Wetland Restoration

Contemporary Issues & Lessons Learned

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This white paper presents a roadmap for future actions to improve wetland restoration outcomes. It is not intended to replicate or replace the extensive and still pertinent book *Wetland Creation and Restoration: The Status of the Science* or numerous other reports and studies documenting underlying reasons for inadequate wetland restoration and mitigation. Rather, the authors briefly outline many already identified common reasons why wetland restorations perform poorly, but also recommend an action agenda for addressing these issues and challenges. This paper is the result of the collective wisdom of a Wetland Restoration Work Group composed of experts in the field of wetland restoration from across the United States, many of whom also work abroad. A monthly webinar series, which started in September, 2014 and continued through 2015, further explored many of the issues and recommendations in this white paper. The webinars were developed by the Association of State Wetland Managers (ASWM) and Work Group members. Webinar presenters included Work Group members, as well as other wetland restoration experts.

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Executive Summary
TO BE ADDED WHEN REPORT IS COMPLETED

Numerous studies documented shortcomings of wetland mitigation and voluntary restoration projects and inability to achieve stated goals. In 2014 the Association of State Wetland Managers organized a Work Group of wetland restoration experts to identify the underlying causes and identify actions to improve progress. During 2014 and 2015 a series of webinars on wetland restoration was organized to further explore wetland restoration practices for selected wetland types. Workgroup members and presenters were asked to identify the top 5 constraints on wetland restoration and identify potential remedies.

I. Introduction

Wetland Restoration Work Group

In response to reports quantifying the shortcomings of restoration over the past decade, the Association of State Wetland Managers (ASWM) created a Wetland Restoration Work Group in 2014 (Appendix A), composed of twenty five experts, including practitioners, regulators, policy makers, scientists and academics. The Work Group was tasked with identifying some of the most significant barriers to wetland restoration and identifying actions that could address these challenges based on lessons learned and the substantial collective expertise of Work Group and others. The Work Group deliberated over evidence and common problems. To share initial findings and broaden the discussion, ASWM and the Work Group developed a webinar series titled "Improving Wetland Restoration Success" that considered a dozen topics in live monthly webinars (Appendix B). These were recorded and posted to the internet. The webinars included experts from diverse fields and regions of the U.S. Each presenter was asked to list the top five constraints on wetland restoration and how to improve the process (Appendix C). The challenges and recommendations identified in this white paper are based on key points provided by webinar presenters, recommendations by Work Group members and ideas from Work Group discussions. The webinar recordings are available to download here: http://www.aswm.org/aswm/aswm-webinarscalls/6773-improving-wetland-restoration-success-project.

The intended audience for this report includes professionals in federal, state and tribal agencies as well as those in private practice and academia. It is intended to be used by anyone who works in the field of wetland restoration including regulators, policy makers, practitioners, wetland managers, and individuals who are interested in voluntary restoration.

In the early 1990's, mitigation to replace permitted wetland losses became national policy. At the same time, funding for programs such as the North American Waterfowl Management Plan and the Wetlands Reserve Program provided financial support for voluntary restoration, which led to hundreds of thousands of acres of restored and created wetlands. However, subsequent studies raised concerns about the ability of replacement wetlands to provide the same services of those that were lost (National Research Council [NRC], 2001).

In 2012, David Moreno-Mateos and co-authors published their review of 621 wetland restoration efforts, some over a century old. They found, in general, lower levels of function and environmental benefits relative to existing natural wetlands. The authors stated:

"Our analysis suggests that even a century after restoration efforts, these parameters remained on average 26% and 23% (respectively) lower in restored or created wetlands than in reference wetlands. Our results also indicate that ecosystem size and the environmental setting significantly affect the rate of recovery. Recovery may be more likely and more rapid if more than 100 contiguous hectares of habitat are restored. In warm climates, and in settings linked to riverine or tidal flows, recovery can also proceed more rapidly. In general, however, once disturbed, wetlands either recover very slowly or move towards alternative states that differ from reference conditions. Thus, current restoration practice and wetland mitigation policies will maintain and likely accelerate the global loss of wetland ecosystem functions." (p. 2)

Further, many of the issues and problems identified in recent years bear strong parallels to issues and problems articulated a quarter century ago in "Wetland Creation and Restoration: the Status of the Science" published in 1989 (volumes 1 and 2) and later in "Compensating for Wetlands Losses Under the Clean Water Act" in 2001 (Kusler & Kentula, 1989; NRC, 2001).

In 2013, Scientific American published an article by John Carey titled, *Architects of the Swamp*, that also sounded the alarm that wetland restoration efforts were not meeting expectations. Carey interviewed wetland restoration experts such as Joy Zedler, Robin Lewis, PWS and John Teal, who agreed that wetland restoration – both voluntary and for mitigation – has less than satisfactory outcomes. The take away conclusions of the article were:

- Wetlands across the U.S. and the world continue to degrade;
- Projects to revive wetlands have wasted millions of dollars, in part because they have attempted return all aspects of an ecosystem to historical conditions;
- Restorationists should specify a major goal, such as boosting fish populations or improving water quality; and
- Restoration has made progress in Delaware Bay, and new plans are addressing wetland losses in coastal Louisiana (Carey, 2013).

These reports and others call into question the premise for much of wetland regulation today, namely, that permit applications can be approved to destroy wetlands if the losses are replaced at another location.

Many of the concerns articulated regarding mitigation also apply to voluntary restoration and wetlands restored to address specific water quality issues. Wetlands are restored or created for many reasons besides compensatory mitigation for direct losses associated with a permit. The goals of these non-compensatory projects are therefore different and measures of progress may also be different. Regardless of the purpose of a project, the issues described here are relevant and important to improving the quality and sustainability of wetland restoration across the landscape.

This report 1) documents barriers and problems associated with wetland restoration practices, 2) explores what can be done to address these challenges, and 3) outlines a series of practical actions to improve wetland restoration outcomes. This paper is divided into two primary sections: 1) Common Challenges and 2) Actions to Improve Wetland Restoration. Each section begins with an overview and then provides more detailed information organized in the chronological order of wetland restoration projects: pre-restoration, during restoration and post-restoration.

II. Common Challenges

Wetland restoration projects fail to perform as planned for many reasons, including but not limited to: poorly articulated performance criteria (often called "success criteria"), inadequate designs, inadequate collection of baseline conditions, unsuitable site selection, unimplemented projects, and inability to adapt wetland restoration plans to new information found during construction. Many of these issues have been documented for many years yet they are repeated time and again. An examination of the underlying causes for wetland restoration failure described over 25 years ago in *Wetland Restoration and Creation: Status of the Science* includes many of these same issues. Some of the challenges identified in reports previously published include:

Practical experience and the available science base on restoration and creation are limited for most types and vary regionally.	Performance expectations in Section 404 permits have often been unclear, and compliance has often not been assured nor attained.
Most wetland restoration and creation projects do not have specified goals, complicating efforts to evaluate "success".	Wetlands are often not restored within a watershed context.
Monitoring of wetland restoration and creation projects has been uncommon.	Support for regulatory decision making is inadequate.
We don't know how to re-create a fully functioning wetland that is identical to the one being lost.	Lack of adequate attention to soils and hydrology.

(Kusler & Kentula, 1989; NRC, 2001)

At the same time, there has been progress. Scientific understanding of how wetland ecosystems work has broadened, and monitoring of wetland health has grown into a large body of methods and techniques. Both natural and restored wetlands have been monitored and data reported. As a result, there is consensus among many scientists and experienced practitioners that the knowledge base exists to achieve a much higher level of performance across many wetland types. Thus, many of the problems identified can be resolved. This section examines some of the common shortcomings, starting with how wetland restoration and project outcomes are described.

A. Tracking Wetland Restoration Progress

To measure the progress of a wetland restoration project, specific performance criteria must first be identified. Unfortunately, the word "success" is often used subjectively to describe wetland restoration project outcomes and it can be interpreted differently depending on the criteria that different agencies or professionals may use to define "success" (Kentula, 2000). All too frequently, quantifiable goals are not even identified and/or implemented. Not surprisingly, Morandi, Piegay, Lamouroux and Vaudor (2014) found that the "projects with the poorest evaluation strategies generally have the most positive conclusions about the effects of restoration." (p. ? in the abstract – I have requested full text)

In many cases, there is a reluctance to admit shortcomings, so any improvement in the site is deemed a "success." For example, abstracts in two different restoration journals between the years 2000 – 2006 used the word "success" 116 times, whereas they only used the word "failure" 10 times. And in an informal poll in 2014 conducted by Dr. Joy Zedler (Professor of Botany at the University of Wisconsin-Madison and the Aldo Leopold Professor of Restoration Ecology and Research Director at the Arboretum), via an online internet search, the words "ecological restoration success" received 530,000 hits, whereas "ecological restoration failure" generated only four .

"I restored it, so it's a success."

"It's green, so it's a success."

"We spent a million bucks, so it's a **$**ucce**$$**."

"I saw a marsh bird,
so it's a success."

If NOTHING is right,
It's still "on its way to success."

"I took a course in restoration, so it's a success."

"Mom likes it, so it's a success."

Dr. Zedler (2007) has proposed avoiding the use of the term "success" altogether, explaining that "As scientists, we do not actually measure success; we measure conditions, structure, processes, ecosystem development, similarity to reference sites, and potential for self-sustainability (by various metrics or indicators)." (p. 164) Robin Lewis, PWS (President of Lewis Environmental Services, Inc., and Coastal Resources Group, Inc.) defines "success" as "the achievement of quantitative criteria established during the design and permitting of a project and before construction begins, and measured and reported regularly during project monitoring." Zedler urges that authors define the word if they chose to use it, so readers/listeners know what is meant. It is also critical to define the time allowed to achieve "success" and to assure that monitoring and management will occur (be adequately funded) during that period.

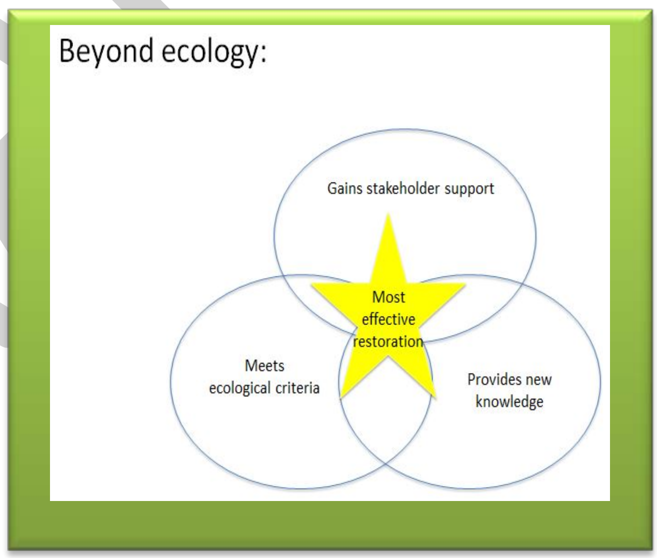
In accordance with the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency's (2008) mitigation rules and regulations, regulators evaluating wetland mitigation projects use identifiable and measureable performance standards, which are "observable or measurable physical (including hydrological), chemical and/or biological attributes that are used to determine if a compensatory mitigation project meets its objective."(p. 19672) Or else they compare with reference aquatic resources, that "represent the full range of variability exhibited by a regional class of aquatic resources as a result of natural processes and anthropogenic disturbances." (p. 19672) In short, the restoration site must perform at pre-determined functions or similar to reference conditions.

However, performance standards themselves are not always appropriate to evaluating wetland restoration. For example, many performance standards have been developed for the wetter areas of the U.S. and do not provide reliable indicators when used in the drier arid western regions of the country. Reference wetlands can be an appropriate tool for planning wetland restoration activities because existing wetlands are more mature than a newly restored site. Some wetland restoration experts recommend using reference wetlands to develop standards against which restoration efforts can be evaluated (Pruitt, 2013). Wetland performance criteria are evolving along with our understanding of wetlands.

There is consensus among scientists and experienced practitioners that wetlands are highly variable and there is no "cookbook" approach for achieving desired outcomes of wetland restoration. Wetlands are complex and dynamic ecosystems, and there are many different wetland types that provide different functions at different levels in different conditions. However, while wetlands exhibit differences based variables such as HGM classification, the region of the U.S, in which it located, vegetation classes, or numerous other characteristics, there are features common to all wetlands that must be considered when attempting to restore wetlands.

B. Overall Barriers to Meeting Performance Criteria

1) Knowledge base is not available



One of the challenges that impede wetland restoration is inadequate expertise. The good news is that more knowledge exists than is used. The barrier can be gaining access to research and acquiring the needed expertise. Barriers include prohibitive costs for access to academic journals, insufficient time to review the literature, a lack of undergraduate and graduate studies on wetland restoration science, a lack of training opportunities for practicing professionals and professional silos. Often information about how to restore a specific wetland type is dispersed among publications that are inaccessible to the majority of practitioners.

Progress can also be hampered by insufficient documentation of performance requirements and advice on how to avoid common mistakes. Although there are many thousands of acres of wetland restoration/mitigation completed, or in process, generally monitoring and reporting information is not readily available. Professionals need access to review and learn about others' efforts in order to improve their own practices. Additionally, the lag time between when research is performed and an article gets published creates significant delays in making important research findings available. It is also a barrier when key findings are written in highly technical language that attracts peer reviewers, but not those who could use the knowledge. Finally, many research articles document methods and results, without providing management implications or recommendations (Cvitanovic et al, 2014).

Inadequate access to knowledge and insufficient training opportunities, including a lack of any central data portal or portals for case studies, data and other resources, impacts both practitioners actually doing the restorations and regulators tasked to review and approve and projects. Thus, many wetland restoration designs are inadequate to achieve desired outcomes. For example, a wetland restoration plant list may be based on the contractor's affiliation with a particular nursery, whose stock may not be appropriate for the region in which the restoration will occur. Considerable expertise is needed for a designer or permit reviewer to identify problems that are likely to occur if the proposed plan is implemented.

It is typically unrealistic for one individual to possess all the expertise needed to carry out wetland restoration projects. In particular, large and/or complex projects require interdisciplinary teams. The absence of one or more types of expertise, (e.g., knowledge about hydric soils) can result in a poor design. Consistent, interdisciplinary coordination, communication and leadership between wetland scientists, engineers, soil scientists and other practitioners throughout the project is necessary. In practice, some state and/or federal regulations may favor specific kinds of expertise over others in developing wetland restoration projects. If these requirements inadvertently ignore or discourage interdisciplinary approaches or other specific expertise that is needed they may increase the possibility of failure. As a result, some projects are overdesigned or ignore crucial elements. (Fejtek, et al, 2014; Garnder, Maynard, Price & Fischenich, 2014; Seijger, van Tatenhove, Dewulf & Otter, 2013) For example, Florida requires that Physical Engineers seal all drawings for their Environmental Resource Permits, even those showing plant species and installation requirements for mitigation. There is no requirement to use a Professional Wetland Scientist or other plant professional. This can lead to many mistakes being made in wetland mitigation design.

2) Inappropriate performance criteria

Often mistakes are made at the very beginning by having unclear project goals. Having vague project goals can lead to inadequate compilation of baseline information such as failure to correctly set hydrology objectives. Inadequate characterization of water quality inputs and existing soil conditions can also constrain progress. Too many projects are judged based solely on plant coverage without looking closely enough to determine if the hydrology and soil health are adequate to support the restoration site over a longer time frame. Appropriate performance criteria can assist practitioners in describing progress made toward meeting objectives. Good performance criteria should list both objectives and standards, enable measurement of the degree to which each objective has been met and then allow determination of the overall outcome (i.e., did the restoration meet the criteria or not? Were there any irregularities and/or shortcomings?) (Kentula, 2000).

Finally, existing program regulations and guidelines generally restrict monitoring times to assess wetland restoration over 3-5 years. For the vast majority of restoration sites, this timeframe is wholly inadequate, particularly for wetland types that develop over a long period of time, such forested wetlands, bogs and fens. Even with wetlands that can develop within a 3-5 year period, weather, hydrologic or other changes may mean that in a particular case a much longer time may be required. In addition, the short timeframe places pressure on the restoration designers to achieve a mature wetland in 3-5 years, which requires 10, 20 or more years to occur naturally. Wetlands are highly variable in the time that it takes to evolve and develop. For those that require a longer time period, some steps in natural succession may be skipped in order to meet criteria in 3-5 years (such as introducing shade intolerant plants before there is shade), and the potential impacts on ecosystem sustainability are not well understood. A number of wetland restoration experts support longer timeframes and/or focusing on one or two objectives and measuring progress rather than attempting to establish long-lived plants or peat-rich soils in a relatively short period of time. For example, Ohio EPA established a 10 year monitoring period for forested wetlands. [another example from John Teal EEP project to be added here]

3) Changing landscapes

Landscapes are dynamic – they have been manipulated and sculpted by both people and nature throughout human history. Restoration projects that do not account for predictable and/or potentially risky changes in the surrounding landscape are at risk (e.g., demographic changes may create more or less competition for land; increases in demand for resources may expand the amount of and type of agriculture or resource extraction activities next to or near the restoration site, etc.).


Photo credit: Edwin Ami

Lack of consideration of the historical, current and projected future context of the proposed restoration site constrains restoration. For example, thousands of miles of drainage tiles are installed beneath the ground across much of the United States. This is a practice that has been employed by farmers for over two centuries and there is no central map or GIS data layer showing where the majority of them are located. Often wetland restoration designs incorporate water budgets that assess water coming onto a site but lack a thorough understanding of the pathway and volume of the water moving off the site. In order to restore a site's hydrology, it is important for a restoration plan to account for the sited hydrologic budget including the sources and type of water entering a site (surface water? groundwater? both?), how it is retained onsite (for example is there a clay lens that would effectively drain a historic wetland if it were punched through during construction), and how it will exit the site (surface runoff? groundwater? drainage tile?). Similarly soils (on and beneath the surface) need to be analyzed beyond a desktop determination of whether hydric soils are present. While GIS mapping may indicate that hydric soils exist, they may be in compacted or depleted due to extensive farming or other intensive land uses (Doherty et al, 2014).

In addition, like wetlands, streams and rivers have undergone a great deal of modification since European settlement. In many farm fields, streams have been moved from the middle of a field to the base of a nearby hillside or have been straightened and channelized. Historical alteration has damaged the streams so that head cuts are incising streams often over a period of years and even decades, draining the groundwater off of historic floodplains and sending vast quantities of sediment downstream or even lowering the water table. It is essential to understand the status and ongoing changes occurring in the landscape where a wetland restoration project will be located and integrate that understanding into the design of a wetland restoration project.

4) Changing climate

Climate change is creating many challenges for wetland restoration efforts. Wetlands are at risk of being lost and altered due to climate, but they are also an effective tool to both mitigate and adapt to climate change. For example, studies by Dr. William Mitch et al, (2013) assert that healthy wetlands absorb more greenhouse gases by storing carbon than they release, and therefore they have a positive net effect. They also have the ability to moderate the effects of drought, store groundwater, clean stormwater, attenuate floodwater peaks, and provide important wildlife habitat – services that are increasingly in need, especially given increasing frequency and magnitudes of extreme weather events associated with a changing climate.

As temperature and precipitation patterns change, landscapes, including wetlands, will respond. The ability of plants and wildlife to adapt to these changes will be variable, so the extent and composition of wetlands are likely to change as well. The plants and animals, as well as hydrology and soil condition that currently exist on a spot on the landscape may not be suited to that site in the future. Rising sea levels will inundate coastal wetlands and shift habitats upslope and inland, where there are no barriers. Adaptive management plans are needed to guide wetland restoration efforts to respond to changes in temperature and precipitation and achieve appropriate project goals. While we anticipate changes to wetland hydrology, soils and biological communities due to climate change, it is not clear that long term monitoring is in place to record those changes.

5) Restoration costs and developing cost estimates

Restoration costs are frequently underestimated, particularly those costs associated with evaluating baseline conditions, post implementation monitoring and long-term management. There is often pressure to further reduce anticipated costs to save money either because funding resources may be limited (in the case of a voluntary restoration project) or in order to increase profits (in the case of mitigation). Regulated entities commonly seek to reduce both the time frame and parameters monitoring. When funding is inadequate, resources are not available to address project failures. There is very little information available to compare restoration costs from site to site or by wetland type so that reasonable cost estimates may be developed.

Further, the overall economic benefits of wetland restoration are often either undervalued or not even considered even though they are frequently greater than the cost of the restoration itself. This is primarily because many wetland benefits are difficult to derive a monetary value for and are non-exclusive so there may often be no direct economic benefit to the agency or organization that is paying for the restoration. Rather, the benefits are spread more broadly and are considered a “public good” (e.g., habitat conservation, flood water attenuation, intrinsic value, etc.).

When looking at costs of wetland restoration and creation, Coastal Resources Group, Inc. (CRG) (2014a,b) reviewed the discussion in King (1991) where he quotes Marylee Guinon as stating that “discrepancies between reported and true restoration costs…due to hidden costs and inaccurate cost data, are the rule rather than the exception and can be astoundingly large.” CRG also noted that King and Bohlen (1994) reviewed the data available at that time and although they report data for 578 projects, 494 of these were only agricultural conversion to previous wetlands through minor drainage modifications such as crushing and blocking drainage tiles at a typical 1993 cost of $1,000 per acre restored. No pre-construction or post-construction costs were assumed for these simple projects, so CRG did not use them in our calculations of typical wetland restoration costs nor the percentage of total costs for various categories. Using the remaining 84 projects, CRG averaged the pre-construction, construction and post-construction percentages of the total cost of a project type and calculated a mean value of 71.6% of the total costs were construction related, and 28.4% were related to pre-construction and post-construction activities such as planning, permitting, surveying, monitoring and reporting (CRG referred to these as “other project costs”).

The importance of this is that CRG found some of the projects it looked at had good construction cost accounting, but little or no pre-construction and post-construction costs. Often agency personnel do monitoring and reporting and do not keep track of their time and costs, or use direct salary costs without accounting for benefits or overhead. Similarly, Spurgeon (1998) reports on costs of seagrass restoration as ranging from $22,230 to $1,689,480 per hectare ($9,000 - $684,000 per acre) in 1997 costs, but also states that these costs do not include any pre- or post-construction costs. Even without those, this range of costs converted to 2013 costs would result in cost estimates of $1.31 - $99.33 per sq ft.

If other costs were 33.3% of the project costs, and construction was 66.7% of the costs, then you could estimate other costs when they were not available as 50% of construction costs

(33.3/66.7). Similarly for the data set in King and Bohlen (1994) the ratio is 28.4/71.6 or 39.7%. CRG therefore used 40% of the construction costs where available to estimate other costs to determine the most likely total cost of a project where "other project costs" are not provided.

In other cases, documents were reviewed that provided information regarding methods for seagrass restoration, however they were lacking in details of restoration outcomes and/or costs needed for CRG's review or had unrealistic costs. For example, the data of King and Bohlen (1994) was updated by King (1998) and the cost of "aquatic bed" restoration was given as $45,000 per acre equivalent to $65,315 per acre in 2013 costs or $1.50/sq ft. The most recent examination of seagrass restoration project costs in the Florida Keys (Coastal Resources Group 2014a) resulted in a range of costs from $0.53 to $50.30, with a mean 2013 cost of $21.45 ($934,362 per acre). This was based upon a review of reports of actual or theoretical expenditures found in reports or resulting from interviews with project managers at fourteen (14) locations in the Florida Keys.

While the data of King and Bohlen (1994) was updated by King (1998) the cost of mangrove restoration was given as $24,000 per acre equivalent to $34,834 per acre in 2013 costs or $0.80/sq. ft. The report of Coastal Resources Group (2014b) found in reports or resulting from interviews for nine (9) mangrove restoration projects located in the Florida Keys cites on a per square foot restored basis costs ranging from $0.33 to $3.99, with a mean cost of $1.59 ($69,260 per acre) in 2013 costs.

Thus up-to-date restoration cost estimates are significantly different in the most recent studies for these two wetland types. The question thus is what are the most up-to-date and accurate cost estimates for restoration of the other wetland types in the USA? And how accurate are they in the real world? It is the opinion of the Work Group members that accurate cost estimates are important for budgeting to cover all anticipated project costs, including monitoring and reporting, and that the lack of accurate budgeting has led to many projects being underfunded, thus leading to early termination of long term monitoring and reporting which limits lessons learned from being published based upon good quantitative data, and thus the routine repetition of mistakes in design and construction.

6) Mitigation vs. Voluntary Restoration vs. restoration for other purposes such as section 319 of the Clean Water Act to reduce nonpoint source pollution – similarities and differences

There are both similarities and differences between compensatory mitigation, voluntary wetland restorations and restoration/creation projects that are designed to meet a specific goal or goals for another program (e.g., fulfilling section 319 of the Clean Water Act to reduce nonpoint source pollution). Voluntary restorations are not undertaken in response to a specific loss like a mitigation project; as such, they are typically not required to achieve a specific reference condition or set of functions identified through a dredge-and-fill permitting process. Wetlands designed to meet a specific program goal such as flood-peak attenuation or nonpoint source runoff reduction fall into a third general category. Regulations and permit application processes that are "one size fits all" do not anticipate differing circumstances. Regulatory permitting is designed primarily for mitigation of wetland losses but there is a need for voluntary restoration, green infrastructure, and other projects (where the project purpose is the restoration project itself) to be approached similarly but also differently.

7) Different Requirements for Restoration vs. Enhancement vs. Creation

These three project types (restoration, enhancement, creation) will lead to different methods for establishing the wetland as well as different performance criteria. Frequently, federal and state agencies prefer restoration over creation based in part on the greater likelihood that sites of historical wetlands are more restorable, especially in their landscape setting and hydrological support (flows, groundwater). Enhancement may reflect a change to a wetland type that did not exist there historically, and it might provide different functions or different levels of the same functions. This may create the need for further discussion and evaluation of the merits of the changes in wetland type and, as a result, ecosystem functions and services. Each of these circumstances requires a somewhat different approach to project design, performance criteria, and measurements to assess progress.

Performance criteria for restoration projects can be based on historical soils, water budget, plant community, geology, watershed position, and other parameters which are endemic to the location or on reference sites that occupy the same landscape position. Enhancement is a conscious decision to increase one or more functions by altering the conditions that existed in the reference state. Creation is simply building the landform, managing the water budget, selecting plant species, and performing the needed management to achieve the objectives. The use of the term "creation" is usually not associated with landscapes which currently or formerly supported wetlands. Long term anthropogenic changes in the landscape, climate change and other factors may sometimes complicate distinctions between restoration, enhancement and even creation.

8) Accountability

Improved permitting standards, requirements, monitoring and enforcement of those standards is necessary to improve wetland restoration outcomes. Regulations may not always keep abreast of current science and technology. More importantly, monitoring and assessment reporting rarely results in revisions and changes to wetland restoration projects to achieve performance criteria. While in theory funding is set aside to deal with mid-course corrections through various financial assurances, there seems to be no correlation between reports of poor performance and subsequent action to create the required wetland restoration project. While regulatory agencies may have a stronger hook in the context of a 404 or 401 authorization to compel corrections to a failing wetland restoration site, it is more difficult to require grant recipients under Section 319 to correct restoration sites that do not meet goals and objectives identified in the grant proposal.

Other areas of professional practice require standards to be met. For example, if an engineer builds a road and it washes away, the contractor is liable for damages. But there is no commensurate penalty for an unrestored wetland. Typically, the permitting process itself is the focus of most personnel time, with much less apportioned for evaluating monitoring reports, site visits, or requiring remedial actions to ensure progress. Often monitoring reports are provided by the permit applicant. Access to this evaluation information is limited and third parties interested in understanding which projects achieve goals (and why) and which do not (and why) cannot easily access project monitoring reports. Finally, as mentioned previously, regulations do not require adequate time to monitor, assess, and report outcomes of restoration projects. In order to impose accountability, both on practitioners and themselves, regulatory and/or funding agencies need to develop institutional memory to track the status of wetland restoration projects over the long run, and not to some arbitrary administrative post construction time-frame. Failure to track projects long term, ultimately makes it more difficult to document and resolve problems and document lessons learned. When problems are not documented, there is little opportunity to improve future outcomes of wetland restoration.

C. Restoration/Construction-Phase Barriers

There are also specific activities during pre-restoration, restoration, and post-restoration projects where common problems have been identified and which are critical to address in order to improve wetland restoration:

Pre-restoration

It is helpful to separate pre-construction activities into two phases. The planning phase includes the resource inventory, assessment, and objective setting activities. The design phase includes the development of "line and grade" construction drawings (if construction is needed), the computation of quantities, the development of seed mixes or planting plans for propagules, and the drafting of specifications for a contractor to carry out the plan. The four points outlined below are important to consider before beginning pre-restoration activities.

1) Site Selection

Wetlands are a component of watersheds and different positions in the watershed support different wetland types. Too often, however, restoration projects treat the project site as an island without considering the broader landscape and the dynamic interactions of land use, hydrology, flora and fauna across the landscape (Kentula, 2000). Further, many wetland sites are based not on which site presents the best opportunity to successfully restore wetlands, but rather on which land is available and has willing sellers. If the wrong type of wetland is planned for a landscape position, some or all criteria won't be met. If the wetland site is correctly identified for its watershed position, it can be expected to provide functions similar to other wetlands in the same watershed, and in adjacent watersheds. This correlation will be valid within a region with similar soils, geology, climate, and other factors.

Most watersheds feature a variety of wetlands which vary widely by position and resulting function. For instance, depressional wetlands in the Prairie Pothole region all occur in the broad interfluves between stream valleys. However, depending on interpretation, there are at least 4 distinct types of Prairie Pothole wetlands, which can be distinguished by soils and hydroperiod, and whether the water source is mostly surface runoff or mostly groundwater. And within the stream corridors of a given watershed, floodplain wetlands vary by the drainage area of the reach, and the resulting differences in floodplain landforms.

2) Hydrology

It is important to plan hydro-periods that are appropriate for each site. This requires understanding the source(s) of water that will reach each wetland, as well as how the water will be retained (clay lens beneath the hydric soils?) and how it will leave the site (drainage tile? groundwater? surface water?). Historically, the tendency has been to provide shallow ponds rather than fully vegetated wetlands, in part due to misunderstood hydrology. Sometimes, however, a pond is the intent, because it is more certain to meet jurisdictional wetland criteria than a sedge meadow, for example. Missing the target of a certain depth of standing water is less serious than missing the target of a spring hydroperiod followed by summer drawdown. Such a hydroperiod target left one mitigation bank bare during a succession of dry years (R. Novitzke, pers. Comm. to J. Zedler). Poor quality of water that will reach a restored wetland can also constrain restoration.

Figure 18. Components of the wetland water budget. ($P + SWI + GWI = ET + SWO + GWO + \Delta S$, where P is precipitation, SWI is surface-water inflow, SWO is surface-water outflow, GWI is ground-water inflow, GWO is ground-water outflow, ET is evapotranspiration, and ΔS is change in storage.)

Source: USGS
http://water.usgs.gov/nwsum/WSP2425/hydrology.html

All wetlands receive and store water, and deliver that water downstream in the watershed. Most wetlands have one or two dominant water sources that drive the hydrologic functions. Dominant water sources include surface inflows (including stream and tidal sources), precipitation, and groundwater discharge. These dominant water sources and how those sources move in and out determine the wetland's hydroperiod Losses may include evaporation and transpiration, groundwater recharge, and surface outflows. Water may be stored on the wetland surface, in its soil profile, or both. The accounting of the inflows and outflows with adjustments in storage is the wetland water budget. The presence of water can be described quantitatively using these parameters: probability, frequency, and duration of surface and groundwater. These parameters describe the wetland's hydrologic regime. The objectives for a wetland project should include the target hydrologic regime. That selected regime should be based on knowledge of the inflow and outflow parameters, and how they drive the water budget. Wetlands that receive either too much or too little water can fail.

The assessment of water quality is also important. Samples from surface inflow and groundwater discharge represent inputs to the wetland. The quality of surface water or soil storage should differ from that of the inflows. Samples from surface outflows and groundwater downstream represent how much the wetland removed or added nutrients and other materials. Usually, water quality criteria are set for the water in storage or in outflows. It is important to make this distinction in setting restoration criteria. If a project is meant to deliver high quality outflows, that function should not be assessed by measurement of water in storage. If the project purpose is on-site wildlife habitat, high nutrient levels might be permissible, but if the purpose is to restore a species-rich meadow, high nutrient content in storage water would likely favor an invasive monotype, precluding high diversity.

3) Soils

Failure to fully assess and plan for soils (avoiding compaction, identifying the need for soil amendments, detecting deep impervious or pervious layers) can also lead to poor outcomes. While desktop screening for hydric soils, or soils with hydric inclusions, is a necessary first step, typically actual sampling including test pits should be conducted to better assess site suitability for wetland restoration and identify potential risks. Excessive excavation and grading activities can significantly disrupt soil profiles. Soil type, treatment, and condition can be a big determinant of success or failure. In some locations soils also need to be evaluated for the presence of toxics and/or pesticides. For example, the restoration of pre-existing marshland around Lake Apopka in Florida in the late nineties resulted in a massive bird die-off. More than 1,000 birds perished, not including the subsequent deaths after migration and due to reproductive damages. The birds were poisoned when they ate fish on former farmlands north of Lake Apopka that had been flooded with lake water. When the land was purchased, it was known there was the possibility it included an unknown quantity of old pesticides that might pose a risk to wildlife. However, no one imagined the chemicals would be deadly (Industrial Economics, 2004). Further soil studies could have prevented this disaster.

All wetlands exist on a substrate of soil, and most have water sources that are affected by movement through adjacent soils. The movement of water through the soil medium, the ability of the soil to store surface and/or groundwater, and the ability of the soil to perform bio-geochemical processes is critical to wetland function. In a large sense, differences in wetland types correlate to differences in soil types. For instance, the presence of an intact perching layer may preclude the ability of a particular wetland to store ground water but allow for greater surface water storage. In many cases, a lack of understanding of soil hydrodynamics leads to unexpected outcomes.

4) Inappropriate plant selection and inclusion of cultivars: over-reliance on plants to measure progress

Many restoration criteria focus on a specific number and density of specific plant species. Other criteria might list inappropriate plants or allow cultivars. According to Bruce Pruitt (2013), "the use of cultivars, cultivated varieties of native species in compensatory mitigation, can affect both the functions of the compensatory mitigation and nearby systems 'contaminated' by the alien genotypes. Loss of disease and cold resistance are some of the potential problems resulting from this gene flow." (p. 5). Depending on the type of wetland restoration and its location in the landscape, seeding and planting may not be necessary. Natural colonization from surrounding native plants should be encouraged where possible. If invasive species are a significant concern, then sowing a cover crop of planting vegetative "plugs" and other measures may discourage the spread of invaders.

Selecting appropriate plants for the specific wetland type is critical. At the same time, hydrology and soil criteria, which may be vague and much less specific in comparison, may be more important to ensure the sustainability of the wetland restoration project. Plant species and assemblages will change over shorter time periods than soil and hydrology over time.

During restoration

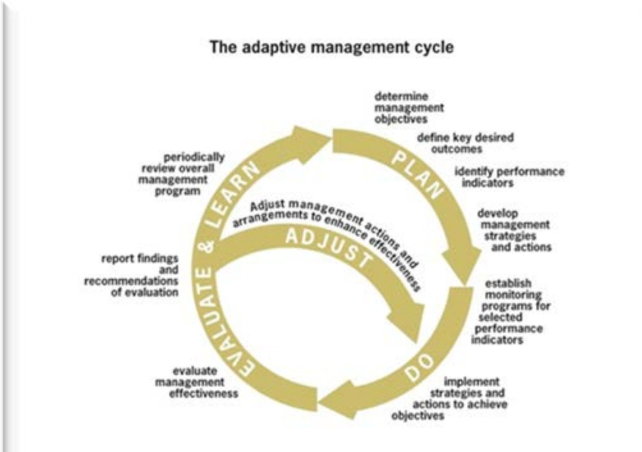
1) Failure to adequately implement design

This may seem easily avoidable, but it happens frequently. Those who design projects are not consistently involved in implementation, and those who implement the designs do not always understand why certain requirements must be followed onsite. This means that he or she may not be consulted to adjust the design to accommodate new information about the site acquired during construction or in other ongoing projects. Costs rise when there are unnecessary design elements or mistakes due to a breakdown in communication between designers and contractors. In some cases the construction company may not have the experience or equipment and materials needed to do the job correctly.

A high quality set of plans and specifications, with accurate quantities, provides a basis for determining a contractor's diligence, and will result in lower construction costs because of a reduced need for the contractor to allow for contingencies. It also provides a good baseline for determining increased or decreased cost due to needed changes which are identified during implementation. While contractors vary in their experience in wetland projects, high quality plans and specifications provide the information needed for even inexperienced contractors to accurately estimate costs for bids, and to implement the project as intended. Finally, quality assurance is a function of the project proponent and must be adequate to routinely assess a contractor's performance, and let the contractor know if he or she is following the plans and specifications. This function is also critical because wetland implementation projects frequently have unexpected site conditions. The uncovering of un-known drainage tile, unexpected subsurface soil conditions, cultural resources, and many other items require a quick resolution, which should be conducted as a change in the plans and specifications. Restorationists who do not follow the approved design risk missing the goals.

2) Lack of an adaptive management framework

Salafsky, Margoluis and Redford (2001) define adaptive management as "the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn" (p. 13). See Appendix E for their Summary of the Framework for Adaptive Management. Without some form of adaptive management framework, any unexpected discoveries (different soils, drainage structures, etc.) cannot be effectively addressed. "Surprises" should always be expected, and someone who understands the restoration project plan thoroughly needs to be on call throughout the construction phase. As Cottam (1987) said, "the unexpected is to be expected."(p. 269)



Source: http://www.parks.tas.gov.au/index.aspx?base=5756

At the end of the implementation phase, the project proponents and the contractor should have a mutual understanding that the job is done, and a formal acceptance should be made. Afterwards, the project moves into an operations phase when two new, but separate activities take place. Operation and Maintenance covers the periodic inspection of the installed works to make sure that they are functioning as intended, and to list those actions needed to repair items that have degraded since the last O&M visit. This includes water control structures and earthwork. It should also include the success if plant propagules. If seeding and/or planting have not established properly, this determination is made as an O&M activity, and remedial actions taken and implemented.

Monitoring is an activity that performs an assessment of the development of wetland functions, and provides a measurement of performance outcomes. Regardless of whether the project was implemented as planned and designed, this activity determines whether the project is on a trajectory to meet the functional objectives. If the restoration is not performing as it should, monitoring indicates the need for a new effort before failure occurs. Operation and Maintenance inspections and Monitoring can and should be conducted at the same time. The distinction is important. A failure due to improper O&M does not mean that the project failed because of improper planning and design, and does not mean that a similar project should be planned differently. However, a properly maintained project where failure is determined during monitoring has implications for the objectives and success criteria on a similar project of the same type to be installed elsewhere. In short, failure must be assigned to either a failure of operation and maintenance, or a failure of the planning process itself.

Post-restoration

1) Poor record keeping & monitoring

Poor record keeping, particularly of monitoring reports, can make it impossible to track changing conditions on the site or to relate what is happening onsite to performance of a nearby reference site or other similar restoration projects. Adaptive management requires information on project performance from the first "as built" assessment to the latest inventory. Only then, can the trajectory for each performance goal be evaluated to determine if changes are needed. The lack of record keeping also creates barriers to knowledge transfer (lessons learned). Mistakes may occur over and over.

2) Monitoring period too short to characterize progress

A wetland needs more time to develop than 3-5 years, the typical time for permit monitoring. If the restoration is not being actively monitored, there are no data to assess functioning. Long term assessment of both undisturbed and restored sites is needed to determine the extent to which goals are achieved or to predict the time needed to meet performance criteria. Comparisons between natural and restored wetlands in the same general area can support evaluation of restoration progress.

Different wetland types have different timeframes at which the intended level of function is expected to occur. A good monitoring plan accounts for this, and establishes time-based criteria. The establishment of trees in a bottomland hardwood site is a classic case. However, many other parameters can and should be expected to change over time. Dynamic soil properties critical to bio-geochemical functions include the build-up of soil organic matter, the increase in porosity, and a change in structure. The formation of surface micro-topography is directly associated with the interaction of plants and hydraulic energy, and cannot be adequately provided during the implementation phase.

3) Monitoring data exist but are not used

Given sufficient investment in time and labor for monitoring and reporting, it is also necessary to establish a regional "data bank" and an effective adaptive management framework. The lack of a regional depository for monitoring data and reports prevents many practitioners from learning how to improve their own wetland restoration efforts. The practice of wetland restoration is hampered by insufficient documentation on who is doing the restoration, what types and for what purposes restorations are being performed, where the projects are located and to what degree performance standards are being met. Where such information exists, it must also be made available and used.

4) Accountability lacking

There is no certification or list of coursework and skills required for wetland restoration practitioners. In essence, anyone can hang out a shingle and call themselves a wetland restoration professional. Those hiring them will have difficulty evaluating the "expert's" level of knowledge and competence. There are rarely any penalties for poor performance. While many practitioners will develop skills and improve their practice over time, there are others who will not, both because there are no consequences for failure to meet performance criteria and because helpful information is unavailable, as discussed above.

III. Actions to Improve Wetland Restoration

A. Overall Recommended Actions

1) Provide a meaningful way to define wetland “functions”.

While the number of potential functions is unlimited, they can be combined to provide a small meaningful subset. This short list can be categorized into the following categories: Hydrologic, Soil Bio-geochemical, Habitat, and Landscape. The functions which any wetland landscape provides should assigned to the wetland “types” defined in recommendation 1. A clear statement of known or expected functions will lead to a solid set of project objectives. Furthermore, most wetland functions can be defined in a watershed context. Wetlands are widely recognized as providing local benefits, but rarely are the benefits of wetland projects presented in terms of expected outcomes linking wetlands in a specific watershed position with results at a watershed outlet.

2) Improve performance criteria

In practice, wetland restoration projects can have a finite endpoint, but ecosystem development does not. The restoration activities can be judged as completed or not, but the performance of a wetland restoration site will vary in perpetuity, as new challenges arise. The UW-Madison Arboretum began restoring what is now Curtis Prairie in 1935. Data on composition in the 1960s allowed it to be called a diverse prairie, and the “world’s oldest restored prairie.” In 2015, at 80 years of age, the 72-acre “restoration icon” faces constraints on control burning, so shrubs and tree saplings dominate large areas, and urban runoff, so wetland weeds invade in the ~16 acres of wetland that receive nutrient-rich stormwater. Restoration is never done (Zedler, Doherty & Rojas, 2014).

Project proponents may need a judgment of “in compliance” in order to terminate work, and most will want a judgment of “success” to showcase their projects. Compliance can be judged objectively if there are both clear goals for performance and a priori standards for the level of performance. A wetland can support native species at the numbers prescribed at the age of 3 years, but the native species won’t persist if the site is gradually shifting toward dominance by a monotype-dominant invasive plant (i.e., one that displaces other species) such as hybrid cattails (*Typha x glauca*) or reed canary grass (*Phalaris arundinacea*) (Frieswyk, Johnson & Zedler, 2008). A judgment of “success” at age 3 is not a science-based judgment, but the term is persuasive in advertising projects.

Short term monitoring data can describe initial conditions and suggest a site's potential to sustain itself.   It is recommended that practitioners measure progress using quantifiable ecological performance standards (e.g., Indices of Biotic Integrity, Floristic Quality based on Conservatism Indices, Wetland Indicator Status). It is important that terminology be clear and consistent. Baseline assessments are needed for both the restored site upon project completion and the reference site(s) at the same time. These should be developed using multiple indicators of structure and function that relate to the specific project objectives.

Establish a clear distinction between projects which aim to restore, create, or enhance a wetland landscape. This step will largely direct the objectives for any wetland project. The objectives of a restoration project will largely be defined by the landscape constraints. Enhancement projects should be defined as conscious decisions to increase one or more specific functions, usually at the expense of other functions. And creation projects should be defined as the establishment of one or more specific functions on a landscape which previously did not support any wetland functions.

3) **Create a common classification system by type**
Federal, state, and local agencies should collaborate to establish a wetland classification system which categorizes all wetlands into specific "types". Existing classification and assessment systems such as the Cowardin System (with LLWW modifiers), the Hydrogeomorphic (HGM) system, the Proper Functioning Condition (PFC) system, and Ecological Site Descriptions (ESD) can be utilized. The system should be robust enough to provide a means to categorize any wetland with other wetlands in a local area that have the same watershed position, water budget, soils, plant communities, and functions. The system should also provide definitions which can be used to spatially map those wetland landscapes at all scales.

A useful classification is one that defines a class or sub-class based on its position in the watershed, the associated soil types, the dominant water source, plant communities, and the functions supported by that particular wetland. And, ideally, the classification should be tied to a particular region. With such a classification, lessons learned in previous projects and research results can be correlated to the wetland in the region of the same type. Seek means to ensure that individual research on any wetland is reported with a correlation to other wetlands in the region of the same "type". With this information, restoration planners can learn which functions and processes a particular project site can perform, and objectives can be based on that knowledge. Furthermore, a knowledge base can help planners specify techniques and practices that are known to achieve desired outcomes.

4) Improve access to knowledge (research data and monitoring reports) and training

Of critical importance for improving wetland restoration is knowledge transfer. Much of what we know about wetland restoration is learned by hands-on, boots-on-the-ground experience. Because multiple disciplines are involved (including hydrology, ecology, soil science, engineering, landscaping, mapping and surveying, data analysis and interpretation) even the best academic training rarely prepares individuals to answer all of the questions presented by a complex wetland restoration project. UW-Madison offers an Ecological Restoration Track in its Botany MS degree program; enrollees take interdisciplinary coursework, review the literature on a topic tailored to their career needs, and conduct a summer practicum, working with professional restorationists.

Restoration scientists need to indicate the management implications of their research and the specific wetland type(s) that could benefit from new approaches. It should be obvious that science-based advice needs to be provided in user-friendly language.

An interdisciplinary team of collaborators should provide training, followed by on-the-ground experience in wetland restoration. Increasingly, this is being recognized. There is an ongoing need for academic programs that provide specialized curriculums for wetland restoration professionals. Training is also essential for those who are involved in regulatory review and oversight, plus management of voluntary restoration programs – including work done through local, state, tribal and federal government programs and non-governmental organizations. Training can also be provided by experienced individuals actively involved in wetland restoration and mitigation activities. Federal and state agency staff can provide a better understanding of what permit applicants must include in their designs and what permittees must accomplish in practice. Providing hands-on restoration training opportunities can also generate more interest in and support for more voluntary restoration.

To the extent to which it is available, promote the knowledge needed to access and use the USDA-NRCS Cooperative Soil Survey. Most areas of the U.S. have high-quality soil mapping, and this mapping is correlated to a large and comprehensive soils database. This database is available for spatial mapping and analysis with the Soil Survey Geographic (SSURGO) dataset. Unfortunately the knowledge needed to fully utilize this information is largely lacking. The data includes valuable information about water budgets, hydrodynamics, bio-geochemical functions, vegetation, and other attributes which are critical to understanding wetland processes.

Additionally, providing free access to science via open-source portals and repositories will improve knowledge transfer. As recommended above, regional depositories for monitoring data and reports need to be created. As a starting point, the Work Group began developing a bibliography of literature on the science, planning, and practice of wetland restoration. Information about how to improve wetland restoration projects is located in many places. For example, Work Group member Robin Lewis, PWS, has established a website on how to restore mangroves at www.mangroverestoration.com.

5) **Encourage interdisciplinary teamwork and consistent leadership throughout the project**

Establish collaboration among state, federal, and local agencies which are independently conducting projects for wetland assessment and classification. In many cases, separate efforts are being conducted independently in the same region, and on the same landscape. These include: USFWS National Wetland Inventory, USACE HGM Regional Guidebooks, NRCS-BLM-USFWS Ecological Site Descriptions, and many state and local assessment and classification systems for wetlands in stream corridors and other wetlands in the watershed.

The same personnel should be in charge of, or available to, the project from design until completion. If goals are not met within the specified timeframe, funding should be available to extend expert involvement in order to establish and monitor mid-course corrections. The design personnel should identify potential issues and problems with the project and propose how to correct them within an adaptive management framework. When there is a change in project personnel, new employees may not be aware of potential problems identified early on in the planning and design process. Project leadership need to support collaboration internally, encourage interaction between disciplines (e.g., engineering and ecology), and develop relationships with NGO's, contractors and suppliers. The use of an integrated planning process and visual tools for education, outreach, engagement, support can be beneficial for communication and scenario planning. Interdisciplinary teams should include members with knowledge and experience in hydrology, soils, plant communities, wildlife, and water quality.

6) **Require documentation of credentials**

Regulatory agencies should provide a method of precertification for qualified wetland restoration practitioners, including designers, and a list of credential requirements for applicants. Develop a list of the kinds of training/expertise that should be demonstrated by individuals and/or teams designing and carrying out restoration projects.

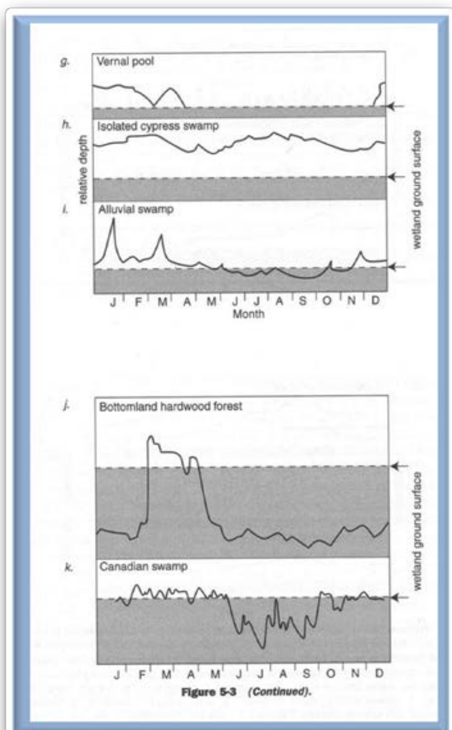


Figure 5-3 *(Continued).*

Require hydrographs of baseline hydrology and hydrological targets. Require As-Built Plans of the completed project for use as baseline monitoring for performance objectives. Require some level of adaptive management (specifying who reviews monitoring data and reports, who calls meetings, and how mid-course corrections will be funded). Record how adaptive management efforts changed the original site plan and subsequent monitoring methods.

Establish criteria for expertise, experience, and knowledge required for all of the disciplines required to implement a successful project. Projects require the input of several disciplines working collaboratively. These disciplines include soils, hydrology, wildlife habitat, water quality, botany, and others. Each of these disciplines is represented by discipline specific professional organizations, but few of these organizations recognize a certification which is specific to wetlands.

7) Enforce accountability

Use federal and state requirements to set monetary incentives for applicants to achieve quantifiable ecological performance standards. Require monetary guarantees that are not released unless goals are met and ensure that monitoring reports document that performance standards have been met. Do not release non-performing bank credits or release bonds or other guarantees for under achieving permittee-responsible mitigation wetlands and/or develop other penalties for poor performance.

Most restoration practitioners agree that a multidisciplinary team is needed for the successful implementation of wetland projects. And most would agree that it is impossible to establish “wetland science” as a separate discipline, which incorporates all the needed skills. However, many scientific and professional organizations provide recognition in specific aspects of their disciplines. Ideally, contacts would be made with pertinent professional societies to seek the development of certifications specific to wetland practice. Within most pertinent disciplines, there are many practitioners of wetland science who are active in their respective organizations. They would have to be the ones to promote this effort.

8) Improve regulations/guidance to adopt new science and technological advances for mitigation compliance criteria

There is a need for improved permitting standards and requirements to keep pace with new science and technology. The policies, guidelines, and regulations that affect both mitigation and voluntary restoration have a significant influence on the level of performance that is achieved. Minimum performance standards for mitigation sites allow permit holders to do only what is absolutely required, rather than achieving the maximum possible for a restoration site.

When performance criteria focus on long-lived, self-sustaining mature (climax) plant species to establish a specific wetland type within the 3-5 year monitoring time frame, the permit holder needs to take shortcuts rather than allow the longer, natural succession process to occur. The consequences of “jump starting” succession are not well understood. For example, a longer process may be critical to building healthy wetland soils that in turn may greatly improve the potential for a wetland to persist over time and reduce vulnerability to invasive species. In restoring long leaf pine wet savannas, restorationists opted to leave slash pine plantations in place to build up litter to carry ground fires that are needed to manage the target long leaf pine (a tree that lives for 300 years)(Kirkman, Goebel, West, Drew & Palik, 2000).

Because policy makers typically demand justification for program changes – especially if these will lead to different or increased performance and potentially increased costs – the overall cost/benefit of improvements should be evaluated. This will require the collaboration of experienced wetland restoration scientists working with program managers in both voluntary restoration and regulatory programs. Perhaps we need to develop an adaptive regulatory framework that responds to advances in science and technology.

In addition to these broad recommendations, below are actions that can be taken to improve restoration/mitigation during by project phase. These address specific challenges during pre-restoration, restoration, and post-restoration activities. A brief summary of best practices for each phase is followed by specific outlined recommendations below:

B. Restoration/Construction Phase Recommended Actions

Planning and Design

This phase is critical to the success of any restoration project because this is when project goals are identified and the means to achieving targeted outcomes will be determined. Baseline studies need to be taken, stakeholder groups need to be identified, and facilitated discussions need to take place which provide decision-makers and stakeholders with information, maps, designs and projections in order to analyze comprehensive trade-off scenarios and make well-informed choices. Having a well thought out and scientifically based restoration design that accounts for the surrounding landscape and watershed priorities is integral to producing anticipated outcomes. And having the wetland restoration designer follow through the project from beginning through to completion is highly recommended.

Restoration objectives and the evaluation of "success" go hand and hand. It is critical that objectives be based on a common understanding of the site's capabilities, how much effort is expected for maintenance of functions, and how the site affects adjacent landscapes in the watershed. The wetland science community has a long history of using terms like restoration, creation, enhancement, etc. And discussions of the distinctions between the three provide some interesting discussions. However, a conscious decision can and should be made at the first stage of planning as to which of the three categories is being proposed.   Furthermore, we should avoid, as much as possible, the common conflicts between "historic conditions", and "which time frame to restore to" when we use the term restoration. Regardless of our understanding of what these three terms mean, the following considerations apply:

1) Restoration
    a. Using landscape based capabilities to guide the objectives
    b. Presence of at least some "reference" sites to guide planning
    c. An expectation of a lower maintenance project
    d. Allowance for temporal variability in function due to natural stresses
    e. Provision of watershed function in the original watershed position
    f. The expectation of many other functions which were unknown at the time of planning, but that which existed before the site was degraded.
2) Creation
    a. Building a project on a landscape that never featured any wetland function
    b. Designing the project for the provision of a small number of well-defined functions
    c. Well defined maintenance activities to maintain the proposed functions
    d. Low tolerance for temporal variability of planned functions
    e. No recognized "reference" conditions to guide planning
3) Enhancement
    a. Conscious decision to increase a small set of defined functions on a landscape that did not formerly provide them.
    b. Recognition that other functions will probably decrease due to the enhancement of those sought.
    c. An increased maintenance effort to maintain the enhanced functions.
    d. Less allowance for temporal variability for enhanced functions

Below is a list of actions that, if not implemented correctly, may lead to poor restoration outcomes.

1) Site evaluation and selection

a) Focus on restoring areas that were once wetlands, and channelized stream reaches, instead of creating wetlands in uplands.
b) Establish current hydrography and conceptual target hydrography by using an analog, historic or constructed reference condition.
    - Select appropriate HGM setting.

- For both ephemeral and permanent water wetlands, match hydro-periods to wetlands appropriate for the sites.

c) Establish current and targeted wetland functions such as nutrient cycling, pollutant sequestration or transformation, carbon export.
   - Document current and predict future water quality conditions at both the watershed and wetland scales.

d) Analyze current and potential future land use practices at multiple scales (e.g., watershed or wetland area) within the catchment of the restoration site.

e) Select appropriate sites and develop plans that will maximize the opportunity for meeting quantifiable ecological performance standards. Knowing that wetland condition is highly influenced by surrounding land uses, place wetland restoration projects in areas where wide buffers are present or can be restored or where the intensity of other surrounding land uses is low.

f) Match objectives with landscape position in the local watershed: identify the hydro-geomorphic wetland class appropriate to project; identify appropriate wetland type by watershed stream order.

2) Design

a) Keep the amount of maintenance needed low.
b) Minimize site disturbances in plan and during construction.
c) Replicate high-performing natural “reference” wetlands.
d) Research NRCS Web Soil Survey water features, and/or on site investigation.
e) Include qualified land design professionals on the team to work with scientists to develop strategies that meet budget and are feasible to build.
f) Planning through design – collaborate to problem solve and vision strategies. Investigate local and innovative materials and construction methodologies to achieve outcome goals. Construction documents should be developed to provide specific guidelines and constraints on contractor, but not to tell them exactly “how to do it”.
g) Use clear strategic graphics to communicate complexity of wetland features to stakeholders.
h) Anticipate the look and vision of natural wetland features within this context. Collaborate with wetland team members on details.
i) Specify feasible soil mix and installation measures. Communicate these as priorities on construction documents, during pre-bid and pre-construction meetings. Ensure that qualified construction monitoring personnel are on-site to adequately monitor and enforce soils supply and installation requirements.
j) Plan for efficient maintenance and long term project sustainability upfront.
k) Strategize on ways to include local businesses, labor forces, community groups for construction and stewardship. Create designs that have visual order. Use materials that are local, resilient and durable.

During Restoration

Many things can go wrong during the construction phase, primarily as a result of not having well-informed or adequately trained construction workers. For example, if construction foremen do not understand the critical nature of soils, heavy equipment can unintentionally compact soils which can then result in a failed restoration. It is imperative to communicate not only how to build it, but also with what. For some wetlands, plant propagation can be successfully achieved simply by letting neighboring wetland plants spread onto the restoration site. Other times, it will be important to provide plantings in order to discourage the spread of invasive species.

1) Ensure that the design plan is implemented and that the designer is involved from start to finish.
2) Start adaptive management when construction begins and continue into perpetuity.
3) If planting is needed, seed at high volumes and plant at high densities.
4) Plant woody plants after water regimes have been established over a period of 3 to 5 years.
5) Limit excavation and grading keeping soil profiles intact.
6) Amend soils to provide high levels of organic matter and appropriate amounts of nutrients to encourage establishment and growth of robust and diverse plant communities.
7) Create buffers greater than 50 meters (if not already present). Ohio EPA studies have indicated that up to 200 meters of forested uplands may be necessary to support sensitive amphibians such as spotted salamanders (Mack & Micacchion, 2006).
8) The wetland may be dependent on a layer of impermeable soil such as a clay lens to maintain hydrology. Breaking through this layer during restoration will likely cause the wetland restoration to fail.

Post-Restoration

This project phase is also essential to the success of a wetland restoration and it is unfortunately the phase which is most often truncated or ignored due to concerns about the lack of sufficient funding to complete. However, due to the complexity of wetland ecosystems it is imperative to make sure that adequate planning and funding is available for this step as most wetlands cannot be restored in the typically short 3-5 year monitoring window. There have been wetland restorations that were deemed a success because they appeared to be functioning properly only to be discovered later that the plantings all died after five years because the hydrology was never sufficiently restored. Although adaptive management is important throughout all phases of a wetland restoration, it is critical in the post-restoration phase, particularly in a changing climate. And in order to contribute to the universal knowledge base for improving wetland restoration success, the data acquired during this phase is critical for developing and sharing lessons learned in order to prevent making the same mistakes and to improve future outcomes.

1) Monitoring/Reporting (including availability)
   a) Require better post construction monitoring follow up.

b) Document current wetland restoration efforts on the regional level to keep professionals appraised of progress in more successful wetland restoration efforts.
c) Develop a feedback loop to allow new data and observations to be incorporated into future restoration efforts.

2) Select appropriate long-term management.

Summary??

Issues that Merit Additional Discussion, Research and Analysis **(Work Group members: upon finishing the paper above, below are some issues that have been touched on but not really thoroughly discussed in work group calls or webinars, Should the following issues be included? If so where and what and how?)**

1. **Performance Standards**- There has been substantial discussion of performance standards in this paper. However performance standards, criteria etc. are a bit of a 'chicken and egg' issue. In this paper there is extensive discussion on the need to require achievement of performance standards, the need to evaluate progress rather than 'success', and criticism of the appropriateness of current performance standards (either they are set too low or they are inappropriate for measuring progress). In addition, given the emphasis that presenters have put on hydrology and soils; perhaps performance standards need to focus more on hydrology and soils and less on plants. If performance standards themselves are part of the problem, should we be encouraging mitigation and restoration standards to focus more on progress toward an endpoint as suggested in the first webinar - on performance progress rather than requiring a specific plant community at the end of a 3-5 year monitoring period? Can we do this in a way that strengthens the ability of wetlands to persist on the landscape and move toward a desirable endpoint? What should we say about plants vs. hydrology vs. soils as indicators of progress

2. **Invasive Species** – This is a very complicated topic and extremely important to an evaluation of wetland restoration performance. It is also one where experts and practitioners hold very strong, diverse and frequently quite passionate opinions.

   The challenges that invasive species pose are highly variable from one species to another and like restoration a 'cookbook' approach is not appropriate. Some invasives are not dominant and, although present, not really a problem. Others form dense monocultures or prey aggressively on other desirable wildlife or plants. In some places, endangered species have become dependent on invasives because native plants are no longer present. In others, invasives are apparently preying on undesirable species and supporting wetland restoration (green crab and spartina). Pesticides can be effective, but the impacts of pesticides on wildlife where pesticides are applied are often not considered. Also, there is always the potential for a widely used pesticide to be delisted and no longer available due to impacts on human health. For example, there have been several studies published recently about detrimental impacts that Roundup – both glyphosate and inert ingredients – may have on human health. Evaluation of allowing versus eradicating invasives must include an assessment of the consequences of the presence of invasive species with the unintended consequences of invasive species control measures. It is not only pesticides that should be evaluated this way. There was a good example of this in the webinar on restoration of marshes on the Atlantic coast of the consequences of digging up the soil and thereby lowering the level of the marsh to control phragmites.

There is also a need to continue work to understand why invasives are so successful and identify additional methods for reducing their dominance where that is a problem. For example, there was a study recently that concluded that the 'pulsing' of nutrients off urban and agricultural landscapes created favorable conditions for invasive species versus natives. Perhaps it is possible to find ways to accelerate succession to more desirable species to reduce the dominance of certain invasive species. In a recent conversation with the New England Corps District, we heard that one wetland restoration practitioner believed that shrubs containing berries should not be planted on new restoration sites because that encouraged the presence of birds who often transport invasive species to the site. Instead willows and alder should initially be planted to establish the shrub community in the Northeast. Other practitioners have discovered that more complete restoration projects, (i.e., not just plugging ditches, but also filling them) can be successful in reducing the dominance of reed canary grass.

There is a different but related example with respect to beaver. Beaver are native, but their occupation of a mitigation site can prevent a site from meeting success criteria. However, in places where beaver are kept out, it is sometimes a foregone conclusion that they will re-establish themselves when the monitoring period ends. Is it worthwhile to manage for a wetland or habitat type that will be eliminated at the end of the monitoring (and active management) period?

Are we asking the right questions to find better solutions for discouraging the presence of at least some invasive species? Do we understand exactly why anthropogenic alterations have created ideal environments for invasive species? Do invasives move into newly restored sites due to poor or incomplete restoration practices? Absence of micronutrients? Loss of mycelium? Do we really fully understand cause and effect? If not, what are the priorities?

3. **Historic Drainage** –Often wetland restoration planning has focused water budgets measuring water coming into a site without a thorough evaluation of how it is leaving the site. In other words, how big is the hole underneath the flower pot? Is historic drainage being identified and addressed on restoration sites? Is drainage in the watershed as a whole considered?
   Rich Weber comment: This is an important issue, but I think it is a small subset of other topics: Inventory and Evaluation, site investigation, water budgeting, etc.

4. **Wetland and stream restoration occur in silos -** Wetland and stream restoration are still largely addressed separately rather than together when in fact many times they likely existed historically adjacent and closely interconnected with each other. Deposition of legacy soils, drainage, stream straightening and multiple other actions have separated streams and wetlands so effectively that they are understood as two separate systems. Is the separation of wetland and stream restoration one of the underlying reasons for failure for some systems?

Rich Weber comment: While the numbers of ecosystem restoration practitioners and growing throughout the world, the U.S. seems to have separated practitioners into very separate camps. Stream restorationists have a somewhat common set of terminology, available training and available information. The same is true for wetland restorationists. However, natural watersheds know no such distinction. Water moves from interfluves, though headwaters, into small reaches, and into large floodplains as surface runoff and groundwater. Each of these distinct landscape positions can be interpreted as a "stream", a "floodplain", a "stream corridor", a "wetland", or even a dry "upland", and is perceived as a single entity. This problem transcends the problem of wetland "success" or "failure" because wetland projects determined to be a "success" by all wetland scientists can have serious negative impacts on stream and floodplain function. Conversely, the same occurs for stream restoration projects. Even in the defined discipline of engineering hydrology, there are two completely different analysis pathways used for the same daily mean flow dataset. The stream hydrologists focus exclusively on annual peak discharges, geomorphic bankfull flow, and duration flows. Wetland hydrolgists focus exclusively on probability-duration-frequency relationships. Even with these strictly defined analysis techniques, a hydrology objective set using one for wetlands will result in a different outcome. The fact is, stream and wetland elements in the watershed are profoundly linked, and a degradation of one results in the degradation of the other. Perhaps the problem is that objectives for each are largely determined based on a small set of functions that usually drive the funds for each project. Streams are for fish, and wetlands are for waterfowl. Both should be funded for improvements in watershed function.

5. **Interdisciplinary planning/a watershed approach** – Support for using a watershed approach is widespread. It is discussed in some areas of the report, but time and again a 'watershed approach' is identified as a key to success. Are there important issues – such as a discussion of how setting watershed wide goals to target and site restoration might improve success– that are missing?
   Rich Weber comment: This is where the opportunities for a rational landscape-based classification system are the greatest. A wetland, stream, etc., etc., exists within a watershed in a position which can be defined by a large number of readily available parameters. And all of the watershed positions are identified for that watershed, the same concepts can be translated to adjacent watersheds of the same size, until a practical limit is reached because of changes in climate, geology, etc. Every lesson ever learned can then be correlated to where that lesson applies within that area. Every function can be applied to exactly where that function can be performed.

Climate Change: The paper and workgroup have touched on climate change. For example, identifying that communities in coastal areas will need to prioritize wetland restoration projects that enable coastal marshes to migrate inward has been raised in a couple webinars in the series. There is a section on it in the report. Is it enough?

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Appendix A: Work Group Member Biographies

(listed in alphabetical order)

Tom Biebighauser???

Robert Brooks???

Lisa N. Cowan, PLA, ASLA

Lisa Cowan, is Principal at Studioverde - a collaborative of landscape architects and practitioners in the fields of resource economics, ecology, horticulture and public art, working together to create high performance landscapes. Lisa's work exemplifies a lifelong interest in the restoration of natural systems and community engagement in the natural world. She has expertise in ecology-based planning, design, low impact construction and land management and was the lead landscape architect on over thirty successful wetland and riparian creation and restoration projects. Lisa is a Co-Chair of the American Society of Landscape Architect's Sustainable Design and Development (SDD) Professional Practice group and is the editor for the SDD blog for the Field. Lisa has also been active in public outreach and education on the Sustainable Sites Initiative rating system (SITES) since 2009.

Rebecca Dils???

Lauren Driscoll???

Norman Famous

Mark Fonseca, PhD

Dr. Mark Fonseca is the Science Director for CSA Ocean Sciences, a marine environmental consulting firm headquartered in Stuart, Florida and with numerous overseas branch offices. Besides ensuring scientific quality for CSA, he conducts applied research with a focus on ecosystem restoration and management, especially with seagrasses. In 2012 he retired from NOAA where he spent over 30 years as a research ecologist and research branch chief. He has authored or co-authored over 80 peer-reviewed papers and dozens of technical reports on the ecology, conservation and mitigation of seagrass ecosystems. In 1998 he also senior authored "*Guidelines for the conservation and restoration of seagrasses in the United States and Adjacent Waters*", which remains a leading national and international treatise on the subject. He holds a B.Sc. in Resource Development from the University of Rhode Island, a M.Sc. in Environmental Sciences from the University of Virginia and a Ph.D. in Integrative Biology from the University of California, Berkeley.

Thomas Harcarik

Tom is an environmental planner with Ohio EPA's Division of Environmental and Financial Assistance where he reviews water and wastewater infrastructure projects seeking financing under the State Revolving Fund (SRF) programs. Tom evaluates environmental impacts, including floodplains, threatened and endangered species, historic properties, and streams and wetlands, under the NEPA-like State Environmental Review Process. He also evaluates stream and wetland restoration and protection projects seeking funding through Ohio EPA's Water Resource Restoration Sponsor Program. Tom also assists the Ohio Power Siting Board by evaluating impacts to aquatic resources resulting from proposed power plants, transmission lines, and wind power projects.

Tom started his career at Ohio EPA as a summer intern where he was a "bug picker" and "fish kicker." Tom has since worked for Ohio EPA for over 29 years, including 17 years in the 401 Water Quality Certification program and Wetland Ecology Group. Additionally, Tom has worked in the enforcement sections for Ohio EPA's solid waste and unregulated hazardous waste programs, where he reviewed cases and served as a liaison to the Attorney General's Office. Tom received his Bachelors of Science in Conservation, with an area of specialization in aquatic ecology, from Kent State University. Tom is an avid backpacker, and lives by the motto, "A bad day in the field always beats a good day in the office!"

Ted LaGrange

An Iowa native, Ted moved to Nebraska in 1993 to work as the Wetland Program Manager for the Nebraska Game and Parks Commission. As Wetland Program Manager he works on a wide variety of wetland issues throughout the state including private land restoration programs, public lands management, resource advocacy and outreach. Prior to moving to Nebraska, he worked for 8 years as a Waterfowl Research Technician for the Iowa Department of Natural Resources in Clear Lake. Stationed in northern Iowa, he worked with the prairie pothole restoration program, especially evaluation of plant and waterfowl response to wetland restoration. Ted received B.S. and M.S. degrees in wildlife biology from Iowa State University. During his college years he spent summers working on refuges in Oregon and New York for the US Fish and Wildlife Service, working on a muskrat ecology study on the Upper Mississippi River, and working on the Marsh Ecology Research Project for Delta Waterfowl and Wetlands Research Station in Manitoba. His professional interests are in prairie wetlands and waterfowl/waterbird ecology.

Roy R. "Robin" Lewis, III, PWS

Roy R. "Robin", Lewis, III is President of Lewis Environmental Services, Inc., and Coastal Resources Group, Inc., a not-for-profit scientific and educational organization, both with offices in Valrico, Florida, and Salt Springs, Florida. He is a Professional Wetland Scientist certified by the Society of Wetland Scientists, and a certified Senior Ecologist with the Ecological Society of America. He has forty years of experience in the design and construction of wetlands with over 200 completed and successful projects in the USA and overseas. He has recently designed, permitted, and supervised initial construction of a 400 ha mangrove restoration project at the Rookery Bay National Estuarine Research Reserve near Marco Island, and a 7,000 ha project in Indonesia. He has also worked and taught wetland restoration in twenty-two foreign countries including Jamaica, Bonaire, the Bahama Islands, Cuba, Costa Rica, Barbados, Guyana, Nigeria, Mexico, Puerto Rico, the US Virgin Islands, India, Sri Lanka, Thailand, Vietnam, Indonesia and

Hong Kong. He specializes in the ecological monitoring, management and restoration of mangrove forests and seagrass meadows and has over 125 professional publications in these and other wetland subject areas.

Michael McDavit

W. Michael Mcdavit is currently the Chief of the Wetlands Strategies and State Programs Branch, Wetlands Division, Office of Wetlands, Oceans and Watersheds, Office of Water, U.S. Environmental Protection Agency. He leads a unit that administers technical and financial support for enhancing State and Tribal wetland programs and conducts the National Wetland Condition Assessment, a national aquatic resource survey of the Nation's wetlands on a five-year cycle. He also collaborates on special projects concerning the protection and restoration of wetland resources, such as the Coastal Wetland Initiative. Mike holds a BS in Environmental Science from the University of Wisconsin at Green Bay and a MPA from the George Washington University. Some of Mike's fondest fieldwork memories involve slogging through Lake Michigan's Green Bay marshes as an undergrad Sea Grant research assistant in the 1970's.

Mick Micacchion

Mick Micacchion is a wetland ecologist at the non-profit Midwest Biodiversity Institute and is certified as a Professional Wetland Scientist by the Society of Wetland Scientists. He has a BS and MS in Wildlife Management, both from the Ohio State University, and retired in 2011 from the Ohio Environmental Protection Agency (Ohio EPA). While working at Ohio EPA he was instrumental in the development of Ohio's Wetland Water Quality Standards rules, wetland assessment tools (including the Ohio Rapid Assessment Method for Wetlands (ORAM), Vegetation Index of Biotic Integrity (VIBI), and Amphibian Index of Biotic Integrity (AmphIBI)) and their integration into Ohio's wetland program, which has worked as a model for the country. He has monitored the physical, chemical and biological features, including the plant, amphibian and macroinvertebrate communities of hundreds of Ohio's natural wetlands and trained hundreds of wetland professionals in the development and use of wetland monitoring and assessment methods including ORAM, VIBI and AmphIBI. He has also monitored, assessed, and reported on the condition of hundreds of Ohio wetland mitigation projects. Mick was a member of the Technical Advisory Group, which developed the methods used in the National Wetland Condition Assessment, and on Ohio's Interagency Review Team, where he was a major contributor to the "Guidelines on Wetland Mitigation Banking in Ohio".

Bruce Pruitt, PhD, PH, PWS

Bruce Pruitt is a Research Ecologist with the Engineer Research and Development Center, Vicksburg, MS (USACE). He is a Professional Hydrologist and Wetland Scientist with over thirty cumulative years of professional level work experience in both private and public sectors. Bruce has lead studies related to ecology, hydrology, and water quality including sedimentology on a diversity of aquatic ecosystems including streams, wetlands, lakes, estuaries, and salt marshes. He has conducted intensive investigations and developed functional assessment models applicable to the Western Kentucky Coalfields, East Everglades, Sharks River Slough, and the Florida Keys. He received a Bronze Metal from USEPA for the wetland functional assessment model he developed and tested for the Florida Keys which is still in use today. Bruce has provided hydrogeomorphic design, construction oversight, and monitoring on several stream, wetland and salt marsh restoration projects. Bruce has also developed and published regional hydraulic rating curves for western Kentucky and the Piedmont of Georgia applicable to functional assessment and stream restoration. Since 1989, Bruce has served as an instructor in numerous applied training courses including federal wetland delineation, functional assessment, and fluvial geomorphology. In his spare time, Bruce enjoys playing guitar and singing with his wife, Melanie; son, Carson; and daughter, Madison. His passion includes music, saltwater fishing and diving.

Myra Price???

Joseph Shisler

Joseph Shisler is a Principal Ecologist at ARCADIS in Cranbury, NJ. A nationally recognized wetlands expert, he received is PhD from Rutgers University in 1975 where he studied in the impacts of alterations to salt marshes. He was at Rutgers University for more than 10 years directing research on wetlands, wildlife use, stormwater management, wetland mitigation, and coastal zone management issues. He has more than 42 years of experience conducting wetland evaluations and restoration projects and has served as a consultant to various state, federal, and international agencies concerning these issues. The New Jersey Wildlife Society recognized his work and presented him with the 1980 Conservationist of the Year award. Governor Kean appointed him chairperson of the New Jersey Wetlands Mitigation Council in 1989 for which he served for 9 years. He has been a consultant for over 20 years in a salt marsh restoration project in Delaware Bay that encompasses 32 square miles. He is a certified Senior Ecologist by the Ecological Society of America and has over 100 professional publications and presentations on wetland subjects.

Marcia Spencer-Famous

Marcia Spencer Famous has been employed as a Senior Planner for the State of Maine's Department of Agriculture, Conservation and Forestry since 1998, with a focus on large-scale development such as windpower and commercial/agricultural ground water withdrawal. Prior to her current position, from 1986 to 1990 Marcia was employed by Downeast Peat, LP, where she investigated natural patterns of recolonization of mined peatlands in order to develop a restoration plan for a mined bog in Maine; and then until 1998 was a self-employed environmental consultant, specializing in wetland assessment and delineation, damaged peatland restoration, and landscape analysis.

From 1986 to 1999, Marcia co-researched with her husband, Norman, and others, factors affecting the natural re-vegetation and regeneration of peatlands damaged by mining practices. In 1999, Marcia participated as one of several expert witnesses in a U.S. Department of Justice and Environmental Protection Agency enforcement case that involved developing a restoration plan for a mined peatland in Michigan. She presented various aspects of the peatland research at symposiums and conferences including: the 'New Developments in Wetlands Science' conference at the University of Sheffield, England (2001); the International Peat Society Annual Meeting in Quebec (2000); the Third and Fourth Annual Peatland Restoration Workshops at Laval University, Quebec (1995 and 1996), and more recently at the Maine Association of Wetland Scientists annual meeting in 2014.

In 2000, Marcia earned a MS in Botany and Plant Pathology at the University of Maine in Orono with a thesis, titled “The Potential for Restoration of Mined Ombrotrophic Peatlands” from which she published an invited paper in Wetlands Ecology and Management titled “Regeneration of three Sphagnum Species” (v.13, 2005: 635-645).

John Teal, PhD

Dr. Teal’s professional career began in the early 1950’s with his Harvard Ph.D. thesis on the trophic relationships in a tiny cold spring in Massachusetts. He then studied salt marshes at University of Georgia Marine Institute at Sapelo Island. After four years, he went to Dalhousie University in Halifax at the new oceanography establishment in eastern Canada. Dr.Teal joined Woods Hole Oceanographic Institution in 1961 and has been Scientist Emeritus since 1995. In addition to research on coastal wetlands he has worked on physiology of large, warm blooded fishes, bird migration over the oceans, oil pollution, and wastewater treatment by wetlands. He has been involved since 1993 in a salt marsh restoration project in Delaware Bay that encompasses 32 square miles. He served on the Louisiana Coastal Area (LCA) scientific advisory committee for the Mississippi delta. Dr. Teal has served on National Academy committees, Federal advisory committees, editorial boards of scientific journals, published in both the scientific and popular literature, and served on local committees. Always interested in the willingness and/or unwillingness of professional scientists to take part in public policy decisions, Dr. Teal has served on the board of the Conservation Law Foundation of New England since 1978 and is now Trustee Emeritus. He was president of the Society of Wetland Scientists in 1998-9.

James Turek

James Turek is a restoration ecologist with the NOAA Fisheries Restoration Center (RC) stationed at the Northeast Fisheries Science Center Lab in Narragansett, RI. Jim has worked with the RC for more than 15 years, managing or providing technical assistance on a variety of coastal habitat restoration projects primarily in Narragansett Bay, Long Island Sound, Buzzards Bay and their watersheds. Much of his work is carried out through NOAA’s Community-Based Restoration Program (CRP) and the Damage Assessment, Remediation and Restoration Program (DARRP) to restore natural resource damage injuries resulting from oil spills and other contaminant releases. His expertise includes planning, designing, cost estimating, implementing and monitoring tidal marsh and freshwater wetland restorations, and dam removals, nature-like fishways and other river barrier removal projects leading to diadromous fish passage and population restoration. Prior to joining the RC, Mr. Turek worked as an environmental consultant for 13 years with firms in Maryland and Rhode Island, where he led or participated in more than 450 wetland delineations, planning studies, impact assessments, and wetland mitigation projects. He also spent 3 years as a fishery biologist at the former NOAA

Fisheries Lab in Oxford, Maryland, where his work included evaluating Chesapeake Bay tidal marsh restoration performance. Jim holds a Bachelor's Degree in Zoology and minor in Geological Sciences from the University of Maine at Orono, and a Master's Degree in Marine Affairs from the University of Rhode Island.

Lawrence "Larry" Urban

Lawrence J. "Larry" Urban is the wetland mitigation specialist for the Montana Department of Transportation with state-wide responsibilities based out of Helena, Montana. He has over 30 years of experience in wetland delineations, functional assessments, monitoring and mitigation site development for both the New Jersey and Montana Department of Transportations. He has been involved in the development of a comprehensive aquatic resource mitigation program to meet wetland and stream mitigation needs for transportation projects throughout the state of Montana that has created over 55 mitigation areas ranging in size from ½ to 300 acres in size. He developed an annual monitoring program for the purposes of managing aquatic resource mitigation sites on both private and state lands to comply with federal, state and Tribal permitting requirements. Assisted in the funding, development and continued oversight of the Montana Department of Transportation's Montana Wetland Assessment Method (MWAM) originally developed in 1989. He has also presented at a number of National and regional wetland mitigation conferences, and participates in annual continuing education courses as an instructor in wetland regulations, mitigation and wetland assessments in the state of Montana.

Richard A. Weber, P.E.

Richard Weber is a Wetland Hydraulic Engineer with the USDA Natural Resources Conservation Service (NRCS), Wetland Team, CNTSC in Fort Worth, Texas from 2006 to present. In this role, Rich has provided national leadership on wetland hydrology, including: Support for Wetland Restoration Program, Wetland Protection Policy, and E.O. 11990 Wetland Assessments. He leads a national training cadre for Wetland Restoration and Enhancement and Hydrology Tools for Wetland Determination courses. From 2005-2006, Rich was Design Engineer at the NRCS Nebraska State Office where he had design and A&E Contracting responsibilities for PL-566, WRP, and EQIP programs. From 1999-2005, he was a Field Engineer at the NRCS in the Scottsbluff, NE Field Office where he had design, construction, and contracting responsibilities for the Wetland Reserve Program, EQIP Irrigation and Animal Waste Management, and CTA conservation practices. From 1997-1999, Rich was an Agricultural Engineer at the NRCS in Chehalis, WA where he had design, construction, and contracting responsibilities for Conservation District funded Stream Restoration and Fish Passage projects, and EQIP program Animal Waste Projects. And from 1986-1997, he was a Watershed Project Engineer at the NRCS in Horton, KS where he performed Construction Contract Administration for PL-566 Watershed Protection and Flood Prevention projects.

Scott Yaich???

Joy Zedler, PhD

Joy Zedler is Professor of Botany at the University of Wisconsin-Madison and the Aldo Leopold Professor of Restoration Ecology and Research Director at the Arboretum. Her research and writings concern wetlands, restoration, and conservation of biodiversity and ecosystem services; she promotes Adaptive Restoration, mentors students, and helps edit the journal, Restoration Ecology. She advises many organizations on environmental issues and restoration projects. She is a Fellow of the Society of Wetland Scientists and a Fellow of the Ecological Society of America, in recognition of her research and service.

Appendix B: Webinars Flyer

WETLAND RESTORATION WEBINAR SERIES

The Association of State Wetland Managers (ASWM) is excited to announce its newest monthly restoration webinar series as part of its effort to tackle some of the biggest challenges for wetland restoration and share insights and lessons learned from experts in the field. Twenty five experts including restoration practitioners, regulators, policy makers and academics have formed a working group to develop a series of 13 informational webinars. This project is part of a larger ASWM effort to examine the underlying reasons for restoration failure and provide solutions. Webinars will be held monthly starting in September 2014 and running through September 2015. Webinars will begin at 3pm eastern, 2pm central, 1pm mountain and 12pm pacific time and will be recorded and posted on ASWM's website. You can stay up to date by checking our website often at: http://www.aswm.org/aswm/aswm-webinarscalls/6773-improving-wetland-restoration-success-project.

2014 – 2015 Webinar Schedule:

Tuesday, September 9 (3pm ET): How Restoration Outcomes are Described, Judged and Explained. Presented by: Joy Zedler, Aldo Leopold Chair of Restoration Ecology, University of Wisconsin; Robin Lewis, Lewis Environmental Services, Inc. & Coastal Resource Group, Inc.; Richard Weber, NRCS Wetland Team, CNTSC; Bruce Pruitt, USACE Engineer Research & Development Center; Larry Urban, Montana DOT. Click here for recording.

Thursday, October 2 (3pm ET): History of Wetland Drainage in the U.S. Presented by Tom Biebighauser, Center for Wetlands & Stream Restoration. Click here for recording.

Tuesday, November 4 (3pm ET): How to Prepare a Good Wetland Restoration Plan. Presented by: Richard Weber, NRCS Wetland Team, CNTSC; Tom Harcarik, Ohio EPA, Division of Environmental & Financial Assistance; John Teal, Woods Hole Oceanographic Institution (Scientist Emeritus); Lisa Cowan, Studio Verde; Mick Micacchion, Midwest Biodiversity Institute. Click here for recording.

Tuesday, December 9 (3pm ET): Atlantic Coast Coastal Marshes & Mangrove Restoration. Presented by: Robin Lewis, Lewis Environmental Services, Inc. & Coastal Resource Group, Inc.; John Teal, Woods Hole Oceanographic Institution (Scientist Emeritus); Joseph Shisler, ARCADIS; Jim Turek, NOAA Fisheries Restoration Center. Click here for recording.

Tuesday, January 20 (3pm ET): Temperate and Tropical/Subtropical Seagrass Restoration. Presented by: Robin Lewis, Lewis Environmental Services, Inc. & Coastal Resource Group, Inc.; Mark Fonseca, CSA Ocean Sciences. Click here for recording.

Tuesday, February 17 (3pm ET): Playa and Rainwater Basin Restoration. Presented by: Richard Weber, NRCS Wetland Team, CNTSC and Ted LaGrange, Nebraska Game & Parks Commission. Click here to register.

Tuesday, March 17 (3pm ET): Pacific Coast Wetland Restoration. Presented by: Charles ("Si") Simenstad, University of Washington & John Callaway, University of San Francisco. Click here to register.

Tuesday, April 21 (3pm ET): Vernal Pool Restoration. Presented by: Mick Micacchion, Midwest Biodiversity Institute. Click here to register.

Tuesday, May 19 (3pm ET): Prairie Pothole Restoration. Presented by: Sue Galatowitsch, University of Minnesota & Carter Johnson, South Dakota State University. Click here to register.

Tuesday, June 9 (3pm ET): Riverine/Riparian Wetland Restoration. Presented by: Richard Weber, NRCS Wetland Team and Larry Urban, Montana DOT. Click here to register.

Tuesday, July 14 (3pm ET): Peat Land Restoration. Presented by: Norman Famous & Marcia Spencer-Famous, Spencer-Famous Environmental Consultants; Richard Weber, NRCS Wetland Team; and Larry Urban, Montana DOT. Click here to register.

Other Topics (dates and presenters to be confirmed): Low Impact Development; Novel Ecosystems

Appendix C: Lexicon

To be filled in with an annotated version of Bruce's lexicon.

Appendix D: Work Group Members' Top 5 Recommendations by Webinar Topic

How Restoration Outcomes are Described, Judged and Explained

Joy Zedler

- Use clear terminology; use terms consistently
- Base assessments on multiple indicators (of structure and function) that relate to the specific project objectives
- Report assessment data (e.g., clapper rail habitat mitigation: 8 attributes, each with quantitative standards)
- Describe progress made toward objectives giving
  - the list of objectives and standards (e.g., nesting habitat with tall cordgrass: max. extended leaf >60 cm on average)
  - the degree to which each objective was met
  - overall outcome: Compliance or not, explaining irregularities/shortcomings
- Limit using "success" to a specific definition in a specific context—say who is making the judgment and for what purpose.

Bruce Pruitt & Richard Weber

Cause of Failure	Recommendation	Selected Measures
Wetland not accurately classified	Use a classification system that is consistent across wetland types and reproducible among wetland scientists	Provide training for wetland restorationists
Inadequate baseline and target restored hydrology	Establish current hydrography and conceptual target hydrography by using an analog, historic or constructed reference condition	Monitor surface and ground water hydrology during normal rainfall, tidal, etc. conditions; Establish current frequency and duration of flooding, ponding, and/or soil saturation; Predict post-construction or restoration conditions and set as an attainable performance standard
Lack of consideration of wetland processes	Establish current and targeted nutrient cycling, pollutant sequestration or transformation, carbon export	Conduct import/export studies and/or establish correspondence with proxies or indicators of processes; Measure increase in biomass or NPP of woody, rooted vegetation, soil organic matter in O and A horizons
Inadequate assessment of current & future adjacent land use practices	Establish current and future land use practices at multiple scales (e.g., watershed, stream segment, wetland area) within the catchment of the	In consultation with state and regional planning centers, forecast future development and land use changes within the catchment of the restoration site; Implement a restoration plan that includes an adaptive management program which accounts for future land use changes

	restoration site	
Inadequate water quality investigation ("build it and they will come "misconception)	Document current and future water quality conditions at both the watershed and stream segment scales	Conduct current physiochemical and biological water quality and sediment quality and quantity conditions; Establish ecological integrity based on baseline conditions with and without project; Set predicted conditions as an attainable performance standard

Robin Lewis

Cause of Failure	Recommendation	Details
1.Wetland restoration designed incorrectly	Better training	Provide training for wetland professionals including consultants, regulators and monitoring and enforcement personnel
2. Inadequate baseline and target restored hydrology	Establish current hydrology and conceptual target hydrology by using an analog, historic or constructed reference condition	Monitor surface and ground water hydrology at a proposed restoration site during normal seasonal rainfall, tidal, etc. conditions; Establish current frequency and duration of flooding, ponding, and/or soil saturation; Predict post-construction or restoration conditions using reference conditions, and set as an attainable performance standard. See above. Training needed.
3. Lack of consideration of the historical context and previously published work on success.	Republish Kusler and Kentula (1989) (the USEPA version) with added notes from the authors or substitutes to bring them up to date. Make freely available.	Simply providing a bibliography is not enough. Wetland professionals and regulators are busy people. It is often difficult or impossible for them to access good free science. This would start to overcome that impediment.
4. Inadequate respect for the experience of current professionals with proven track records.	Provide a method for precertification by regulatory agencies and requirements for applicants to use trained professionals in wetland design.	In consultation with federal, state and local wetland planning, and design and permitting agencies, develop approved lists of wetland design and construction professionals who have proven track records of successful restoration and monitoring, and recommend their use.
5. Beef up compliance monitoring and enforcement activities to stop repeated errors in design with distribution of "lessons learned."	Document current wetland restoration and creation efforts on the regional level to keep professionals apprised or progress in more successful wetland restoration and creation efforts.	Current progress towards improving the practice of successful wetland restoration and creation is hampered by the lack of freely availability documentation on who, what and where are the successful projects being done, and what monitoring and reporting is available for professionals to review and learn about these efforts and improve their practices.

Larry Urban

Problems Encountered	Recommendations	Details
1. Aquatic restoration not constructed properly	Hire construction contractors with experience & qualifications in restoring aquatic resources (e.g., streams & wetlands. Require As-Built Plans of the completed project for purpose of monitoring performance objectives & to determine if adaptive mgt is necessary.	Montana Dept. Of Transportation has developed a list of pre-qualified construction contractors for aquatic resource restoration projects. This may be prudent for other areas of the country, as it is specialized work in every aspect. Contractors who have experience in such work will be more efficient and provide inputs during construction that result in a better product on the ground.
2. Lack of experienced oversight professionals	Insure that an experienced restoration professional is on site during stream / wetland construction.	Ensures that a project is correctly constructed and provides direction to the contractor. When problems with designs are encountered in the field; corrections can be made at the direction of the restoration professional.
3. Poor site selection	Focus on restoring areas that were once wetlands, and channelized stream reaches, instead of creating wetlands in uplands.	Millions of acres of wetlands and miles of streams have been degraded for various reasons (mining, industry, flood control, etc.). Restoration of former ecosystem functions will benefit the landscape and watershed, as well as the public.
4. Scientific studies versus regulatory monitoring	Both communities need to agree on what constitutes monitoring requirements and assess the costs of implementation of regulatory requirements to monitor restored areas.	In the world of mitigation restoration, few have the funds or dollars to conduct detailed bio-geochemical analyses, and import/export studies of nutrients. Funds are drying up in many avenues; agencies are short on staff and funding to conduct annual inspections, etc. Work together to provide better projects.
5.Regional performance standard templates	The majority of regulatory performance standards have been developed for the wetter areas of the US and do not equate to the drier arid regions of the country.	There need to be regional performance standards developed similar to the Regional Delineation supplements. As well as the development of performance standards for stream restoration.
6. Drowned woody vegetation plantings	Plant woody plants after water regimes have established over a period of 3 to 5 years.	Many resource agencies want woody vegetation planted immediately, but experience is that even with good hydrologic data site, actual hydrology will throw a curveball. Suggestion: plant woody plants as water regimes establish after 2- 3 years, to prevent drowning and avoid costs of replanting.

How to Create a Good Wetland Restoration Plan

Richard Weber

Cause of Failure	Recommendation	Selected Measures
Restoration Objectives not in line with Site Potential	Match objectives with Landscape position in the local watershed	Identify Hydrogeomorphic wetland class appropriate to project
Soil substrate breached, causing reduction of hydroperiod in recharge wetland	Maintain perching layer	Research NRCS Web Soil Survey water features, and/or on site investigation
Riverine restoration technique applied to Groundwater Discharge site	Identify appropriate wetland type by watershed stream order	Use soil properties to identify flooded/ponded soils vs. groundwater discharge soils
Depressional restoration fails to maintain planned depth/duration	Analyze water budget	Use water budgeting technique

Tom Harcarik

Cause of Failure	Recommendation	Selected Measures
Inadequate screening and selection of restoration site	Develop better tools to assess the proposed site for its restoration potential and effectiveness of action	Require specific data collection for proposed restoration site that extends beyond the project boundary and accounts for watershed scale influences. Require more detailed analysis of soils and hydrology
Lack of adequate buffers	Ensure adequate buffers are present to meet project specific goals	Require average and minimum buffer widths that account for site specific project goals such a protecting the site from adjacent land uses or the needs of targeted biological communities
Contractor not familiar with wetland restoration or importance of key restoration design features	Ensure contractors are familiar with wetland restoration construction techniques, and understanding of soils, hydrology, vegetation	Develop better screening methods, list of qualifications. Have design consultants and regulators attend pre-bid and pre-con meeting. Consider developing list of pre-qualified contractors based on demonstrated knowledge and success
Inadequate post-construction follow-up. Resistance to devoting time and resources to monitoring and correcting problems	Require better post construction monitoring follow up	Ensure implementers (and regulators) are collecting the appropriate data to measure the restoration site performance
Failure to incorporate lessons learned	Analysis data collected at restoration sites to determine what worked and what didn't and why	Develop feedback loop to allow new data and observations to be incorporated into future restoration efforts

Mick Micacchion

Cause of Failure	Recommendation	Selected Measures
Goals cannot be quantified preventing accurate assessments and limited incentive to achieve high quality.	Use quantifiable ecological performance standards as goals for mitigation and other restorations.	Use IBIs or other quantifiable ecological performance standards as goals. Set goals of "GOOD" or better ecological condition to assure restored wetlands compensate for losses, have high environmental resilience, and require minimal management.
No financial obligation for permittee or banker to meet performance standards.	Require monetary guarantees that are not released unless goals are met.	Make sure site and plans will lead to meeting quantifiable goals. Do not release non-performing bank credits or release bonds or other guarantees for under achieving permittee-responsible mitigation wetlands.
Natural wetlands have lower ecological condition when their surrounding land uses have high levels of human disturbance while a large percentage of mitigation wetlands perform at low levels in any landscape.	Give mitigation and restored wetlands the highest chance of success by placing them in landscapes with low levels of human disturbance.	Select appropriate sites and develop plans that will maximize the opportunity for meeting quantifiable ecological performance standards. Knowing that wetland condition is highly influenced by surrounding land uses place wetland restoration projects in areas where wide buffers are present or can be restored and the intensity of other surrounding land uses is low.

Lisa Cowan

Cause of Failure	Recommendation	Selected Measures
Collaboration between agencies, wetland team, stakeholders is minimal.	Use integrated planning process and visual tools for education, outreach, engagement, support.	Project leadership should encourage and support collaboration internally, break down territory staking and barriers. Develop relationships with NGO's, contractors and suppliers and foster 2-way communication.
Contractor bids over budget. Change orders are often used during construction to address unanticipated challenges.	Include qualified land design professionals, such as a landscape architect on team to work with scientists to develop strategies that meet budget and are feasible to build.	Planning through design – collaborate to problem solve and vision strategies. Investigate local and innovative materials and construction methodologies to achieve outcome goals. Construction documents should be developed to provide specific guidelines and constraints on contractor, but not tell them exactly "how to do it".
Wetland features look contrived and manmade.	Use clear strategic graphics to communicate complexity of wetland features.	Anticipate the look and vision of natural wetland features within this context. Collaborate with wetland team members on details. Minimize CAD drafting of details until end to reduce need for time consuming revisions.

Poor wetland plant community establishment and performance.	Soil mixes and construction methodologies for installation are critical and measures taken for each project to ensure requirements are enforced.	Specify feasible soil mix and installation measures. Communicate these as priorities on construction documents, during pre-bid and pre-construction meetings. Ensure that qualified construction monitoring personnel are on-site to adequately monitor and enforce soils supply and installation requirements.
Lack of community support for LID or green infrastructure projects that include wetlands.	More outreach and education throughout process. Plan for efficient maintenance and long term project sustainability upfront.	Use visual tools and other community engagement methodologies to engage stakeholders. Strategize on ways to include local businesses, labor forces, community groups for construction and stewardship. Create designs that have visual order. Use materials that are local, resilient and durable. High performance plants.

Atlantic Coast Coastal Marshes & Mangrove Restoration

Robin Lewis

Cause of Failure	Recommendation	Details
1. Mangrove restoration designed incorrectly.	Better training.	Provide training for wetland professionals including consultants, regulators and monitoring and enforcement personnel who deal with mangrove restoration issues.
2. Use of Inadequate baseline and target restored hydrology and topographic data.	Establish current hydrology and conceptual target hydrology by using a reference condition in a nearby mangrove forest.	Monitor surface and ground water hydrology at a reference site as well as the proposed restoration site during normal seasonal rainfall, tidal, etc. conditions. Establish current frequency and duration of flooding, etc.
3. Lack of consideration of the historical context and previously published work on success.	Republish Kusler and Kentula (1989) (the USEPA version) with added notes from the authors or substitutes to bring them up to date. Make freely available.	Simply providing a bibliography is not enough. Wetland professionals and regulators are busy people. It is often difficult or impossible for them to access good free science. This would start to overcome that impediment. Use of the website www.mangroverestoration.com as a starting point is recommended.

4. Inadequate respect for the experience of current professionals with proven track records.	Provide a method for precertification by regulatory agencies and requirements for applicants to use trained professionals in mangrove design.	In consultation with federal, state and local wetland planning, and design and permitting agencies, develop approved lists of mangrove design and construction professionals who have proven track records of successful restoration and monitoring, and recommend their use.
5. Beef up compliance monitoring and enforcement activities to stop repeated errors in design with distribution of "lessons learned."	Document current mangrove restoration and creation efforts on the regional level to keep professionals apprised on progress in more successful mangrove restoration and creation efforts.	Current progress towards improving the practice of successful mangrove restoration and creation is hampered by the lack of freely availability documentation on who, what and where are the successful projects being done, and what monitoring and reporting is available for professionals to review and learn about these efforts and improve their practices.

John Teal

Cause of Failure	Recommendation	Selected Measures
Not having complete tidal flows.	Have good hydrology data and modeling.	
Too rigidly following initial model results.	Carefully consider monitoring observations.	Let system develop on its own as long as that fits into final goals.

James Turek

Causes of Failures/Challenges	Reasons and Recommendations	Details
Tidal reconnection lacks sufficient hydrology for restoring native marsh plant community.	Culvert size and/or invert elevation are key factors in tidal hydrology reconnection; complete thorough and iterative upfront model analysis needed.	Upfront site feasibility site (FS) needs to include water surface elevation (WSE) survey with dataloggers installed within the restricted site and the contributing hydrology of the unrestricted estuary. Data needs to be tied into tidal datum, plus accurate project site topography and bathymetry digital elevation needed for creating DEM.
Poor site drainage during ebb tide cycles.	Marsh substrate elevations are too low relative to the restored tidal hydrology.	Need water surface elevation (WSE) survey for at least one complete lunar cycle for proposed restoration site; multiple WSE dataloggers needed for site, especially for tidal reconnection sites. Sediment/soil placement and substrate elevations need to account for dewatering, settling and compaction of placed materials.

Property owners abutting project site concerned restoration will impact their properties.	Increased regular flood and storm tides may increase land flooding or alter tidal inlet.	Thorough assessment needed during FS especially adequate survey data for DEM and hydraulic modeling proposed tidal reconnections. Early-phase project consensus-building and community outreach is essential to project understanding and support/acceptance.
Unanticipated costs and inadequate project funds available for the project.	Take into account all work tasks during all project phases including in-water construction.	Need to account for all project phases: upfront assessment includes adequate base mapping and modeling, complete alternatives analysis, and regulatory permitting including EFH assessment and consultation with NMFS. Construction costs for in-water work are higher than on-land work as specialty equipment is needed. Post-project monitoring is essential to evaluating project including SETs to assess marsh elevational capital.

Joseph Shisler

Cause of Failure	Recommendation	Details
1. Salt marsh restoration or creation is designed incorrectly.	An understanding of the system and what is expected to be there when completed. This has to be from both the literature and field experience.	Use of ecological benchmarks from adjacent wetlands to assist in the wetland restoration. An understanding of the salt marshes ecology and factors affecting the system. A background in the literature and how the systems function. All wetlands are not the same.
2. Over design the wetland restoration or creation project.	Allow the natural process assist in the development of the wetland.	Need to have an understanding of the wetland ecology and how the system changes with location and time.
3. The wetland does not meet goals.	Adaptive management during the restoration time until the project meets goals.	It is important for yearly evaluation and implementing corrective actions (adaptive management) during the development of the project to insure that goals will be met. The potential problems can be determined in the design phase and how they will be corrected.
4. Not meeting goals because there is a change in personnel from the design to project completion.	The same personnel should be in charge of the project from design to the project meets its goals.	The design personnel should have identified potential issues and problems with the project and how to correct them. When there is a change in personnel they usually are not aware of problems.

5. Beef up compliance monitoring and enforcement activities to stop repeated errors in design with distribution of "lessons learned."	Document current restoration and creation efforts on the regional level to keep professionals apprised on progress in more successful restoration and creation efforts.	Current progress towards improving the practice of successful restoration and creation is hampered by the lack of freely availability documentation on who, what and where are the successful projects being done, and what monitoring and reporting is available for professionals to review and learn about these efforts and improve their practices. There is a need to evaluated projects that are 20+ years to assess how they are functioning and identify problems.

Temperate and Tropical/Subtropical Seagrass Restoration: Challenges for the 21st Century

Robin Lewis

Challenge	Recommendation	Details
1. Seagrass restoration designed incorrectly.	Better training.	Provide training for wetland professionals including consultants, regulators and monitoring and enforcement personnel who deal with seagrass restoration issues.
2. Use of Inadequate baseline and target restored water quality and oceanography.	Establish current oceanography and conceptual target water quality by using a reference condition in a nearby seagrass meadow.	Monitor existing water quality and oceanography at a reference site as well as the proposed restoration site. during normal seasonal conditions; Establish reasons for lack of existing seagrass in the proposed restoration site.
3. Lack of consideration of the historical context and previously published work on success and failure.	Republish Kusler and Kentula (1989) (the USEPA version) with added notes from the authors or substitutes to bring them up to date. Make freely available. (Done)	Simply providing a bibliography is not enough. Wetland professionals and regulators are busy people. It is often difficult or impossible for them to access good free science. This would start to overcome that impediment. Use of the website www.seagrassrestorationnow.com as a starting point is recommended.
4. Inadequate respect for the experience of current professionals with proven track records.	Provide a method for precertification by regulatory agencies and requirements for applicants to use trained professionals in seagrass restoration.	In consultation with federal, state and local wetland planning, and design and permitting agencies, develop approved lists of seagrass design and construction professionals who have proven track records of successful restoration and monitoring, and recommend their use.
5. Beef up compliance monitoring and enforcement	Document current seagrass restoration and creation efforts on the regional level to keep professionals	Current progress towards improving the practice of successful seagrass restoration and creation is hampered by the lack of freely availability documentation on who, what and where are the

activities to stop repeated errors in design with distribution of "lessons learned."	apprised on progress in more successful seagrass restoration and creation efforts.	successful projects being done, and what monitoring and reporting is available for professionals to review and learn about these efforts and improve their practices.

Mark Fonseca

Challenge	Recommendation	Details
1. Complex and inappropriate metrics of success.	Utilize simple, parsimonious metrics that are appropriate for the defining success.	**Acreage** and **persistence** are the foundation of success; these are needed for computed discounted lost (or gained) ecosystem services; if you build it, they will come.
2. Site selection.	Revise criteria to include emerging understanding of ecosystem bistability.	To offset the ongoing loss of seagrass habitat, opportunities for both restoration and mitigation need to include ANY unvegetated seafloor where the factors limiting natural seagrass recruitment (e.g., wave energy, bioturbation) can be manipulated and sustained.
3. Quantifying interim services.	Credit interim recovery of services and not just loss.	For example, sites that must be periodically disturbed, such as channels and harbors only count the loss of any seagrass recruited in the interim; there is no credit for the interim gain and service of those recruited seagrass.
4. Restoration of dynamic seagrass beds (e.g., *Halophila* spp., and patchy habitats).	Changing the monitoring scale both temporally and spatially to accurately capture the scale of variance.	Snapshot and extremely short duration monitoring will not provide defensible assessments of these communities. Regulatory agencies that continue to utilize these methods will fail in their ability to accurately assess both baseline conditions and restoration performance.
5. Recognition of seagrass services by the public.	Champions.	Seagrasses provide far more ecosystem services to the U.S. than corals – but the public is largely unaware of this. Many of the injuries to and loss of seagrasses likely arise from an uninformed public and their representation.

Playa and Rainwater Basin Restoration

Ted LaGrange & Richard Weber

Cause of Failure	Recommendation	Selected Measures
Not understanding wetland type, function, and dynamics.	Understand and assess wetland type, function, and dynamics.	Tools such as HGM classification, soils maps, Cowardin classification are very valuable. So is understanding wetland dynamics, something that wildlife agencies and natural heritage programs can help with.

Not fully assessing and fixing alterations to the wetland.	Fully assess and fix wetland alterations to the extent possible.	Locate any outlet drains and/or pits and remove them. Measure sediment depth or depth to the clay pan and remove culturally-accelerated sediment if needed.
Not fully assessing and fixing alterations to the watershed.	Fully assess and fix watershed alterations to the extent possible.	Define and examine the watershed. Seek ways to improve water delivery and reduce inputs of culturally-accelerated sediment.
Failure to use an interdisciplinary team.	Understand when you need help and get it.	Establish bio-engineering teams, and work together collaboratively.
Failure to implement wetland management.	Consider the need for wetland management in the restoration design. Get management input and implement management.	Wetland management can require a different skill set than restoration does. Seek help from wildlife agency staff with management expertise.

Appendix E: Summary of the Framework for Adaptive Management

(taken from *Adaptive Management: A Tool for Conservation Practitioners*)

Conditions That Warrant an Adaptive Management Approach

Condition 1:	*Conservation Projects Take Place In Complex Systems*
Condition 2:	*The World Is a Constantly and Unpredictably Changing Place*
Condition 3:	*Our "Competitors" Are Changing and Adapting*
Condition 4:	*Immediate Action Is Required*
Condition 5:	*There Is No Such Thing as Complete Information*
Condition 6:	*We Can Learn and Improve*

Steps in the Process of Adaptive Management

START:	*Establish a Clear and Common Purpose*
STEP A:	*Design an Explicit Model of Your System*
STEP B:	*Develop a Management Plan That Maximizes Results and Learning*
STEP C:	*Develop a Monitoring Plan to Test Your Assumptions*
STEP D:	*Implement Your Management and Monitoring Plans*
STEP E:	*Analyze Data and Communicate Results*
ITERATE:	*Use Results to Adapt and Learn*

Principles for the Practice of Adaptive Management

Principle 1:	*Do Adaptive Management Yourself*
Principle 2:	*Promote Institutional Curiosity and Innovation*
Principle 3:	*Value Failures*
Principle 4:	*Expect Surprise and Capitalize on Crisis*
Principle 5:	*Encourage Personal Growth*
Principle 6:	*Create Learning Organizations and Partnerships*
Principle 7:	*Contribute to Global Learning*
Principle 8:	*Practice the Art of Adaptive Management*

Appendix F: Climate Change Considerations