswell, J. 1998. Qualitative inquiry and research design: Choosing among five traditions. Thousand Oaks, CA: Sage.

Davenport, M. A., Bridges, C. A., & et al. 2010. Building Local Community Commitment to Wetland Restoration: A Case Study of the Cache River Wetlands in Southern Illinois, USA. Environmental Management 45(4):711-722. https://doi.org/10.1007/s00267-010-9446-x

Davidson, N. C. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Research 65(10), 934-941. https://doi.org/10.1071/MF14173

Dawson, L., Elbakidze, M., Schellens, M., Shkaruba, A., & Angelstam, P. K. 2021. Bogs, birds, and berries in Belarus: The governance and management dynamics of wetland restoration in a state-centric, top-down context. Ecology and Society 26(1). https://doi.org/10.5751/ES-12139-260108

DiEnno, C. M., & Thompson, J. L. 2013. For the love of the land: How emotions motivate volunteerism in ecological restoration. Emotion, Space and Society 6:63-72. https://doi.org/10.1016/j.emospa.2012.02.002

Doremus, H. 2007. Precaution, science, and learning while doing in natural resource management. Washington Law Review 82(3):547-580.

Druschke, C. G., & Hychka, K. C. 2015. Manager perspectives on communication and public engagement in ecological restoration project success. Ecology and Society 20(1):58-67. https://doi.org/10.5751/ES-07451-200158

The Nature Conservancy. Ecological Buffers [Pamphlet]. 2015. Retrieved from https://www.nature.org/content/dam/tnc/nature/en/documents/PA_Shale_Development_Ecological_Buffers.pdf

Ehrenfeld, J. G. 2000. Evaluating wetlands within an urban context. Urban Ecosystems 4(1):69-85. https://doi.org/10.1023/A:1009543920370

Ehrenfeld, J. G. 2001. Defining the Limits of Restoration: The Need for Realistic Goals. Restoration Ecology 8(1):2-9. https://doi-org.ezproxy.rit.edu/10.1046/j.1526-100x.2000.80002.x

Ehrenfeld, J. G., H. Bowman Cutway, R. Hamilton and E. Stander. 2003. Hydrologic description of forested wetlands in northeastern New Jersey, USA - an urban/suburban region. Wetlands 23:685-700.

Elliott, G., M. Chase, G. Geupel, and E. Cohen. 2004. Developing and Implementing an Adaptive Conservation Strategy: A Guide for Improving Adaptive Management and Sharing the Learning Among Conservation Practitioners. PRBO Conservation Science, CA.

Elser, J. J., Fagan, W. F., Denno, R. F., Dobberfuhl, D. R., Folarin, A., Huberty, A., Interland, S., Kilham, S.S., McCauley, E., Shulz, K.L., Siemann, E.H., & Sterner, R. W. 2000. Nutritional constraints in terrestrial and freshwater food webs. Nature 408(6812):578-580.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. 1995. Writing Ethnographic Fieldnotes. London, US: The University of Chicago Press.

EPA [US Environmental Protection Agency]. 1980. Guidelines for specification of disposal sites for dredged or fill material. Federal Register 45:85336–85357

Erwin, K. L. 1991. An Evaluation of Wetland Mitigation in the South Florida Water Management District. https://environment.com/wp-content/uploads/2012/02/Evaluation-of-Wetland-Mitigation-1991.pdf

European Commission. (n.d.). Our Oceans, Seas and Coast: Implementation of the Marine Strategy Framework Directive. European Commission: Environment. Retrieved April 3, 2021, from https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/implementation/index_en.htm

Fabricius, C., & Cundill, G. 2014. Learning in Adaptive Management: Insights from Published Practice. Ecology and Society 19(1). http://dx.doi.org/10.5751/ES-06263-190129

Fennessy, M. S., Rokosch, A., & Mack, J. J. 2008. Patterns of plant decomposition and nutrient cycling in natural and created wetlands. Wetlands 28(2):300–310. doi:10.1672/06-97.1

FWS [US Fish, Wildlife Service]. 1983. Interim guidance on mitigation banking. Ecological services instructional memorandum No. 80. USFWS, Washington DC

FWS [US Fish and Wildlife Service]. 1981. US Fish and Wildlife Service mitigation policy; notice of final policy. Fed Regist 46:7644–7663

Geist, C., & Galatowitsch, S. M. 1999. Reciprocal Model for Meeting Ecological and Human Needs in Restoration Projects. Conservation Biology 13(5):970-979.

Gittman, R. K., Baillie, C. J., Arkema, K. K., Bennett, R. O., Benoit, J., Blitch, S., Brun, J., Chatwin, A., Colden, A., Dausman, A., DeAngelis, B., Herold, N., Henkel, J., Houge, R., Howard, R., Hughes, A. R., Scyphers, S. B., Shostik, T., Sutton-Grier, A., & Grabowski, J. H. (2019). Voluntary Restoration: Mitigation's Silent Partner in the Quest to Reverse Coastal Wetland Loss in the USA. *Frontiers in Marine Science*, *6*. https://doi.org/10.3389/fmars.2019.00511

Glaser, B. and A. Strauss. 1967. The discovery of grounded theory: Strategies for qualitative research. New York: Aldine Publishing Company.

Grabas, G. P. and D. Rokitnicki-Wojcik. 2015. Characterizing daily water-level fluctuation intensity and water quality relationships with plant communities in Lake Ontario coastal wetlands. Journal of Great Lakes Research 41:136-144

Greenway, M. 2010. Wetlands and Ponds for Stormwater Treatment in Subtropical Australia: Their Effectiveness in Enhancing Biodiversity and Improving Water Quality? Journal of Contemporary Water Research & Education 146(1):22-38. https://doi.org/10.1111/j.1936-704X.2010.00389.x

Guest, G., Bunce, A., & Johnson, L. 2006. How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. Field Methods 18(1):59-82. https://doi.org/10.1177/1525822X05279903

Gwin, S.E., Kentula, M.E. & Shaffer, P.W. 1999. Wetlands 19: 477. https://doi.org/10.1007/BF03161687

Hammer, D. A. 1996. Creating Freshwater Wetlands (2nd ed.). Lewis.

Hanson, G. C., Groffman, P. M., & Gold, A. J. 1994. Denitrification in Riparian Wetlands Receiving High and Low Groundwater Nitrate Inputs. Journal of Environmental Quality 23:917–922.

Herman KD, Masters LA, Penskar MR, Reznicek AA, Wilhelm GS, Brodowicz WM, Gardiner KP. 2001. Floristic assessment with wetland categories and examples of computer applications for the state of Michigan (FQA). Natural Heritage Program, 2nd ed. Michigan Dept of Nat. Res., Lansing, Michigan

Hernandez, M. E., & Mitsch, W. J. 2007. Denitrification in created riverine wetlands: Influence of hydrology and season. Ecological Engineering 30:78–88. doi:10.1016/j.ecoleng.2007.01.015

Higgs, E. S. 1997. What is good ecological restoration? Conservation Biology 11(2):338-348.

Hoeltje, S.M. & Cole, C.A. 2007. Environmental Management 39: 385. https://doi.org/10.1007/s00267-006-0212-z

Holland, C.C. & Kentula, M.E. 1992. Wetlands Ecology and Management 2: 157. https://doi.org/10.1007/BF00215322

Holtmann, L., Juchem, M., Brüggeshemke, J., Möhlmeyer, A., & Fartmann, T. 2018. Stormwater ponds promote dragonfly (Odonata) species richness and density in urban areas. Ecological Engineering 118:1-11. https://doi.org/10.1016/j.ecoleng.2017.12.028

Holtmann, L., Philipp, K., Becke, C., & Fartmann, T. 2017. Effects of habitat and landscape quality on amphibian assemblages of urban stormwater ponds. Urban Ecosystems 20(6):1249-1259. https://doi.org/10.1007/s11252-017-0677-y

Houlahan, J. E., and C. S. Findlay. 2004. Estimating the "critical" distance at which adjacent landuse degrades wetland water and sediment quality. Landscape Ecology 19:677–690

Houlahan, J. E., P. A. Keddy, K. Makkay, and C. S. Findlay. 2006. The effects of adjacent land use on wetland species richness and community composition. Wetlands 26:79–96.

Hough, P., & Robertson, M. 2008. Mitigation under Section 404 of the Clean Water Act: Where it comes from, what it means. Wetlands Ecology and Management 17(1):15-33. https://doi.org/10.1007/s11273-008-9093-7

Jähnig, S. C., A. W. Lorenz, D. Hering, C. Antons, A. Sundermann, E. Jedicke, and P. Haase. 2011. River restoration success: a question of perception. Ecological Applications 21(6):2007-2015. http://dx.doi.org/10.1890/10-0618.1

Kellert, S. R., Mehta, J. N., Ebbin, S. A., & Lichtenfeld, L. L. 2000. Community Natural Resource Management: Promise, Rhetoric, and Reality. Society & Natural Resources, 13(8):705-715. https://doi.org/10.1080/089419200750035575

Kentula, M. E. 1999. Restoration, Creation, and Recovery of Wetlands: Wetland Restoration and Creation (Research Report No. 2425). United States Geological Survey. https://water.usgs.gov/nwsum/WSP2425/restoration.html

Koontz, T. M., Gupta, D., Mudliar, P., & Ranjan, P. 2015. Adaptive institutions in social-ecological systems governance: A synthesis framework. Environmental Science & Policy 53:139-151. https://doi.org/10.1016/j.envsci.2015.01.003

Kuusemets V. and Mander U. 2002. Nutrient flows and management of a small watershed. Landscape Ecology 17: 59–68.

Shappell, L.J., Howard, H. G., 2018. Supporting Actionable Decision-Making For Wetland Permitting In New York From Urban To Rural Environments. EPA Wetland Program Development Grant. Final Report. New York Natural Heritage Program, Albany, NY.

Lauridsen, T. L., Jeppesen, E., & Andersen, F. O. 1993. Colonization of submerged macrophytes in shallow fish manipulated Lake Vaeng: impact of sediment deposition and waterfowl grazing. Aquatic Botany 46:1–15.

Le Roy, M., Sawtschuk, J., Bioret, F., & Gallet, S. 2018. Toward a social–ecological approach to ecological restoration: a look back at three decades of maritime clifftop restoration. Restoration Ecology 27(1). https://doi-org.ezproxy.rit.edu/10.1111/rec.12849

Lewis, R. R. 1990. Wetlands restoration/creation/enhancement terminology: Suggestions for standardization. J. A. Kusler and M. E. Kentula (eds.), Wetland creation and restoration, the status of the science. 417–422. Island Press, Washington, DC.

Lodge, K. A., & Tyler, A. C. 2020. Divergent impact of grazing on plant communities of created wetlands with varying hydrology and antecedent land use. Wetlands Ecology and Management 28(5):797-813. https://doi.org/10.1007/s11273-020-09750-z

Lucas, R., Earl, E.R., Babatunde, A.O., & Bockelmann-Evans, B.N. 2014. Constructed wetlands for stormwater management in the UK: A concise review. Civil Engineering and Environmental Systems 32(3):251-268. https://doi.org/10.1080/10286608.2014.958472

Marton, J. M., Fennessy, M. S., & Craft, C. B. 2014. Functional Differences between Natural and Restored Wetlands in the Glaciated Interior Plains. Journal of Environmental Quality 43(1):409-417. https://doi.org/10.2134/jeq2013.04.0118

Matthews, J. W., & Endress, A. G. 2008. Performance Criteria, Compliance Success and Vegetation Development in Compensatory Mitigation Wetlands. Environmental Management 41:130-141. https://doi.org/10.1007/s00267-007-9002-5

Mazmanian, D. A., & Sabatier, P. A. 1989. Implementation and Public Policy with a New Postscript. University Press of America.

McKinney, R.A., Charpentier, M.A. 2009. Extent, properties, and landscape setting of geographically isolated wetlands in urban southern New England watersheds. Wetlands Ecological Management 17:331–344. https://doi.org/10.1007/s11273-008-9110-x

Middleton, B. A. 2003. Soil seed banks and the potential restoration of forested wetlands after farming. Applied Ecology 40(6). https://doi.org/10.1111/j.1365-2664.2003.00866.x

Miles, I., Sullivan, W. C., & Kuo, F. E. 1998. Ecological restoration volunteers: the benefits of participation. Urban Ecosystems, 2(1).

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Wetlands and Water Synthesis. World Resources Institute, Washington, DC.

Mitsch, W. J., & Wilson, R. F. 1996. Improving the Success of Wetland Creation and Restoration with Know-How, Time and Self-Design. Ecological Applications 6(1):77-83.

Mitsch, W. J., Wu, X., Nairn, R. W., Weihe, P. E., Wang, N., Deal, R., & Boucher, C. E. 1998. Creating and Restoring Wetlands. BioScience 48(12):1019-1030. https://doi.org/10.2307/1313458

Moore, T. L.C., & Hunt, W. F. 2012. Ecosystem service provision by stormwater wetlands and ponds – A means for evaluation? Water Research 46(20):6811-6823. https://doi.org/10.1016/j.watres.2011.11.026

Moreno-Mateos, D., Alberdi, A., Morriën, E. et al. 2020. The long-term restoration of ecosystem complexity. Nat Ecol Evol 4:676–685. https://doi.org/10.1038/s41559-020-1154-1

Moreno-Mateos, D., Power, M. E., Comin, F. A., & Yockteng, R. 2012. Structural and Functional Loss in Restored Wetland Ecosystems. PLOS Biology 10(1):1-8. https://doi.org/10.1371/journal.pbio.1001247

Morse, J. 1994. Designing funded qualitative research. In Handbook for qualitative research, ed. N. Denzin and Y. Lincoln, 220–35. Thousand Oaks, CA: Sage.

Murray, Carol & Marmorek, David. 2003. Adaptive Management: A Science- Based Approach to Managing Ecosystems in the Face of Uncertainty.

NRC [National Research Council]. Committee on Restoration of Aquatic Ecosystems-Science. 1992. Restoration of aquatic ecosystems: science, technology and public policy. National Academies Press, Washington, D.C., USA.

NRC [National Research Council]. 2001. Compensating for Wetland Losses under the Clean Water Act. National Academy of Sciences, Washington, DC

Newman Grace, J.B., Koebel, J.W., S. 1996. The Effects of Nutrients and Hydroperiod on Mixtures of Typha Domingensis, Cladium Jamaicense, and Eleocharis Interstincta: Implications for Everglades Restoration 6(3):774–783.

New York State Invasive Species Management Strategy (Ecology and Environment, Inc., Comp.). (2011, August). https://www.dec.ny.gov/docs/lands_forests_pdf/ismgmtstrategy.pdf

Norton, B. G., & Steinemann, A. C. 2001. Environmental Values and Adaptive Management. Environmental Values 10(4):473-506.

Ortiz-Burgos S. 2016. Shannon-Weaver Diversity Index. In: Kennish M.J. (eds) Encyclopedia of Estuaries. Encyclopedia of Earth Sciences Series. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-8801-4_233

Ostrom, E. 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science 325(5939):419-422. Retrieved April 3, 2021, from http://www.jstor.org/stable/20536694

Pahl-Wostl, C. 2006. Transitions towards adaptive management of water facing climate and global change. Water Resources Management 21(1):49-62.

Pahl-Wostl, C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environmental Change 19(3): 354-365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. 2015. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Administration and policy in mental health 42(5):533-544. https://doi.org/10.1007/s10488-013-0528-y

Palmer, M. A., Bernhardt, E. S., & Allan, J. D. 2005. Standards for ecologically successful river restoration. Journal of Applied Ecology 42(2):208-217. https://doi.org/10.1111/j.1365-2664.2005.01004.x

Parrish, J. D., Braun, D. P., & Unnasch, R. S. 2003. Are We Conserving What We Say We Are? Measuring Ecological Integrity within Protected Areas. BioScience 53(9):851-860

Perrow, M. R., Schutten, J. H., Howes, J. R., Holzer, T., Madgwick, F. J., & Jowitt, A. J. D. 1997. Interactions between coot (Fulica atra) and submerged macrophytes: the role of birds in the restoration process. Hydrobiologia 342-343:241–255. doi:10.1023/A:1017007911190

Peet, R.K. & Wentworth, T.R. & White, Peter. 1998. A flexible method for recording vegetation composition and structure. Castanea 63:262-274.

Plummer, R., Crona, B., Armitage, D., Olsson, P., Tengö, M., & Yudina, O. 2012. Adaptive Comanagement: A Systematic Review and Analysis. Ecology and Society 17(3). Retrieved March 9, 2021, from http://www.jstor.org/stable/26269066

Pollock, M. M., R. J. Naiman, and T. A. Hanley. 1998. Plant species in riparian wetlands: a test of biodiversity theory. Ecology 79: 94– 105.

Porter, J. J., Demeritt, D., & Dessai, S. 2015. The right stuff? Informing adaptation to climate change in British Local Government. Global Environmental Change 35:411-422. https://doi.org/10.1016/j.gloenvcha.2015.10.004

Race, M. S. 1985. Critique of present wetlands mitigation policies in the United States based on an analysis of past restoration projects in San Francisco Bay. Environmental Management 9(1): 71-81

Race, M. S., & Fonseca, M. S. 1996. Fixing Compensatory Mitigation: What will it take? Ecological Applications 6(1). https://doi.org/10.2307/2269556

Reed, M. S. 2008. Stakeholder participation for environmental management: A literature review. Biological Conservation 141(10):2417-2431. https://doi.org/10.1016/j.biocon.2008.07.014

Reiss, K. C., Hernandez, E., & Brown, M. T. 2009. Evaluation of Permit Success in Wetland Mitigation Banking: a Florida Case Study. Wetlands 29(3):907-918.

Richards, C., Blackstock, K.L., Carter, C.E., 2004. Practical Approaches to Participation SERG Policy Brief No. 1. Macauley Land Use Research Institute, Aberdeen.

Richter, J., & Roelcke, M. 2000. The N-cycle as determined by intensive agriculture – examples from central Europe and China. Nutrient Cycling in Agroecosystems 57:33-46.

Rissman, A. R., & Sayre, N. F. 2012. Conservation Outcomes and Social Relations: A Comparative Study of Private Ranchland Conservation Easements. Society & Natural Resources 25(6):523-538. https://doi.org/10.1080/08941920.2011.580419

Rittel, H., and M. M. Webber. 1973. Dilemmas in a general theory of planning. Policy Sciences 4:155–69. (Reprinted in N. Cross, ed. Developments in design methodology, pp. 135–44. Chichester: J. Wiley & Sons, 1984)

Robb, J. T. 2002. Assessing Wetland Compensatory Mitigation Sites to aid in Establishing Mitigation Ratios. Wetlands 22(2):435-440.

Ruhl, J. B. 2009. Adaptive Management for Natural Resources- Inevitable, Impossible or Both? In Rocky Mountain Mineral Law Institute (Vol. 54). https://www.researchgate.net/profile/Jb-Ruhl/publication/228138240_Adaptive_Management_for_Natural_Resources_-_Inevitable_Impossible_or_Both/links/02e7e52b138b26e37a000000/Adaptive-Management-for-Natural-Resources-Inevitable-Impossible-or-Both.pdf

Salafsky, N., Margoluis, R., Redford, K. H., & Robinson, J. G. 2002. Improving the Practice of Conservation: a Conceptual Framework and Research Agenda for Conservation Science. Conservation Biology 16(6):1469-1479. https://doi.org/10.1046/j.1523-1739.2002.01232.x

Section 404 of the Clean Water Act: Background about Compensatory Mitigation Requirements under CWA Section 404. (n.d.). Retrieved November 21, 2019, from United States Environmental Protection Agency website:https://www.epa.gov/cwa-404/

Star, S. L., & Griesemer, J. R. 1989. Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology. Social Studies of Science 19(3):387-420.

Sterling, E. J., Betley, E., Sigouin, A., Gomez, A., Toomey, A., Cullman, G., Malone, C., Pekor, A., Arengo, F., Blair, M., Filardi, C., Landrigan, K., & Porzecanski, A. L. 2017. Assessing the evidence for stakeholder engagement in biodiversity conservation. Biological Conservation 209:159-171. https://doi.org/10.1016/j.biocon.2017.02.008

Stryszowska-Hill, K. M., Benson, C. E., Carberry, B., Twiss, M. R., & Langen, T. A. 2019. Performance of wetland environmental quality assessment indicators at evaluating palustrine wetlands in northeastern New York State. Ecological Indicators 98:743-752. https://doi.org/10.10.1016/j.ecolind.2018.11.051

Sudol, M. F., & Ambrose, R. F. 2002. The US Clean Water Act and Habitat Replacement: Evaluation of Mitigation sites in Orange County, California, USA. Environmental Management 30(5):0727-0734. https://doi.org/10.1007/s00267-002-2787-3

Sultana, P., & Abeyasekera, S. 2008. Effectiveness of participatory planning for community management of fisheries in Bangladesh. Journal of Environmental Management 86(1):201-213. https://doi.org/10.1016/j.jenvman.2006.12.027

Sutton-Grier, A. E., Gittman, R. K., Arkema, K. K., Bennett, R. O., Benoit, J., Blitch, S., Burks-Copes, K. A., Colden, A., Dausman, A., DeAngelis, B. M., Hughes, A. R., Scyphers, S. B., & Grabowski, J. H. 2018. Investing in Natural and Nature-Based Infrastructure: Building Better Along Our Coasts. Sustainability 10:523.

Toogood, S. E., & Joyce, C. B. 2009. Effects of raised water levels on wet grassland plant communities. Applied Vegetation Science 12(3):283-294. https://doi.org/10.1111/j.1654-109X.2009.01028.x

Tosey, P., M. Visser, and M. N. K. Saunders. 2012. The origins and conceptualizations of 'triple-loop' learning: a critical review. Management Learning 43:291-307. http://doi.org/10.1177/1350507611426239

Turner, R. E., Redmond, A. M., & Zedler, J. B. 2001. Count it by Acre or Function-Mitigation Adds Up to Net Loss of Wetlands. National Wetlands Newsletter 23(6): 5-6-14-16.

USACE [Department of the Army, Corps of Engineers] 73 Fed. Reg. 19594 (Apr. 10, 2008) (to be codified at 33 C.F.R. pt. 325 & 332).

USEPA [United States Environmental Protection Agency]. 2021. National Pollutant Discharge Elimination System (NPDES). https://www.epa.gov/npdes/stormwater-maintenance

USEPA [United States Environmental Protection Agency]. 2019. National Estuary Program (NEP). Retrieved May 4, 2021, from https://www.epa.gov/nep/national-estuary-program-reporting-environmental-results

USEPA [United States Environmental Protection Agency]. 2009. Stormwater Wet Pond and Wetland Management Guidebook. Washington, DC: EPA 833-B-09-001.

USEPA [United States Environmental Protection Agency]. (n.d.). History of the Clean Water Act. In Laws & Regulations. Retrieved March 16, 2021, from https://www.epa.gov/laws-regulations/history-clean-water-act#:~:text=The%20Federal%20Water%20Pollution%20Control,law%20to%20address%20water%20pollution.&text=Made%20it%20unlawful%20for%20any,was%20obtained%20under%20its%20provisions

USEPA [United States Environmental Protection Agency]. (n.d.). Wetlands Compensatory Mitigation [Pamphlet]. Retrieved January 4, 2020, from: https://www.epa.gov/sites/production/files/2015-08/documents/compensatory_mitigation_factsheet.pdf

Uphoff, N. 1996. Learning from Gal Oya - Possibilities for Participatory Development and Post-Newtonian Social Science. In Asia-Pacific Journal of Rural Development:103-107. https://doi.org/10.1177/1018529119960206

US Fish & Wildlife Services. 2019. Floristic Quality Assessment https://www.fws.gov/midwest/endangered/section7/s7process/plants/FQA.html

Van Meter, K. J., & Basu, N. B. 2015. Signatures of human impact: size distributions and spatial organization of wetlands in the Prairie Pothole landscape. Ecological Applications, 25(2), 451-465. https://doi.org/10.1890/14-0662.1

Vinke-de Kruijf, J., & Pahl-Wostl, C. 2016. A multi-level perspective on learning about climate change adaptation through international cooperation. Environmental Science & Policy 66:242-249. https://doi.org/10.1016/j.envsci.2016.07.004

Walters, C. J., & Hilborn, R. 1978. Ecological Optimization and Adaptive Management. Annual Review of Ecology and Systematics 9(1):157-188. https://doi.org/10.1146/annurev.es.09.110178.001105

Wetland condition and adjacent land use. 2018. Retrieved March 26, 2019, from The New York Natural Heritage Program website: http://www.nynhp.org/epa-adjacent-areas

Welker, A. L., Wadzuk, B. M., & Traver, R. G. 2010. Integration of Education, Scholarship, and Service through Stormwater Management. Journal of Contemporary Water Research & Education 146(1):83-91. https://doi.org/10.1111/j.1936-704X.2010.00394.x

Weller, S. C., Vickers, B., & Bernard, R. H. 2018. Open-ended interview questions and saturation. PLOS One 1-18. https://doi.org/10.1371/journal.pone.0198606

Williams, Byron K., Robert C. Szaro, and Carl D. Shapiro. 2009. Adaptive Management: The US Department of the Interior Technical Guide. Washington, DC: US Department of the Interior

Wilson RF, Mitsch WJ. 1996. Functional assessment of five wetlands constructed to mitigate wetland loss in Ohio, USA. Wetlands 16: 436-451

Woodcock, T. S., Monaghan, M. C., & Alexander, K. E. 2010. Ecosystem Characteristics and Summer Secondary Production in Stormwater Ponds and Reference Wetlands. Wetlands 30(3):461-474. https://doi.org/10.1007/s13157-010-0057-3

Wu, B., & Cai, L. A. 2006. Spatial Modeling: Suburban Leisure in Shanghai.Annals of Tourism Research 33(1):179-198. https://doi.org/10.1016/j.annals.2005.10.013

Zedler, J. B. 2005. Ecological Restoration: Guidance from Theory. San Francisco Estuary and Watershed Science 3(2). https://doi.org/10.15447/sfews.2005v3iss2art4

Zedler, J. B. 2000. Progress in wetland restoration ecology. Trends in Ecology & Evolution 15(10):402-407. https://doi.org/10.1016/S0169-5347(00)01959-5

Zedler, J. B., & Callaway, J. C. 1999. Tracking Wetland Restoration:Do Mitigation Sites Follow Desired Trajectories? Restoration Ecology 7(1):69-73.

Zedler, J. B., & Kercher, S. 2005. Wetland Resources: Status, Trends, Ecosystem Services, and Restorability. Annual Review of Environment and Resources 30(1):39–74.

Zedler, J. B. 2007. Success: an unclear, subjective descriptor of restoration outcomes. Ecological Restoration 25(3):162-168. http://dx.doi.org/10.3368/er.25.3.162

Zirschky, J. H., Perciasepe, R., Herbert, T. R., Davison, R. P., & Hall, D. K. (n.d.). Federal Guidance for the Establishment, Use and Operation of Mitigation Banks. United States Environmental Protection Agency. Retrieved March 16, 2021, from https://www.epa.gov/cwa-404/federal-guidance-establishment-use-and-operation-mitigation-banks-0

Appendix A: *Regression Table*

Table A- 1: Parameter estimates and confidence intervals for each response model. Note that bolded parameters are redundant dummy variables and estimates were found using their counterparts.

Model	Term	Estimate	Wald Chi-Sq.	p-value	Lower 95% CI	Upper 95% CI
DI	Intercept	2.7	99.9	<0.0001	2.2	3.2
	Act Mgmt	(+)	-	-	-	-
	Mod Mgmt	-1.5	28.2	<0.0001	-2.0	-0.9
	Crt	-0.4	9.0	0.003	-0.7	-0.15
	Rst	(+)	-	-	-	-
	SWW	1.9	14.5	<0.0001	-2.3	-1.0
	Voluntary	(-)	-	-	-	-
	Volunteers	(+)	-	-	-	-
	No Volunteers	-0.6	7.1	0.008	-1.0	-0.2
	Muni Own	-0.8	4.9	0.03	-1.6	-0.1
	Non-Profit Own	(+)	-	-	-	-
FQI	Intercept	14.8	74.8	<0.0001	11.4	18.1
	Muni Own	-5.8	14.1	0.0002	-8.8	-2.7
	Non-Profit Own	(+)	-	-	-	-
	Phas	(+)	-	-	-	-
	No Phas	-2.8	5.3	0.02	-5.1	-0.4
	PRM	2.4	6.7	0.0096	0.6	4.2
	SWW	12.9	46.1	<0.0001	9.2	16.6
	Voluntary	(-)	-	-	-	-
	Mod Mgmt	-3.8	12.7	0.0004	-6.0	-1.7
	Act Mgmt	(+)	-	-	-	-
	Crt	-3.9	17.1	<0.0001	-5.7	-2.0
	Rst	(+)	-	-	-	-
RAM	Intercept	1.7	858.6	<0.0001	1.6	1.8
	PrvLU Altered	-0.1	12.4	0.0004	-0.2	-0.1
	PrvLU Undeveloped	(+)	-	-	-	-
	SWW	0.4	43.7	<0.0001	0.3	0.5
	PRM	0.1	3.3	0.07	-0.01	0.2
	Voluntary	(-)	-	-	-	-
	Plc Wet	(-)	-	-	-	-
	Not Plc Wet	0.2	22.8	<0.0001	0.1	0.3

Appendix B: *Equations*

Equation B-1 (manual Part A score): LULC+ Frag scores or **max of 50 pts**

LULC: Land use land cover tally based on grid layover

Frag scores: Summation of total fragments tallied during grid layover analysis (maximum of 40 pts)

Equation B-2 (NYRAM5 Score): $\frac{Part\ A(max\ 50\ pts) + Part\ B\ (max\ 70\ pts)}{135}$x 100

Part A: On Screen Landscape assessment

Part B: Field stressor assessment

Appendix C: *NYRAM Data Sheets*

New York Rapid Assessment Method (Level 2) Field Worksheets

Developed by New York Natural Heritage Program
625 Broadway, 5th Floor, Albany, NY 12233-4757 (518) 402-8935 Fax (518) 402-8925 www.nynhp.org

Part A: Onscreen rapid assessment

Area of focus: The Landscape Buffer, a 540-m buffer around the center point.
Note: If the sample point will likely be moved in the field, complete this portion *after* the field survey.

Site description

Observer ______________________ Date of onscreen assessment ____________

Site name ______________________ Site code ____________

Pub. date of the imagery: ______________________ Sample location was determined (*circle one*): *Randomly* *Subjectively*

Option 1: Use zonal statistics in ArcGIS, calculate the mean LCA score for a 540-m buffer around the center point ("LCA540" score), and then follow the calculation outlined below in Option 1.

Option 2: Complete the following LULC and fragmenting features tables.
Please note: Although score calculations are shown below, these may be completed after field survey or in Microsoft Excel. The % LULC column should sum to 100%, and the max Total LULC score is 40.

Land Use Land Cover (LULC)

Qualitatively assess the percent area occupied by each of the following land cover types.
GIS tip: in layout view, apply a 50 x 50 m grid to the data frame. Google Earth or GIS: use the measure polygon tool to measure type area.

	% LULC		*Type score*
Impervious surface *pavement, buildings, rock quarries*	________	*x 4 =*	______
Intensely managed *golf, row crops, sand/gravel mining*	________	*x 4 =*	______
Actively managed *lawn, timber, hay, ROW, grazing, unpaved road*	________	*x 3 =*	______
Lightly managed *old field, ditch, plantation, Stormwater pond*	________	*x 2 =*	______
Natural *forest, wetland, shrubland, water*	________	*x 0 =*	______

Sum type scores = ________ *÷ 10*

Total LULC score = ________

Fragmenting features

Tally the number of fragmenting features in each category found in Landscape Buffer.
GIS tip: add New York State road, railroad, hiking & snowmobile trail layers

	Feature tally		*Feature score*
4-lane paved road *4-lanes or larger*	________	*x 6 =*	______
2-lane paved road	________	*x 4 =*	______
Railroad *Active or abandoned*	________	*x 4 =*	______
Utility line *Right-of-way (ROW)*	________	*x 2 =*	______
Unpaved road/trail *Grave/dirt road, hiking or snowmobile trail*	________	*x 1 =*	______
Other*:	________	*x =*	______

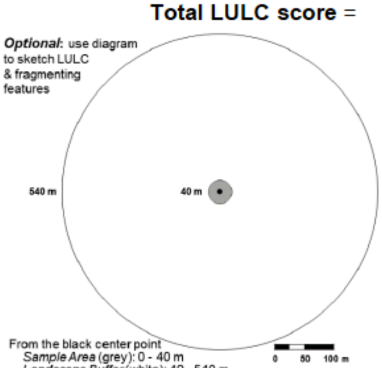
**Select an equivalent multiplier: 1, 2, or 4*

Total fragment score = ________
[sum feature scores or *maximum* score of 40]

***Option 2** (manual)*
LULC + Frag scores *or* **max of 50 pts**: ________

***Option 1** (automated)*
$\text{Log}_{10}(\text{LCA540} + 1) \times 15$ ________

Optional: use diagram to sketch LULC & fragmenting features



From the black center point
Sample Area (grey): 0 - 40 m
Landscape Buffer (white): 40 - 540 m

Part B: Wetland stressor field worksheet

Area of focus: 40-m radius Sample Area (SA) & the surrounding 100-m Field Buffer (FB)

Observers ______________________ Date ____________

County ____________________ Town ____________________

Site name ____________________ Site code ____________________

UTM or Lat/Long: ____________ / ____________ Field point in the GPS? Yes No

Wetland community description

Target NWI wetland class (≥ 90% of SA): EM SS FO1 FO4

Optional: NYNHP/ Nature-Serve/ other comm. class ____________

Optional: Landscape setting or Wetland origin (e.g., natural, created) ____________________

Basic guidelines for establishing a Sample Area (SA) in the field

Refer to the methods manual for detailed guidelines and pre-field office activities. Note: <10% of SA should contain water >1 m deep. If applicable, randomly generated points are invalidated if moved >60 m.

Standard, 0.5 ha (5,025 m^2; 1.24 acres)

SA dimensions determined by (circle one):

tape measure visual estimate

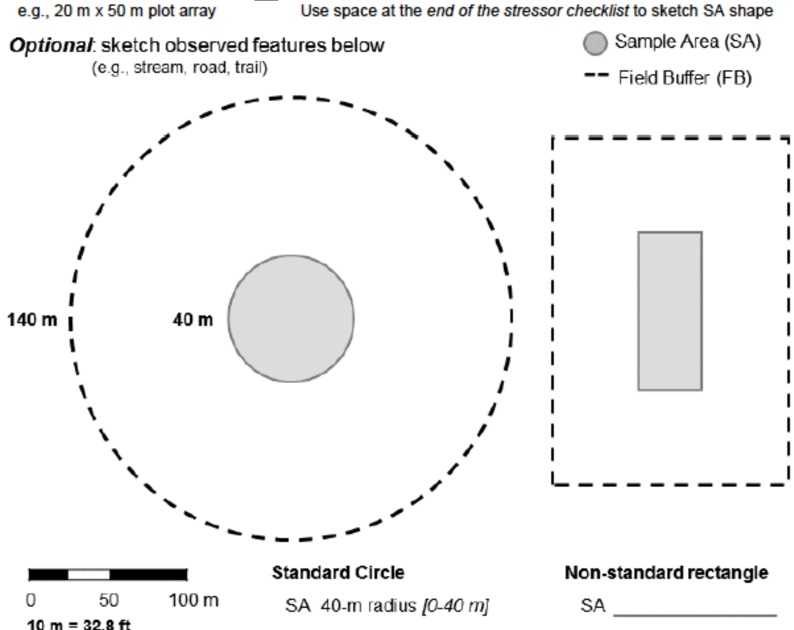
☐ CIRCLE - 40-m radius

Non-standard, 0.1-0.5 ha

☐ RECTANGLE
e.g., 20 m x 50 m plot array

☐ OTHER
Use space at the *end of the stressor checklist* to sketch SA shape

Optional: sketch observed features below
(e.g., stream, road, trail)



Standard Circle

SA 40-m radius *[0-40 m]*

FB 100-m radius *[40-140 m]*

Non-standard rectangle

SA ____________

FB ____________

NYRAM 5 - Part B Site code: ____________ Date: ___________

Wetland stressor checklist

Mark "X" in each applicable column if stressor is present in the Sample Area (SA), Field Buffer (FB), or absent (Abs) from both areas.

Tips: Keep an eye out for invasive species to include in the Invasive Richness Survey (pp. 7-8). Stressor sums at the bottom of each page are optional, but may be helpful when making the final checklist sum for each column.

VEGETATION ALTERATIONS

V1. Vegetation modification occurred within the past year, unless noted	SA	FB	Abs
Excessive wildlife herbivory *(e.g., deer, geese, insects)*	____	____	____
Moderate/intense livestock grazing *(>25% bare soil)*	____	____	____
Mowing *(low intensity lawn or hay)*	____	____	____
Golf course or highly maintained turf *(NOT typical residential lawns)*	____	____	____
Right-Of-Way: cleared *(brush cutting, chemical, etc. assoc. with powerlines & roads)*	____	____	____
ROW, but no maintenance evident within past year	____	____	------
Logging within 2 years	____	____	____
Annual agricultural row crops	____	____	____
Plantation *(conversion from natural tree species, e.g., orchards, forestry)*	____	____	____
V2. Invasive plant species abundance (see invasive richness list)			
Absent (circle one if applicable): SA FB Both	------	------	____
Uncommon (Present, ≤ 20% cover) – List species in the invasive survey (see end)	____	____	------
Abundant (Present, > 20% cover) – List species in the invasive survey (see end)	____	____	------
V3. Other vegetation alterations *(e.g. woody debris removal)*			
____________________	____	____	____
____________________		____	____

HYDROPERIOD MODIFICATION

H1. General hydroperiod alterations	SA	FB	Abs
Ditching, tile draining, or other dewatering methods	____	____	____
Stormwater inputs *(e.g., source pipe, impervious surface/roads/parking lot)*	____	____	____
Water inflow reduced by upstream structure *(dam / weir / culvert; including perpendicular road, railroad beds)*	____	____	____
Water outflow reduced due to impounding structure *(see above examples)*	____	____	____
H2. Stream/riverine-specific modifiers			
Artificial levee *parallel* to stream *(including parallel road, railroad beds)*	____	____	____
Channelized stream: straightened, hardened, or incised	____	____	____
H3. Other indicators of hydro modification *(e.g. high temperature discharge, dead/dying standing trees)*			
____________________		____	____
____________________		____	____
Sum of stressor tallies for each column on this page:	____	____	____

NYRAM 5 - Part B

Site code: ____________ Date: ____________

OTHER HYDRO/TOPOGRAPHIC MODIFICATIONS

T1. Development, filing, grading	SA	FB	Abs
Residential development: Low-moderate (≤2 houses/acre)	____	____	____
High (>2 houses /acre)	____	____	____
Commercial development *(e.g., buildings, factories, parking lots)*	____	____	____
Other filling/grading activity (not road-related; *e.g., exposed soils, dredge spoils*)	____	____	____
Landfill or illegal dump (*excessive garbage, trash*)	____	____	____
T2. Material removal			
Artificial pond, dredging (not ditch-related)	____	____	____
Mining/quarry (circle those present): sand gravel peat topsoil	____	____	____
T3. Roads, railroads, trails			
Hiking or biking trail (well-established)	____	____	____
Unpaved dirt/gravel road (established ATV, logging roads)	____	____	____
Railroad (circle those present): active abandoned rail-to-trail	____	____	____
Paved road: 2 lane	____	____	____
4 lane or larger	____	____	____
T4. Microtopography Soil surface variation <1 m in height (not pavement)			
Vehicle or equipment tracks: ATV, off-road motorcycles	____	____	____
Skidder or plow lines	____	____	____
Ruts in unpaved road (within poorly maintained *unpaved* roads)	____	____	____
Livestock tracks	____	____	____

SEDIMENT TRANSPORT

S1. Potential sediment stressors (within past year, unless noted)			
Active: construction (soil disturbance for development)	____	____	____
plowing (agricultural planting)	____	____	____
Forestry (circle if known): clear cut, even-aged management (within 2 years)	____	____	____
selective tree harvesting, salvage (within 1 year)	____	____	____
Livestock grazing (intensive, ground is > 50% bare)	____	____	____
Sediment deposits / plumes	____	____	____
Eroding banks / slopes	____	____	____
S2. Other evidence of sedimentation / movement (water consistently turbid, active mine, etc. – list if present)			
________________________________		____	____
________________________________		____	____
Sum of stressor tallies for each column on this page:	____	____	____

NYRAM 5 - Part B Site code: ____________ Date: ___________

EUTROPHICATION

E1. Nutrient inputs	SA	FB	Abs
Direct discharge: agri. feedlots, manure spreading/pits, fish hatcheries	______	______	______
septic/sewage treatment plant	______	______	______
Adjacent to intensive annual row crops	______	______	______
Adjacent to intensive pasture grazing (>50% bare soil)	______	______	______
Dense/moderate algal mat formation	______	______	______
E2. Other evidence of contamination or toxicity (acidic drainage, fish kills, industrial point discharge, etc. – list if present)			
______	______	______	______
______	______	______	______
Sum of stressor tallies for each column on this page:	______	______	______

ADDITIONAL NOTES OR SKETCH OF NON-STANDARD LAYOUT

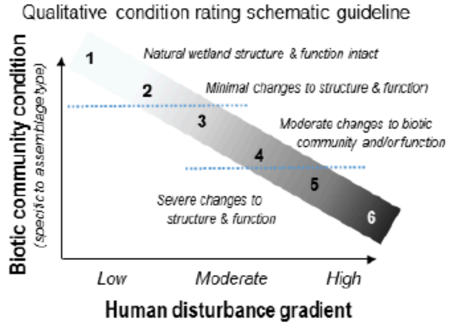
Qualitative condition rating

After completing the survey, describe overall site quality (SA + FB) as it relates to the level of human-mediated disturbance.

Least disturbed 1 2 3 4 5 6 *Highly disturbed*

Circle the number that best describes the site:

Qualitative condition rating schematic guideline



NYRAM 5 - Part B Site code: ____________ Date: ___________

Invasive & nonnative species richness survey

Check or list all invasive and nonnative species present in the Survey Area (SA) and/or Field Buffer (FB). Note that the richness value only represents the number of *unique* species observed in both the SA and FB (i.e., *do not double* count a species).

Plants

Scientific name	Common name	USDA code	SA	FB
Acer platanoides	Norway maple	ACPL		
Agrostis gigantea	Redtop	AGGI2		
Ailanthus altissima	Tree-of-heaven	AIAL		
Alnus glutinosa	European alder	ALGL2		
Alliaria petiolata	Garlic mustard	ALPE4		
Aralia elata	Japanese angelica tree	AREL8		
Artemisia vulgaris	Mugwort	ARVU		
Berberis thunbergii	Japanese barberry	BETH		
Butomus umbellatus	Flowering rush	BUUM		
Celastrus orbiculatus	Oriental bittersweet	CEOR7		
Centaurea stoebe	Spotted knapweed	CEST8		
Cichorium intybus	Chicory	CIIN		
Cirsium arvense (syn. *C. setosum, C. incanum, Serratula arvensis*)	Canada thistle	CIAR4		
Cynanchum spp.	Swallowwort (black, pale or white)	CYNAN		
Daucus carota	Queen Anne's lace	DACA6		
Dioscorea oppositifolia	Chinese yam	DIOP		
Dioscorea polystachya	Chinese yam	N/A		
Elaeagnus umbellata	Autumn olive	ELUM		
Euonymus alatus	Burning bush/Winged euonymus	EUAL13		
Frangula alnus	Glossy/smooth buckthorn	FRAL4		
Galeopsis tetrahit	Hemp-nettle	GATE2		
Glechoma hederacea	Ground ivy	GLHE2		
Glyceria maxima	Reed manna grass	GLMA3		
Heracleum mantegazzianum	Giant hogweed	HEMA17		
Hydrocharis morsus-ranae	Common frogbit	HYMO6		
Hypericum perforatum	Common St. Johnswort	HYPE		
Iris pseudacorus	Yellow iris	IRPS		
Ligustrum vulgare	European privet	LIVU		
Lonicera japonica	Japanese honeysuckle	LOJA		
Lonicera spp.	Shrub honeysuckles (nonnative)	LONIC		
Lysimachia nummularia	Creeping Jenny, moneywort	LYNU		
Lythrum salicaria	Purple loosestrife	LYSA2		
Microstegium vimineum	Japanese stiltgrass	MIVI		
Murdannia keisak	Marsh dewflower	MUKE		
	Sum of unique species observed on this page			

NYRAM 5 - Part B

Site code: _____________ Date: ___________

Scientific name	Common name	USDA Code	SA	FB
Myosotis scorpioides	True forget-me-not	MYSC		
Myriophyllum spicatum	Eurasian water-milfoil	MYSP2		
Persicaria hydropiper (syn. *Polygonum hydropiper)*	Water-pepper smartweed	PEHY6 (POHY)		
Persicaria perfoliata	Mile a minute	POPE10		
Phalaris arundinacea	Reed canarygrass	PHAR3		
Phragmites australis	Common reed	PHAU7		
Poa compressa	Canada bluegrass	POCO		
Poa trivialis	Rough bluegrass	POTR2		
Prunus avium	Sweet cherry	PRAV		
Ranunculus ficaria	Lesser celandine	RAFI		
Reynoutria japonica (syn. *Polygonum cuspidatum, Fallopia japonica*)	Japanese knotweed	REJA2 (POCU6, FAJA2)		
Rhamnus cathartica	Common buckthorn	RHCA3		
Rosa multiflora	Multiflora rose	ROMU		
Rubus phoenicolasius	Wineberry	RUPH		
Solanum dulcamara	Climbing nightshade	SODU		
Trapa natans	Water chestnut	TRNA		
Trifolium repens	White clover	TRRE3		
Tussilago farfara	Coltsfoot	TUFA		
Typha x glauca	Hybrid cattail	TYGL		
Verbascum thapsus	Common mullein	VETH		
Veronica officinalis	Common speedwell	VEOF2		

Animals & pathogens

Adelges tsugae	Hemlock Wooly Adelgid		
Agrilus planipennis	Emerald Ash Borer		
Anaplophora glabripennis	Asian Longhorned Beetle		
Cipangopaludina spp aquatic snails	Invasive Aquatic Snails		
Dendroctonus frontalis	Southern Pine Beetle		
Halyomorpha halys	Brown Marmorated Stink Bug (BMSB)		
Orconectes rusticus	Rusty Crayfish		
Lymantria dispar	Gypsy Moth (caterpillar)		

Additional species observed, but not listed above

Sum of unique species observed on this page _______________

 Site code: ____________ Date: ___________

Part B *field data summary*

Summarize your data and enter values into the empty spaces below.

STRESSORS

Sum tallies in the Wetland Stressor Checklist (do *not* include invasive richness survey data here). Use the stress multiplier to calculate the Metric Score. Stressor score = sum of the metric scores.

		SA		FB		Absent
Stressor tally sum		____		____		____
Stressor Multiplier (SM)	×	8	×	4	×	0
Metric Score	=	____	=	____	=	____
Stressor score		____				

INVASIVE PLANT COVER (%)

Where invasives are present, circle the number that corresponds to tallies indicated in section V2. Sum the values to obtain the invasive cover score. (Invasive score = zero if no invasive were observed in the SA or FB.)

Please note: All values below account for points earned when tallied in section V2 above. This scoring adjustment removes double-counting concerns for this metric, and in doing so, causes some values to be negative.

	SA	FB
Uncommon (≤ 20% absolute cover)	-4	-2
Abundant (>20% absolute cover)	8	4
Pervasive in SA (>75% relative cover)	15	---
Invasive cover score	____	

INVASIVE & NONNATIVE PLANT SPECIES RICHNESS (#)

Count all unique plant, animal, & pathogen species observed in the SA & FB. If absent, write zero.

Invasive & nonnative richness ____

QUALITATIVE CONDITION RATING

Value generally describes the SA *and* the buffer, from least disturbed (1) to heavily disturbed (6) (see p. 6).

Condition rating ____

Part B cumulative score ____ [Part B is capped at a maximum of 70 points. If Part B>70, use 70 when calculating your final score.

Stressors score + Invasives cover score + Invasive richness + Condition score.

NYRAM5 Score: ____

$$\left(\frac{Part\ A\ (\max 50\ pts) + Part\ B\ (\max 70\ pts)}{135}\right) \times 100$$

Scores range from a minimum of 1 to a maximum of 100.

Submit your NYRAM score to NYNHP's databank & see how your score stacks up: www.nynhp.org/shappell

Adjacent areas upland structure & stressor field worksheet

Observers ______________________ Date ____________

Site name ______________________ Site code __________ F-code ____________

County ______________________ City/Town ______________________

Basic Guidelines

Standard layout includes three regularly placed 10m x 10m plots starting at the biological wetland edge (≤50% FAC/FACW/OBL), on which the first buffer plot (BP) is centered (0m). Moving upland, the second and third plots should be placed 25m and 50m from the wetland edge, respectively; indicate how that measurement was made (meter tape, GPS, or paced). GPS points should be taken at each BP center, but if a plot center is inaccessible, indicate your reasoning in the Lat/Long space provided. Aspect (°): take the down-slope aspect within each plot (use mag. north). Slope (°): obtain a representative slope for the 10-m plot using a clinometer.

Habitat type: indicate whether the plot is Natural (**Nat'l**: e.g., unmanaged forest, shrubland, water); Lightly Managed (**LM**: e.g., old field, ditch, plantation, Stormwater pond); Actively Managed (**AM**: e.g., lawn, hay, ROW, grazing, timber, unpaved road); Intensely Managed (**IM**: e.g., golf, row crops, sand/gravel mining); Impervious Surface (**IS**: e.g., pavement, homes/buildings). If habitat types along the 50-m transect transitions from natural to human land use, take a GPS point at the boundary (e.g., forest edge & yard); no BP strata or stressor data need be collected at the boundary.

Table 1	Dist. from wet edge (m)	Method (Circle one)	Aspect (mag N)	Slope (degrees)	Point in GPS?	Latitude/UTM	Longitude/UTM	Habitat type (Circle one)
BP0		N/A			Yes No			Nat LM AM IM IS
BP25		Tape GPS Pace			Yes No			Nat LM AM IM IS
BP50		Tape GPS Pace			Yes No			Nat LM AM IM IS
Nat'l edge		Tape GPS Pace			Yes No			N/A

Strata Composition (Part A)

Circle all that apply: Canopy Type: D = Deciduous; E = Evergreen; B = Broad-leaf; N = Needle-leaf; A = Absent: No tree canopy. Estimate lichen on tree trunks (0-3m high) using four cover classes: 0; <1/3; 1/3 to 2/3; >2/3 of the trunk is covered in lichen.

Strata cover: Circle one cover class for each category: 0 = Absent; 1 = Sparse (<10%); 2 = Moderate (10-40%); 3 = Heavy (40-75%); 4 = Very heavy (>75%). For data validation, also give a raw estimate of strata cover (%). Trees are classified as individuals >5m high, while shrubs and saplings ("Shrub/Sap") are woody plants <5m high. Short vines are <0.5m high. Coarse Woody Debris (CWD) includes down wood >7.5 cm diameter.

Strata Category	**Buffer Plot 0**	%	**Buffer Plot 25**	%	**Buffer Plot 50**	%
Canopy Type	D E A		D E A		D E A	
Leaf Type	B N		B N		B N	
Arboreal lichen	0 1 2 3	%	0 1 2 3	%	0 1 2 3	%
Trees (>5m high) Big (DBH>0.3m)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Little (DBH<0.3m)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Shrub/Sap (<5m high) Tall (2-5m high)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Medium (0.5-2m)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Short (<0.5m)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Short Vines	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Herbs/Forbs/Grams	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Lawn or Old Field (circle one)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Ground Moss	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
% invasive cover	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Bare ground	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Natural litter, duff (not yard waste)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
CWD (>7.5 cm D)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Rocks	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Water	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	
Other* (describe)	0 1 2 3 4		0 1 2 3 4		0 1 2 3 4	

* Examples of "other" categories: Tall Vines (>5m high); Submerged Aquatic Vegetation (SAV); yard waste (clippings, leaves, etc.); trash.

Adjacent areas upland structure & stressor field worksheet

Stressor checklist (Part B). Use the checkboxes to indicate stressor "presence" within observed buffer plot(s). The "flag" column functions as a footnote when additional comments/notes pertain to a specific stressor.

Habitat/Vegetation stressors

Buffer plot #	0	25	50	Flag
Forest cutting (clear of selective)	☐	☐	☐	
Tree plantation	☐	☐	☐	
Tree canopy herbivory (insect)	☐	☐	☐	
Shrub/sapling layer browsed	☐	☐	☐	
Herbicide/pesticide use	☐	☐	☐	
Mowing/shrub cutting	☐	☐	☐	
Trails	☐	☐	☐	
Soil compaction (wild animal or human)	☐	☐	☐	
Off-road vehicle damage	☐	☐	☐	
Soil erosion/deposition (from wind, water, or overuse)	☐	☐	☐	
Other	☐	☐	☐	

Comments/Flags (V#):

Residential & Urban stressors

Buffer plot #	0	25	50	Flag
Road (paved or unpaved)	☐	☐	☐	
Power Line	☐	☐	☐	
Parking lot/pavement	☐	☐	☐	
Golf course	☐	☐	☐	
Lawn/park	☐	☐	☐	
Suburban residential	☐	☐	☐	
Urban/Multifamily	☐	☐	☐	
Landfill	☐	☐	☐	
Dumping	☐	☐	☐	
Trash	☐	☐	☐	
Other	☐	☐	☐	

Comments/Flags (R#):

Hydrology stressors

Buffer plot #	0	25	50	Flag
Ditches, Channelization	☐	☐	☐	
Dike/Dam/Road/RR bed (impede horizontal flow)	☐	☐	☐	
Water level control structure	☐	☐	☐	
Excavation, Dredging	☐	☐	☐	
Fill/Spoil banks	☐	☐	☐	
Freshly deposited sediment (unvegetated)	☐	☐	☐	
Soil loss/Root exposure	☐	☐	☐	
Wall/Riprap	☐	☐	☐	
Inlets, Outlets	☐	☐	☐	
Point Source/Pipe (effluent or stormwater)	☐	☐	☐	
Impervious surface input (sheetflow)	☐	☐	☐	

Comments/Flags (H#), Other:

Agricultural & Rural stressors

Buffer plot #	0	25	50	Flag
Rural residential	☐	☐	☐	
Pasture/Hay	☐	☐	☐	
Row crops - tilling	☐	☐	☐	
Orchard/Nursery	☐	☐	☐	
Fallow field (recent-resting row crop field)	☐	☐	☐	
Old field (old grass, shrubs, trees)	☐	☐	☐	
Irrigation	☐	☐	☐	
Drain tiling	☐	☐	☐	
Livestock or Domestic Animals	☐	☐	☐	
Confined Animal Feeding	☐	☐	☐	
Gravel Pit	☐	☐	☐	
Other	☐	☐	☐	

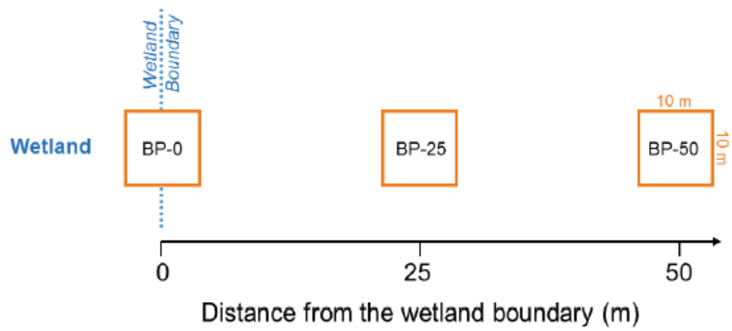
Comments/Flags (A#):

Invasive species.
Write-in additional species as needed. See NYRAM form for full suggested species list.

Buffer plot #	0	25	50	Flag
Agrilus planipennis (EAB)	☐	☐	☐	
Ailanthus altissima	☐	☐	☐	
Alliaria petiolata	☐	☐	☐	
Berberis thunbergii	☐	☐	☐	
Celastrus orbiculatus	☐	☐	☐	
Cichorium intybus	☐	☐	☐	
Cirsium spp.	☐	☐	☐	
Cynanchum spp.	☐	☐	☐	
Daucus carota	☐	☐	☐	
Elaeagnus spp. (*E. umbellata, E. angustifolia*)	☐	☐	☐	
Euonymus alatus	☐	☐	☐	
Frangula alnus	☐	☐	☐	
Glechoma hederacea	☐	☐	☐	
Hesperis matronalis	☐	☐	☐	
Hypericum perforatum	☐	☐	☐	
Ligustrum vulgare	☐	☐	☐	
Lonicera japonica	☐	☐	☐	
Lonicera spp. (shrub)	☐	☐	☐	
Lotus corniculatus	☐	☐	☐	
Lysimachia nummularia	☐	☐	☐	
Lythrum salicaria	☐	☐	☐	
Microstegium vimineum	☐	☐	☐	
Myosotis scorpioides	☐	☐	☐	
Nasturtium officinale	☐	☐	☐	
Phalaris arundinacea	☐	☐	☐	
Phragmites australis	☐	☐	☐	
Reynoutria japonica	☐	☐	☐	
Rhamnus cathartica	☐	☐	☐	
Rosa multiflora	☐	☐	☐	
Rubus phoenicolasius	☐	☐	☐	
Saponaria officinalis	☐	☐	☐	
Solanum dulcamara	☐	☐	☐	
Trifolium repens	☐	☐	☐	
Tussilago farfara	☐	☐	☐	
Verbascum thapsus	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	

Comments/Flags(I#):

Schematic of a standard upland adjacent area plot layout:



Calculating the upland adjacent area rapid assessment score (UP-RAM)

Field RAM pre-score: Use the strata scoring tables on the following page to calculate plot scores for BP0 and BP25. Plot scores, along with the following variables populate equation 1 to produce the Field RAM pre-score.

> *$BP50_w$*: The field RAM pre-score includes BP50 habitat type as a weighted score: Natural = 0; Lightly Managed (LM) = +0.5; Active Management (AM) = +0.9; and Impervious surface (IS) = +1.2.
>
> *$BUFF_w$*: Based on your measured distance to natural edge, score as follows: ≤1 m wide = +4; ≤8 = +4; ≤15 m = +2; <100 m = +1; >100 m = 0.
>
> *INV_w*: This is a constant based on the presence of more than one nonnative invasive plant species. If two or more invasive species were observed across either BP0 or BP25 add two (2) points.
>
> *Equation 3: Field RAM pre-score*

$$Field\ RAM\ score = Abs(BP0\ score - BP25\ score) + BUFF_w + BP50_w + INV_w$$

UP-RAM final score

Using your site's digitized Area of Interest (AOI), use the zonal statistics tool in ArcGIS to calculate the maximum impervious surface score within the AOI polygon. Use that maximum score to assign weighting as follows (IS_{MAX}): <20 = 0; ≥20 = +2; ≥50 = +5; ≥50 = +8. Scoring threshold were modeled after National Wetland Condition Assessment 2011 reference wetland protocols.

> *Equation 4: UP-RAM final score*

$$UP - RAM\ = IS_{MAX} + \ Field\ RAM\ score$$

Table 7: Use strata composition data to complete the following scoring tables. Points are assigned based on cover classes selected in Part B. Points are earned (+) or deducted (-) based on strata composition. Stressor and invasive species data collected in Part B should be tallied (counted) and entered in the field below. Habitat type weighting decreases with land use intensity and distance from the biological wetland boundary; refer to BP-specific weighting scores below.

BP0 strata scoring

Strata Category	Cover class criteria	(+)	CC criteria	(-)
Canopy	"absent"	+5	*NA*	---
Arboreal lichen (Cover class 2 = zero pts)	0 or 1	+1	3	-1
Big Trees	0- 2	+2	3 or 4	-2
Little Trees (Cover class 2 = zero pts)	0 or 1	+1	3-4	-2
Tall Shrub/Sap (Cover class 2 = zero pts)	0 or 1	+2	2-4	-1
Medium Shrub/Sap (Cover class 2 = zero pts)	0 or 1	+2	2-4	-1
Short Shrub/Sap (Cover class 2 = zero pts)	0 or 1	+2	2-4	-1
Bare ground (Cover class <3 = zero pts)	3 or 4	+1	--	--
Herbs/Forbs/Grams (Cover class 2 = zero pts)	0 or 1	+1	3 or 4	-1
Lawn or Old Field	0 or 1	+0	--	--
	2	+1	--	--
	3 or 4	+2	--	--
% invasive cover	0 or 1	+0	--	--
	2	+17	--	--
	3	+34	--	--
	4	+51	--	--
	Sum (+)		Sum (-)	
Additive strata score: BP0				
Total stressor tally: BP0				
Total invasive tally: BP0				
Habitat type score: BP0 (N=0; LM=2; AM=3; IM=4; IS=5)				
BP0 total plot score: [sum grey boxes]				

BP25 strata scoring

Strata Category	Cover class criteria	(+)	CC criteria	(-)
Canopy	"absent"	+5	*NA*	---
Arboreal lichen (Cover class 2 = zero pts)	0 or 1	+1	3	-1
Big Trees	0- 2	+2	3 or 4	-2
Little Trees (Cover class 2 = zero pts)	0 or 1	+1	3-4	-2
Tall Shrub/Sap (Cover class 2 = zero pts)	0 or 1	+2	2-4	-1
Medium Shrub/Sap (Cover class 2 = zero pts)	0 or 1	+2	2-4	-1
Short Shrub/Sap (Cover class 2 = zero pts)	0 or 1	+2	2-4	-1
Bare ground (Cover class <3 = zero pts)	3 or 4	+1	--	--
Herbs/Forbs/Grams (Cover class 2 = zero pts)	0 or 1	+1	3 or 4	-1
Lawn or Old Field	0 or 1	+0	--	--
	2	+1	--	--
	3 or 4	+2	--	--
% invasive cover	0 or 1	+0	--	--
	2	+17	--	--
	3	+34	--	--
	4	+51	--	--
	Sum (+)		Sum (-)	
Additive strata score: BP25				
Total stressor tally: BP25				
Total invasive tally: BP25				
Habitat type score: BP25 (LM=0.9; AM=1.3; IM=1.8; IS=2.2)				
BP25 total plot score: [sum grey boxes]				

Appendix D: *Interview Information*

Questionnaire D-1:

1. Demographic questions
    a. Tell me about your educational/professional background. Job title/ areas of expertise, how did you decide to pursue what you are doing today?
    b. How far is your home from this site?
    c. How far is your place of work from this site?
2. In what capacity are you involved with the XXX restoration project? (part of job, volunteer, education/teacher, education/student)
3. How long have you been involved?
4. Tell me about how you were/have been involved at the restoration for XXX?
5. What are the successes that you have encountered at this project?
6. What are the challenges that you have encountered at this project?
7. Do you have prior experience in restoration projects?
    a. If so, what kinds? How many?
    b. If not, why not?
8. What is your vision for XXX restoration project?

Description D-2:

<u>Interviews: Data Saturation</u>

The topic of data saturation, or ensuring that the number of interviews is sufficient to draw conclusions, has been considered. There is not one completely accepted method to reach this point in qualitative studies (Guest et al. 2006, Weller et al. 2018). However, depending on the type of qualitative study being administered, there is literature investigating what data saturation may look like case by case. Particularly relevant to this research, phenomenological studies (the study of what it is like to experience a particular situation) have been found to meet data saturation at lower interviewees (5 or more) rather than 30-200 interviewees for ethnography studies, grounded theory studies, or ethology studies (Morse 1994, Creswell 1998). Since many of my interview questions regarded an individual's perception of a restoration project itself, data saturation occurring after only a few interviews corroborates what is found for this type of research. Further, by using one common saturation point in conjunction with this knowledge, end points for data collection can be more concrete. “Theoretical saturation” was first introduced by Glaser & Strauss (1967) as the point when “no additional data are being found whereby the (researcher) can develop properties of the category... the researcher becomes empirically confident that a category is saturated”. For those who consider grounded theory in a very serious manner, this would only hold true when the development of a theory is occurring (Guest et al. 2006). This type of saturation occurs when all variations in the phenomenon being studied have been considered in the new theory being created (Guest et al. 2006). Since this approach involved concentrated effort to search for as many variations as possible, and did not completely pertain to the uses of my study, I employed another technique used to reduce vagueness in this definition of theoretical saturation. Guest et al. (2006) “operationalized” theoretical saturation to be "the point in data collection and analysis when new information produces little or no change to the codebook." In other terms, when no new codes emerged from my data set, I was confident that saturation had been met for that particular group (site). This instance occurred during the analyses phase of my interview data for both wetland sites, showing that the information gained is robust enough to use as interpretative leverage

Description D-3:

Interviews: Total Analysis

During the summer of 2018 and during the fall of 2019, interviews were conducted from 4 aquatic restoration sites. Interviews were recorded and later coded for common themes. Comparisons across relevant sites revealed common themes, especially pertaining to challenges and successes. More than half (63%) of stakeholders across all four sites cited a social challenge which included interactions among stakeholders, and ranged from public acceptance of the project, gaining volunteers to help maintain the project, to coordination of logistics.

Nearly all (94%) participants named at least one success within their respective projects; however, these were more variable than the challenges and ranged from purely ecological to social. Successes like meeting regulatory or grant requirements were mentioned along with building partnerships within the local human community. Additionally, having corporate cooperation with recommendations for ecological integrity at one site was listed as a success. Interestingly this same participant cited their main challenge as ecological, indicating obtaining the correct ecological structure or species was a hurdle in the project. One stakeholder said it was "too early" in the project to cite any specific success.

One of the final questions queried individuals' ultimate vision for the project; the question was intentionally open ended. "Visions" for each project varied, however the most common response (42%) was broad environmental impacts, including spreading awareness about water quality and helping to reduce overall sediment input to Lake Ontario. Other responses were very specific and intrinsic to a particular site, such as increasing the stream water levels, increasing shading of the stream by trees, or meeting permit compliance for a wetland. Three people mentioned that their vision had been met, and two out of three people mentioned permit/grant compliance as their main success at their projects. This shows that those who view meeting the end goal of permit or grant requirements often think that the ecological state at projects at the time of compliance will likely remain the same as time progresses.

At the High Acres Nature Area location (comprised of 3 individual sites) there was 100% similarity in responses for this final question about project visions. All five participants mentioned building current partnerships and ongoing research; this common theme was only seen in the High Acres case. High Acres has an active volunteer base that works in conjunction with student researchers conducting undergraduate and graduate research on their various wetland sites on the property. These partnerships have been established since 2011 and have continued to grow throughout the years.

The varying responses among stakeholders was evident and was a common theme among respondents, across questions. Boundary Object Theory frames a way to understand stakeholders collaborating on a common task with varying goals (Star & Griesemer 1989). By picturing each restoration project as a boundary object, it can more easily be understood that several stakeholders with varying goals and agendas can work through the project to meet the overall need of restoration. These findings were used as preliminary results to build the foundation of this thesis project off of. They suggested that ecologically successful projects may need many stakeholders with various goals in order to be successful long-term. Through further investigation of ecological and social drivers at each site the hypotheses were tested.

Table D- 4: Summary of main categories and sub-categories of coded interview data

Main Categories from Questions	Specific Sub-Categories
Successes	Partnerships
	Ecological
	Social
	Too Early
Prior Experience	Yes
	No
Challenges	Social
	Ecological
	Time
Visions	Partnership Growth
	Permit Compliance
	Grant Requirements
	Broad Impacts
Role	Volunteer
	Job
Background	Science
	Engineering
	Arts
	Business
	Construction

Table D- 5: Most common intensive study site volunteer attributes and perceptions.

Site	"What are the successes you have encountered at this project?"	"What are the challenges you have encountered at this project?"	Active Volunteers	Educational Purposes	Completed Interviews	Town/Location
High Acres Nature Area	Ecological/ Partnerships	Social/ Ecological	Yes	Yes	5	Perinton, NY
RIT	Social	Social (Communication)	No	Yes	3	Rochester, NY
Shipbuilders Creek	Social/ Partnerships	Time	No	No	5	Webster, NY
Buckland Creek	Ecological/ Social	Social/ Time	No	Yes	5	Brighton, NY