Wetland Restoration

Contemporary Issues & Lessons Learned

The Association of State Wetland Managers

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Cover photo by Jeanne Christie, Association of State Wetland Managers

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ASWM WETLAND RESTORATION WORKGROUP

In response to reports quantifying the shortcomings of wetland restoration over past decades, the Association of State Wetland Managers (ASWM) created a Wetland Restoration Work Group in 2014, composed of twenty five experts, including practitioners, regulators, policy makers, scientists and academics. The Work Group was tasked with identifying the most significant barriers to wetland restoration and identifying actions to address these challenges based on lessons learned and the substantial collective expertise of the Work Group and others. To share initial findings and broaden the discussion, ASWM and the Work Group developed a monthly webinar series titled "Improving Wetland Restoration Success." The webinars included experts from diverse fields and regions of the U.S. Each presenter was asked to list the top constraints on wetland restoration and identify solutions. The findings identified in this white paper are based on key points provided by webinar presenters, Work Group members and other outside wetland restoration experts. Each webinar was recorded and is available to download here: http://www.aswm.org/aswm/aswm-webinarscalls/6773-improving-wetland-restoration-success-project. Work Group biographies can be found in Appendix B. Members and their affiliations are listed below.

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ASWM thanks all Wetland Restoration Work Group members (see listing on page 4 and biographies in Appendix B), webinar presenters and reviewers, whose generous contributions and expert insights made this project possible. ASWM is very grateful for webinar presentations by additional wetland restoration experts: Wendy Anderson, Craig Annen, Steven I. Apfelbaum, Tom Biebighauser, Dr. Robert P. Brooks, Dr. Aram Calhoun, Dr. John Callaway, Matt Daniels, Dr. W. Lee Daniels, Dr. Alexander Felson, Dr. Siobhan Fennessy, Ellen Fred, Dr. Susan Galatowitsch, Dr. John Groninger, Bren Haase, Will Harmon, Dr. Eric Hazelton, Dr. W. Carter Johnson, Dr. Marilyn Jordan, Dr. Mary Kentula, William P. Klein, Jr., Alan J. Leak, Julie Merritt, Joseph A. Morgan, Dr. John Andrew Nyman, David Olson, Ben Peterson, Dr. Denise Reed, Thomas Ries, Dr. Christina Schaefer, Matt Schweisberg, Charles ("Si") Simenstad, Dr. John Stanturf, Dr. Eric Stein and Jeff Williams. ASWM would also like to thank Robert Brooks for his participation and guidance in developing a workshop at the 2014 CEER/SER conference in New Orleans as part of this U.S. EPA supported project. ASWM is very grateful for the U.S. Environmental Protection Agency, Wetlands Division, for financial support and project guidance, especially from Rebecca Dils (Project Manager), Myra Price, and Michael McDavit.

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EPA United States Environmental Protection Agency

Photo Credit: Jeanne Christie

EXECUTIVE SUMMARY

Numerous studies have documented the shortcomings of wetland mitigation and voluntary restoration projects to achieve stated goals. However, despite these findings, there is little overall evidence that wetland restoration outcomes have significantly improved - and wetlands continue to be lost. There is general agreement among restoration professionals that the science exists to achieve restoration goals and that wetland restoration performance will improve if certain barriers are addressed. In 2013, the Association of State Wetland Managers began to identify some of the barriers and established a Work Group of 25 restoration experts, including practitioners, academics, consultants, regulators, and policy makers, to further identify and analyze these barriers and develop recommendations to address them.

Chapter 1 of this document is a detailed problem statement with recommended actions. In this section, ten overall barriers are identified, including: vague project goals and subjective evaluation of wetland restoration outcomes; insufficient monitoring horizons; narrowly focused regulations and permit conditions; altered landscapes and changing land uses; silos for wetland and stream restoration; underestimation of restoration costs in developing cost estimates; lack of certification, accountability and enforcement; limited access to technical expertise, training and knowledge sharing; and lack of an adaptive management framework. The Work Group also dug deeper and identified specific barriers for three restoration phases: 1) pre-construction 2) during construction and 3) post-construction. Thus this paper offers information on many levels – from the broader "big picture" issues to the detailed "in the field" issues, which in many ways reflects the diversity of our Work Group as well as the different cross cutting actions that must occur in carrying out a wetland project.

Chapter 2 includes specific actions that can be taken to implement Chapter 1's recommendations to improve restoration outcomes. There is a strong emphasis placed on understanding the hydrology and soil conditions on and adjacent to a site and utilizing a watershed approach to planning. Complex barriers such as climate change, invasive species and water rights are more difficult to address, and each topic has a special appendix to explore these complex issues in greater detail.

In light of the fact that wetland restoration is undertaken by many types of groups (i.e. agencies, non-profits, private landowners, etc.) and due to the immense diversity of wetland types and restoration goals that drive restoration projects, this paper does not delve into great depth on specific wetland types or projects. Rather, the authors provide an overview of the overarching challenges for wetland restoration. Voluntary restoration and compensatory restoration share some of the same challenges but also differ in some significant ways, and the authors identify these similarities and differences to the extent possible. Many of the challenges identified in this paper are not new; however, new solutions are being tested every day, so our understanding of wetland science continueds to advance.

This white paper presents potential solutions to restoration challenges and barriers as well as recommendations that are expanded in Chapter 2 – identifying specific steps that can be taken to improve wetland restoration outcomes as well as providing examples of initiatives that have been or are currently taking place to resolve some of the barriers. It is essentially 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.

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 different wetland types provide different functions at different levels in different conditions. However, while wetlands exhibit differences based on variables such as hydrogeomorphic (HGM) classification, the region of the U.S, in which it located, vegetation classes, and numerous other characteristics, there are features common to all wetlands that should be considered when attempting to restore wetlands. Due to the diversity of individuals and groups involved in wetland restoration throughout the United States, the audience for this paper is quite broad: practitioners, policymakers and regulators. However, those working in the field of wetland restoration should be able to improve their overall practice from these findings.

In short, the track record for wetland restoration has been less than optimal. Fortunately, many lessons have been learned over the past 50 years and there are wetland professionals throughout the country who have found methods to effectively address the barriers identified in Chapter1. However, much of this information is stored in the minds of those who have learned these lessons over time. Our intent with this paper is to disseminate this information, provide guidance for improving restoration outcomes and to identify practical solutions for those who can implement them.

INTRODUCTION

Photo Credit: Ruth Ladd

In the early 1990's, mitigation of 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 et al, 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). A few examples of consistent issues include: a lack of specific restoration goals; inadequate monitoring timeframes; lack of expertise utilized in the design; and cookbook approaches to wetland restoration, among many others (see p. 13 for more).

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, Bill Mitsch and John Teal, who agreed that wetland restoration – both voluntary and for mitigation – has produced 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 focus a on specific goal, such as boosting fish populations or improving water quality for each project; and
- Some restoration work does represent progress, such as Delaware Bay, and new plans are addressing wetland losses in coastal Louisiana (Carey, 2013).

Compensatory restoration (i.e., mitigation) is a requirement of permit conditions to avoid, minimize or make up for lost wetland functions due to unavoidable impacts.

Voluntary restorations are not undertaken in response to a specific loss.

These reports and others call into question the premise for much of wetland policy today, namely, that permit applications can be approved to destroy wetlands because losses can be replaced at another location. The fact is, mitigation rarely replaces in full the wetland functions that are lost due to permitted impacts (Goldsberg, N. & K.C. Reiss, 2016; Morgan, J.A. & P. Hough, 2015).

Many of the concerns articulated regarding compensatory mitigation also apply to voluntary restoration as well as to wetlands restored to address specific issues such as water quality or migratory waterfowl. The great majority of wetlands are restored or created for reasons other than compensatory mitigation (i.e., for direct losses associated with a permit). The goals of these non-compensatory projects are typically 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.

The intended audience for this report includes professionals in federal, state and tribal agencies as well as those in private practice and academia. It should be useful to anyone who works in the field of wetland restoration including regulators, policy makers, practitioners, wetland managers, and individuals who are interested in wetland restoration. 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 chapters: 1) Overall Challenges and 2) Actions to Improve Wetland Restoration.

CHAPTER ONE

CHALLENGES AND RECOMMENDATIONS FOR IMPROVING WETLAND RESTORATION

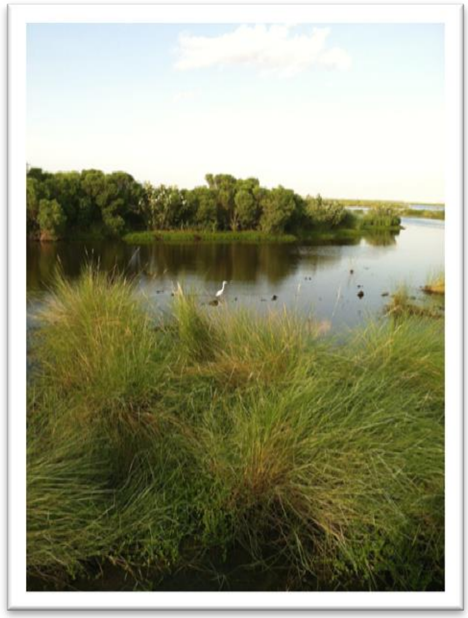


Photo Credit: Marla Stelk

Wetland restoration projects fail to perform as planned for many reasons, including but not limited to: poorly articulated performance criteria (often called "success criteria"), insufficient collection of baseline conditions, unsuitable site selection, incorrect wetland type selected, inadequate planning and designs, inadequate site supervision during construction, inability to adapt wetland restoration plans to new information found during construction, and lack of follow up maintenance, adaptation and long-term management. Many of these issues have been documented for many years, yet they are repeated time and again. Some of the challenges identified in reports previously published are summarized below:

- Practical experience and the available science base on restoration and creation are limited for many types and vary regionally.
- Many wetland restoration and creation projects do not have specific and measureable goals, complicating efforts to evaluate progress towards achieving performance and "success."
- Monitoring of voluntary wetland restoration and creation projects has been less rigorous than for mitigation projects.
- Knowledge is lacking on how to re-create a fully functioning wetland that is *identical* to the one being lost (even though the premise of regulations are that it is possible to do so).
- Performance expectations in Section 404 federal permits have often been unclear and/or relied heavily on regulation, and compliance has often not been assured, attained nor well-documented.
- Wetlands are often restored or created without considering the broader watershed context.
- Support for regulatory decision making is inadequate and a lack of resources handicaps efforts to review projects and identify ways to require changes to improve performance.
- Lack of adequate attention to soils and hydrology has impeded our understanding of how to restore wetlands.
  (Kusler & Kentula, 1989; NRC, 2001)

At the same time, there has been progress. Scientific understanding of how wetland ecosystems work has broadened, and monitoring and reporting of both natural and restored wetland health has supported development of restoration methods and techniques. 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.

1) Subjective Evaluation of Wetland Restoration Outcomes & Vague Project Goals

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 identified and/or implemented. When studying French river restorations, Morandi, Piegay, Lamouroux and Vaudor (2014) reached a similar conclusion and found that the "projects with the poorest evaluation strategies generally have the most positive conclusions about the effects of restoration." (p. 1)

Having vague restoration goals can lead to inadequate compilation of baseline information which can in turn lead to failure to correctly set hydrologic objectives. Inadequate characterization of existing water sources (e.g., surface flow, groundwater), water quantity and quality inputs and existing soil conditions can also lead to design mistakes. Too many projects are monitored and evaluated relying largely on desired plant coverage without looking closely enough to determine whether the hydrology and soil health are adequate to support the restoration site over a longer time frame.

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

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

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

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

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

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

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

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 (Zedler 2007). And in an informal poll in 2014 conducted by Dr. Joy Zedler (Aldo Leopold Professor Emerita at the University of Wisconsin-Madison), via an online internet search, the words "ecological restoration success" received 530,000 hits, whereas "ecological restoration failure" generated only four.

More often than not, voluntary wetland restoration projects do not develop performance standards with which to measure a site's performance, as they are not required to mitigate the loss of wetland functions. Thus, it is understandable that any improvement is often viewed as a "success." Monitoring data from a voluntary wetland restoration can still contribute to the science of wetland restoration and may be used to show funders that their money has been well spent.

RECOMMENDATION: Develop Clear Project Goals & Objectives and Use Appropriate & Quantifiable Performance Standards to Measure Progress

Zedler (2007) proposed avoiding the term "success" altogether, explaining that scientists, do not measure success; they measure conditions, structure, processes, ecosystem development, similarity to reference sites, and potential for self-sustainability (by various metrics or indicators). 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 authors to define the word if they choose to use it, so readers/listeners know what is meant. It is also critical to define the length of time required to achieve a yes/no outcome that is implied by the use of the term, and to assure that monitoring and management will occur (and be adequately funded) during that period.

> **Avoid using subjective terms like "success" to describe outcomes. Restorations should achieve "quantitative criteria established during the design and permitting of a project and before construction begins, and measured and reported regularly during project monitoring."**

SMART (specific measurable, achievable, relevant, timebound) objectives have been the core of recent guidance documents for river restoration, to address the challenges of vague goals. The concept was coined by George T. Doran in 1981 for use by management in corporate settings, but it been co-opted for several other types of ecological restoration. In fact, since 1997, the U.S. Fish & Wildlife Service Comprehensive Conservation Plan (CCP) training course for the National Wildlife Refuge System has stated that restoration objectives should meet the following criteria: specific, measurable, achievable, results-oriented, and time-fixed (Adamcik, et al, 1997; Schroeder, 2006).

The U.S. Fish & Wildlife Service describes their approach to SMART objectives below:

Specific. Avoid ambiguity by wording objectives clearly. A clearly worded objective is easy to understand and the meaning is difficult to misinterpret. Specificity results by including WHO will do the action, WHAT we will do, WHEN and WHERE we will do it, and WHY we will do it. (WHO may implicitly be the refuge staff, and "WHEN" we might integrate into an implementation schedule or the description of a strategy.) Avoid or minimize general phrases like "maintain high-quality habitat," "for the benefit of migratory birds," or "improve the visitor experience," as these phrases are subject to interpretation.

Measurable. Objectives should contain a measurable element that we can readily monitor to determine success or failure. Otherwise, we cannot tell if the strategies employed are appropriate, when we have met an objective, or if we should modify it. In evaluating measurability, ask, "What would we monitor to assess progress toward achieving this objective?" For example, we could not determine progress toward "high-quality habitat" or a "high-quality" visitor experience unless we have measurable criteria for "high quality." The nature of the measurable element may vary, as might the difficulty in measuring it. Still, we must have something to indicate progress. While evaluating a water depth objective may only require gauge readings, monitoring a component of vegetative structure may require systematic surveys of vegetation density or composition.

Achievable. Objectives, no matter how measurable or clearly written, must be achievable. If you cannot resolve constraints on achieving an objective, then you must discard or rewrite it. Do not ask more of the land or wildlife than it can deliver, and use sound professional judgment to develop reasonable expectations of time, staff, and funds available to pursue the objective. However, some *apparent* constraints may be surmountable. Consider an objective to reduce refuge contaminants originating off-refuge. Though outside Service authority, this objective may be achievable through partnerships with other Federal agencies, the State, or private stakeholders.

Results-oriented. Objectives should specify an end result. For example, a habitat objective that is results-oriented will provide a detailed description of the desired habitat conditions expected. When reading a results-oriented objective, it should be possible to envision the result of achieving the objective.

Time-fixed. Objectives should indicate the time period during which we will achieve them, so as not to be open-ended. It is acceptable to include a range of completion dates to provide some degree of flexibility. Consider developing an implementation schedule for objectives and/or strategies, perhaps in 5-year increments.

In accordance with the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency's (2008) mitigation rule, *Compensatory Mitigation for Losses of Aquatic Resources,* regulators evaluating wetland mitigation projects should 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 should 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 pre-determined functions or in a manner similar to reference conditions.

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). They should also be explicit about timeframe expectations. Some performance may be expected year 1, other year 3, other year 5 or 20. Most projects require many years to reach potential and mature. Time definitions are critical component of good criteria. However, not all performance standards are appropriate for the evaluation of every wetland restoration project. 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. This is why many wetland restoration experts recommend using reference wetlands to develop standards against which restoration efforts can be evaluated (Pruitt, 2013).

Reference wetlands can be an appropriate tool for measuring the progress of wetland restorations because existing wetlands are more mature than a newly restored site therefore they can be used to set targets for performance and to measure the site's progress along a trajectory. However, it can be difficult to chase a moving target, as reference wetlands will continue to mature and in some areas, healthy reference wetlands no longer exist. Wetland performance criteria are evolving along with our understanding of wetlands.

While the number of potential functions and services provided by wetlands is very broad, they can be combined to fall under a small number of categories. This short list can be categorized into the following: Hydrologic, Soil Bio-geochemical, Habitat, and Landscape. The functions that any particular kind of wetland can provide should be determined and used to set the project goal(s). IBIs can be used to provide overall information on a wetland's condition and at what level it is performing the functions specific to its wetland type. A clear statement of known or expected functions will lead to a solid set of project goals and objectives.

For voluntary projects that require a permit, the goals will help to define the benefits of the project in the permit application, and also its limits. For mitigation and mitigation banks, the "goal" is to replace what was lost, but that should be based on desired functional replacement. For an individual project, it will typically need to include a specific area (acres) but should also include functional goals.

Wetland Taxonomy

For the purposes of wetland restoration, federal, state, and local agencies should collaborate to establish a wetland taxonomy 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, Ecological Site Descriptions (ESD), and stream classification systems can be utilized. The taxonomic 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 that can be used to spatially map those wetland landscapes at all scales. Such a local resource would go a long way toward getting permitters, proponents, and landowners on the "same page". In areas of the US with high quality soil mapping, the definition of type should include the list of soil map units which occur on each type. In fact, there are areas of the US where such a system has been informally adopted, notably in the Prairie Pothole areas of the Dakotas, and the Rainwater Basin region of Nebraska. In both cases, soil map units are correlated to hydrologic regimes, hydrodynamics, and water budget processes. There is remarkable consistency in the high quality of restorations in these areas.

A useful taxonomic system is one that defines a class or sub-class based on its position in the watershed, its morphology, the associated soil types, the dominant water source, plant communities, and the functions supported by that particular wetland. And, ideally, the type identified should be tied to a particular region. With such a system of nomenclature, lessons learned in previous projects and research results can be correlated to all other wetlands 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.

2) Insufficient Monitoring Timeframes

Existing mitigation program regulations and guidelines generally require monitoring to assess wetland restoration only for 3-5 years. For the vast majority of restoration sites, this timeframe is inadequate, particularly for wetland types that develop over a long period of time, such as forested wetlands, bogs and fens. Wetlands are highly variable in the time that it takes to evolve and develop. Short timeframes place pressure on the restoration designers to achieve a mature wetland in 3-5 years, which requires 10, 20 or more years to mature naturally. As a result, 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 or forcing soils to support plant types that have not had time to develop soil microbiology), and the potential impacts of accelerating wetland restoration on ecosystem sustainability are not well understood.

When performance criteria focus on establishment of 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 may feel the necessity to take shortcuts rather than allow the longer, natural succession processes to occur. The consequences of "jump starting" succession are not well understood. A longer process may be critical to building healthy wetland soils that in turn may greatly improve the potential for native wetland vegetation to persist over time and reduce vulnerability to invasive species. For example, 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).

Performance criteria are typically condition-based and therefore motivate design and implementation geared toward achieving a condition, rather than a process that creates and maintains that condition. While all wetlands do depend to some extent on spatially and temporally variable processes for their creation and maintenance, riverine or riparian wetlands are particularly dependent on variable processes. In other words, performance criteria often default to static condition measures, rather than measures of trends or processes, and that promotes design and practice that leads to static, structural outcomes with short-lived benefits. 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 practice, wetland restoration projects 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" faced constraints on control burning, so shrubs and tree saplings dominated large areas until they were hand cut, and wetland weeds were invading portions of the ~16 acres of wetland that receive nutrient-rich stormwater. Restoration is never done (Zedler, Doherty & Rojas, 2014).

RECOMMENDATION: Develop Achievable Performance Criteria for Short Term Evaluation and Establish a Long-Term Management Plan

A number of wetland restoration experts support longer timeframes and/or focusing on one or two objectives for measuring progress in achieving goals rather than attempting to establish late succession plants or peat-rich soils in a relatively short period of time. For example, the Ohio EPA established a 10-year monitoring period for forested wetlands to provide a longer monitoring period. The coastal marsh restoration of the Estuarine Enhancement Program of Public Service Enterprise Group, Inc. (PSEG) planned to monitor restoration for about 12 years (Teal and Peterson, 2007, and references therein), but due to slow development in one marsh, monitoring there is now in its 19th year.

Regulations need to be realistic about the potential outcomes of compensatory mitigation. In reality, mitigation projects rarely fully replace the associated permitted loss of wetlands. Regulations should require effective mitigation based on current science; simply requiring 100% "success" in replacing what was lost is unrealistic – at least in the timeframe of a few years. To suggest otherwise with goal statements is misleading to the public, and encourages false statements regarding project outcomes.

Regarding Policy and Regulations:
The natural world is in constant flux and our knowledge of science and technology continually expands. Regulations need to be regularly reviewed and updated to incorporate best available science and technological advances.

Project proponents may need a judgment of "in compliance" in order to terminate work and a positive evaluation to showcase their projects. Compliance can be judged objectively if there are both clear goals for performance and performance criteria for the level of performance anticipated at the end of the monitoring period. The length of the monitoring period should be determined by the wetland type, condition and project goals. It is important to establish monitoring criteria most likely to indicate a wetland is on a trajectory for meeting the project goals. Historically vegetation is often used as the principal indicator of project performance. A wetland can support native species at the numbers prescribed at the age of three 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 and Zedler, 2008).

Short-term monitoring data can describe initial conditions and suggest a site's potential to sustain itself, and it can describe trends – is the project trending toward desired outcomes, and does short-term monitoring describe processes that will be necessary for long-term value and outcomes? Rather than just achieving objectives in the short term, a project should also *trend* toward desired long-term conditions and processes for creating and maintaining desired conditions. 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). These should be developed using multiple indicators of structure and function that relate to the specific project objectives. Monitoring locations need to be representative of the entire wetland restoration project. Criteria for selection of monitoring sites should ensure that the data collected will provide an assessment of the entire project.

Wetlands cannot reach maturity in 3-5 years. Compliance should be measured by ability to reach specific performance goals that are achievable in the time frame allowed.

It is recommended that practitioners measure progress using quantifiable ecological performance standards where available and required (e.g., Indices of Biotic Integrity, Floristic Quality based on Conservatism Indices, Wetland Indicator Status, and/or hydrologic and soil health criteria). Many state wetland programs have developed their own guides for floristic quality assessments. The U.S. EPA has a webpage which explains how to develop an index of biological integrity here: http://water.epa.gov/type/wetlands/assessment/fact5.cfm. The U.S. Army Corps of Engineers publishes national and regional guidebooks for using the hydrogeomorphic approach for assessing wetland functions - they can be found here: http://el.erdc.usace.army.mil/wetlands/guidebooks.cfm. And the Natural Resources Conservation Service developed Ecological Site Descriptions that provide a consistent framework for describing rangeland and forestland soils and vegetation – information about them can be found here: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/.

Performance criteria should also be written to account for a project's response to low frequency natural events. For instance, a Riverine wetland which has just experienced a 25-yr. peak discharge event can be expected to show evidence of deposition and scour. These sediment cycling processes maintain floodplain macro-topography over time and are critical to the creation and maintenance of riverine wetlands. They also provide new bare surfaces for plant community regeneration, and can even remove older stands of woody vegetation. These features should be expected to dynamically adapt as successive flood events occur. In another case, highly functioning playa wetlands on the High Plains go through an annual dry cycle, to the point where wind blows dry soil to maintain the playa form through wind deflation. Lack of ponding during dry years should be expected to maintain long-term function. And finally, an extreme case is exhibited by high gradient groundwater discharge-fed headwaters in mountainous regions. After a forest fire on the watershed, the entire reach may be covered with large amounts of sediment. As long as the watershed recharge process is intact, the site's groundwater level will adjust to the new surface, and provide the hydrologic conditions needed for re-establishment of hydrophytes and maintenance of the site's function. But this site will look very damaged immediately after the deposition event. When extreme events interfere with site development, extension of a standard monitoring period is appropriate.
Long term maintenance plans/requirements should be developed after the monitoring period has ended in order to ensure that any deviations from the restoration trajectory are identified and resolved. For voluntary restoration projects this can be accomplished through citizen science monitoring efforts. For compensatory restoration projects, some states such as Florida have developed long-term maintenance requirements.

3) Narrowly Focused Regulations & Permit Conditions

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). In general, federal and state dredge and fill permitting regulations were designed primarily in response to projects that destroy wetlands - not those that restore or alter them.

Mitigation is a requirement of permit conditions to avoid, minimize or make up for lost wetland functions due to unavoidable impacts. Wetlands regulations anticipate that wetlands will be restored to provide compensatory mitigation (replacement) of wetlands and wetland functions as a condition of a permit for actions that result in the loss of wetlands (e.g. construction of buildings, roads etc.). Regulatory permitting is designed primarily for determining whether or not a loss of wetlands, and/or other aquatic resources, is approved and what will be done to mitigate for the losses.

In contrast, voluntary restorations are not undertaken in response to a specific loss. Rather, the the goal is to restore a desired condition. 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. Project goals associated with voluntary restoration may include habitat management, flood and storm water management, recreation, water quality improvement and similar objectives. However, most often these goals are associated with local, state, regional, national and/or international wetland or fish and wildlife management plans.

While voluntary wetland restoration is not always subject to state and federal wetland permit requirements, it is quite common for the construction activities associated with voluntary restoration projects to trigger the need for a permit. Many if not most wetland restoration projects have some impact on existing aquatic resources, even though in many instances those resources are degraded. Even where the goal is to provide a net benefit, projects may involve excavation to deepen wetlands, disposal of excavated material (potentially in a wetland), construction of dikes or other water control structures, diversion of the flow from existing waterways, alteration of vegetative communities, or other construction activities in streams and wetlands. These activities can have adverse impacts on other wetland functions – for example, increased use of an area to filter stormwater could have an adverse impact on existing habitat.

Particular project goals may specify a type of project that is not necessarily a restoration to an earlier "historical" wetland type, i.e. wetland establishment (creation) and/or enhancement. Although various definitions exist for restoration and related activities, the authors of this report use the definitions developed by The Federal Geographic Data Committee, Wetlands Subcommittee, composed of several federal agencies – see below:

Restoration: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- *Re-establishment:* the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres.
- *Rehabilitation:* the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions of degraded wetland. Rehabilitation results in a gain in wetland function, but does not result in a gain in wetland acres.

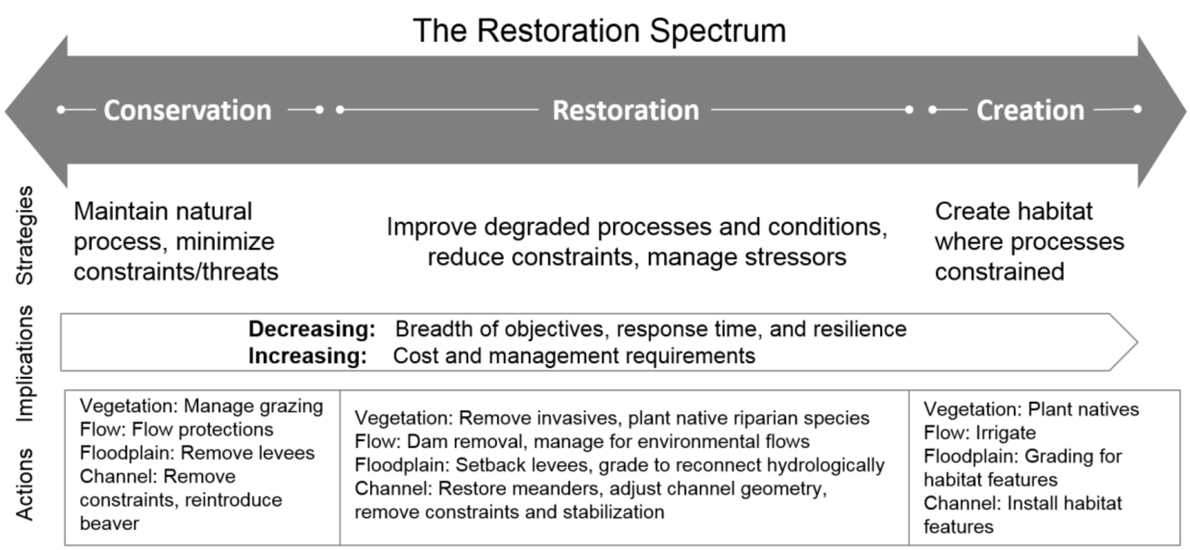
Establishment (Creation): the manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist on an upland or deepwater site. Establishment results in a gain in wetland acres.

Enhancement: the manipulation of the physical, chemical, or biological characteristics of a wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or for a purpose such as water quality improvement, flood water retention or wildlife habitat. Enhancement results in a change in wetland function(s) and can lead to a decline in other wetland function, but does not result in a gain in wetland acres. This term includes activities commonly associated with the terms enhancement, management, manipulation, directed alteration. (U.S. EPA, 2012)

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 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 complicate distinctions between restoration, enhancement and even creation.

Photo Credit: Jeanne Christie

There can be ambiguity in these terms and often these categories have blurry lines – a single project may have elements of restoration, creation and enhancement (see the "restoration spectrum" for riverine restorations below, adapted from Beechie, 2013). And various definitions have been employed (see Natural Resources Conservation Service, 2010, National Research Council, 1992, and Lewis, 1989). The important point is that different project goals will guide the choice of different project types, and may require 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 restorable, especially in their landscape setting and hydrological context (catchment, 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 or potentially the loss of some existing 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. The outcomes of decisions from the discussion and evaluation may further necessitate revised design of the proposed restoration, and/or possible compensatory requirements to offset the change in ecosystem services.



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RECOMMENDATION: Establish Appropriate Performance Criteria Based on Restoration Goals and Project Type

Establish appropriate performance criteria based on project goals and whether the aim is to restore, create, or enhance wetland functions. What is achievable for a wetland restoration project will largely be defined by the landscape constraints and not only by historic wetland type. Enhancement projects should be defined as conscious decisions to increase one or more specific functions, usually at the expense of other functions – these trade-offs need to be fully evaluated. It is very difficult, however, for regulators to evaluate applications for enhancements unless the site is highly degraded. Creation projects should be defined as the establishment of one or more specific functions on a landscape that previously did not support wetland functions.

Voluntary restoration and enhancement projects are evaluated under all pertinent regulatory criteria; however, some provisions typically used for compensatory mitigation are not readily applicable. That is, the specific acreage and functional goals of the project are defined by the project sponsor – not by the need to replace a permitted loss. Regulatory agencies need flexibility to incorporate this distinction when reviewing restoration projects, while still maintaining regulatory requirements. Whatever the purpose of the wetland restoration project is, applicable quantifiable performance goals should be incorporated and appropriate indicators monitored over time to determine if specific objectives have been met. Even in circumstances where a permit is not required, monitoring will help to guide future expenditure of grant or other funds and suggest ways to improve overall outcomes.

Ideally, permitting standards and requirements need 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. In reality, revising regulations can be difficult and time-consuming given differing political perspectives and stakeholder opinions. Nonetheless, parties have a common interest in the fairness and efficiency of the regulatory process, and should agree that revisions are based on current science. Performance standards for mitigation sites require permit holders to achieve certain outcomes. Raising standards for performance criteria could lead planners to aim higher and achieve greater outcomes. The streamlining of voluntary restoration projects is most effective and appropriately applied with interagency coordination and in areas of high degradation, or when only minor alterations are needed to improve existing resource conditions. However, voluntary restoration projects which are improperly designed and located given existing conditions at a particular site may have substantial adverse impacts and may require as much review time as for a development project. Regulatory agencies often retain authority to require adjustments of acreage and functional goals if the project would otherwise result in unacceptable adverse impacts or functional tradeoffs.

Regulations should be reviewed and revised as necessary to reflect advances in science and technology. 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.

4) Altered Landscapes and Changing Land Uses

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

Lack of consideration of the historical, current and projected future landscape context of the proposed restoration site can place projects at risk. 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 detecting tiles can be challenging because there is often no central map or GIS data layer showing where the majority of these 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 site's hydrologic budget including the sources and type of water entering a site (e.g., surface water, groundwater, or both), how it is retained onsite (i.e., is there a clay lens that would effectively drain a historic wetland if it were punctured during construction?), and how it will exit the site (e.g., surface runoff, groundwater, drainage tile, etc.). Similarly soils (on and beneath the surface) need to be analyzed onsite to avoid relying solely on a desktop determination of whether hydric soils are present. While GIS mapping may indicate that hydric soils exist, they may or may not be present at a specific location. In addition they may be compacted or depleted due to long-term cultivation or other intensive land uses.

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 and/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, sending vast quantities of sediment downstream and lowering the water tables. It is essential to understand the land use history, current status and ongoing changes occurring in the landscape where a wetland restoration project will be located and integrate that understanding into its design.

Anthropogenic changes to the landscape may limit the potential to restore a site to its "historical condition." In some situations it may not be possible to restore a site's natural hydrology. Urban wetlands face enormous pressures from development, pollution and abuse. And climate change will make wetland restoration more complicated and challenging into the indefinite future.

Anthropogenic changes to the landscape may limit the potential to restore a site to its "historical condition." In some situations it may not be possible to restore a site's natural hydrology. Urban wetlands face enormous pressures from development, pollution and abuse. And climate change impacts are creating many barriers for wetland restoration that will likely become more complicated and challenging into the indefinite future. Wetland restoration projects will ultimately be shaped by local hydrology, soils and various inputs from the surrounding watershed. Over the course of this project wetland experts repeatedly cited the inability to correctly understand these parameters led to project failure. To learn more about the role of wetland restoration to mitigate and adapt to climate change, as well as the potential negative impacts to wetland from climate change, please go to Appendix G.

RECOMMENDATION: Research the Site's Land Use History and Model Potential Future Stressors Using Historical Trend Data

During the planning and design phase, a thorough assessment of the surrounding landscape's land use history, such as modified streams, drainage tiles and compacted soils, should be incorporated. The amount of buried agricultural drainage in the U.S. is extensive. Tom Biebighauser describes this in his recorded webinar, "A History of Wetland Drainage: How They Pulled the Plug." In it Mr. Biebighauser describes how proficient and innovative early farmers were in building and burying drainage tiles in order to have access to fertile land for agriculture. And in a webinar on "Wetland Restoration in Urban and Highly Disturbed Landscapes," presenter Steven I. Apfelbaum described a former agricultural piece of land that his company was trying to restore that had five layers of historical tile drainage. It is imperative to understand where water is coming from and where it is leaving the project site in order for a restoration project to function properly.

Photo credit: Edwin Ami

The source, timing and volume of water reaching a proposed restoration site as well as the onsite soils must be correctly identified and evaluated. Also, likely future land uses and stressors, such as increasing impervious surface area, invasive species, changing precipitation patterns, extreme events that are more frequent and more intense, and other issues should also be considered and addressed in the wetland restoration design through a "scenario planning" or "alternatives analysis" process. It is important to ensure that the project does not limit future options for upstream, downstream and floodplain restoration. It is equally important to account for the inherent uncertainty associated with natural systems and our imperfect knowledge. Perhaps one of the dominant causes of failure to meet project expectations is that there is not a culture of considering multiple paths or design options. Only few regulatory contexts actually require formal assessment of alternatives or scenarios, but every project will benefit from some degree of assessment of alternative actions, alternative design components, or alternative emphases on the same design components. Similarly, perceived project constraints should be questioned. Often, a project can be improved by removing the constraint instead of planning around it or forcing the project to work with it (e.g., moving a building, obtaining an easement, etc.). These kinds of choices can be explored during an alternative analysis process (Skidmore, et al 2011).

If the project site is located near or in an urban area, a build-out analysis can provide important projections of future land use that may impact the restoration site in the future or possibly make it even more important for various reasons, e.g., stormwater retention, open space, wildlife habitat, etc. A build-out analysis allows stakeholders to see what their community will look like when all available land is developed to the extent allowed under current zoning and regulations. The results of a build-out analysis are typically communicated through maps and charts. (For a good guide on Build-Out Analysis see the Pennsylvania Land Trust Association website conservationtools.org at http://conservationtools.org/guides/42-build-out-analysis.)

5) Separation of Wetland and Stream Restoration

The management, oversight, and regulatory context of wetland and stream restoration are generally carried out separately rather than in combination, resulting in inconsistencies in regulation and practice and some degree of duplication of effort. Riverine and wetland systems, are often adjacent and closely interconnected with each other. Deposition of legacy soils, drainage, stream straightening resulting in stream downcutting (headcuts), the construction of dikes and levees, and multiple other actions have separated streams and wetlands so effectively that they are now rarely considered as connected or related understood as two separate systems. Stream restorationists have their own somewhat common set of stream terminology, available training and available information. Restoration terminologies used by wetland managers do not always parallel or match those used by stream restoration experts. 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 may be managed and restored as a single entity. This partitioning of the landscape can create problems that transcend the issue of wetland "success" or "failure" because a wetland project determined to meet its goals by wetland scientists could have serious negative impacts on nearby stream and floodplain function. Likewise, a stream restoration project may have negative impacts on adjacent wetlands.

Even in the defined discipline of hydrologic engineering, there are two completely different analysis pathways used for the same daily mean flow dataset. For instance, the Natural Resources Conservation Service has technical guidance in their National Engineering Handbook Part 654 – Stream Restoration Design Guide which focuses largely on the analysis of annual peak discharges, geomorphic bankfull flow, and duration flows. In NRCS's National Engineering

Photo Credit: Jeanne Christie

Handbook Part 650, Chapter 19 – Hydrology Analysis for Wetland Determination and Restoration, riverine wetlands are analyzed using probability-duration-frequency relationships. Both techniques use the same mean daily flow dataset. Even with these strictly defined analysis techniques, a hydrologic objective set for wetlands will result in a different outcome than one for streams. The fact is, stream and wetland elements in the watershed are linked, and degradation of one may cause degradation of the other. Perhaps the problem is that objectives for each are based on a small set of functions that led to funding for each project. Management goals defined for streams may conflict with goals for associated wetlands, and vice versa. One example would be impoundment of a cold water trout stream for enhanced waterfowl habitat.

RECOMMENDATION: Use a Watershed Approach

Support for using a watershed approach is widespread (NRC 2001). Time and again a watershed approach is identified as a key to achieving project goals. A wetland, stream, etc., exists within a watershed in a position which can be defined by a large number of well understood parameters. When the watershed positions are identified for one 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. Lessons learned (i.e. how to avoid problems) can then be correlated to where that lesson applies within that area. EPA Region 5 published a Wetlands Supplement titled "Incorporating Wetlands into Watershed Plans" in February 2013. In this publication they highlight six steps for watershed planning shown in Box 1 on pg. 31.

The Environmental Law Institute and the Nature Conservancy also released a publication in 2014 titled, Watershed Approach Handbook: Improving Outcomes and Increasing Benefits Associated with Wetland and Stream Restoration and Protection Projects. In this report, they outline five elements of a watershed approach:

1. Identification of watershed needs, including a determination of how watershed needs identified by various regulatory and non-regulatory programs can inform the watershed approach.
2. Identification of desired outcomes, or the specific and usually measurable results desired in the future. An outcome is a stated desired future condition that will result from undertaking a variety of projects within the watershed. Desired outcomes (e.g., meet water quality standards) provide the goals by which to align and prioritize many types of projects and actions, including wetland and stream restoration projects.
3. Identification of potential project sites, generally based on the ability of wetlands and streams to develop and persist in a particular location. This element focuses on identifying suitable sites that have a high likelihood of providing the desired ecological functions on a sustainable basis, including both intact areas that may warrant protection and degraded areas that may warrant restoration.

4. Assessment of the potential of sites to meet watershed needs, generally through ranking the relative ability of potential protection and restoration sites to support particular ecosystem functions and services that help address one or more established watershed needs.
5. Prioritization of project sites, based on their relative ability to sustain wetland characteristics, address watershed needs, and/or contribute to achieving desired watershed outcomes. Generally, project sites that are more likely to produce more functions and address specific watershed needs should be prioritized over project sites that will provide smaller incremental results. (ELI and TNC, 2014, p. 38.)

6) Underestimation of Restoration Costs

Restoration costs are frequently underestimated, particularly 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 in order to expedite the release of credits (in the case of mitigation) or because funding may be limited (in the case of a voluntary restoration project). Regulated entities commonly seek to reduce both the time frame and parameters for monitoring. There is also very little information available to compare restoration costs from site to site or by wetland type so that reasonable cost estimates may be developed. When funding is inadequate, resources are not available to address project shortcomings.

This can be exacerbated by mitigation banking practices that drive credit prices down to where they can really only pay for the simplest of restoration. For example, when mitigation occurs on a piece of private property that is easily restored and heavily subsidized by the private landowners, mitigation credits may be available at an extremely low price. However, credits at these prices are not sufficient to cover the cost to restore higher order river systems or higher priority restoration projects that are conceived for mitigation projects by In-Lieu Fee sponsors. On the other hand, when mitigation banks are allowed to charge exorbitant rates it can also create barriers for wetland restoration efforts. For example, there have been instances where banks have cost little to construct, but have charged high fees – well beyond the cost to restore the site.

Accurate cost estimates are important for budgeting to cover all anticipated project costs, including monitoring and reporting. The lack of accurate budgeting has led to many projects being underfunded. This underfunding leads to early termination of long term monitoring and reporting. Lack of reporting on the full range of results limits the lessons that can be learned. Thus routine mistakes in design and construction are repeated.

Additional costs may include a required alternatives analysis that could add 5-10% to design cost, but would also likely reduce risk and risk-related costs. An alternatives analysis moves practitioners away from the practice of just coming up with what they think is best, forces them to be more analytical about finding the best solution, and holds them accountable to a cost comparison of different approaches.

BOX 1: Five Steps for Watershed Planning
(Source: EPA Region 5 Wetlands Supplement: Incorporating Wetlands Into Watershed Planning)

Planning
1) Build partnerships
    - Identify issues of concern
    - Set preliminary goals
    - Develop indicators
    - Conduct public outreach
2) Characterize the watershed
    - Gather existing data and create a watershed inventory
    - Identify data gaps and collect additional data if needed
    - Analyze data
    - Identify causes and sources of pollution that need to be controlled
    - Estimate pollutant loads
3) Finalize goals and identify solutions
    - Set overall goals and management objectives
    - Develop indicators/targets
    - Determine load reductions needed
    - Identify critical areas
    - Develop management measures to achieve goals

Implementation
4) Design implementation program
    - Develop an implementation schedule
    - Develop interim milestones to track implementation or management measures
    - Develop criteria to measure progress towards meeting watershed goals
    - Develop monitoring component
    - Develop information/education component
    - Develop evaluation process
    - Identify technical and financial assistance needed to implement plan
    - Assign responsibility for reviewing and revising the plan

Monitoring
5) Implement watershed plan
    - Implement management strategies
    - Conduct monitoring
    - Conduct information/education activities

Long-Term Management
6) Measure progress and make adjustments
    - Review and evaluate information
    - Share results
    - Prepare annual work plans
    - Report back to stakeholders and others
    - Make adjustments to program

On a related note, 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 individual company, 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, clean water, storm surge protection, etc.). This can lead to skewed cost-benefit analysis results for decisions about whether or not to fund a wetland restoration project and/or to pursue a robust monitoring strategy to evaluate performance and employ adaptive management as needed during and after construction.

RECOMMENDATION: Include Pre and Post-Construction Costs in Estimates

According to Roy R. "Robin" Lewis, III (Lewis Environmental Services, Inc. and Coastal Resources Group, Inc.), pre and post-implementation costs, including baseline data acquisition, long-term monitoring, adaptive management measures, and reporting, are generally around 35-50% of the total costs for a wetland restoration (see Box 2 on pages 29). This amount should be added to the estimated construction costs in order to more fully capture the overall costs of the project. Report and share information about current restoration costs with others to aide in better future estimations.

The Nature Conservancy has recently released a new resource called the "Stewardship Calculatorand Handbook" to assist practitioners with estimating long-term stewardship costs. The use of tools like this, as well as the development of similar simple and free tools to help develop estimated restoration costs, would go a long way to improve the accuracy of cost estimates as well as provide greater financial support for long-term maintenance activities.

Additionally, mitigation agencies should ensure that mitigation ratios reflect the costs of transferring mitigation from one wetland type. Mitigation oversight agencies should use cost and pricing data as part of the mitigation ratio determination when allowing mitigation that is not in-kind with the wetland type impacted.

Box 2: Cost Estimate Case Study

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 their calculations of typical wetland restoration costs nor the percentage of total costs for various

Box 2: continued

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 accounting of 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 one could estimate other costs when they were not available as 35% 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 documents, information regarding methods for seagrass restoration lacked 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) were 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/sq ft., 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) were 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), based on information from reviewing monito ring reports or interview responses, found that for nine (9) mangrove restoration projects located in the Florida Keys the cost on a per square foot restored basis ranged 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?

7) Lack Of An Adaptive Management Framework

Using a "cookbook approach" to wetland restoration does not work. The future world is uncertain and ecological systems have significantly different variables that regulate their development and functions. Every wetland is unique.

A thorough consideration of the ecosystem to be restored is critical and although proven techniques may be employed, there will always be the potential for unforeseen responses. With any restoration project, there is uncertainty about whether it will work, and there is additional uncertainty about the future and how it will affect the project. If one does not anticipate uncertainty (which is increasing with climate change) it will be much more difficult to respond to unexpected results when they occur, nonetheless recognize them when they occur (Hilderbrand, Watts & Randle, 2005). For instance, if a portion of a recently restored wetland is ignored because the rest of the project is not completed, invasive plant species can begin to take hold. Waiting until the project is finished is too late. If the invasive plant species are treated immediately, it can be a small job but waiting for any period of time will make the job much bigger and, if put off too long, it may become impossible to address without incurring substantial expense. Not detecting problems related to hydrology and biotic recovery often leads to insurmountable problems. Experimentation and monitoring are necessary to ensure that the wetland restoration is on a trajectory toward mature growth. Decision making should be linked to monitoring results.

RECOMMENDATION: Use an Adaptive Management Approach Throughout the Life of the Project

Adaptive Management is a science-based program wherein decision-makers identify and prioritize the uncertainties they face in managing natural resources, then reduce uncertainty through monitoring and research, and feed the results back to reconsider decisions. Hypothesis-driven field experiments test alternative restoration actions, and outcomes indicate which approach to implement more widely. The most effective field studies also indicate how and why the "best approach" achieves more restoration objectives than other approaches. (Zedler, 2017)

Adaptive management should be incorporated into every step of the process – from planning to design, through construction, completion and long-term management. 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). Without some form of an 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)

It is important to include procedures and a framework for adaptive management at the very beginning of the project during pre-design discussions. Adaptive management should start with clearly articulated SMART objectives and performance criteria and a monitoring plan that is directly tied to those objectives (see pages 15-16). The SMART objectives that are developed should lead to appropriate performance criteria and monitoring protocols. Part of an adaptive management framework includes consideration that the project site's conditions and performance may deviate from the original plan due to circumstances beyond anyone's control. Many of these deviations can be planned for at the beginning if informed by an alternatives analysis and/or scenario modeling exercise. Corrective measures or contingency plans created ahead of time will reduce uncertainty and therefore the additional expenses and time required to attain stated objectives. The graphic on page 35 is a good illustration of the steps involved in an adaptive management framework.

Construction documents should identify critical constraints that could have significant negative impact on the project performance and either rule them out or provide an alternative if the proper timing or methods are not feasible. Many factors may delay initiation of construction, which will then affect the seasons and conditions for construction activities. For instance, the correct season for construction activities should be specified, e.g., earthwork operations and placement of soils should not occur where saturated or frozen soils would negatively affect grades and soil compaction. Optimal times for seeding and planting should be clearly defined, and alternative measures should be included in the construction notes or specifications to address delays that will negatively affect plant establishment.

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At the end of the construction phase, the project proponents and the contractor should agree that the job is done, and the project is formally accepted. As-Built conditions should be described at this time. Afterwards, the project moves into an operations phase when two new, but separate activities take place: operations and maintenance, and monitoring. The distinction is important, however. Operations and management include activities that remediate the degraded physical structure(s) of the restoration, while monitoring activities track the ability of the project to provide physical, biological and/or chemical functions that are supported by the physical structure.

Operation and maintenance (O&M) 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 of plant propagules. If seeds and/or plantings have not established properly, this determination is made as an O&M activity, and remedial actions taken and implemented. For mitigation banks or other projects authorized under a permit, O&M requirements may be included as permit conditions.

Monitoring is an assessment of the development of wetland functions, and it provides a measurement of progress towards meeting performance criteria. 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 remedial action before failure occurs. O&M inspections and monitoring can and should be conducted at the same time.

As part of adaptive management, it is important to assess the reasons that performance criteria are not met. Inability to achieve goals due to improper O&M does not mean that the project had improper planning and design, and does not mean that a similar project should be planned differently. However, unmet objectives of a properly maintained project may mean that the objectives and performancecriteria were poorly determined. In short, reasons should be assigned to either inadequate operation and maintenance, or unsuitable performance criteria. Either may result in required remedial action to meet permit conditions, for projects that are designed to meet mitigation requirements.

8) Lack of Accountability

There is no certification or list of coursework and skills required specifically for wetland restoration practitioners. In essence, anyone can hang out a shingle and call themselves a wetland restoration professional. Those hiring wetland restoration professionals may know little about the skills needed and will have difficulty evaluating the “expert’s” level of knowledge and competence. From the information available, it appears 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 not meeting performance criteria and because information to refine and improve skills is hard to access or unavailable, as discussed earlier.

Monitoring and enforcement of performance standards are necessary to improve wetland restoration outcomes. However, there is widespread concern among wetland restoration professionals that monitoring and assessment reports rarely result 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 address performance shortcomings.

While regulatory agencies may have a stronger hook in the context of Clean Water Act (CWA) sections 404 or 401 authorizations to compel corrections to unmet restoration goals, it is more difficult to require grant recipients under CWA section 319 (or some other grant program) to correct restoration sites that do not meet goals and objectives identified in the grant proposal. Other areas of professional practice require performance standards to be met. For example, if an engineer designs a road and it washes out after construction, the contractor is liable for damages if he or she didn't follow the construction specifications, or the engineer is liable if there was an error in design. But there is no parallel procedure to assign liability for a restored wetland that doesn't meet performance criteria to recoup the cost of the inadequate restoration or the loss of wetland functions.

Monitoring reports are usually provided by the permit applicant. Often 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 it. In order to impose accountability, both on practitioners and regulators, regulatory and/or funding agencies need to develop and make available to the public institutional records to track the status of wetland projects over the long run. Many voluntary restoration projects may not require dredge and fill permits, but there are other reasons to monitor performance outcomes, particularly if public funds are provided for the project.

RECOMMENDATION: Require Documentation of Credentials, Provide Incentives and Enforce Accountability

Restoration practitioners are currently not held to common professional standards and expectations. Wetland restoration performance would likely improve if regulatory agencies provided a method of assessing competency such as precertification for qualified wetland restoration practitioners, including designers, and a list of credential requirements for applicants to use in selecting qualified experts. For example, regulators could require examples of projects that achieved goals, evidence of skills in site assessment, proficiency in providing hydrographs of baseline hydrology and hydrological targets and require As-Built conditions of the completed project for use as baseline monitoring for performance objectives. Wetland professionals should be able to implement adaptive management responses (specifying who reviews monitoring data and reports, who calls meetings, and how mid-course corrections will be funded). Professionals should also be able to demonstrate how adaptive management efforts changed the original site plan and subsequent monitoring methods.

Professionals should also be required to provide an assessment of alternatives and a scenario analysis in order to demonstrate competancy. Three or four alternatives compared by their probability of meeting each SMART (specific, measureable, attainable, relevant, trackable) objective or performance criterion, their cost, potential adverse impacts and tradeoffs, and their risks serves to justify a selected alternative and provides opportunity for all stakeholders to have their interests evaluated.

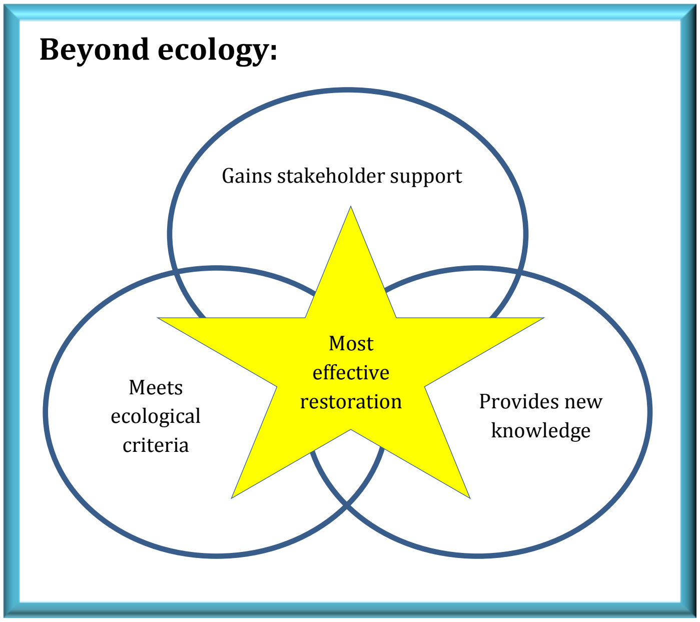
Projects often require expertise in several disciplines, including soils, hydrology, wildlife habitat, water quality, botany, and others. Each discipline has specific professional organizations. Many scientific and professional organizations provide certification and recognition in specific aspects of their disciplines, but none recognize a certification that is specific to wetland restoration. Ideally, Federal and/or State agencies contacts would be made with pertinent professional societies to seek the development of certifications specific to wetland practice.

Federal and state agencies can provide monetary incentives for permit applicants to achieve quantifiable ecological performance standards by requiring that bonds are not released unless goals are met, i.e., monitoring reports document that performance criteria have been achieved. Agencies should not release non-performing bank credits or release bonds or other guarantees for under achieving permittee-responsible mitigation of wetlands if there is poor performance. A few states are already doing this. In Michigan, this process was found to be effective, but also time consuming. States should anticipate that administrative staff time will be needed to track performance bonds or letters of credit, submittal and approval of monitoring reports and so on for hundreds of authorized mitigation projects over a period of years. Field staff site inspections are also needed prior to release of funds.

Although criteria are project specific, a standardized format will assist in monitoring, reporting, and evaluation of compliance by the regulatory agency, as well as facilitating gathering of data and overall program evaluation. For example: if you have a set of standardized hydrologic criteria (depth, depth to groundwater, days of inundation, etc.) that are used for all projects, but then insert the specific criteria for a specific project, you have information that can be readily report, compiled, and compared. It is a balancing act between standardization and specificity. Many projects also call for very specific criteria based on individual aspects (e.g. monitoring of a particular rare plant on the project site).

9) Limited Access to Expertise, Training and Knowledge Sharing

One of the challenges that impede wetland restoration is limited access to expertise, training and knowledge sharing. The good news is, considerable knowledge exists to restore wetlands to meet performance criteria and project goals. But there are barriers to gaining access to research, training and acquiring the needed expertise. These include prohibitive costs for access to academic journals, insufficient time to review the literature, a lack of studies in wetland restoration science, a lack of training opportunities for practicing professionals, a lack of access to information about performance of wetlands previously restored, and a lack of interdisciplinary teamwork and knowledge sharing.



Inadequate access to knowledge and insufficient training opportunities in many parts of the country, including a lack of any central data portal or portals for case studies, data and other resources, impacts both the practitioners undertaking the restorations and the regulators tasked with review and approval of projects. Learning opportunities can also be hindered by strained budgets for federal, state and tribal agencies in water and wetlands programs which have generally experienced decreases in funding in recent years (Zollitsch & Christie, 2015). In-the-field trainings can be cost-prohibitive as can certain online learning opportunities such as online courses and webinars by corporate and educational institutions. Travel and lodging expenses add an additional cost burden to those who wish to participate in field trainings and/or knowledge sharing events such as conferences and workshops.

Professionals need access to review and learn about others' efforts in order to improve their own practices and avoid common mistakes. As mentioned previously, the expense of subscribing to journals prevents many practitioners from accessing important studies. The lag time between when research is performed and an article gets published creates significant delays in making important research findings available. And it is challenging 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 discussing management implications or making recommendations on best practices. (Cvitanovic, et al. 2014).

Given sufficient investment in time and labor for monitoring and reporting, it would be possible to review information available in these monitoring reports to evaluate common challenges and solutions to wetland restoration projects. The development of a regional "data bank" could provide this information. Currently the lack of a regional depository for monitoring data and reports limits an important opportunity for many practitioners to learn 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. Although there are many thousands of acres of wetland restoration/mitigation completed, or in process, generally monitoring and reporting information is not readily available. In some cases, such as when monitoring reports are submitted to meet permitting requirements, they may be subject to confidentiality provisions, or the database where the information is stored may need to be secure to protect confidential information. The issue of confidentiality needs to be addressed while finding ways to make monitoring data available and usable to inform future projects.

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, rather than improving performance, they will have the opposite effect. As a result, some projects are overdesigned or ignore crucial elements. (Fejtek, et al. 2014; Gardner, Maynard, Price and Fischenich, 2014; Seijger, van Tatenhove, Dewulf and Otter, 2013) For example, Florida requires that Professional Engineers seal all drawings for their Environmental Resource Permits, including those showing plant species and installation requirements for mitigation. There is no requirement to use a Professional Wetland Scientist, Professional Landscape Architect or other ecological professional. If appropriate disciplines are not included in the restoration project it can lead to mistakes in wetland restoration design and implementation.

RECOMMENDATION: Improve Access to Knowledge and Training and Engage Multi-Disciplinary Interdisciplinary Teams

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.

Peer-to-peer knowledge sharing can be very effective. Some states have wetland restoration workgroups in which state (including wildlife agencies), federal (including NRCS, USFWS), local, and non-government organizations (i.e., Ducks Unlimited, the Nature Conservancy) staffs collaborate and share information. In Michigan, for example, these groups have recommended regulatory performance standards, agreed on the content of permit applications, and organized pre-application site inspections for voluntary restoration projects to identify goals and issues. In short, knowledge sharing involves active open and ongoing collaboration among regulatory staff, scientists, academics, practitioners and more.

There is also an ongoing need for academic programs that provide specialized curriculums for wetland restoration professionals. For example, 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.

Academic programs need to provide comprehensive curricula for aspiring wetland restorationists and workshops to enhance skills of current practitioners.

Training is also essential for those who are involved in regulatory review and oversight, as well as those professionals tasked with management of voluntary restoration programs. This includes work done through local, state, tribal and federal government programs and non-governmental organizations. Ideally, an interdisciplinary team of collaborators could provide training, followed by on-the-ground experience in wetland restoration. Training can also be provided by experienced individuals actively involved in wetland restoration and mitigation activities. With appropriate training, federal and state agency staff can provide better direction on 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.

Where available, educators should provide training in accessing and using comprehensive GIS data layers such as 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. The soil survey alone includes valuable information about water budgets, hydrodynamics, bio-geochemical functions, vegetation, and other attributes which are critical to understanding wetland processes. Elevation data are critical to carrying out LLWW (landscape position, landform, water flow path, and waterbody type) evaluations – determining direction of water flow remotely. And historical land cover inventories can guide voluntary restoration and help to define needs and goals. Unfortunately the knowledge needed to fully utilize this and other GIS layers in wetland restoration information is often lacking. The provision of user friendly access to portals of GIS data or map viewers, and ongoing tech support can help address this knowledge gap.

There are also some non-traditional training opportunities. The EPA's National Wetland Condition Assessment, a nationwide survey of the ecologic condition of the nation's wetlands, included field training for states on the knowledge and field expertise required for effectively monitoring and assessing wetland health to gather data for the national assessment. Many state, federal and private sector scientists were engaged in the conduct of the 2011 survey and the 2016 survey. Such unique partnership opportunities can address aspects of the knowledgebase by building technical capacity and contributing to the development of new wetland science tools and techniques.

Providing free access to science and research via open-source portals and repositories will also improve knowledge transfer. In addition, restoration scientists need to indicate the management implications of their research and the specific wetland type(s) that could benefit from new approaches. Science-based advice also needs to be provided in user-friendly language. As recommended above, regional depositories for monitoring data and reports need to be created although data security needs need to be addressed. Information about how to improve wetland restoration projects is located in many places. For example, Work Group member Robin Lewis has established a website on how to restore mangroves at www.mangroverestoration.com.

Open access regional depositories for monitoring data and reports are needed.

It is also unrealistic for one individual or one discipline 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 hydrology, hydric soils or technical understanding of the design, bid and construction process) can result in a poor design and implementation. For example, one wetland staffer would not have the expertise to do a comprehensive site visit without the landowner, a biologist, and an engineer (potentially among others) all onsite together. Each has unique expertise to contribute. Large projects may also require a soils scientist, an ecological landscape architect and additional expertise as well to design a project that will meet performance criteria.

Also, 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 needs to support collaboration internally, encourage interaction between disciplines and stakeholders (e.g., engineering and ecology), and develop relationships with NGO's, contractors and suppliers. The use of an integrated planning process and decision-support tools for education, outreach, engagement, support can be beneficial for communication and scenario planning. For example, some states have developed GIS based tools to prioritize wetland restoration sites such as the Restorable Wetland Prioritization Tool in Minnesota and the Wetland Protection and Restoration Prioritization Tools developed by The Nature Conservancy for Wisconsin. The Environmental Law Institute also published "A Handbook for Prioritizing Wetland and Stream, Restoration and Protection Using Landscape Analysis Tools" that supports the use of a watershed approach to site selection based on its ability to meet one or more objectives. Depending on project goals and the complexity, interdisciplinary teams should include members with knowledge and experience in hydrology, soils, plant communities, fish and wildlife, and water quality.

The make-up of a restoration team is important. Better outcomes will result with a multi-disciplinary, integrated team.

On a regional level it is useful to establish collaboration among state, federal, and local agencies which are independently conducting projects for wetland restoration, assessment and classification. Although in some states, there has been significant collaboration and knowledge sharing, in many cases, separate efforts are being conducted independently in the same region, and on the same landscape.

The U.S.D.A Forest Service has a Collaborative Forest Landscape Restoration Program (CFLR) is a model for others who are interested in developing a collaborative approach including stakeholders. In their publication "Breaking Barriers, Building Bridges: Collaborative Forest Landscape Restoration Handbook" they identify four general perspectives that are typically involved in a collaborative restoration project: 1) scientific, 2) systems, 3) cultural, and 4) personal (Egan & Dubay, 2014).

Riley, Steinfeld, Winn and Lucas (2015) speak to the benefit of an integrated and collaborative approach in native plant restoration efforts for highly disturbed sites:

> Collaboration between the revegetation specialist, project engineers, and contractors during construction activities assures that the revegetation plan is understood and implemented appropriately on the ground. Through this collaboration, a timeline is created to incorporate revegetation activities at the appropriate phases of construction to increase the chances of revegetation success. When project construction begins, the revegetation specialist is available to consult on contract specifications, including placement of salvaged topsoil, soil treatments, and temporary/permanent erosion control measures. The specialist can also evaluate the quality of the material sources, such as topsoil, mulch, and erosion control products, to prevent the introduction of invasive weed seeds. As changes occur, the revegetation specialist and engineers work together to assure that the revegetation plans are modified appropriately. (p. 47)

In an online search conducted by the Association of State Wetland Managers, very little was found for information regarding collaboration techniques for restoration projects as a primary subject. Much of the literature available online speaks to research collaboration, but not hands-on field projects. The Forest Service's CFLR, however, has a diagram (see Box 3 below) for their collaborative monitoring process and much of the information can be applied to various steps in wetland restoration as well.

There are many publications available online, however, for the healthcare field, and in one such publication they provide a useful list of important teamwork components:

- Open communication
- Nonpunitive environment
- Clear direction
- Clear and known roles and tasks for team members
- Respectful atmosphere
- Shared responsibility for team integration

- Appropriate balance of member participation for the task at hand
- Acknowledgment and processing of conflict
- Clear specifications regarding authority and accountability
- Clear and known decisionmaking procedures
- Regular and routine communication and information sharing
- Enabling environment, including access to needed resources
- Mechanism to evaluate outcomes and adjust accordingly

(O'Daniel & Rosenstein, 2008)

BOX 3: Overview of CFLR Multiparty Monitoring Process

Hold Multiparty Meeting - Identify common goals adn monitoring concerns for the p roject. Construct communications framework outlining information transfer between project stakeholders.

Develop Monitoring Plan - Describe indicators to measure change built on reliable data collection methods. Specifically address where, when, and who will gather project data.

Gather Data - Collect pre-treatment measures, repeated measrues, to determine post-treatment progress. Ensure data are kept in a long-term safe place.

Analyze Results - Conduct reliable and simple calculations on data from local, regional, and national perspectives. Schedule multiparty team meetings to discuss and interpret results.

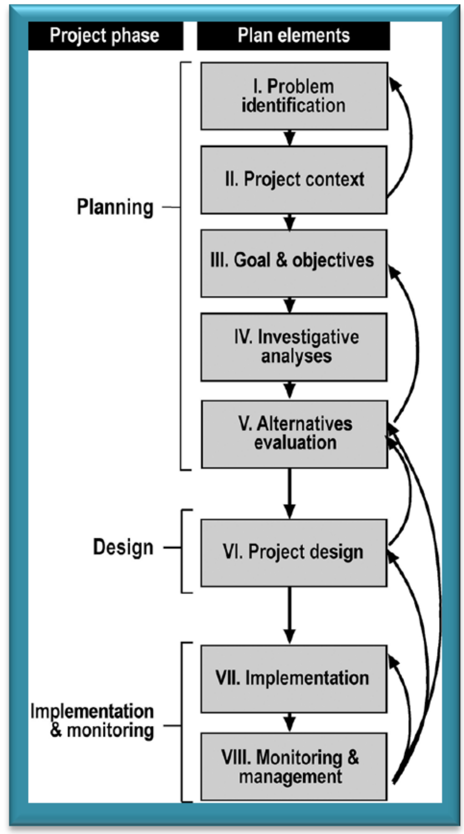
Share Results - Keep process transparent, adaptive, and flexible. Suggest tangible prescriptions, when new information becomes available. Report results illustrating criteria that were and were not met.

As important as formal collaboration is informal collaboration. Information collaboration is encouraged by identifying expertise in various disciplines and opening lines of communication among agencies and organizations. Knowing whom to contact with a particular issue and getting their expert advice can make a huge difference in outcomes. A network of agencies and organizations that provide mutual support for one another is critical when working with wetlands. The Association of State Wetland Managers provides this on the national level.

PRIMARY BARRIERS BY PROJECT PHASE

Common barriers to effective restoration are often associated with particular phases of a project. The issues described below may mirror some of the previous challenges, but this section describes the challenges that must be met through each phase of an individual restoration project. Addressing these successfully is dependent on the expertise and experience of the different professionals who carry out a project - from wetland scientists to heavy equipment operators.

These barriers need to be addressed in order to improve wetland restoration. Thoughtful planning and design is a crucial first step for any wetland restoration project. So is bidding out a project to hire competent heavy equipment operators. While there is no one method that is universally accepted in the design and construction professional community, often phases and descriptions are standardized. Sometimes the phases are dictated by the reviewing agency or municipality. Other times they are left to the discretion of the design team. Regardless, adaptive measures are often required at many stages during the development and implementation of a restoration project. Skidmore, et al (2013), outline the three project phases as shown in the box on the right.



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1) Planning

The planning phase can include resource inventory, site selection, assessment of current site conditions and potential stressors, setting goals and objectives, budgeting, permitting and conceptual designs. The following mistakes outlined below are important to consider in planning.

a) Poor Site Selection

Wetlands are a component of watersheds and different positions in the watershed support different wetland types. Too often, 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 restore wetlands, but rather on which land is available, has the lowest costs and has willing sellers or funding program participants. If the wrong type of wetland is planned for a landscape position, some or all criteria will not be met. If the watershed position of the wetland site is correctly identified, the wetland restoration project can be expected to provide functions similar to other wetlands with the same landscape position 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 that 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 four distinct types of Prairie Pothole wetlands that 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 by the floodplain landforms on which they exist.

b) Inadequate Assessment of Hydrology

It is important to plan a hydro-period that is within the capability of the site. This requires an understanding of 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? evapo-transpiration?). Historically, there was a tendency to maximize the depth and duration of water rather than allow for areas that are only saturated, in part due to misunderstood hydrology and not wanting to end up with too dry or too small of a project footprint. Also, missing the target of a certain depth of standing water is less serious (since there is likely to be some water) than missing the target of a more sensitive spring hydroperiod followed by summer drawdown. Such a hydroperiod target left one mitigation bank site unable to meet vegetation criteria during a series of dry years (R. Novitzke, pers. comm. to J. Zedler). Hydrologic sources with polluted water feeding a restored wetland can also limit restoration potential.

Photo Credit: Jeanne Christie

All wetlands receive and store water, and most types deliver that water to downstream reaches in the local 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. Wetland hydrology can be complex. For example some wetlands can receive groundwater during wet periods and recharge groundwater during dry periods. 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 it. The 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 won't meet performance criteria.

The assessment of water quality is also important in setting objectives. Samples from surface inflow and groundwater discharge represent inputs to the wetland. The quality of surface water or soil stored water within the wetland may differ from that of the inflows. For example, 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 measuring water in storage. If the project purpose is on-site wildlife habitat, high nutrient levels might be incompatible with restoring a desired habitat. For example, a species-rich meadow fed by high-nutrient storage water would likely shift to an invasive monotype, precluding high native-plant diversity.

c) Failure to Fully Assess and Plan Substrate Conditions

Virtually 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 recharge ground water but does support surface water storage. In another case, the presence of a shallow compaction layer may prevent the entry of water to the deep profile, reducing the soil storage needed to maintain a saturated wetland. In many cases, a lack of understanding of soil hydrodynamics can lead to unexpected outcomes.

Failure to fully assess and plan for soils (avoiding compaction, identifying the need for soil amendments, detecting deep impervious or pervious layers) can lead to poor outcomes. While desktop screening for hydric soils, or soils with hydric inclusions, is a necessary first step, on site sampling including test pits should be conducted to assess site suitability for wetland restoration and identify potential risks. Excessive excavation and grading activities can significantly disrupt soil profiles. This can render the top soil layer deficient in organic matter and nutrients that are essential to establishing a healthy plant community.

In some locations, soils also need to be evaluated for the presence of toxins and/or pesticide residues, and risks need to be carefully evaluated. For example, the restoration of pre-existing marshland around Lake Apopka in Florida in the late nineties resulted in a significant bird die-off. When the land was purchased, it was known that it included an unknown quantity of pesticide residues that might pose a risk to wildlife. Twenty thousand tons of contaminated soils were removed. However, the environmental risk assessment indicated that some pesticide residues remained, including DDT and its metabolites, which were of concern for piscivorous birds. Regardless, the old farm fields in the North Shore were flooded, and the subsequent arrival of birds was seen as a "success" until more than 1,000 birds perished. The birds were poisoned when they ate fish on the former farmlands north of Lake Apopka that had been flooded with lake water (Industrial Economics, 2004).

d) Inappropriate Plant Selection

Many restoration criteria focus on a specific number and density of plant species. Unfortunately, some project designers may select plants unsuitable to the site or allow cultivars. According to 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).

However, it may be difficult to define and obtain "purely native" plants through native plant commercial sources. There are some arguments in the native plant supply industry about what constitutes a "native" plant, if the species is known to freely hybridize in nature (e.g., *Vaccinium corybosum*). There are also many challenges to restoring native plant communities with shifting plants zones due to climate change, as well as the stressors that impact restoration projects near altered agricultural and urban landscapes. Anticipated natural succession, where relevant, should also be taken into consideration in plant selection.

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 in a "seed wall" or within the existing soil's "seed bank" may be adequate for revegetation. . If invasive species are a concern, then sowing an annual cover crop and planting vegetative "plugs" along with follow up control measures may discourage the spread of invaders and allow desirable plants to colonize. In the majority of cases, however, sites require seeding and planting, sometimes at high densities to assure the establishment of desired plant communities that can compete with invasive species.

Selecting appropriate plants for the specific wetland type is critical but desirable plants will persist over time only if the hydrology and soils are correct for the desired wetland. While plants are the primary focus of performance criteria because they are the above ground manifestation of a wetland's performance, but plants might not persist beyond the typical 3-5 year post construction monitoring period. Hydrology and soil criteria are far more important to ensure long term performance when combined with proper plant selection and a design that includes proven methodologies to support plant establishment.

2) Design

Many wetland restoration designs and executions are inadequate to achieve desired outcomes for reasons discussed in detail in previous sections. Often, considerable expertise is needed to identify problems that are likely to occur and ensure a well thought out design is developed. As discussed previously, it is important to ensure that the wetland professional and/or interdisciplinary team working on the design has the necessary expertise.

The design phase is not a stand-alone linear process – but often has several sub-phases, such as conceptual design, preliminary design development, final design, construction documentation, and bid phase – all of which should include an evaluation of whether the design is meeting the goals and objectives set up during the planning phase and whether the goals and objectives should be revised or adapted to meet additional findings discovered during design.

The design phase should address the development of a sequenced construction process: the establishment of site access; protection of sensitive systems and features, such as streams; installation of erosion control measures and Best Management Practices (BMPs); grading plans that guide earthwork removal and soil restoration activities; planting and seeding plans (site revegetation); a list of estimated quantities; construction notes; boiler plate contract items and construction specifications for a contractor to carry out the plan.

Recommendations for Planning and Design Phases

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 (performance criteria) will be determined. Depending on the scale, complexity, and nature of the project, baseline studies should be performed and stakeholder groups should be identified and engaged. The amount of public involvement and complexity of steps taken should be shaped by the scale of the project, use of public funds, and the potential for either positive or negative impacts on public water resources. For larger projects in particular, facilitated discussions need to take place to assess stakeholder desires and concerns and to provide decision-makers and stakeholders with information, maps, designs and projections in order to analyze comprehensive trade-off scenarios and make well-informed choices. A scientifically based restoration design that accounts for the surrounding landscape, water budget and watershed priorities is integral to producing desired outcomes. For complex projects, an experienced, collaborative multi-disciplinary (integrated) wetland restoration team involved from beginning through to completion is a well-established method that greatly improves the likelihood of achieving project performance standards and budget goals.

Restoration objectives and the evaluation of outcomes 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. Additional information on vegetation or other biota using IBIs that indicates the project is high quality ensure the suite of functions particular to the wetland type are being performed at high levels. Also, it is important to clearly articulate the goals of the project as that will determine whether or not it should be designed as a wetland restoration, enhancement, or creation.

Below is a list of actions that, if implemented correctly, are likely to lead to improved restoration outcomes.

1) **Site evaluation and selection**
   - ✓ Focus on restoring areas that were once wetlands or restoring the hydrologic function of stream reaches that supported those wetlands, instead of creating wetlands in uplands.
   - ✓ Establish current hydrography and conceptual target hydrography by using an analog, historic or constructed reference condition taking into account recent changes in the larger watershed.
     - Select appropriate hydrogeomorphic (HGM) setting.
     - Match hydro-periods to wetlands appropriate for the sites. Is the source of water surface, or groundwater, or both? Evaluate the soils onsite.
   - ✓ 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.
   - ✓ Analyze current and potential future land use practices at multiple scales (e.g., watershed or wetland area) within the catchment of the restoration site.
   - ✓ 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[1] are present or can be restored or where the intensity of other surrounding land uses is low. In other words, make sure the proximity to stressors (i.e., soil compaction, vegetation removal, development) is minimized.
   - ✓ Match objectives with landscape position in the local watershed: identify the hydro-geomorphic wetland class appropriate to project; identify appropriate wetland type by location with respect to watershed stream order.
   - ✓ An early site visit with regulatory staff might be advised before final site selection and purchase.

[1] The New Hampshire Office of Energy and Planning (Chase, et al. 1995) define a wetland buffer as "A naturally vegetated upland area adjacent to a wetland or surface water" (p.7) And the Washington State Department of Ecology (Castelle, et al., 1992) defines wetland buffers as "areas that surround a wetland and reduce adverse impacts to wetland functions and values from adjacent development. Wetland buffers can include both upland and aquatic areas contiguous with a wetland edge…" (p.3). The types of buffers used will depend on the context of the site.

2) **Design**

Collaboration and communication

✓ Hold pre-application meetings with permit staff, & understanding regulatory issues early in the process while design changes can be more readily made, will avoid roadblocks during the permitting process.

✓ Make early contact with regulatory staff for projects that may be controversial, complex, or involve significant alteration of current resources (e.g. dam removal, conversion of forested wetlands).

✓ Collaborate to problem-solve and vision strategies. Include qualified professionals of needed disciplines on the team to develop strategies that meet budget goals and are feasible to build.

✓ Strategize on ways to include local businesses, labor forces, community groups for construction and stewardship. Create designs that have visual order in developed areas where the community may use the site for passive recreation or educational engagement.

✓ Communicate not only how to build it, but also with what. For some wetlands, vegetation can be established 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.

✓ Use clear strategic graphics to communicate complexity of wetland features to stakeholders and permit application review staff. Anticipate the look and vision of natural wetland features within this context. Collaborate with wetland team members to achieve goals.

Research & design

✓ Replicate high-performing natural "reference" wetlands.

✓ Research NRCS Web Soil Survey Water Features data for frequency and duration of flooding, ponding, and groundwater levels, and conduct site investigations to verify that the actual soils are representative of those mapped. Make sure to document the consideration of alternative sites and methods where dredge and fill permits are required. Regulatory staff are required to evaluate whether steps have been taken to avoid and minimize impacts; provide the documentation to show how this was done.

✓ Develop construction documents with specific guidelines and constraints to guide the contractor.

Plant selection, soils and materials

✓ Include proven methods that support plant establishment and reduce maintenance such as: conserving, protecting and amending on-site soils and subgrades to prevent compaction; specifying high performance native plant species; designing plant communities understanding the value of plant interrelationships; mulching and low impact erosion control measures that maintain site stability long term.

✓ Minimize site disturbances during construction through clear delineation of protected areas and measures to protect site resources.

✓Specify feasible soil mix and installation measures. Clearly 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. This may be required as a condition of a dredge and fill permit.

✓Investigate local and innovative materials and construction methodologies to achieve performance goals.

✓Prioritize the use of on-site materials and reducing waste. Use materials that are local, resilient and durable.

Bids, budgets and scheduling

✓Have qualified design professionals estimate funds required for time, labor and materials. This will result in a more accurate construction bid. Plans, notes, quantities and specifications that are general and lack the necessary detail can result in bloated bids or low bids that result in expensive change orders during construction.

✓Adaptive measures and a contingency budget should be included in the final design and permit documents to address corrective or alternative methods that may be necessary during construction. Adaptive measures (or remedial actions) may take the form of specific construction items (e.g., irrigation) that can be requested on a time and materials basis. Including adaptive measures in the bid documents is another way to prevent expensive change orders. The construction documents should identify critical constraints that could have significant negative impact on the project performance and either rule them out or provide an alternative if the proper timing or methods are not feasible. For instance, changes in season may impact construction activities, such as earthwork operations and placement of soils, which should not occur where saturated or frozen soils would negatively affect grades and soil compaction. Windows for seeding and planting should be clearly outlined, and alternative measures should be included in the construction notes or specifications that address delays that will negatively affect plant establishment.

✓It is important to establish, during the planning and design phases, schedule flexibility in order to address any unexpected problems during construction that require adjustments to meet wetland design goals and construction requirements. Bureaucratic construction requirements that incentivize prioritization of time schedules over meeting wetland design goals and construction requirements should identified and addressed. One option is to institute a partnering process, ideally during design and before construction that brings together the owner/client, design team, construction managers, regulators, and the contractor to anticipate and problem-solve solutions before construction mobilization occurs.

3) Implementation & Monitoring

a) Inadequate Implementation of the Design

This may seem easily avoidable, but it happens frequently. Wetland project designers are not consistently involved in the construction onsite. Thus, those who implement the designs often do not understand why certain requirements must be followed during construction and may make decisions that can critically affect future performance of the wetland. For example, operators of grading equipment who take pride in a level site for buildings, parking lots, etc. may not understand the need for "rough" microtopography. The need for very precise elevations to meet hydrologic criteria may also be a new concept. Construction monitoring by appropriate members of the design team or by a third party qualified wetland construction expert (who has access to the design team for questions and input), is critical to address the complexities of constructing a wetland project, maintaining the integrity of the design and making responsible decisions on adaptive measures that address unanticipated field conditions or adjusting the design if there are significant schedule delays. For example, discovery of undetected drainage tiles, 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, or with an adjustment in cost or time requirements.

As stated earlier, contingencies should be anticipated and the contract should provide the flexibility to use adaptive measures needed to achieve restoration goals. Clear lines of communication and an agreed upon system for project documentation (that includes accurate measurement of quantities) should be maintained by both the construction oversight and contractor personnel. Weekly progress reports by the contractor and regular site meetings to discuss progress, delays and challenges, can help a project stay on schedule and on budget.

Contractors and their personnel vary in their experience in constructing wetland projects. A well-developed set of high quality construction plans and specifications provides the guidance and performance measures needed by them. However, plans, notes and specifications are only as good as the people reading, understanding and executing them. An inexperienced contractor will require additional oversight by an experienced quality assurance manager.

Photo credit: Jeanne Christie

The contract should include experience standards for site supervisors and critical construction personnel in charge of quality control. It is the job of the contractor to manage and direct their personnel and know when to ask questions of the design team to clarify issues that the design might not address. There should be contract provisions in place that allow the construction oversight personnel to direct the contractor to make corrections or stop work to allow for an assessment of corrective actions needed.

b) Poor Record Keeping and 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 criteria such as performance of a nearby reference site or other performance criteria. Adaptive management requires information on project performance from the first "as built" assessment to the latest inventory throughout the monitoring period. Only then, can the trajectory for each performance goal be evaluated to determine if changes are needed. Incomplete record keeping can also create barriers to knowledge transfer (lessons learned) and thus, mistakes may occur over and over again.

c) Monitoring Period Too Short

A wetland often 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 performance. Long term comparative 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 and maturation of trees in a bottomland hardwood site is a classic case. Many other parameters can and should be expected to change and some can take decades. 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 often directly associated with the interaction of plants and hydraulic energy, and, in many cases, cannot be adequately provided during the construction phase, or even in 3-5 years. It takes time. An example is a bottomland hardwood system, where natural microtopography is provided by windthrow pits and sediment accumulations around coarse woody debris. These phenomena only occur in mature stands. Another example are herbaceous wetlands dominated by tussock forming vegetation such as Tufted Hairgrass or Tussock Sedge, or even ant mounds.
However, for projects that do not support extended monitoring, e.g., small, landowner funded voluntary projects, small individual mitigation projects, it is important that monitoring be designed to assess the trajectory toward successful long term establishment and sustainability. Such criteria still need to be developed for many types of wetlands.

Recommendations for Implementation and Monitoring Phase

Many things can go wrong during the implementation and monitoring 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 remove existing soil from the site or unintentionally compact soils which can then result in a failed restoration.

- ✓ Ensure that the design plan is implemented and that the same project designer is involved from start to finish.
- ✓ Ensure that permit requirements are communicated clearly to the construction team.
- ✓ Start adaptive management as needed when construction begins and continue into perpetuity.
- ✓ If planting is needed, seed at appropriate volumes and plant at appropriate densities. Sometimes these will be very high and other times not. It varies by both wetland type and location.
- ✓ Whenever possible, limit excavation and grading keeping soil profiles intact.
- ✓ If needed, amend soils to provide appropriate levels of organic matter and nutrients to encourage establishment and growth of robust and diverse plant communities.
- ✓ Create appropriate buffers (if not already present). For example, 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).
- ✓ The wetland may be dependent on a layer of impermeable soil such as a clay lens to maintain hydrology. It is imperative to keep this intact. Breaking through this layer during restoration will likely cause the wetland restoration to drain instead of hold water.

This project phase is also the phase that is most likely to be 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 it is challenging to restore wetlands – or at least settle on a path for long-term performance - in the typically short 3-5 year monitoring window. There have been wetland restorations that appeared to be functioning properly only to have 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. And in order to contribute to the universal knowledge base for improving wetland restoration success, the availability of 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)
   - ✓ Require thorough post construction monitoring follow up.

- ✓Document current wetland restoration efforts on the regional level to keep professionals appraised of progress in more successful wetland restoration efforts.
- ✓Develop a feedback loop to allow new data and observations to be incorporated into future restoration efforts.
- ✓Standardize reporting to the extent possible to facilitate summaries and comparisons of projects, and to simplify record keeping.

2) Select appropriate long-term management.
   - ✓ Specify who is responsible for the site. This is especially important for mitigation banks, or long term management of other mitigation sites. If there are conservation easements, who is responsible for oversight?
   - ✓ Secure funding for long-term management. This may be through bonds or letters of credit, or through endowment of a third party manager (e.g. a local conservation organization or conservancy). A cooperative agreement regarding this may be included as a permit condition where permits are required.
   - ✓ Access "secured" funding (e.g., performance bonds, letters of credit, or endowments) to finance adaptive/remedial measures when site does not meet performance criteria.
   - ✓ Monitor for and control invasive species.
   - ✓ Maintain water control structures.
   - ✓ Monitor for unauthorized access issues.

Photo Credit: Jeanne Christie

CHAPTER TWO

NEXT STEPS: AN ACTION PLAN FOR IMPROVING WETLAND RESTORATION

As described in the previous chapter of this white paper, restoration is carried out through a series of actions that must be executed to achieve the intended outcome(s). It is an iterative process. Improving on the process will also be iterative because changes in one part of the process will have implications for other areas. For example, a change to wetland restoration goals will change the project design and the performance criteria. The development of new criteria will lead to a new round of testing and refining.

Over the past 30+ years, the science of wetland restoration has developed and wetland professionals have identified and found solutions for many challenges posed by restoring both wetlands and streams to the landscape. A greater understanding of water connectivity and cycles within watersheds has informed ecological restoration efforts and underscored the importance of landscape level restoration efforts to improve the health of wetlands and streams collectively. It is no small achievement that the overall framework for pursuing wetland and stream restoration is now widely accepted. Developing goals, establishing performance criteria, using reference wetlands - these and other basic building blocks of restoration are used by wetland and stream restoration practitioners throughout the U.S.

However, significant challenges remain. The variable geography of North America and particularly its many wetland types that exist presents many challenges. In addition, landscapes have been changed significantly through decades of anthropogenic alterations. As a result, half the wetland area in the lower 48 states no longer exists. Thousands upon thousands of streams have been moved and straightened. The entire hydrologic system in the U.S. has been simplified and the consequences of these changes are likely to continue to unfold for decades. Thus, these alterations, both historical and current, may limit the potential for wetland and stream restorations to meet desired goals, particularly if the goal is to restore a wetland or stream system to a much earlier point in history on a less altered landscape. Changing climatic conditions and weather patterns create additional challenges. Increasingly, wetland restoration professionals and federal, state, and local regulators are gaining a more nuanced understanding of the complexity of these challenges.

While many individual wetland professionals have identified how to meet performance criteria for wetland restoration, often this information is not broadly available to other wetland restoration professionals. For some wetland restoration types there is more information available than for others, but generally there is no regional or national repository for information about how to approach wetland restoration by individual wetland type. In addition, it is difficult to access information on wetland restoration outcomes and more particularly about the actions that have resulted in goals and criteria not being met. The lack of access to this information has made improving restoration based on field experience an inexact and inefficient process.

The actions listed on the following pages are not comprehensive. They represent a series of specific logical steps that could be undertaken to address the broader challenges and recommended solutions described in the previous sections. Even after implementation, these actions may not result in complete restoration in all cases, but should make a definite improvement over the status quo. Many of the actions that are recommended in this section are directed toward incorporating and disseminating effective methods and overall approaches that have been identified but not broadly shared.

Finally, wetlands exist in a watershed and often in proximity to streams and other aquatic resources. From an ecological perspective streams can be understood as part of a larger wetland complex. But decades of draining wetlands and alteration of streams have separated them on the landscape to the extent that they have been perceived as separate and stream and wetland restoration practices have been pursued separately. Thus the 'practice' of restoring streams has lagged behind wetlands. However, currently the science of stream restoration is progressing and stream restoration is being carried out with increased frequency both as a form of compensatory mitigation and voluntary restoration. There is growing support for

Improved Wetland Restoration Practices Provide Potential to Adopt More Green Infrastructure Solutions

American Rivers defines "green infrastructure" as an approach to water management that protects, restores, or mimics the natural water cycle. Green infrastructure is effective, economical, and enhances community safety and quality of life. It incorporates both the natural environment and engineered systems to provide clean water, conserve ecosystem values and functions, and provide a wide array of benefits to people and wildlife. Green infrastructure can provide cost effective alternatives to traditional hard infrastructure projects.

Green infrastructure is often used in urban areas where it may not be feasible to carry out pure wetland restoration projects due to the limits of the built environment. Many of the lessons learned and opportunities for improvements in wetland and stream restoration are likely to be useful in improving green infrastructure project outcomes as well.

integrating wetland and stream restoration programs and practices. Therefore a number of recommendations on the following pages are directed to both wetland and stream restoration. Collaboration and coordination among wetland professionals, including wetland restoration practitioners, regulators, and program managers, will be needed to address the challenges to restoration previously described. In many cases, it will be logical to pursue more than one of the recommended actions either simultaneously or in sequence.

Looking toward the future, there will continue to be a need to review, analyze and revise practices based on new information gathered through the application of improved wetland restoration practices. States and federal agencies engaged in review and oversight of compensatory mitigation and/ or voluntary restoration are encouraged to review existing practices to identify opportunities to revise and update best management practices (BMPs) and guidance to address the challenges identified in this document. For example, U.S. Army Corps of Engineers (Corps) districts could update their compensatory mitigation guidance to be current with the 2008 mitigation rule which anticipated many of the challenges identified in this paper. Over time, national and state guidance should be updated to reflect successful approaches to addressing the challenges identified in this report. In many cases, there are benefits to be derived from collaboration between the compensatory and voluntary restoration program managers since there are important commonalities as well as nuanced differences that require the cooperation of both communities to address holistically.

In addition, other entities such as state or regional wetland organizations, scientific nonprofits, academic institutions, and others may be able to work towards synthesizing research and/or evaluating performance criteria, and developing databases. In many cases, this will be an efficient way to address impediments to successful wetland and stream restoration since many of the challenges are inherently related to each other and need to be considered concurrently. Therefore establishment of national, regional or state workgroups as well as the utilization of existing ones to carry out the recommendations in this report is recommended. In the following pages, each overall challenge previously identified is summarized and specific actions are listed that can be taken to implement the broader recommendations.

CHALLENGE 1: Subjective Evaluation of Wetland Restoration Outcomes and Vague Project Goals.

The word "success" is a subjective judgment and should be avoided. The exception is where it is based on clear criteria, quantifiable goals and performance standards. Vague goals create challenges in assessing whether a restoration project is performing as planned. There is also pressure in both compensatory mitigation and voluntary restoration projects to judge a project as 'successful' whether or not it is merited.

RECOMMENDED ACTION #1: Develop Clear Project Goals & Use Appropriate and Quantifiable Performance Standards to Measure Progress

Performance goals and criteria should be SMART (Specific, Measurable, Achievable, Results-Oriented, Time-fixed), address hydrology, soils, and vegetation, and reflect incremental change. Actions should be taken to develop performance standards appropriate to wetlands, streams, and wetland/stream complexes. Reference sites can play an important role.

1. National, regional, and/or state workgroups should work collaboratively to provide guidance on how permit applicants should develop appropriate wetland restoration goals and performance standards. These should be updated over time based on new information (such as evaluations of wetland restoration performance described below).

2. Federal and state agencies should pursue revising wetland restoration performance criteria for both compensatory mitigation and voluntary restoration programs so that incremental improvement can be evaluated focusing initially on abiotic conditions (hydrology, soils) and then moving onto biotic (plants) as measures of performance. For example, the application of progressive performance goals can start with physical site design in the early stages of a restoration project followed by evaluation of successful establishment of hydrology in wetland soils. This approach can support 'self-design' as restoration progresses. Vegetation, amphibian, or other IBI scores are reliable indicators of the conditions of abiotic and biotic wetland components. Use of appropriate reference sites can support this approach.

3. Government agencies, academia and/or other organizations should work collaboratively to establish regional reference sites in similar kinds of landscapes that are appropriate to wetland and stream types. Information about the sites should be gathered into a database as a resource to use in establishing desired outcomes. The database should include information about both abiotic and biotic

The 2008 Mitigation Rule: A Template for Revising Wetland and Stream Restoration Guidance

The 2008 Mitigation Rule provides a framework for addressing appropriate revisions to U.S. Army Corps of Engineers District compensatory mitigation guidance with the potential of incorporating many of the recommendations in this chapter.

Examples of appropriate updates to reflect the requirements of the 2008 mitigation rule are to:

1) Update District guidance to meet the minimum and allow for longer monitoring periods where appropriate to wetland type and site variables;

2) Require inclusion of an historic baseline data evaluation for a proposed mitigation site;

3) Include guidance on costs and financial management;

4) Require inclusion of an adaptive management section in compensatory mitigation plans; and

5) Develop guidance on how mitigation sponsors will demonstrate their qualifications to carry out the wetland or stream restoration project.

wetland/stream characteristics as well as level of landscape disturbance and allow for realistic goals to be established.

4. Federal and state agencies should review existing guidance and/or develop new guidance on how to set appropriate goals for a wetland or stream restoration site considering factors such as an evaluation of site capacity (i.e. hydrogeomorphic classification) onsite and off-site stressors, and achievable reference condition.

5. Federal or state agencies, academia and/or other organizations should carry out regional and/or national evaluations of mitigation performance to evaluate whether projects are achieving project goals and ecological performance criteria. The results should be used to re-evaluate existing policies and identify opportunities to improve wetland restoration outcomes.

6. Guidance on how to carry out an evaluation of restoration performance should be developed to enable the collection of some data consistently and thereby allow for direct comparisons of projects nationally. This guidance might include descriptions of an overall approach and framework and/or specific data to collect in each independent study that can be aggregated and analyzed to identify common and dissimilar findings. This could be developed by government agencies, academia or another organization with appropriate experience and expertise.

7. Research into identifying reliable incremental performance standards for identification of hydrology, soil and vegetative performance criteria should be carried out. For example, IBIs can be used to determine how all wetland criteria (hydrology, soils, plants) are performing and correspondingly at what level the suite of functions associated with that wetland type are performing. This research could be accomplished by academia, federal and/or state agencies or through national or regional workgroups. The first step in such an effort should be a thorough review of existing literature and experience.

CHALLENGE 2: Insufficient Monitoring Timeframes. The 3-5 years commonly allowed to evaluate wetland restoration success is not sufficient to measure achievement of performance goals for many wetland types which can take many years to be established. One consequence of this short timeframe is the tendency to rush succession to establish the desired vegetation which may bypass establishment of critically important hydrology, soils, etc.

RECOMMENDED ACTION #2: Develop Achievable Performance Criteria for Short-Term Evaluation and Establish a Long-Term Management Plan

Reliance on biotic criteria over a short timeframe for measurement of success creates some significant problems establishing achievable performance criteria. In recent years, there has been increasing recognition that longer monitoring timeframes and measurement of abiotic and biotic performance are likely to yield more reliable indicators of progress toward meeting project goals. In order to support this change in focus a number of actions need to be undertaken.

1. Research should be carried out by federal agencies, academia and others to identify abiotic performance measures with priority given to those that can be used to evaluate performance in the early part of the monitoring period to ensure that hydrology and soils are suitable to support wetland restoration outcomes.

2. Federal and state agencies should develop guidance on how to develop a tiered set of performance standards for a wetland and stream restoration project using a trajectory to identify different criteria at different points in time. Initial scoping work could be undertaken by regional workgroups including participation by Internal Review Teams (IRTs). Monitoring data gathered should be linked to progress toward meeting defined performance criteria.

3. Federal and state agencies should provide direction on the monitoring period for a project based on wetland type, level of disturbance, broader landscape impacts, climate variability and any other relevant factors so that length of the monitoring period is appropriate for the wetland/stream type (i.e., tidal marsh vs freshwater bottomland hardwood forest).

4. In order to build on experience, it is recommended that regional workgroups, state and federal agencies or other appropriate organizations develop regional performance standard templates for wetlands and streams which include recommendations for monitoring time frames appropriate to wetland/stream type. If this work is undertaken by regional workgroups it will enable integration of state, federal, and local performance requirements.

5. Federal and state agencies should establish and gather data on regional reference sites in similar kinds of landscapes that are appropriate to wetland/stream types. Sharing this information in a regional or national database will provide a resource to use in establishing desired outcomes. This should include information about both abiotic and biotic wetland/stream characteristics as well as level of landscape disturbance to allow for realistic goals and performance criteria to be established.

6. In order to support development of achievable performance criteria, there are substantial benefits to making current monitoring information broadly available to share knowledge and increase the efficiency of parties involved in identifying and using abiotic and biotic performance criteria. Sharing monitoring data can also help restoration practitioners avoid collecting data less likely to be useful and/or continuing practices less likely to lead to desired outcomes. Potential existing sources include the Corps RIBBITS database (could be expanded to include raw monitoring data) and state compensatory mitigation monitoring databases as well as those developed and managed by voluntary restoration programs.

7. It will be important for the agencies and/or workgroups identifying performance criteria to periodically revisit the process of analyzing performance criteria and monitoring data to evaluate the best indicators of progress toward achieving wetland restoration outcomes as well as appropriate timeframes for evaluating wetland restoration performance.

8. Federal and state agencies should develop guidance and BMPs for developing long term management plans. Guidance should address performance evaluation as well as establishment of sustainable financing to support long term adaptive management.

CHALLENGE 3: Narrowly Focused Regulations and Permit Conditions. Permitting programs were historically designed to regulate projects that degraded and destroyed wetlands and streams and compensatory mitigation was designed to replace aquatic functions and values lost as a result of those activities. However, there are an increasing number of projects nationally that are directed toward restoring, creating and/or enhancing ecosystem services that provide wildlife habitat, flood attenuation, water quality improvement, recreational opportunities, etc. Strict application of existing permitting criteria may create barriers to carrying out projects that restore natural landscapes.

RECOMMENDED ACTION #3: Establish Appropriate Performance Criteria Based on Restoration Goals & Project Type

Federal and state permitting programs should be evaluated to identify barriers to carrying out restoration projects. However, wetland and stream restoration projects vary greatly in size and scope and pros and cons must be identified and analyzed before any systemic changes to existing permitting programs are undertaken to improve permitting efficiency for these categories of projects. When appropriate, these types of projects may merit alternative approaches to establishing criteria for project goals and outcomes, performance criteria, monitoring requirements,

Identifying Barriers/Solutions

On November 29, 2016 the Natural Floodplain Functions Alliance in held a one-day workshop on "Overcoming Policy and Permitting Challenges to Implementing Natural Infrastructure Solutions".

Workshop participants identified the following barriers to carrying out wetland restoration projects:

1. Variable criteria for requiring a Letter of Map Revision (LOMR) and Conditional Letter of Map Revision (CLOMR) Applicability and Process for the Federal Emergency Management Agency when a wetland and/or stream restoration occurs in a mapped floodplain.
2. Use of Out-of-Date Engineering Models.
3. Requirements for highly detailed information to get authorization to use the Section 404 program Nationwide 27 (Aquatic Restoration).

Workshop participants also identified opportunities to provide technical assistance/capacity building, including:

1. Create a clearinghouse of available grants.
2. Measure the effectiveness of nature-based solutions: compare to traditional approaches.
3. Develop training on how to access and use tools.

etc. However, many of the restoration projects will continue to be required to comply with permit requirements, where there is the potential for unintended consequences such as flooding adjacent landowners' properties or decreasing the quality of existing critical resources.

1. In order to articulate the difficulties in applying permitting standards designed to address degradation of natural resources to restoration/natural infrastructure wetland projects, national and regional workgroups should provide a general analysis of the wetland/natural infrastructure restoration projects[2], their goals and commonly used performance measures. This summary could include voluntary restoration programs, watershed restoration projects, natural hazard reduction programs, etc. Managers of these programs, permit applicants and regulatory program staff should meet to discuss challenges working with federal and state regulatory agencies to meet requirements and learn about regulatory program staff concerns about potential issues that are identified when these projects are reviewed. Potential solutions should be identified in the white papers.

2. National or regional groups should identify common regulatory barriers encountered in carrying out projects specific to individual regulatory programs, and include recommendations for resolving these barriers. These may include state or federal dredge and fill permits, letters of map revision for floodplains, Endangered Species Act issues and other challenges. Workgroups should collect a representative set of case studies that describe projects where barriers were encountered and assess the pros and cons of their resolution. Groups should identify whether these barriers require resolution at the national, regional, state or local level. (Note - more than one level may need to be addressed). A plan for moving forward to make program changes to address identified barriers should be developed and carried out.

3. National and regional workgroups should identify appropriate performance criteria when compensatory mitigation is not the goal. IBIs can be used to assess both compensatory mitigation and voluntary wetland and stream restoration projects. Goals for voluntary restoration, natural infrastructure, etc. should clarify whether the goal is attainment of a previous condition or a different wetland/stream type based on changes in the broader watershed, site capacity and program goals. Adoption of appropriate and streamlined

Photo Credit: Jeanne Christie

[2] Definition of Natural and Green Infrastructure: https://www.aswm.org/wetland-science/wetlands-and-climate-change/natural-green-infrastructure

SMART incremental ecological performance standards should be encouraged consistent with recommended actions described earlier in this chapter.

4. Where there is agreement, state, regional or national level federal agencies should develop appropriate memorandums of agreement, create general permits , document agreed upon performance standards and criteria etc. to streamline and expedite wetland/stream restoration, natural infrastructure restoration, etc. This is appropriate for projects where the goal is to restore and/or improve the site to a higher functioning natural system. For projects where development of a high functioning system is not the goal, develop criteria for how to assess where there can be trade-offs on a project including maximizing one benefit over another based on program goals.

CHALLENGE 4: Altered Landscapes and Changing Land Uses.

Lack of consideration of historical and current landscapes as well as incomplete understanding of hydrology, soils and other site specific characteristics are frequently the cause of poor restoration plan design and unmet goals. The ability to accurately assess site characteristics and design achievable outcomes on a particular site is essential.

RECOMMENDED ACTION #4: Research the Site's Land Use History and Model Potential Future Stressors Using Historical Trend Data

During this project, 23 wetland restoration webinars were held involving 56 speakers who addressed strategies for carrying out wetland restoration projects in a wide variety of wetlands types throughout the country. Consistently, the single most often cited reason for wetland restoration project failure was the inability to correctly assess the restoration site and plan a wetland restoration that could be achieved on that site. Hydrological sources and constraints, onsite and offsite stressors, soil compaction and other factors should be examined before determining what kinds of wetland or stream restoration is achievable at a specific location. If the site was not properly assessed then the design, plan and onsite construction actions will not achieve the desired outcomes.

Offsite Evaluation Tools: An Example

The Watershed Resources Registry (WRR) (http://watershedresourcesregistry.com/) provides a comprehensive approach through the use of data layers indicating priority resources for preservation and restoration. It was developed by multiple state and federal agencies and non-government organizations.

Specifically, it uses an interactive mapping tool to characterize and prioritize natural resource management opportunities using a Watershed Approach. Areas across Maryland have been scored on a scale of one to five stars based on their potential benefits for restoration or preservation. Users can either access the interactive mapping tool or download the data directly.

The WRR provides the opportunity to:

1. Identify candidate locations
2. Assess and compare potential projects
3. Export data and print site maps for field visits

1. National and regional workgroups should develop guidance on how to carry out baseline assessments for wetland and stream restoration suitability determinations. They should work with the academic community to provide direction on how to evaluate hydrogeomorphology, current sources of hydrology, onsite soils and landscape stressors. Guidance should include: 1) appropriate application of reference sites in similar landscape settings to understand how a restored wetland or stream is likely to behave in altered landscapes; 2) direction on off-site and on-site information that should be gathered with respect to site conditions and landscape alterations that may impact restoration performance; and 3) direction on how to use existing information, e.g., historical trend data, to understand and/or model potential future stressors.

2. National and/or regional workgroups should identify existing tools and methodologies that exist to evaluate the ability of a site to support the wetland and/or stream type proposed for restoration, including existing watershed assessment tools and examples of local watershed plans. Recommendations should be developed on how to use these tools to understand the proposed restoration site and its watershed context.

3. For off-site analysis, national and/or regional workgroups should provide guidance on how existing databases and GIS analysis can be used as a screening tool to assess the potential for meeting wetland/stream restoration performance goals. Guidance should also be provided on how to use existing GIS data layers such as historic maps, aerial photography, topo maps, soil maps, hazardous waste sites, FEMA floodplain maps, the National Wetlands Inventory, endangered species habitats, cultural resource locations and other appropriate information that can be combined to provide a valuable off-site screening resource. There are currently many efforts to develop comprehensive GIS tools to assist with identifying potential restoration sites such as the Watershed Resources Registry, Minnesota's Restorable Wetland Prioritization Tool, and a decision support tool currently under development by the Wisconsin Department of Natural Resources and The Nature Conservancy to inform wetland mitigation siting decisions for all wetlands and watersheds across the state[3].

The most commonly cited problem: Inability to correctly assess the site and surrounding landscape in planning for restoration.

[3] The title of the WI DNR and TNC project and upcoming report (due to be released in October, 2017) is "Wetlands by Design: A Watershed Approach" and the tool under development is called the "Wetlands and Watersheds Explorer." An overview can be found online here: https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/wisconsin/science/big-picture-approach-to-protecting-our-waters.xml.

4. For on-site analysis, national and/or regional workgroups should provide guidance on how onsite reconnaissance can validate and/or revise off-site evaluation. This may include confirmation of hydric soils, existing hydrology (including surface and groundwater sources) and wetland landform type and/or stream order and condition as well as other unavailable or potentially incorrect information. Onsite assessment methods should require evaluation of past (often successive) wetland drainage and stream relocation impacts. Ideally, site soils should match reference site data that may be used in evaluation of project potential. Both stream and wetland information should be included in the baseline assessment where both are present.

5. National or regional workgroups should develop guidance on how to evaluate and set appropriate goals for restoration when attainment of a historic wetland type is not achievable given anthropogenic changes, anticipated climate change impacts, etc. An ecological approach should be applied that anticipates a range of acceptable project goals and performance criteria to be met.

CHALLENGE 5: Separation of Wetland and Stream Restoration. Many streams and wetlands are part of the same aquatic system and historically stream/wetland/floodplain complexes occurred commonly on the landscape.[4] Today, however, stream and wetland restoration are largely implemented separate. Both stream and wetland mitigation and voluntary restoration may also be separated programmatically. This separation of practices and program implementation can continue the separation of these historically interconnected systems on the landscape.

RECOMMENDED ACTION #5: Use a Watershed Approach

1. Case studies should be shared and pilot projects should be undertaken at the regional level by federal and state agencies to identify methods of awarding stream and wetland restoration credits, without double counting, by mitigation banks.

2. Members of the academic community working with practitioners should synthesize information available on how to undertake holistic restoration projects that reconnect wetlands, floodplains and rivers using the historic proximity of these waters as a guide, but adapting projects to current landscape condition. Share information about case studies.

3. Federal agencies should develop a report summarizing information on existing mitigation banks that credit streams, buffers, wetlands, endangered species, etc. They should develop guidance on how mitigation credits can include both streams and wetlands. This approach would most likely not use linear feet but aerial metrics instead.

[4] However, there are a large number of wetlands that have isolated hydrology that are driven entirely by rainfall, runoff, and/or ground water. In Ohio, an estimated 44% of wetlands are considered to have so called "isolated hydrology". Therefore, a large percentage of the time, about half, wetland restoration projects will involve restoring aquatic resources without hydrology contributions from streams and/or rivers.

4. State and Federal agencies should develop performance standards for restoration and monitoring protocols for wetlands and streams combined.

5. National and regional workgroups should gather information from field practitioners to develop white papers evaluating the permitting and programmatic barriers to integrating wetland and stream restoration. Include recommendations for addressing barriers.

6. Federal and state agencies should develop programmatic incentives for integrating stream and wetland restoration. For example, grant programs could prioritize such projects.

7. National or regional workgroups should provide a framework for integrating stream and wetlands restoration including creating integrated assessment methods and providing opportunities to build restoration teams of stream and wetland professionals.

CHALLENGE 6: Underestimation of Restoration Costs. Restoration costs, particularly costs associated with evaluating baseline conditions, monitoring and long term management are frequently underestimated by as much as 30% or more. Inadequate evaluation of baseline conditions, relatively short time frames for monitoring performance and the need for long term management are also cited as common barriers to achieving performance goals.

RECOMMENDED ACTION #6: Include Pre and Post Construction Costs in Estimates

1. Nationally, federal agencies should provide guidance on how to account for all project phases in establishing costs. Regional workgroups should take this information and refine it to reflect project costs in their region including region-specific costs such as the purchase of water rights in the West. One regional source of information on costs is the

Stewardship Calculator and Handbook

The Nature Conservancy has created a free and simple calculator that estimates long-term stewardship costs and the amount that should be set aside to provide a secure source of future funding.

The calculator can be used by:

- Land managers to estimate the long-term stewardship costs associated with voluntary conservation projects, both for conservation easements and fee-owned land;
- Mitigation providers to estimate long-term management costs and establish endowments;
- Long-term land stewards and easement holders to determine the funding they will need to complete long-term management tasks on mitigation properties before they assume such responsibility; and
- Regulators to ensure sufficient funds are set aside for long-term management.

For more information please visit: https://www.conservationgateway.org/ConservationPlanning/ToolsData/Pages/stewardshipcalculator.aspx

State Departments of Transportation which are tasked with estimating typical project costs on a regular basis.

2. National and state workgroups can provide training on The Nature Conservancy's long-term stewardship calculator and also determine if there are other cost evaluation tools that exist and can be adapted such as tools used by the Corps Civil Works program.

3. National and state workgroups should share effective practices from around the country. For example, California mitigation projects include information about short- and long-term financial assurances. The North Carolina Division of Mitigation Services has a portal with cost information. The Corps Jacksonville District has conducted a pilot project addressing project costs as well. A checklist identifying all costs that should be included in estimating overall project costs could be developed.

4. Federal and state agencies should utilize existing databases to include information on overall projects costs to share.

5. The academic community should provide another dimension to understanding project costs by demonstrating how an estimation of the change in value of ecosystem services should be considered in the calculation of overall project costs. This information should be used on a watershed scale to document the increased value of ecosystem services when multiple restoration projects occur within a watershed.

CHALLENGE 7: Lack of an Adaptive Management Framework. Flexibility is required to achieve performance criteria. Even with a good plan to work from, the unexpected will happen. As discussed previously, historic alterations of the project site and surrounding landscape, current and future stressors and the uncertainties of a changing climate are likely to have a profound impact on the potential for a wetland or stream restoration project to achieve performance criteria. Adaptive management beginning from the initial project design through post restoration long-term management and monitoring is likely to be needed.

RECOMMENDED ACTION #7: Use an Adaptive Management Approach Throughout the Life of the Project

1. Academic institutions, nonprofits, state and federal agencies should work collaboratively to develop guidance on how to develop an adaptive management plan for mitigation projects. Field experience can be extremely helpful in developing guidance. When possible, guidance should be tailored to the region of the country and wetland/stream restoration type.

2. Federal and state agencies should identify reference sites suitable for developing appropriate targets and project goals and performance criteria, but that also allow for variability as part of an adaptive management framework.

3. Federal and state agencies should require permit applicants to include an adaptive management plan as part of the design for compensatory mitigation and voluntary restoration projects from the design through the long-term management phase. The ability to carry out adaptive management should be reflected in any RFP's the permit applicant uses to carry out the project.

4. Federal and state agencies should require adaptive management in the initial restoration project plan as well as financial assurances sufficient to carry out potential adaptive management during the long term management and monitoring phases of a project.

5. Adaptive management activity can provide information about how to improve restoration practices. National and state workgroups should pursue analyzing monitoring data, performance criteria and adaptive management activities to improve practices and thereby minimize the need for adaptive management in future restoration projects.

6. National and state workgroups should share case studies of adaptive management, i.e., demonstrate how measurement of performance criteria led to adaptive management to improve wetland and stream restoration practices.

7. Federal and state agencies should consider providing additional guidance on adaptive management for very disturbed landscapes allowing for projects that experiment and test assumptions to better identify appropriate reference sites and improve performance criteria.

8. Federal and state agencies should consider creating incentives for undertaking adaptive management to address issues that occur such as early (incremental) release of credits for voluntary corrections and achievement of performance criteria for mitigation banks.

CHALLENGE 8: Lack of Accountability. There are two major categories of issues with respect to accountability in wetland and stream restoration. The first is ensuring that professionals have the training and knowledge to carry out the wetland/stream restoration project proposed. Although a variety of certification programs exist, currently, there is no broadly accepted certification or set of criteria used to specifically ensure that wetland and stream restoration professionals are qualified. This can lead to an absence of liability for a failed restoration plan. The second is there is a need to guarantee that there are sufficient compliance requirements in place to ensure the performance criteria and project goals for a restoration project are achieved. As discussed previously in this report, feedback loops to require improvement in restoration performance is lacking.

RECOMMENDED ACTION #8: Require Documentation of Credentials, Provide Incentives for Meeting Performance Standards & Enforce Accountability

1. Professional societies, academia or states should provide opportunities for certification for professionals that demonstrate wetland and/or stream restoration competency. For example, the Society of Ecological Restoration has created a new certification program for ecological restoration professionals. State certification of Professional Wetland Scientist certifications exists in some cases for wetland delineators and a separate certification could be designed to demonstration wetland restoration competency. In addition, universities and colleges could provide specialized curricula in integrated wetland and stream restoration. In support of a more integrated approach universities could also review existing curricula and degree requirements to ensure and integrated approach to wetlands and stream restoration is supported.

2. Professional organizations, nonprofits, and federal and state agencies should develop articles, outreach materials, etc. that provide guidance on how to hire competent wetland or stream restoration professionals, e.g., the correct questions to ask, required experience and desired educational level. It is important to note many restoration projects require teams of professionals in wetland science and other professions and guidance on how to ensure that the appropriate team of professionals is carrying out a restoration project may be equally important.

3. National and regional guidance established by federal and state agencies involved in both compensatory mitigation and voluntary restoration should be developed to support establishment of both short and long-term financial assurances adequate for the wetland or stream restoration project that is proposed. The amount required to achieve this will be variable depending on the costs of restoration which are, in turn, determined by the goals and performance criteria as well as variables such as baseline conditions and the cost of monitoring (both short- and long-term measurements).

4. State or regional agencies providing oversight for compensatory mitigation should hold discussions to identify ways to support compliance with project goals and follow through with revising practices to meet this objective. This should be addressed not only for the mitigation banks but also for in lieu fee projects and permittee responsible mitigation.

Preparing Students for Wetland Professions: A White Paper to Assist Planning by Institutions of Higher Education

In the spring of 2017, the Association of State Wetland Managers (ASWM) completed a two year study of wetland training, including a needs assessment, research on the characteristics of high quality wetland training, required and preferred skills for wetland professionals entering both the public and private sectors, and evaluation of different training tools. As part of this project, ASWM has developed a set of recommendations for institutions of higher education designed to assist universities and colleges and support nationwide efforts to strengthen the education of wetland professionals and, consequently, their ability to conserve, manage and protect wetlands.

For more information visit https://www.aswm.org/pdf_lib/preparing_students_for_wetland_professions_draft_042817.pdf

5. State or regional workgroups should work collaboratively to identify ways to incentivize improved track records for meeting performance criteria. In compensatory mitigation, this could potentially be achieved by providing more credits for meeting performance criteria and fewer credits if performance criteria are not achieved. This should be considered for both stream and wetland restoration design and construction.

6. Federal and State regulatory agencies should ensure that the criteria for meeting performance standards is reflected in the monitoring requirements so that monitoring can demonstrate progress towards meeting performance criteria. When monitoring indicates that performance criteria are not being met, action should be taken by sending letters of noncompliance, using bonds or financial assurances in place to fix problems, or withholding credits for compensatory mitigation projects.

7. Building on the synthesis of current practices discussed previously, regional workgroups should develop templates for monitoring reports to standardize data collection and provide opportunities to review monitoring performance on a regional basis. To enable analysis, data should be in a publicly accessible on a regional or national database. The collection of standardized data, even if it is only part of the overall data collected on a specific site, would allow for regional analysis of mitigation and/or restoration sites with a goal of improving overall performance criteria, monitoring requirements, etc. (Note: Monitoring data need to be regionalized and correlated with appropriate reference sites in order to be comparable to similar wetlands or streams.)

CHALLENGE 9: Limited Access to Expertise, Training and Knowledge Sharing.

Many wetland professionals agree that the ability to address the challenges described previously is severely handicapped by the lack of training and access to knowledge about how to restore wetlands and streams to meet performance criteria at all educational and professional levels. Many of the recommendations on the previous pages will improve access to information. Additional recommendations that reinforce these through training are listed below.

RECOMMENDED ACTION #9: Improve Access to Knowledge & Training and Engage Interdisciplinary Teams

1. As discussed previously, state and regional groups should organize and work together to address expertise and knowledge shortfalls and develop regionally appropriate guidance, best management practices, and databases for information sharing.

2. Federal and state agencies, nonprofits, the private sector or professional associations should establish mentoring programs for new employees working in wetlands.

3. Appropriate entities should establish a clearinghouse of information on restoring wetlands and streams by wetland type, stream type, etc. This could include documentation, videos, webinars, etc.

4. Training could be provided by national or regional workgroups, nonprofits, federal or state agencies, academia and others on these and other topics. The training may need to be adapted for specific audiences. For example, the training needed by a federal or state wetland/stream permit reviewer to evaluate a proposed restoration plan may be different from the training needed by professionals developing the wetland restoration project.

Possible topics include:

a. How to incorporate ecological performance standards into adaptive management
b. How to evaluate site suitability, review site design and construction, and what questions to ask to ensure project has appropriate and achievable goals and performance criteria
c. How to combine stream and wetland restoration to achieve a holistic watershed restoration approach
d. How to provide long term protection including financial assurance protection instruments, adaptive management and monitoring progress

5. Academic institutions should develop specialized wetland/stream restoration curricula and/or specialized classes and concentrations or certificates as well as continuing education opportunities on specialized wetland/stream restoration topics.

Photo Credit: Jeanne Christie

6. Professional organizations, nonprofits, the private sector, federal and state agencies and others should develop training to address the topics listed here and throughout this chapter.

7. Academic institutions should work with students to carry out research pro jects to analyze effectiveness of performance criteria, restoration techniques, etc. to improve wetland and stream restoration practices. It should be noted that long-term studies (5-20+ years) may yield significantly different results than those carried out on a shorter timeframe and there should be a priority placed on supporting long-term research. In addition, the accessibility of monitoring data in regional and/or national databases will provide the opportunity for academic institutions to undertake studies likely to result in new insights on how to develop improved performance criteria, improved restoration practices, etc.

8. Scientific journals and academic institutions should partner with federal and state agencies and others to provide broader access to wetland and stream professionals who cannot access research findings due to the prohibitive cost of gaining access to scientific studies.

ACTIONS TO IMPROVE OVERALL PROJECT MANAGEMENT & GOVERNANCE

The final part of Chapter 1 addressed primary barriers by projects phase. It described common issues that impede effective restoration that are often associated with a particular phases of an individual project and provided recommendations on how these could be addressed. Below are recommendations for improvements in overall management and oversight that will reinforce and support sound decisionmaking for individual wetland and stream restoration projects.

1. National and regional groups should develop guidance and provide training on how oversight by wetland professionals can guide and ensure a successful project. This includes how to address issues that come up on site during construction as well as how to work successfully with heavy equipment operators and other construction professionals. Guidance should support the presence of wetland and stream restoration experts (determined by the type of project) on site throughout the construction phase of the project.

2. National and regional groups can develop guidance and provide training on how to write a Request for Proposals (RFP) that will require compensatory mitigation projects that will support an ecosystem approach to restoration rather than focusing primarily on credit type and amount. Other topics to address include: developing construction specifications that will allow for adaptive management; how to write contracts, how to carry out bidding strategies that will lead to the selection of competent contractors and what should be included in conceptual design plan, construction document plan and post-construction monitoring.

3. Federal and state regulatory agencies should incorporate procedures into compensatory mitigation oversight to ensure regulatory staff are engaged in reviewing progress towards acheivement of performance goals in wetland and steam restoration projects from the beginning through the end of the monitoring stage. They should provide guidance and training so that program staff is able to assess that projects are being carried out per plan and that the restoration is in compliance with banking instruments in in-lieu fee projects, monitoring criteria etc.

4. Federal and regional workgroups should identify opportunities for public engagement in carrying out wetland restoration projects, and share effective outcomes and challenges.

5. Federal and regional workgroups should identify mechanisms to ensure training is available to heavy equipment operators on how to carry out wetland and stream restoration which is very different from practices used in roadbuilding and other types of development oriented movement of earth.

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Photo Credit: Jeanne Christie

APPENDIX A: 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, Ph.D., & Richard Weber

Constraints	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 restoration site	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

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

Constraints	Recommendation	Details
Wetland restoration designed incorrectly	Better training	Provide training for wetland professionals including consultants, regulators and monitoring and enforcement personnel
Inadequate baseline and 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.
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.
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.
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

Constraints	Recommendations	Details
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.
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.
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.
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.
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.
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

Constraints	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

Constraints	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

Constraints	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

Constraints	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	Include qualified land design professionals, such as a landscape architect on team to work with scientists to develop strategies that meet	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

unanticipated challenges.	budget and are feasible to build.	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

Constraints	Recommendation	Details
Mangrove restoration incorrectly.	Better training.	Provide training for wetland professionals including consultants, regulators and monitoring and enforcement personnel who deal with mangrove restoration issues.
Use of Inadequate baseline and 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.
Lack of consideration of the historical 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.

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.
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, Ph.D.

Constraints	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

Constraints	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, Ph.D.

Constraints	Recommendation	Details
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.
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.
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.
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.

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

Constraints	Recommendation	Details
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.
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.
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.
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.
Beef up compliance monitoring and enforcement activities to stop repeated errors in design with distribution of "lessons learned."	Document current seagrass restoration and creation efforts on the regional level to keep professionals apprised on progress in more successful seagrass restoration and creation efforts.	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 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, Ph.D.

Constraints	Recommendation	Details
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.
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.
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.
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.
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

Constraints	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.

Pacific Coast Wetland Restoration

John Callaway, Ph.D.

Constraints	Recommendation	Details
Sticking with the tried and true approach / lack of experimentation	Include experimentation in restoration design across a range of scales, from mesocosms to large-scale sites	Need to identify critical factors up front and design replicated experiments to evaluate factors that limit restoration development, as well as new techniques for restoration
Narrow focus for restoration design and planning	Incorporate landscape and regional planning into restoration design	Follow the lead of the multiple projects on the Pacific Coast that have considered regional issues in restoration prioritization and planning.
Too much emphasis on "command and control"	Work with natural processes to promote development of restoration sites	Consider natural plant dispersal and recruitment in planting needs; promote natural sediment accumulation and creek development in restoration sites.
Sediment will become a limiting factor for many coastal restoration projects	Manage sediment as a valuable resource rather than disposing of it as "spoils"	Tidal wetlands must keep pace with sea-level rise. However, many systems are experiencing reductions in watershed sediment inputs and this will be compounded by future increases in sea-level rise.
Urbanization and climate change will constrain many projects	Evaluate constraints and manage for resiliency	Coastal wetlands are highly sensitive to elevation and future restoration efforts could be severely constrained by urbanization on one side and rising seas on the other. Planning for change and resiliency will be necessary to maintain wetlands into the future.

Charles Simenstad

Constraints	Recommendation	Details
Focus on re-creating wetland structure rather than restoring impaired processes	Concentrate on restoring naturally dynamic processes, particularly uninhibited tidal flooding, sediment and large wood delivery, natural disturbance regimes	Avoid "designing"; mimicking natural processes is seldom effective and often costly; take advantage of uninhibited natural processes to "self-design"; but, take into account altered capacity for dynamic processes and other "novel ecosystem" effects;

Inattention to landscape context	Conduct systematic assessment of potential and capacity to restore full connectivity, especially via ecosystem sustaining processes such as sediment accretion, channel migration, etc.; identify constraints at multiple space and time scales	Evaluate and "design" site specific restoration in the context of the landscape/watershed, including a thorough understanding of scaling factors (e.g., channel structure), potential constraints and changes in watershed forcing (e.g., water and sediment delivery), shoreline development, sea level rise, and other factors threatening estuarine wetland sustainability
Lack of considering natural disturbance a critical element to wetland structure and function	Set priority on watershed/landscape settings where natural disturbance persists; restore to allow natural disturbance, not suppress it	Select or design restoration that has capacity to absorb and benefit from restoration in a natural disturbance regime; avoid design features that inhibit disturbance, e.g., features that prevent tidal-fluvial flooding, recruitment and movement of large wood, beavers, etc.
Demand for instant gratification	Avoid management measures that are believed to "jump-start" the time required to create a functional or desired ecosystem (e.g., "Fast-Forwarding" of Hilderbrand *et al.* (2005)	Conduct a "cost-function" assessment of restoration actions designed to replicate what tidal and other natural processes accomplish more effectively with time; avoid excavating channels, planting, controlling water flow and other manipulations that may be "counter functional" in the long run
Perpetuating the "Cookbook Myth" (Hilderbrand *et* 2005)	Must incorporate adaptive management (experiments) to resolve many uncertainties; cookbook approach won't work	Demand monitoring and active adaptive management for highly uncertain management measures; require reporting to managers, practitioners, scientists and stakeholders

Vernal Pool Restoration: How to Restore the Landscape

Mick Micacchion

Constraints	Recommendation	Selected Measures
A general assumption that all constructed wetlands will provide habitat for pond-breeding (vernal pool) amphibian species	Need to understand and incorporate essential habitat features into vernal pool restorations that will attract amphibians and other vernal pool organisms	Develop site plans that include all of the habitat features needed to support healthy populations of vernal pool amphibian species. Provide settings with appropriate surrounding landscape features, hydrology sources, hydroperiods, pool slopes and depths, and other features.

Vernal pool restorations located where they are isolated from other high performing vernal pools	Strategically locate vernal pool restoration projects	Place vernal pool restorations close to high quality vernal pools and within migration distances of existing populations of pond-breeding amphibian species. Situate on hydric soils and connect new pools to existing pools through reforestation.
No goals for wetland restoration projects that are specifically aimed at restoring biologically diverse vernal pools	Set goals and monitor the restored vernal pools to determine if they are being utilized by the targeted amphibian species and are otherwise of high quality	Use Amphibian IBI score or other quantifiable ecological performance standards as goals. Set goals of "GOOD" or better ecological condition to assure restored VPs compensate for losses, have high quality pond-breeding amphibian communities, high environmental resilience, & require minimal management.

Aram Calhoun, Ph.D.

Recommendation	Justification	Literature
Create pools as a last resort	It is very difficult to replicate pool hydrology and a high percentage of attempts in our region fail	Denton RD, Richter SC (2013) Amphibian communities in natural and constructed ridge top wetlands with implications for wetland construction. J Wildl Manag 77:886–889 Korfel CA, Mitsch WJ, Hetherington TE, Mack JJ (2009) Hydrology, physiochemistry, and amphibians in natural and created vernal pool wetlands. Restor Ecol 18:843–854
If you must create pools, pay attention to context (HGM) and nature of native pools (density, vegetation, soil type)	Hydroperiod drives vernal pool function. Establish current hydrology and conceptual target hydrology by using an analog, historic or constructed reference condition. If this fails, goals for classic pool native flora and fauna fail.	Calhoun AJK, J Arrigoni, RP Brooks, ML Hunter, SC Richter. 2014. Creating Successful Vernal Pools: A literature review. Wetlands Gamble DL, Mitsch WJ (2009) Hydroperiods of created and natural vernal pools in central Ohio: a comparison of depth and duration of inundation. Wetl Ecol Manag 17:385–395
Pay attention to landscape setting and historical context	Vernal pool functions are tied to quality of adjacent forested habitat for support of amphibians , support of carbon dynamics, and role of pools in terrestrial ecology	Richter SC, Price SJ, Kross CS, Alexander JR, Dorcas ME (2013b) Upland habitat quality and historic landscape composition Influence genetic variation of a pond-breeding salamander. Diversity 5:724–733 Compton BW, McGarigal K, Cushman SA, Gamble LR (2007) A resistant-kernel model of connectivity for amphibians that breed in vernal pools. Conserv Biol 21:788–799
Create pools to provide breeding	Many created pools support generalist	Petranka JW, Harp EM, Holbrook CT, Hamel JA (2007) Long-term persistence of amphibian

and post-breeding habitat for target species, not to enhance species richness	amphibians but, either owing to hydroperiod or lack of forested post-breeding habitat, do not support persistence of target species	populations in a restored wetland complex. Biol Conserv 138:371–380
Have clear long-term monitoring protocols, measures of success, and remediation plans if measures are not met and SHARE losses and successes with practitioners	One cannot create a vernal pool without clear goals (what are target species? what functions must be replace? Is the adjacent habitat suitable?). Monitoring must be at an ecologically relevant time scale: invasive plants or animals or facultative species may take over five years to become established. If more people publish the failures and share successes through resources used by practitioners, the science and art could advance more quickly.	Calhoun AJK, J Arrigoni, RP Brooks, ML Hunter, SC Richter. 2014. Creating Successful Vernal Pools: A literature review. Wetlands Vasconcelos D, Calhoun AJK (2006) Monitoring created seasonal pools for functional success: a six-year case study of amphibian responses, Sears Island, Maine, USA. Wetlands 26:992–1003 Lichko LE, Calhoun AJK (2003) An evaluation of vernal pool creation projects in New England: project documentation from 1991–2000. Environ Manage 32:141–151

Christina Schaefer, Ph.D.

Constraints	Recommendations	Selected Measures
Overall reduction in viable and functioning vernal pool ecosystems (San Diego County loss about 97%)	Conserve and preserve vernal pool complexes before allowing impacts that require mitigation/restoration	Vernal pool restoration science is too young to guarantee comprehensive improvement of ecosystem functions in perpetuity, specifically given climate change and the California drought. There are no comprehensive studies that show that vernal pool restoration is successful in the long term, but some studies show their failures. Provide for comprehensive regional guidelines (e.g., NCCP, HCP) and ordinances for vernal pool conservation.
Failure of vernal pool restoration due to inadequate baseline conditions	If you must create pools to mitigate unavoidable impacts, do so only where pools once (historically) existed. Collect adequate baseline data by experienced vernal pool restoration practitioners and biologists.	Vernal pools require functioning hydrology, and with it impermeable soils. It has been shown that artificially created impermeable soil layers do not work (bentonite has different physical characteristics than the extant clay layers and hard pans that characterize SoCal vernal pools). Develop hydrological models for vernal pool conditions. Collect baseline data within the vernal pool complex (or watershed), including botanical surveys, faunal surveys (incl. fairy shrimp sampling), and soil tests.

Vulnerability of restored vernal pools to edge effects, fragmentation, and other threats due to their position in the landscape	Avoid creating postage stamp vernal pools that lack sufficient/appropriate watershed, buffers, and landscape context	Vernal pool functions require an appropriate watershed to allow for reliable filling of pools. Vernal pool ecosystems are sensitive to edge effects, including trampling, invasive species introduction, pollution, predation, and lack of pollinator access.
Failures due to inadequate experience by restoration contractor	Only use experienced contractors with documented track record of successful vernal pool restoration. This is not necessarily the lowest bid.	Vernal pool restoration requires micro-topographic grading to create functioning vernal pool basins and mima mounds without penetrating the hard/clay pan. This requires years of specialized experience. Vernal pools are unique ecosystems and the contractor must have an understanding of the baseline physical and ecological conditions. There is a common misunderstanding that a low bid saves tax payer money; however, in the end, a low bid may actually be more expensive down the line due to changes orders, remediation costs, or project failure.
Failures of successfully installed vernal pool restoration due to lack of continued monitoring and management	Set up management funds. Avoid disturbance through monitoring; use programmatic reference sites and consistent monitoring protocols and metrics geared toward ecosystem function rather than singling out one organism over another, and protect restored pools through long-term management.	Meaningful monitoring is important to show ecosystem functions of the entire system, not just plants. Use statistically rigorous monitoring protocols, but avoid over-monitoring (killing with good intentions). Long-term monitoring is important to inform adaptive management and buffer from climate change effects. Vernal pools are susceptible to invasive species that accumulate phytomass, which prevent proper hydrological function and result in species extirpation. Calculate management funds/endowments using experienced personnel that understand what it takes. Consider managed grazing.

Prairie Pothole Restoration

Susan Galatowitsch, Ph.D.

Constraints	Recommendation	Details
Over-estimating ecosystem resilience	Assess likelihood that wetland plant community will recolonize after reflooding	Resilience is a function of duration of drainage and distance to natural wetlands
Spread of invasive species	Control species such as RCG, especially prior to and following reflooding	Invasive perennial plants cause arrested succession in more than 75% of PP restorations.
Conflicting project goals	Recognize tradeoffs between goals—especially biodiversity support and	Stormwater and nutrient interception are ecosystem stressors that greatly reduce biodiversity support.

	water quality or stormwater interception	
Inadequate after care	Continue to manage vegetation during the establishment phase	For nearly a decade following reflooding, a PP restoration is still in a state of recovery and typically more invasible.
Lack of adaptive management	Link decision-making to monitoring	Ignorance is not bliss. Not detecting problems related to hydrology and biotic recovery often lead to insurmountable problems.

Carter Johnson, Ph.D.

Constraints	Recommendation	Details
Climate change effects remain undetected	Initiate monitoring on long-term field sites and/or use wetland models to simulate future conditions	Because of high variability in climate and other factors that influence wetland water budgets, negative effects of climate change may go undetected for decades
Wetlands restored in high risk parts of the PP	Priority for restoration should match up geographically with areas expected to have the best wetland climate	Western, drier parts of the PPR may experience greatest loss of wetland functionality. Future climate in the east looks more productive
Wetland restoration too little too late	Massive restoration efforts will be needed to offset wetland losses due to climate warming and drying	Wetland losses continue to exceed gains. This trend needs to be reversed soon if we are to at least partially mitigate for climate change.

Riverine/Riparian Wetland Restoration

Richard Weber & Larry Urban

Constraints	Recommendation	Selected Measures
Problems encountered during construction due to lack of information.	Feasibility studies must address all technical aspects of a proposed project in enough detail to prevent problems from occurring during construction.	Accurate topographic survey
		Geotechnical information – soils, rock strata, groundwater elevations, etc.
		Hydrologic analysis – modeling for the watershed
Inexperienced construction oversight personnel.	Contract specifications should require that an experienced Stream/ Wetland Restoration Specialist provide oversight during the entire construction project.	Develop standard contract language requiring experienced Construction oversight personnel.

Undermined log drop structures in stream.	Install geotextile fabric on all log drop structures to prevent undermining by streams flows by tacking to logs	Develop a standard plan detail for construction plans showing the location of geotextile in relationship to log drop structure design.
Inexperienced construction contractors.	Hire only contractors experienced in stream and/or wetlands work.	Contract bid requirements should require experienced construction firms to construct the aquatic resource restoration projects, specifically for riverine systems. More efficient and knowledgable in building such systems, may reduce costs.
Post-construction reviews	Recommend separate post construction meetings with agencies and contractor /oversight professional.	Agency review may provide recommendations for future projects. Post con with contractor and oversight professional to discuss the good, bad and ugly for improvements to future plans, specifications and projects.
Hydrology Not Restored	Match Channel Water Surface Profile to Stream Corridor Groundwater Table, Flood frequency and Duration	Properly Identify System as Riverine or Slope. Design Channel Water Surface Profile to support system's groundwater and flooding frequency and duration

Peatland Restoration

Marcia Spencer-Famous

Constraints	Recommendation	Selected Measures
Peatland not restored to pre-disturbance condition.	Re-assess what is possible at the site, the stage of recolonization, and time frame for achieving the target peatland community. "Adaptive management"	Develop a plan to "jump start" or guide/correct recolonization: *i.e.,* addition of nutrients, seeding with target species, removal of invasive plants, adjust hydrology if possible. Adjust expectations.
Early recolonizing plant community is a sparse sedge monoculture, may include mosses such as *Polytrichum commune*, but not a sphagnum-dominated community.	Monitor to determine if the recolonizing species are "companion species" providing protected niches for sphagnum to recolonize. *Eriophorum vaginatum var. spissum* is desirable.	Monitor for several years for recolonization by sphagnum. Search areas such as along ditches sides and in small protected areas, as well as under companion plants. Consider re-seeding with live sphagnum fragments. Sphagnum recolonizes a site slowly.
Recolonizing peat surface is subject to wind erosion, frost heaving and desiccation.	Stabilize the peat surface to improve growing conditions.	If plants are not yet re-established, consider ways to create micro-topography. Seed with an early re-colonizer such as *Eriophorum vaginatum var. spissum*. Add nutrients to jump start growth. Protect the peat surface by spreading straw over newly re-seeded areas, especially when sphagnum is spread.

Richard Weber

Constraints	Recommendation	Selected Measures
Soil Saturation not restored due to inadequate water supply.	Account for lost groundwater inputs.	Disable surface ditches or subsurface drainage which is intercepting groundwater inputs at the wetland boundary (discharge).
Soil Saturation not restored due to excessive removal of groundwater	Account for excessive groundwater drawdown from interior channels, ditches, or open excavations	On watercourses, match interior channel water surface profile to groundwater level targets. Minimize open excavations that draw down groundwater levels.
Deep ponding is in excess of restoration targets	Assess the potential for subsidence that has caused land surface to be below existing local surface outlets	Adjust restoration goals to account for local infrastructure grades (roads, culverts). Modify existing outlets to match subsided land surface.

Norman Famous

Constraints	Recommendation	Selected Measures
High pH and excess nutrient levels (surface water, groundwater and calcareous soils)	Change restoration goals from a low-nutrient fen to a nutrient-rich non-peatland wetland.	Adjust groundwater levels to control the height and plant composition of the new target wetland types.
Excess of weedy non-wetland species including invasives	Account for low groundwater levels (e.g., excessive drawdown, shallow initial excavation). Remediate by flooding or saturating dry sections to control weedy species.	Lower surface elevation to saturate or flood the surface. Adjust level of outlet structure. Construct water control weirs.
Lack of Sphagnum moss establishment	Wait 2-3 years for water levels to stabilize. Establish companion plants and 10% cover of dead woody debris. 'Give it time'	Delay Sphagnum moss applications until ground and surface water levels are determined and companion plants are well established. Match Sphagnum species with surface and subsurface water levels. Adjust restoration goals.

Larry Urban

Constraints	Recommendation	Selected Measures
Evaluation of the subsidence of ground surface due to de-composition and compression of organic soils.	Evaluate soils by conducting detailed geotechnical evaluations.	Geotechnical evaluations must understand the complexity of organic soil types such as Saprists, Fibrists and Hemists. Rates of decompositions within Saprist soils is an unknown in the Rocky Mountain region and should be considered in restoring fen/carr systems.
Higher than anticipated groundwater tables.	Installation of piezometers to evaluate groundwater prior to construction.	Five years of groundwater data and hydraulic analysis/modeling did not predict groundwater elevations would be higher than existing ground surface. Water elevations are at their historical levels now that the site has equilibrated to normalcy. Non-native grasses are disappearing from the site and native grasses /sedges/rushes are establishing.
Drowned shrub and tree plantings. Scrub/Shrub credit development unlikely due to high water table and will require adaptive management efforts.	Await the development of hydrology within site possibly 2 to 3 years dependent upon weather cycles.	Schedule supplemental plantings of woody plants after water levels have equilibrated to the site conditions. Also to change the woody species to be planted based upon the new site conditions.

Stream/Wetland Restoration

Will Harmon

Constraints	Recommendation	Selected Measures
Credit determination methods generally do not exist for stream/wetland complexes.	Create a third category for mitigation debits and credits called stream/wetland complexes. Apply on debit and credit side.	Focus on groundwater connection, floodplain connectivity, bed form diversity, lateral stability, and riparian vegetation as a minimum.
Most credit determination methods are linked to changes in dimension, pattern, and profile.	Link restoration activities to changes in function-based parameters.	Same as above.

Projects over-promise success by not assessing restoration potential.	All projects should state the restoration potential as the highest level of restoration that can be achieved based on health of watershed, reach scale assessment and constraints.	Catchment assessment, function-based assessment using parameters above and a statement about the restoration potential. Level 3 (Geomorphology) = Stability Level 4 (Physicochemical) = Water Quality Level 5 = (Biology) = Biology to a reference condition

Matt Daniels

Constraints	Recommendation	Selected Measures
Lack of monitoring and maintenance	Require monitoring and maintenance plans	Monitor projects for at least 5 years. Budget up to 10% of implementation costs for outyear maintenance.
Poor site selection and inability to overcome severe problems	Complete initial feasibility assessments prior to site selection	Collect data and complete analyses to document the limiting factors and constraints. Ensure that goals and objectives are appropriate and realistic. Assess the ability to overcome limiting factors.
Application of inappropriate restoration treatments	Clarify cause and effect pathways. Link treatments to limiting factors and objectives.	Peer review Enlist an interdisciplinary team to ensure that a broad range of issues are contemplated.
Inexperienced or unqualified construction contractor	Contractor selection must be based on more than low bid. Selection must also consider experience and qualifications	Require contractors to submit experience in the form of 5 restoration project examples. Require contractors to submit qualifications by describing components of past restoration work. Require use of GPS to improve implementation quality control, if applicable.
Lack of a project champion	All projects need a leader or dedicated team to see it through from start to finish and beyond.	Project designers need to be involved in all project aspects including planning, design, construction oversight and monitoring.

Urban/Highly Disturbed Wetland Restoration

Steven Apfelbaum

Constraints	Recommendation	Selected Measures
Location, Location, Location	Inappropriate hydraulic, hydrologic and land use context	Watershed context placement is necessary
Inadequate quantity, quality of seed/plant used	Seedbank quantitative analysis and planting of cover crops, annual,	Seed bank evaluation using soil sampling and greenhouse growing; seedbank management to reduce risk of invasive plant dominance using

and planting swamped by invasive plant seedbank (which was not understood)	biennial and perennial final species	cover crops, soil preparation to stimulate undesirable seed banks. Also understand seed and propagule rain from upstream watersheds
Misunderstanding hydraulic performance and water quality and overdeepending and overly increased depth duration	Confirm hydraulic performance through field measurements and indicators rather then rely on H and H modeling.	Measure hydraulics and depth duration and align with planting specifications and construction plans
Substrate compaction	Heavy substrate compaction (often coupled with deicing materials salt-related substrate structure collapse) from earth moving restricts plant growth.	Use of low loading construction equipment, polyacrilimiad resins, and other techniques to reduce compaction.

Tom Ries

Constraints	Recommendation	Selected Details
Lack of historic records or as-built surveys to understand the geotechnical conditions	Research historic aerials & photos of the site to get a better understanding of it's prior use which might affect the designs	NRCS (or original SCS) records as well as the original survey field notes can very useful tools to ascertain the prior site conditions. Also, interviews with former land owners can be useful in learning about a site's history
Contaminated soils Undocumented utilities and subsurface conduits	Perform many more borings and even pit digs to really investigate the potential for contamination which will affect the design Ground Penetrating Radar (GPR) may be necessary to identify the location of undocumented utilities and potential conflicts	Highly urbanized sites have a long history of various uses, much of which may of occurred prior to today's regulatory rules and restrictions; it is imperative to look for potential contamination in these types of settings Highly urbanized sites have a long history of various uses and 'in those days' there were no records kept of utility locations; all efforts should be taken to avoid conflicts during the construction phase
Archaeological ramifications	Perform a through archaeological investigation when there's greater than 50 years of urban use at a site	Archaeological conflicts can completely 'kill' a site plan. Historic building foundations may need to be preserved and acknowledged so avoidance of these potential conflicts is paramount

'Loved To Death'	Habitat restoration in urban settings provide very affect ways to educating a large populace, however, too many people can negatively affect it's ecology	Roping off sensitive areas from tramping and keeping the public a distance from the wildlife, especially protected species is important and should be addressed in the design with buffer areas, limited access locations while still providing some access to the site

Alexander Felson, Ph.D.

Constraints	Recommendation	Selected Measures
Urban stressors create a new range of pressures	Coordinate with other professionals involved in city making and maintenance to explore better restoration options.	Integrate adaptive management into restored urban ecosystems. Develop restoration projects as design experiments to test performance and function. Rethink reference ecosystems and historic landscapes to guide our approach
Go beyond the "biggest bang for the buck" approach focusing on the greatest habitat restoration potential and include lower value locations where funding exists.	Diversify restoration types to include a range of urban interventions	Develop ecosystem functions including social ecological values for restored ecosystems and develop an education and marketing campaign to promote specific restored landscape types as tools for urban ecosystem function. Piggyback on the green infrastructure movement and learn from other fields already involved in building projects. Build restoration into multiple areas (e.g. infrastructure, parkland, streetscapes, neighborhoods).
Take on more risks and ethical challenges at multiple levels in order to increase the role of restoration ecologists in society.	Maintain an open and inclusive attitude towards restoration projects and look for opportunities to expand the types of restored ecosystems projects.	Rather than taking a hard stance on restoration ecology and issues such as invasive species, allow more diverse perspectives and approaches to permeate. This needs to be balanced with the recognized value of field experience and the application of a deep understanding of historic landscape reference sites within the context of a changing climate.
Expand opportunities for restoration ecologists.	Restoration ecology is a fairly conservative field. Consider expanding the role restoration ecologists play in city making.	Restoration ecologists could focus on a wider range of themes including project siting and scope, stakeholder and local negotiations, project design and aesthetics. Develop multifunctional landscapes with restoration as a component.
Bridge across theory and practice, linking basic and applied science: the world needs more restoration ecologists.	Restoration ecologists have a rich history of bridging theoretical ideas in ecology with applied practice. This integration needs to be further promoted and supported through bridging academics with practitioners and building experiments and testing	Funding that could support interdisciplinary restoration ecology linking academics with practitioners is essential. Restoration ecologists also need to recognize where there is uncertainty or missing knowledge in order to better grapple with what areas need further research. Many assumptions about what makes a good restoration project need to be reevaluated critically and explored in greater detail through rigorous testing and field experiments. We need to integrate increased

	into design projects.	monitoring and assessment on the restoration projects that are built.

Evaluating the Ecological Performance of Compensatory Mitigation

Joseph A. Morgan

Constraints	Recommendation	Selected Measures
Few studies of the performance of compensatory mitigation since 2008, and many states have not evaluated their programs at all.	States, particularly those with large and active compensatory mitigation programs, should conduct periodic self-audits to determine that both ecological and administrative goals are being met.	• Leverage federal grants, such as EPA WPDG, to fund activities related to improving mitigation performance. • Eligible state universities can be a useful resource for states with limited employee time to dedicate to mitigation evaluations.
Studies are conducted on an ad-hoc "one-off" basis, making it difficult to compare across time and space.	States should develop a long-term approach to mitigation to facilitate periodic evaluations of program performance.	• Employ a standard study design that can leverage existing aquatic resource surveys as reference. • Organize project files in a geospatial database & establish standard reporting procedures for mitigation projects.
Few studies have evaluated differences in outcomes between compensation mechanisms (banks, ILF, permittee-responsible).	Study designs should be constructed to compare all three mechanisms where appropriate.	• Refer to Siobhan & Eric's study design for wetlands. • Administrative performance may be addressed through file review and/or "windshield" surveys without the need for time-intensive and expensive sampling.
Very few studies have evaluated the performance of stream compensation.	Studies should examine all forms of aquatic resource compensation, not just wetlands.	• We are working on developing a similar study design for stream compensation. • Valuable information can be gleaned from existing data – file reviews don't require the same level of effort/fieldwork, see Palmer & Hondula (2014).

Eric Stein, Ph.D.

Constraints	Recommendation	Selected Measures
Poor site selection and design	Incorporate landscape ecology and historical ecology understanding into design	Analyze historical distributions of wetlands at the watershed scale. Create templates for watershed-scale restoration based on this understanding. Mitigation projects must select and design sites consistent with the overall watershed plan

Failure to investigate and understand hydrology to a sufficient level to inform restoration design	Conduct analysis of historic, current, and model anticipated future hydrologic conditions prior to design.	Several seasons of surface and subsurface hydrologic monitoring should occur at the proposed site AND an appropriate reference site, prior to restoration design. Modelling should demonstrate ability to maintain hydrology under expected future conditions. Include adaptive hydrologic monitoring to correct errors and unanticipated events early in the restoration process.
Inadequate or poorly conceived monitoring	Monitor broad suite of structure and functional indicators at project and reference site using a BACI design	Standardized monitoring procedures, indicators/indices, and data templates should be used. Pre-restoration monitoring at the project and reference site should occur for several years before design in approved. Post-restoration adaptive monitoring should occur for a minimum of 20 years. Permittees could pay into regional monitoring entities for this
	Create and enforce standard data templates, web services, and apis to facilitate information sharing	Regional data exchange networks would allow better sharing of lessons learned and would provide broader access to data from past sites that could be used to improve the science of wetland restoration.

Siobhan Fennessy, Ph.D.

Constraints	Recommendation	Selected Measures
Studies of performance often limited in scope, making comparisons difficult (through time and across regions)	States need consistent methods to evaluate mitigation projects and program performance.	• Adopt standard methodology as proposed • Benchmark with NWCA and/or statewide data
Many states have incomplete or inaccessible project records that prevents ability to track and assess	Electronic databases of compensatory mitigation projects are needed	• Funding needed to gather and organize current and historic data on compensatory mitigation and improving the our ability to track these data into the future • Use database to initiate studies of compensatory mitigation using the study design
Consistent performance standards lacking, prevents adaptive management and project improvement	Use the data collected to develop better performance standards and monitoring protocols	• Pilot studies can show relationship between performance standards and project success • Standards must be ecologically relevant, use existing biological assessment methods (VIBI)

Water Rights & Wetland Restoration

Alan J. Leak

Constraints	Recommendation	Selected Measures
Lack of Planning for acquisition of the necessary water rights	At the start of the project identify if water rights will be necessary	• Engage a water rights professional • Determine the type of water impact • Contact and meet with the water rights administrator in your State to discuss the project
Did not identify that the excavation for the wetland pond would expose groundwater	Determine the potential exposure of groundwater for any wetland excavation	• Contract with a Geotechnical engineer to construct soils borings and conduct groundwater level monitoring • Engage a professional to provide opinions regarding potential groundwater level fluctuations
No budget for long term water rights accounting and administration	Assure that the long term maintenance budgets include water rights accounting and administration	• Obtain an estimate from a water rights professional for the long term water rights accounting and administration • Identify the person who will be responsible for water diversions / deliveries and connect them with the water rights professional
Did not expect the time required to obtain water rights for the project	Plan that water rights can take a substantial time to acquire/adjudicate/permit	• Depending on the State in which the project is constructed, you may need to conduct water rights evaluations early on and live with the results of the process • Don't cut corners / establish contingencies (20%)

Julie A. Merritt

Constraints	Recommendation	Selected Measures
Geographic area closed to new appropriations of water	Identify site with existing water rights	Locate a landowner with existing water rights who is willing to convert water rights from existing use to wetland use
Existing water rights for project site are determined to be less than expected	Have knowledgeable professional review water rights as part of initial site selection	Choose sites with rights that have been vetted and/or identify other rights in the vicinity that may be purchased and relocated
Application to change denied do to unacceptable change in timing, location or amount	Research other water rights in the area for potential adverse effect	• Modify project to address timing, location or amount discrepancies • Obtain additional water rights to resolve adverse effect
Cost and time budgets for water rights overrun	Be prepared to invest in an initial assessment for water rights and allow for year or more for application process	Team with experienced water right professionals and include $ and time in budgets for initial assessment and water right authorization process

Managing Invasive Species in Wetland Restoration Projects: Considerations for Common Reed, Reed Canary Grass, Purple Loosestrife, Nutria and Feral Hogs

Margaret Pepper & Wendy Anderson

An integrated approach is necessary but many methods require in-depth training and proper federal and state permits for wildlife damage management – always consult with your USDA Wildlife Services office.If feral swine or nutria are known to occur in your area, monitor the wetland for their presence through sightings, sign, or damage. If you believe feral swine or nutria are present, please contact the USDA-APHIS-Wildlife Services program in your State for advice or assistance with damage management operations. Visit our website at http://www.aphis.usda.gov/wildlife-damage or call 1-866-4-USDA-WS to reach the office nearest you.

Ben Peterson

Constraints	Recommendation	Selected Measures
New infestation of purple loosestrife into an un-infested site	• Prevent human caused spread • Prevent spread via wind, water and animals	• Make sure all clothing, footwear, pets, tools, equipment, and vehicles are cleaned before entering and exiting the site • Investigate upstream and upwind locations to see if purple loosestrife is present; coordinate control of plants in those locations
Purple loosestrife persists after one year of control effort	• Ensure control of missed plants • Plan a long-term IPM control strategy	• Clip and bag flowers just before herbicide treatment • After initial herbicide treatment , re-treat missed plants with herbicide ~ 3-4 weeks later • Eradication of the plant is difficult, use a combination of control methods (chemical, manual, mechanical) to efficiently and thoroughly control the plant each year
Purple loosestrife returns after ~ five years of control effort	• Continue with control efforts • Prevent new infestations via human, wind, water or animal vectors	• Plan for perpetual maintenance control of this common wetland weed • Annual surveys at the height of flowering will help ensure all plants are located

Craig Annen

Constraints	Recommendation	Selected Measures
Emphasis on restoring wetland structure without regard to dynamic processes.	Perform pre-treatment site assessments detailed enough to understand site-specific processes that are reinforcing invasions	Recognize feedback cycles that maintain both invaded and remnant states; restore and/or manipulate feedbacks and other dynamic processes (litter accumulation, nutrient cycling, fire regimes, etc.) concomitant with applying direct suppression measures (e.g. herbicide use).

Much of the applied suppression research is inadequate to guide invasion management (experiments in artificial environments, short-term single-site experiments with over-reaching conclusions, experimental units too small to be ecologically meaningful).	Encourage researchers to conduct longer-term suppression experiments over larger spatial scales.	Establish a dialogue among academic researchers, land managers, and R&D divisions of contracting firms in order to target specific research needs and share perspectives/experience. Conduct research in field settings rather than greenhouses and campus gardens to improve external validity.
Improper use of herbicides and herbicide-additive systems.	Encourage applicators and researchers to have a better understanding of plant anatomy, physiology, and herbicide-additive chemistry.	Conduct workshops with an emphasis in proper use of herbicides and additives (adequate spray coverage, proper mixing procedures, how additives enable herbicides to penetrate thick leaf cuticles, factors that affect herbicide performance, importance of cleaning and neutralizing spray equipment, etc.).

Establishing Reference Conditions for Performance Standards & Long Term Monitoring Results: Soils, Hydrology and Vegetation

Robert Brooks, Ph.D.

Constraints	Recommendation	Selected Measures
Projects do not mimic natural wetlands	Use data from reference wetlands for design and performance	Match landscape position, appropriate wetland type; match hydrology, soil, and vegetation metrics; avoid chronic stressors
Use of inappropriate evaluation metrics & permit conditions	Use the same methods for assessing conditions and functions, as for evaluating performance	Variables from 3 levels: 1 – Landscape, 2 – Rapid Assessment with stressors, and 3 – Intensive Assessment
Insufficient match of hydrology	Use predictive model or reference hydrographs	Match to regional hydrographs & metrics; record data over variable conditions or simulate variation in models (e.g., WetBud)
Inappropriate use and selection of plants species	Compare to appropriate reference wetlands (proper type); build in lag time for maturation	Vegetation – Floristic Quality Index (FQI) Wentworth Index (wetland indicator status) Invasive species management & control
Selecting/creating improper soil type	Excavating into subsoil = less organic matter; requires amendments	Soil texture; organic matter from initiation; hydric soil if available; match reference sites

W. Lee Daniels, Ph.D.

Constraints	Recommendation	Selected Measures
Low soil organic matter levels limit microbial reduction processes, plant rooting etc.	Save and replace native high OM hydric soil materials (where feasible) and/or add appropriate organic amendments.	If possible, stockpile native O+A horizon materials and maintain them in a wet and vegetated condition. Direct haul topsoil from donor to creation site. Add stable low N+P composts at 25 to 35 dT/Ac.
Soil compaction limits rooting, water penetration, organic matter incorporation and microbial activity.	Limit subsoil compaction when and where possible. Rip and loosen graded subsoils to necessary rooting depth. Loosen topsoil following placement.	If water budget design requires a compacted "perching seal", estimate and reconstruct required rooting depth. Monitor bulk-density post-construction. Rip and loosen when > 1.35 for fine-textures and >1.75 for sands. Limit major grading & ripping to driest periods of year.
Inaccurate interpretation of relict soil redox features indicates soils are hydric when they are not "active".	Carefully describe and assess redox features with depth before and immediately after site construction. Follow-up with detailed assessments at years 1, 3, 5 etc.	Describe soils in multiple test pits before development and quantify color (including size and abundance) of all horizons vs. depth. Conduct follow-up assessments with sufficient observations to allow statistical tests of whether matrix chroma is shifting down, Fe-concentration abundance is increasing, etc.
Hydrology is not correct; e.g. wrong hydroperiod for intended wetland type.	Use HGM to provide input for an appropriate and rigorous *a priori* water budget estimation during the design process.	Determine HGM setting of both the impact and the proposed creation site. Quantify whether or not groundwater is a significant input via a minimum of 6 month of field data for mid-winter to early summer. Avoid bias in W-N-D year selection for water budgeting and include groundwater when applicable.

Eric Stein, Ph.D.

Constraints	Recommendation	Selected Measures
Monitoring and management periods are too short	Develop regional programs to allow for monitoring and management for min of 20 yrs.	Mitigation sites meet functional success criteria within acceptable (asymptotic) ranges of variability at 10, 15, 20 years post installation. Recovery following episodic disturbances (e.g. fire, flood) occurs within 5-7 years
Performance standards do not require development of physical template and functional hydrology	Work with permitting agencies to develop function based performance measures that are implemented in a tiered manner	Mitigation sites achieve hydrologic function necessary for success within first three years following installation. Plant success measures deferred until after hydrologic functions are achieved
Poor site selection and design	Incorporate landscape ecology and historical ecology understanding into design	Analyze historical distributions of wetlands at the watershed scale. Create templates for watershed-scale restoration based on this understanding. Mitigation projects must select

		and design sites consistent with the overall watershed plan
Performance standards not adequately anchored to reference conditions	Develop regional reference networks and make the data readily available. Reference sites monitoring routinely over time	Every region maintains a set of reference wetlands representing all wetland types. Reference sites are routinely monitored and data is made broadly and easily available

Gulf Coast Restoration Post-Katrina

Bren Haase

Constraints	Recommendation	Selected Measures
Funding: Recommended plan exceeds $50 Billion	Wise expenditure of available funding on high priority/most impactful projects	Continued update of plans incorporating new information and lessons learned from previous implementation
Scale: Projects on order of thousands of acres	Better resource management ($, sediment, water) Better contractor management (industry capacity)	• Louisiana Sand Resource Database • Mississippi River Hydrodynamic Study • LaGov Financial Management System • Industry Days • 5) Market Soundings
Assessing success: How do we know we are accomplishing anything?	Continued improvement of monitoring, AM and forecasting/hind casting tools	• System-wide Assessment and Monitoring Program • Coast-wide Reference Monitoring System • Barrier Island Comprehensive Monitoring Program • 4) Programmatic AM - Master Plan Updates

William P. Klein

A direct quote from the FY 2017 Corps budget proposal:
"The Budget continues to reflect the tough choices necessary to put the country on a fiscally sustainable path."

Pre-LCA Study Guidance:
If you can clearly demonstrate agreement between the various stakeholders and the Corps
If you can clearly demonstrate cooperation between the various stakeholders and the Corps
And If you can clearly demonstrate a combined will to accomplish the same thing between the stakeholders and the Corps
Then I can show you the money.

Congress serves the people, all of the people. If you have a **lack of agreement** on what and how to do ecosystem restoration, if you do not have **cooperation** among the various stakeholders and the Corps, and if you cannot demonstrate a **combined will** to accomplish the same thing between the stakeholders and the Corps, then Congress **will look to those projects and those folks who can clearly demonstrate agreement, cooperation, and combined will.**

John Andrew Nyman, Ph.D.

Constraints	Recommendation	Selected Measures
Over-filling vertically: many wetlands created with dredged material are too high to provide significant habitat for fish.	Recognize that creating wetlands higher than natural wetlands delays rather than extends fish use of created wetlands.	Flooding patterns: percent flooding and duration of flooding events.
Over-filling laterally: wetlands created with dredged material have less edge than most natural wetlands.	Recognize that creating wetlands with little edge delays rather than extends the abundance of high quality fish and wildlife habitat.	Edge habitat: area of open water within 10m of emergent vegetation (m^2)/project area (ha).
Assuming bigger is more efficient: barrier islands and back barrier marshes created with dredged material generally support too many predators to allow successful nesting by shorebirds.	Create numerous wetlands that are too small, isolated and salty to support raccoons, coyotes, and feral pigs.	Nest success.

Denise Reed, Ph.D.

- Tailor the scientific tools to meet the needs
  - Not all answers require the most detailed approaches
- Identify the key decision drivers
  - Focus analysis there to get useful results
- Focus on the big picture
  - There are so many aspects of wetlands that are impossible to predict
- Acknowledge what you don’t know
  - Scenarios can help explore ‘uncertainty space’
- Allow nature to work – don’t try to over-engineer
  - Some natural dynamics cannot be replicated

Bottomland Hardwood Restoration

John Stanturf, Ph.D.

Constraints	Recommendation	Selected Measures
Seedling quality variable and of	• Adopt Target Seedling Concept	• Collect seed from more stands • Provide more information on sources

limited genetic composition	• Capture more genetic variability in seed collection	• Test planting stock on more sites
Low stocking levels in planted stands limit long-term management options	• Increase survival • Increase planting density	• Control competing vegetation (herbicides, cover crops) to reduce mortality • Plant more seedlings to achieve higher stocking with given mortality levels
Long-term effort is required	• Incorporate full project cycle in funding programs • Adopt adaptive management	• Require explicit objectives that specify expected restoration trajectories • Monitor and report on performance at site, landscape, and program levels
Climate change will alter river base levels and introduce more frequent extreme events	• Adapt to projected climate change in species selections • Increase diversity of composition and structure (risk reduction)	• Increase understanding of intimate species mixtures • Revise planting guideline for site matching as climate changes

John Groninger, Ph.D.

Constraints	Recommendation	Selected Measures
Delivering high quality ecosystem services on restored lands	State and justify clear and specific restoration objectives	Monitor and report restoration performance in terms of pre-selected indicators (economic impact, key species occurrence, diversity of desired cover types)
Invasive species	• Accept the inevitability of a changing biota on some sites • Retain focus on ecosystem functionality • Steady funding to allow consistent management	Performance based, but with focus on establishing clear relationships between biotic composition and indicator performance on a site specific basis
Putting into action the understanding that many disturbances are inherent to a healthy ecosystem	• Establish and maintain manager-driven research cooperatives to address common problems at the regional level • Multi-disciplinary training for managers	Relating existing site conditions to those needed to achieve high priority ecosystem services

Not Lost In Translation: How to Select the Right Wetland Restoration Team

Lisa Cowan, John Bourgeois, & Matt Schweisberg

Constraints	Recommendation	Selected Measures
Contractor "drama" and poor wetland performance, before, during and after construction due to inadequate contract documents.	Construction documents do not effectively communicate and anticipate complexity of wetland construction. This should be balanced with some built-in flexibility to allow contractor to work efficiently and effectively.	1. Realistic performance goals determined early by experienced core team. 2. For contract document preparation, qualified design professional should lead and perform quality control. 3. Develop consistent and effective contract language and graphics with contractor in mind. 4. Keep Core Team involved in reviews
Loss of original project vision due to a "hand-off" of responsibilities.	Keep your "Core Team" involved from start to finish.	Have the foresight to select a team with the skill set to oversee all phases of the project. Plan for turnover and provide redundancy where possible. Document your decision-making process and be transparent with your decisions.
Lack of continuous contact, inspections, communication	Inspections by key Team members	Up-front schedule for inspections and/or meetings at critical points in construction process requiring approval before proceeding to next step/phase
Inadequate Budget and/or unrealistic schedule	Every aspect must be compared and contrasted to available budget and appropriate timeframes	Ongoing communication/meetings to review budget, expenses, and schedule

Long Term Management & Legal Protections for Voluntary Restoration

Ted LaGrange

Constraints	Recommendation	Selected Measures
Not meeting the needs of the landowner.	Understand the needs of the landowner and work collaboratively to meet their needs and your needs.	Seek information of what drives the decisions of landowners (human dimensions information).
Not knowing the agreement options available.	Learn about the options available, such as agreements and easements.	Work with agreement or easement experts to develop and implement the appropriate option for the site and landowner.
Not defining the goal & not understanding the	Develop a goal, and determine what type of wetland you are working	Tools such as HGM classification, soils maps, Cowardin classification are very valuable. So is understanding wetland dynamics, something

wetland type and disturbance dynamics.	on and the natural dynamics that drove the ecology of the wetland.	that wildlife agencies and natural heritage programs can help with.
Failure to use an interdisciplinary team.	Understand when you need help and get it.	Establish 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.

Jeff Williams

Constraints	Recommendation	Selected Measures
Land and landowner eligibility criteria not verified	Ensure all owners listed on deed meet the income, signature authority, and highly erodible land and wetland conservation compliance	Work closely with field staff to understand legal and technical requirements to close conservation easement, receive payment and complete restoration efforts.
Other leases or easements	Title review and landowner interviews	Access agreements by adjacent owners may have to be nullified, grazing or cropping rental agreements may be terminated for the parcel in question to remain eligible for WRE.
AAI database searches (phase I)	Check for hazardous materials	Previous land uses such as agriculture may have hazardous materials including leaking barrels, underground storage tanks, dump sites, etc.
Make sure all parties on deed are on-board	Communicate with them	Some times there are many parties included on the deed and all must approve the sale and meet eligibility criteria.

Ellen Fred, Esq.

Constraints	Recommendation	Selected Measures
Misunderstood protection requirements	Work closely with agency requiring/facilitating restoration to ensure correct protection tool used	Clear communication, good representation
Missed deadlines/timing	Start conservation easement process early; drafting/negotiation takes time	Enlist good guidance, work with agency(ies) and counsel

OTHER WEBINARS IN IMPROVING WETLAND RESTORATION SUCCESS SERIES:

Novel Ecosystems & Wetland Restoration

Joy Zedler, Ph.D.
Marilyn Jordan, Ph.D.

Improving Wetland Restoration "Success": What We've Learned So Far

Jeanne Christie
Marla Stelk

Photo Credit: Jeanne Christie

APPENDIX B: WORK GROUP MEMBER BIOGRAPHIES

(listed in alphabetical order)

John Bourgeois

John Bourgeois became Executive Project Manager of the South Bay Salt Pond Restoration project in December 2009. John brings over 18 years of experience working on large scale wetland restoration issues to the Project. For the previous 12 years, he worked as a restoration ecologist with the Bay Area ecological consulting firm H. T. Harvey & Associates where he worked on numerous closely related San Francisco Bay wetlands projects. Prior to coming to California, John worked on wetland issues at the USGS National Wetland Research Center, the Coastal Restoration Division of the Louisiana Department of Natural Resources, and the U.S. Forest Service's Institute of Pacific Islands Forestry. John has a M.S. from the University of Louisiana at Lafayette, a B.S. from Tulane University. He currently lives in Los Gatos with his wife Susan, where he is very active in his community having served on the planning commission and other committees for over 10 years.

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.

Chris Darnell

Chris Darnell is a Fish and Wildlife Biologist at the U.S. Fish and Wildlife Service where he leads the Coastal Program in the Branch of Habitat Restoration. Chris coordinates the National Coastal Wetlands Conservation Grant Program and represents the Service to the Interagency Coastal Wetlands Work Group. In his spare time, Chris provides staff support to the Service's Blue Carbon Initiative and a Mangrove resilience study.

Tim Dexter

Tim Dexter works within the Environmental Services Section of MassDOT as a Wetlands and Water Resources Analyst, and is the Highway Division's Fish and Wildlife Program Coordinator. Tim has a M.S. in Environmental Studies in Conservation Biology from Antioch University New England, and a B.S. in Biology from Westfield State University. Tim conducts program-wide ecological planning and design for Highway Division transportation projects; develops and manages the Division's proactive fish, wildlife and ecology programs; implements strategies to integrate climate change adaptation and resiliency into the project development process; oversees transportation & wildlife research; and, delivers on-the-ground projects in the field of road ecology through collaboration with MassWildlife, conservation organizations, academia, and citizen scientists.

Rebecca Dils

Rebecca is a Policy Analyst for the U.S. EPA and currently leads numerous efforts to enhance state wetland programs with a focus on providing support for comprehensive state wetland restoration programs. She has consulted the Department of Energy on NEPA compliance issues and conducted assessments of critical environmental areas for Indiana communities as an analyst for the Center for Urban Policy and the Environment. She also led a variety of restoration task forces for the Coalition to Restore Urban Waterways in Oakland, California. She is honored to have received a Point of Light Award for her efforts to provide environmental education to at-risk youth in the Washington DC area. In her 25 years of public service under EPA, her professional achievements have focused on stakeholder involvement in environmental decision-making and supporting community-led conservation efforts. Rebecca is lucky enough to bike to work on the C&O canal and watch the changing tides of Potomac River.

Norman Famous, M.S. Consulting Peatland, Wetlands and Wildlife Biologist

Norm has worked on peatlands since 1978, conducting environmental surveys and assessments, writing restoration plans and creating and restoring small peatlands. As part of a three person team, Norm evaluated the natural recolonization and regeneration of 39 mined bogs in NE North America between 1987 and 1993 by sampling vegetation and evaluating environmental factors that influence natural restoration processes. The team prepared restoration plans for mined bogs in Maine (for industry); Canada (Province of New Brunswick), and Michigan (U.S, DOJ and EPA). In 1999, Norm was one of several expert witnesses in a U.S. DOJ/Environmental Defense Section and EPA enforcement case). Between 1993 and 1997 Norm conducted a breeding bird monitoring program for 23 mined and unmined peatlands in Maine and New Brunswick, Canada.

In 1991 Norm co-authored and presented papers on Natural Regeneration of Mined Peatlands in eastern NA and a radiotelemetry study on Coyote use of peatlands in Eastern Maine. In 1992, he was an invited speaker at a Peatland Reclamation Workshop in New Brunswick, Canada and at a workshop on the Status of Canadian Peatlands in Alberta, Canada where he summarized the current status of restoration work in North America. He co-chaired and presented at a peatland restoration session for the SWS in 1993. In 1994, Norm was an invited speaker at a symposium on Restoration of Temperate Wetlands in Sheffield, England, where he co-presented invited papers on natural restoration patterns in peatlands of Northeastern North America and on a reclamation plan for a bog flooded by seawater. During the 1990's, Norm taught three peatland ecology and restoration accredited workshops, and taught Field Ornithology for over 20 years at the University of Maine in Orono. More recently, Norm co-presented a lecture on peatland restoration at the 2014 annual meeting of the Maine Association of Wetland Scientists.

Norm holds a M.S. degree in Plant Systematics from the University of Maine at Orono where he conducted a biosystematic study of three members of the Solidago canadensis complex in NE North America. Norm presently works as a wetlands/ecological consultant and lives in Augusta, Maine.

Mark Fonseca, Ph.D.

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!"

Kristen Hychka, Ph.D.

Kristen Hychka is deeply interested in the interface between research and management of aquatic ecosystems. She is a Research Associate with the University of Rhode Island Science

(URI), Ecology, and Communications Lab. Her MS in Wildlife and Fisheries Science and PhD in Geography were both done at Penn State in the Cooperatives Wetland Center/Riparia. At Penn State she primarily worked on watershed characterizations and on developing indicators of wetland condition at the landscape- or watershed-scale. She did a postdoc at the US EPA Atlantic Ecology Division where she worked on variety of social-ecological projects including: mapping ecosystem service benefitsheds, developing online social network analysis methods, and exploring social barriers to ecosystem restoration through interviews with natural resource managers. At URI her work has focused on stakeholder engagement and ommunication and includes: understanding science communication about coastal processes through textual analysis of media content, developing Story Maps as outreach tools, and improving scenario development in participatory modeling efforts.

Amy Jacobs

Amy is the Agriculture Program Director for The Nature Conservancy's Chesapeake Bay Program. Amy grew up in York County, Pennsylvania and spent weekends on her grandparent's farm. After completing college, she located to the Eastern Shore of Maryland where she has been working with landowners on the Eastern Shore and Delaware since 1997 to assess wetland health and identify restoration opportunities in agricultural landscapes. Working with The Nature Conservancy on agricultural issues has given Amy the opportunity to merge her family history and passion for both farming and the environment. Amy is committed to finding solutions that will support agriculture and the growing demands for food and also have a positive effect on the environment through solution-oriented, science-based approaches and working collaboratively with a diverse range of partners. In the Chesapeake Bay, Amy is leading projects on Delmarva to demonstrate the economic value of targeting natural habitat restoration to achieve water quality and habitat benefits and developing new collaboration with agribusiness to increase nutrient use efficiency on cropland. Amy holds a bachelor's degree in Forestry and Wildlife from Virginia Tech and a master's degree in Environmental Forest Biology from the State University of New York and Syracuse University.

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".

Myra Price

Myra Price is an Environmental Protection Specialist for EPA's Wetlands Division in the Office of Wetlands, Oceans, and Watershed and the Office of Water. She has work for EPA in Washington, DC for seventeen years in both regulatory and non-regulatory programs. Her main focus in the Wetlands Division is on the wetlands grant program and voluntary wetland restoration and protection. Myra is the EPA coordinator for the 5-Star Wetland Restoration Challenge Grant program which supports small local or community restoration training grants. She has received degrees in Watershed Management, Chemistry and Biology from New Mexico State University and the University of Arizona.

Bruce Pruitt, Ph.D., 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.

Joseph Shisler, Ph.D.

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.

Peter Skidmore

Peter Skidmore, P.G. has 25 years' experience providing planning, review and guidance for river restoration projects across the US and internationally and has chaired boards and founded non-profit organizations focused on protection and restoration of rivers. He currently works for the Walton Family Foundation where he manages a grant portfolio focused on restoring river health in the Colorado River Basin. Peter is a registered professional geologist and holds a B.S. in Geology from Macalester College and M.S. in Earth Sciences from Montana State University.

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, Ph.D.

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, Ph.D.

Dr. Scott Yaich joined Ducks Unlimited's staff in National Headquarters in 2001, and currently is DU's Chief Scientist. Prior to assuming that position in 2014, he served as Director of Conservation Operations for NHQ since 2007, and Director of Conservation Programs and Director or Conservation Planning between 2001 and 2007. Before coming to DU, Dr. Yaich worked for the Arkansas Game and Fish Commission for 13 years as Wetlands and Waterfowl Program Coordinator, Chief of the Wildlife Division, and Deputy Director over the agency's Wildlife, Fisheries, and Enforcement divisions, and worked as a regional biologist with the U.S. Fish and Wildlife Service for four years. Over his over 30-year career, he has served on or led numerous national and international bodies related to wetland and waterfowl conservation, including the North American Wetlands Conservation Council, the North American Waterfowl Management Plan Committee, the North American Bird Conservation Initiative's U.S. Committee, the national State of the Birds science team, and the Mississippi Flyway Council. Dr. Yaich received his Ph.D. and M.A. from Southern Illinois University and his B.A. from the University of Delaware.

Joy Zedler, Ph.D.

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 C: INVASIVE SPECIES

Invasive species management 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 specific non-target wetland species is not typically evaluated as part of pesticide registration (surrogate, representative species are evaluated, however). Also, there is always the potential for a widely used pesticide to be cancelled due to impacts on human health or other reasons, making it no longer commercially available. 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.

APPENDIX D: CLIMATE CHANGE CONSIDERATIONS

Concerns about the impacts of climate change and biodiversity loss have heightened the interest in the ecosystem functions and benefits provided by wetlands, one of the most productive ecosystems in the world (Perrings, 2010; Russi et al., 2013). In fact, scientists in China have attributed the increase in droughts, floods and sandstorms in northern China to their shrinking supply of wetlands (Tianyu, 2009). It is now widely recognized that wetlands provide many benefits that are needed to mitigate and adapt to climate change and this reality is fundamentally altering the discussion about why we should preserve and restore them (Christie & Bostwick, 2012; Russi et al., 2013).

California Drought Dry Riverbed 2009
Source: National Oceanic and Atmospheric Administration

Until recently, efforts to address climate change have only revolved around how to mitigate climate change by reducing greenhouse gases through investments in renewable energy, cleaner fuels and more efficient technologies. Most scientists, however, predict that even if we significantly reduce our carbon footprint immediately, the impacts of our past actions will continue to increase the occurrence and severity of extreme climatic events such as droughts, hurricanes and floods (Pew Center on Global Climate Change, 2006). Wetlands, however, are an effective tool to both mitigate and adapt to climate change. For example, Dr. William Mitch et al, (2013) assert that healthy wetlands absorb more greenhouse gases by storing carbon than they release, and therefore have a net positive effect. And not only do they absorb carbon, but they also have the ability to moderate the effects of drought, store and treat groundwater, clean stormwater, attenuate floodwater peaks, increase downstream baseflows, and provide important wildlife habitiat (Christie & Bostwick, 2012). Strategic wetland restoration efforts will therefore play an increasingly important role in our efforts to not only mitigate, but to also adapt to the impacts of climate change (Perrings, 2010; IPCC Working Group II, 2014).

It is important to remember, however, that wetlands are also vulnerable to climate change (Kusler, 2006). Climate change is altering the frequency and type of precipitation events experienced around the world as well as global average temperatures (IPCC Working Group II, 2014). When wetlands are exposed to too much polluted stormwater run-off or changes in temperature and hydrology, they can be seriously degraded. When wetlands are degraded or when they are converted to other land uses, their ability to absorb excess carbon is reduced they may emit large amounts of methane, further accelerating global warming. Although much is still unknown about the extent of methane releases from different wetland types, what this essentially means is that wetlands can serve as both sources and sinks for greenhouse gases simultaneously (O'Connor et al., 2010).

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. This may result in the spread of more invasive species and/or a need to reevaluate "native" species. Rising sea levels will inundate coastal wetlands and shift habitats upslope and inland, where there are no barriers such as towns, houses, roads and railroad lines. In areas where barriers exist and prohibit marsh migration, wetlands may be lost. Adaptive management plans are needed to guide wetland restoration efforts to respond to changes in temperature and precipitation and achieve appropriate project goals. While changes to wetland hydrology, soils and biological communities are anticipated due to climate change, it is not clear that long term monitoring is in place to record and guide adaptation to those changes.

So even though wetland restoration can assist efforts to mitigate and adapt to climate change, protection of existing wetlands will be an important part of any climate change adaptation plan. Adaptive management and longer term monitoring and assessment of wetland restorations will need to be developed to anticipate and manage climate change risks (Erwin, 2009; IPCC Working Group II, 2014; Stein, et al., 2014). Regional studies, criteria and collaboration will be needed to manage wetland restoration projects within watersheds that go beyond municipal and state boundaries. Water rights in the western part of the United States create immense challenges to working on a watershed and/or regional scale and will need to be addressed. Cross-agency and interdisciplinary efforts will be needed to balance the sometimes divergent demands for ecosystem benefits that provide needed goods and services to human populations and the ecosystem functions that are needed to maintain biodiversity and ecological health.

Photo Credit: Jeanne Christie

APPENDIX E: WATER RIGHTS FOR AQUATIC RESTORATION IN THE WESTERN U.S.

Introduction:

In the arid Western United States, water laws govern the use of available surface and ground water and dictate how that water may be utilized through all types of aquatic restoration projects. Water, has long been a contentious source of conflict between a variety of stakeholders in the western US ranging from cattlemen to farmers, and businesses to cities/towns. This is due to the many competing uses of water, a scarce resource in the Western U.S., including: irrigation for a variety of commodity food crops; provision of power to run homes, factories, and businesses; stock water for livestock; drinking water humans and for use in washing and maintaining the human lifestyles of people living in cities and towns. Conflicts over water and how it is used, as well as its ownership, has led to many long and contentious court cases and conflicts on the western landscape. It is one of the most valuable if not the most critical of all the natural resources found in the Western U.S.

In the Western U.S., approximately 19 states have water rights laws that play an integral part in the planning and implementation process for aquatic restoration efforts and water use for a variety of purposes ranging from agriculture to industry, and from domestic to recreational use. In all of these states, since the 1850's, the primary doctrine that governs surface water rights is the "prior appropriation doctrine." This doctrine allocates water rights based upon a rule of capture. The first person to use water from a source established the 'first' right to take as much water as was needed for a specific use. The next person could then take water from the amount that remained. And so on down the line. Today, water right priorities also include water rights set aside for use by Native American tribes, as well as federal, state and municipal users. In some situations, Tribal or governmental water rights may take precedence over individual users.

The first principle of water rights is: "First in time of use is first in right to use (i.e. the earliest user on a stream has the first right to use the water – "Priority Dates"). The setting of priority dates of use is the mechanism that creates the hierarchy from most senior to the most junior; making those newest rights the last that can use water and only if it is available for use. In some states, water rights were assigned prior to the Federal government recognizing a territory as a state. In Montana, some of the earliest water rights assigned to water rights holders date back to the 1860's, well before statehood in November 1889.

The second principle of appropriation is: "Water must be applied to a beneficial use that is the basis and measure of the right." The majority of beneficial water right usage is tied to societal needs and may include: aquifer recharge, aquifer water supply storage and recovery projects, stock water for livestock, agricultural irrigation, domestic drinking water supplies, industrial water use, power generation and recreational uses. Other beneficial uses of water rights focus upon the ecosystem aspects of riverine systems and the intention to protect those uses from further degradation, such as maintenance of surface water within streams for fish and wildlife habitat; enhancement and preservation of stream flows for fisheries (salmon recovery/spawning), and use of surface water within federal and state wetland systems and refuges for shorebird and waterfowl migration. But in many cases there is a lack of clarity and decision making abilities concerning the restoration of drained and degraded aquatic habitat such as wetlands.

History:
In many instances surface water has been over appropriated and apportioned out to the point where stream flows are lacking and water supply availability is extremely limited except for those with senior water rights. In addition groundwater depletion by irrigation pumping is leading to lower groundwater levels and causing drops in river and stream flows. As a result, there have been ongoing judicial cases being fought in many western states concerning surface and groundwater rights.

Arizona:
In Arizona, surface water is a rare commodity, and as such it is now the focus of real estate developers, utilities, natural resource agencies and cities in the courts as to who receives and gets to utilize treated effluent water discharged from sewage facilities in several of the major cities. In most cases this water would be returned to natural streams and rivers to maintain the natural condition and provide downstream users with a supply of water, but is now a major source of contention for use by other entities. As result, in 2009, the Arizona governor requested the Arizona Department of Water Resources, Arizona Department of Environmental Quality and Arizona Corporation Commission to establish a statewide Blue Ribbon Panel on Water Sustainability concerning future water resource supplies for long term sustainability of Arizona water supplies through increased water conservation practices and recycling. The panel was specifically tasked with providing advice and recommendations to three Arizona agencies on the technical, legal and policy aspects of promoting recycling of wastewater, gray water, industrial water and stormwater. One of the areas being evaluated is to investigate the possibility of restoring wetlands and riparian areas using gray water and treated effluent in an effort to improve water quality and water storage capacity in some areas of the state.

Colorado:
The state of Colorado has had a long running dispute since 1902 with the state of Kansas over water flows in the Arkansas River, and has been taken to the U.S. Supreme court on four separate occasions by Kansas to clarify allowed water usage by Colorado (Kansas v. Colorado (105 Orig.). In the 1907 case (206 U.S. 46), the Supreme Court affirmed its authority to settle the dispute between the states, but at the same time dismissed Kansas's petition on other grounds. The Supreme Court examined over 8,000 pages of transcripts that had been produced as a result of the litigation; it found that the "perceptible injury to portions of the Arkansas valley in Kansas" was justified by "the reclamation of large areas in Colorado, transforming thousands of acres into fertile fields." The Supreme Court explicitly invited Kansas to institute new proceedings if the situation worsened significantly. In 1943, Kansas filed suit again, but the Court (320 U.S. 383) ruled that Kansas had insufficient evidence to prove the increased water usage was a serious detriment to the interests of Kansas and suggested through a Special Master of the Court to develop a water compact agreement

between the two states. In 1949 the Arkansas River Compact was developed by Kansas and Colorado as a means of administering a fair and equitable distribution of surface water between the states. However, since that time, increased development for both residential and agricultural use has caused an increase in water usage by the state of Colorado from the Arkansas River. This increased usage and diversion of water, has denied the downstream water users in Kansas sufficient water supplies to maintain agriculture, drinking water, etc. In 1995, Kansas again filed suit against Colorado alleging that they had overused their share of water outlined in the 1949 compact. In the 1995 case (514 U.S. 673), the court indicated that Colorado was indeed pumping extra water out of the Arkansas River into a storage reservoir that was in clear violation of the compact. As a result of that 1995 court decision, the Supreme Court through its Special Master in its 2001 decision paper (533 U.S. 1), indicated that Colorado had indeed denied downstream users in Kansas sufficient water and ordered Colorado to pay damages for its use of water in excess of its entitlement from 1969 to 1995. Kansas was awarded money rather than water allocations, and objected to the decisions as it did not provide any changes in water allocation or prevents Colorado from doing what they had been doing to deplete and deny Kansas water users of water resources they needed for a variety of uses. Colorado objected as they had to pay interest on the judgement dating back to 1969 for the costs of the illegal water used and other court fees for that period of time (32 years) to the State of Kansas. As of 2016, this case is still ongoing and water delivery to Kansas from Colorado has not been changed.

Montana:

In Montana, there has been several court cases concerning reserved water rights, most recently concerning Tribal Reserved Water Compacts that define the amount of water needed to fulfill the various treaties the Federal government signed with each of Montana's tribes. These reserved water compacts are quite complex. The most recent compact includes tribal water rights both on and off the reservations. These compacts require approvals by both the state legislature and Congress before they can be enacted into law. For some of these water compacts, the tribes have been in negotiations with the State of Montana for almost 30 years and in some cases are still awaiting Congressional approvals. To date, all seven tribal compacts have been approved by the state legislature (Confederated Salish & Kootenai of the Flathead Nation, Blackfeet Nation, Crow Nation, Northern Cheyenne, Gros Ventre and Assiniboine Tribes of the Fort Belknap Reservation, Chippewa Cree Tribe of the Rocky Boy Reservation, and Assiniboine Sioux of the Fort Peck Reservation), but only the Northern Cheyenne, Chippewa Cree and Crow Nation water compacts have been approved by the US Congress (MT DNRC 2016). However, in addition to the water compacts on the seven Native American reservations within Montana, there are reserved water compact rights that have been approved for the Federal government concerning National Parks, National Monuments, National Wildlife Refuges, National Forests, and federally managed lands under jurisdiction by Federal Natural Resource agencies to protect natural resources from de-watering and water quality degradation.

One of the biggest water rights cases in the past several years in Montana focused upon the interconnection between groundwater and surface water in basins closed to new surface water rights. In this court case, Montana Trout Unlimited LLC LP LLC v. Montana Department of Natural

Resources and Conservation (DNRC) (TU v DNRC No. 05-069 April 11, 2006), there were concerns about the effects of new groundwater appropriations approved by the DNRC being used to circumvent basins closed to new surface water appropriations and the potential effects of groundwater depletions that could affect the surface water of a river system in Montana (Smith River). The language of the statute that closed the Smith River Basin to new appropriations of surface water required that an applicant for a groundwater permit must prove that the groundwater being sought to appropriate was not "…immediately or directly connected to surface water…" As the Smith River basin had been closed to all new surface water appropriations due to over-allocation, local land owners began developing groundwater to irrigate agricultural lands when water levels were low in the Smith River and prevented them from exercising their surface water rights.

Prior to the TU lawsuit, the DNRC's method for determining whether or not groundwater was immediately and directly connected to surface water involved conducting an aquifer test and using models to determine if it was likely that the pumping of groundwater would induce flow from nearby rivers or streams into the well. In TU v DNRC, the argument was made that in using this method, the DNRC had neglected to consider the tributary groundwater that had not made it to the stream yet but that would eventually make it to the stream and become surface water. Groundwater appropriations that tapped into this water were termed "pre-stream capture" of surface water. In ruling in favor of TU, the Court determined that the DNRC had erred in allowing groundwater permits that resulted in pre-stream capture in closed basins. The outcome was the acknowledgement that groundwater and surface water are inextricably linked in almost all cases.

Water Rights for Wetland Restoration and Preservation:

This leads us to the problem of securing water rights for wetland restoration and preservation in the western United States. In the various court cases from state to state, the interests focused primarily of water usage for interests other than natural resources and fish & wildlife. As such, many aquatic restoration efforts may require application for a water right when intentionally appropriating water for a beneficial use (wildlife) and/or other compensatory mitigation efforts involving wetland creation, rehabilitation, re-establishment and/or enhancement efforts.

The Montana Department of Natural Resources developed a policy guidance document, *Guidance for Landowners and Practitioners Engaged in Stream and Wetland Restoration Activities* (by Michael Downey, Water Resources Division – Montana DNRC 04-16) that was reviewed and approved by a number of natural resource agencies that focuses on stream and wetland restoration projects as they pertain to Montana Water Use Act. The purpose of this guidance is to provide an educational resource for practitioners in Montana who are involved in stream and wetland restoration activities. In these instances, the term "beneficial use" is often utilized and associated with wetland and stream projects as they constitute a beneficial use under the Montana Water Use Act. As each western state has its own water rights and water laws, this Montana document could be utilized as guidance document for practitioners to review when planning projects in other states.

The Montana policy indicates that restoration projects can be quite variable and diverse. As a result these types of wetland and stream restoration activities are neither entirely exempt from water rights law, nor are they always mandated to acquire water rights. Based upon these potential variations, the Montana policy is broken down into two distinct sections to address restoration projects wetlands and stream

Montana Water Policy for Wetland Projects:

1. Water rights are dependent upon the kinds and types of restoration efforts being implemented and whether or not they occur in a closed or open basin for either groundwater and/or surface rights.

2. Water Rights Research: In developing wetland projects, existing water rights for the project site, as well as any adjoining properties and downstream water rights should be researched and evaluated. It is important to determine as examples: seniority and date of original appropriation; type of right (surface or groundwater/ domestic or agricultural); volume and quantities of water usage; periods of usage (April to October, year-round, etc.) and source of water. Early investigations will also identify if a watershed is open or closed to new appropriations for both groundwater and surface water. Most western US states have electronic databases where you can research water rights information for a watershed or region of the state. Here are a few websites:

    - Montana water resource information can be found at: http://dnrc.mt.gov/divisions/water
    - Colorado water resource information can be found at this website: http://water.state.co.us/Home/Pages/default.aspx
    - California Department of Water Resources can be found at: http://www.water.ca.gov/
    - Arizona Department of Water Resources website: http://www.azwater.gov/azdwr/
    - Washington Department of Ecology Water Resources website: http://www.ecy.wa.gov/programs/wr/wrhome.html
    - Utah Division of Water Rights website: http://www.waterrights.utah.gov/
    - New Mexico Office of the State Engineer / Interstate Stream Commission website: http://www.ose.state.nm.us/WR/WRrules.php
    - North Dakota State Water Commission and Office of State Engineer website: http://www.swc.nd.gov/reg_approp/waterpermits/
    - South Dakota Department of Environment and Natural Resources website: http://denr.sd.gov/des/wr/wr.aspx
    - Idaho Department of Water Resources website: http://www.idwr.idaho.gov/

3. Artificial Wetlands: In the case of wetland projects that intentionally divert, impound, or withdraw a quantity and volume of water from a human-controlled diversion for beneficial use within a project site, a water right is required. In order for the wetland to work, water must be diverted to maintain the wetland in perpetuity and annual maintenance is required to maintain the delivery of hydrology into the site (i.e., constructing a diversion structure from an existing irrigation canal to divert water into a wetland system as the major source

of water.) This would require a water right for creating a new diversion point/place of use/purpose. (It should be noted that in the operating bylaws for some irrigation districts, water cannot be diverted for uses other than agricultural crop production or livestock watering, thereby prohibiting its use for developing wetlands.)

4. Creation: In creating wetlands in uplands where no wetlands have historically existed before, a water right is required. All impoundments relying on a berm to "create" wetlands requires a water right for the entire planned volume of water appropriation to be utilized within the site at maximum pool elevation (i.e., creating berms above ground elevation within an agricultural field and then flooding it to a designed full pool elevation to create wetlands).

5. Restoration: Wetland restoration involves the rehabilitation of degraded and/or drained wetlands so that the soils, hydrology, vegetative community and functionality match in close approximation to the "original" or "historic" condition of the former wetland to be restored. As a result such projects need to be developed without any artificial controls and/or management through the diversion of water intentionally for the improvement of the wetland. If water levels needed to create wetland conditions can be achieved by removing drainage devices, no water right is required. However, this does not preclude a claim of injury from a downstream entity if the changed conditions affect an existing water right. No water rights may be required unless quantities and duration of water use changes from the historical condition. For example, restoration of prairie potholes, riparian floodplain wetlands, vernal pools, etc. should rely on natural water supplies, i.e., precipitation, stormwater runoff, flood events and/or groundwater.

6. Water Rights Needed: For the determination of whether or not a project will require a water right, the question of water rights should be addressed in the initial stages of the design process rather than at final design. It should be one of the driving factors in site selection for restoration. Any restoration design should be compared to the reference condition of the natural wetlands and their characteristics in the area of the proposed project or watershed in order to determine water usage. This should include an analysis of a number of critical components, including: a determination as to the periods and durations of hydrology within that system (i.e., permanent, ephemeral, seasonal, and/or intermittent); species composition and types of the vegetation communities; base and flood streamflow inputs into the wetlands; periods of inundation and seasonal availability; and a determination of water use by that wetland through a water budget.

7. Plugging Ditches/Drains: In areas where wetlands have been converted to agricultural lands via the construction of drainage ditches or tile drains, the plugging and removal of these ditches and drains does not require a water right. However, knowledge of how the water is going to respond within a site to these actions is important as it could lead to flooding of adjacent properties. It could also affect the availability of water for users down gradient from the site. The party responsible for the restoration project could be liable for

damages from flooding or interference with an existing water right.

8. Water Budgets: For any wetland project, water budgets should be undertaken to determine the consumptive use of water and evapotranspiration (ET) loss within the proposed project area, and how that compares with the natural reference conditions. If these are comparable, then no water right is needed.

Stream Projects:

1. Channel Restoration: Typically channel restoration projects within degraded streams are restoring the channel morphology by raising stream bed elevations, restoring sinuosity to the stream channel, re-creating pool/riffle complexes, installing habitat features (log jams, root wads, etc.), replanting streambanks with woody riparian vegetation, placement of strategic rock weirs/grade control structures, and restoring floodplain connectivity. In most situations, these types of restoration activities do not require water rights as stream flows are to be maintained in the new channel as a flow through system. However, if grade control structures are installed that impound, pool, or pond up greater than 0.1 acre foot of water behind them; or a permanent irrigation diversion structure is installed within the new channel, a water right is required.

2. Habitat Structure Placement: Some restoration projects may simply involve the addition of woody debris through the placement of root wads and other large natural wood structures into a stream for the purposes of improving habitat for fish and other aquatic organisms. These structures are inserted solely for the purposes of improving aquatic habitat and do not necessarily increase water storage within the stream channel. However, if these wood habitat structures are installed and cause and the stream flows to be impounded, pool, or pond up greater than 0.1 acre foot of water behind them; or are utilized as part of a permanent irrigation diversion within the new channel, a water right is required.

3. Beaver Dam Analogues/Mimics: A new tool in use today by a variety of agencies and conservation groups in order to restore streams and their associated wetlands and to increase water storage are the beaver dam analogues that mimic natural beaver dams. These are often used in streams that are incised and are placed in areas where beavers may have been extirpated and were historically present in the past. The purpose of their installation is done to promote channel stability, dissipate high water energy from flood events, and to restore floodplain connectivity and wetlands adjacent to the channel. Usually these structures are temporary in nature and consist of biodegradable materials such as cut willows, aspens, red-osier dogwood, and fir/pine boughs similar to the materials often found in beaver dams. The anchors for these structures is usually a line of wooden posts driven into the stream bottom and the cut woody material is then woven between the posts to create the beaver dam mimic structure. As these structures are designed to be temporary and porous in order to slow water flows down, these structures often build up deposited cobble, gravel, sediments, and other organic and inorganic materials over time. Water rights are not necessary for these temporary structures, but if these structures are to

be permanent and use any man-made control gates, culverts, head gates, ditches and/or pipelines then a water right application is required to be submitted.

Here are some websites providing some additional information:

https://olis.leg.state.or.us/liz/2015R1/Downloads/CommitteeMeetingDocument/74228
http://www.okanoganhighlands.org/restoration/triple-creek/about-beaver-restoration

4. Streambank Restoration/Stabilization: Any work that occurs along the banks of a stream and/or river that does not impound water or block stream flows would not require a water right.

5. Riparian Vegetation Re-Establishment: The planting, seeding and installation of cuttings along a stream bank do not require a water right. New plantings may require some type of temporary irrigation system to ensure survivability during the first few years of plant root systems become established. In these cases, a water right would not be necessary, so long as the water is being applied solely to insure the survivability of the riparian plantings and that the consumptive use is not intended to be more than what is intended to be naturally occurring over the long term of the project.

6. Dam removal: Removal of dams may be problematic in the sense of the dam's original purpose (irrigation storage, hydroelectric power, drinking water) on the landscape and its potential effect on downstream water rights holders and users. During the dam construction water rights were required for the dam operation, and downstream water rights were considered for each user. As a result each downstream water right needs to be considered in any decommissioning and removal of that dam structure.

7. Fish Passageways: As these are constructed to divert and route stream lows for fish migration and movements they do not require a water right.

8. Flow Augmentations: The increase of instream flow through water transactions that include, but are not limited to: acquiring instream flow water rights and protecting water instream through prior appropriations; acquiring other purposed water rights and changing them to instream flow; protecting water instream through prior appropriations, storing/releasing water; and the establishment of diversionary reduction agreements for the purposes of maintaining adequate steam flows for recreation and fisheries conservation. Any flow augmentation project that involves the acquiring of protectable (prior appropriated water rights) water supplies, including storage, to purpose or repurpose for instream use for fisheries conservation always involves water rights, often of a complex nature.

APPENDIX F: WETLAND RESTORATION LEXICON

Term	Definition	Source
Active Water Table (see also Water Table)	A condition in which the zone of soil saturation fluctuates, resulting in periodic anaerobic soil conditions. Soils with an active water table often contain bright mottles and matrix chromas of 2 or less.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Adaptation	A modification of a species that makes it more fit for existence under the conditions of its environment. These modifications are the result of genetic selection processes.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Adaptive Capacity	Adaptive capacity can be an inherent property of the system (whether natural- or human-induced), a planned action to intervene (i.e., alter the biotic or abiotic structures and processes or change social and political settings (Hobbs et al., 2011) thereby improving capacity, or a post-impact action to recover or restore capacity. Innovative and resilient solutions that promote adaptive capacity will yield more manageable, responsive, and tolerant responses – i.e., sustainable ecosystems.	Hobbs et al., 2011
Adaptive Management	Adaptive Management prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state. Adaptive Management allows projects to proceed in the face of uncertainty, accelerating project implementation and benefits. Because it eliminates some undesirable outcomes, Adaptive Management also increases the likelihood that restoration projects will achieve full success.	Fischenich, C. and C. Vogt. 2012. The Application of Adaptive Management to Ecosystem Restoration Projects. ERDC TN-EMRRP-EBA-10 April 2012.

Adaptive Co-Management	Adaptive co-management stems from the traditional concepts of adaptive management (e.g., "learning-by-doing," monitoring, and adjusting actions in response to monitored results), but relies on the collaboration and engagement of transdiciplinary partners in the long-term operation and monitoring of the ecosystem (Cundill and Fabricius, 2009; Fry et al., 2007). Once again, the key to effective adaptive co-management is the deployment of indicator-based ecosystem response models that facilitate the monitoring of ecosystem status and/or its response to interventions based on success criteria or performance measures tied to project goals and objects, and the establishment of "triggers" (i.e., ecological response thresholds) dictating a change in management activities (Cundill et al., 2011; Cundill and Fabricius, 2009; Linkov et al., 2006).	Cundill and Fabricius, 2009; Fry et al., 2007, Cundill et al., 2011; Linkov et al., 2006
Aerobic	A situation in which molecular oxygen is a part of the environment.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Alternative 1 (i.e., Alternative Plan, Plan, or Solution)	An alternative can be composed of numerous management measures that in turn are comprised of multiple features, activities, or treatments. Alternatives are mutually exclusive, but management measures may or may not be combinable with other management measures or alternatives (Robinson, Hansen and Orth 1995). All alternative plans identify those structural or non-structural actions that may be changed and the consequences or benefits will be compared to the no-action alternative.	Burks-Copes, K. A. 2012. A Community-based Ecosystem Response Model for the Cottonwood Riparian Forests of the Missouri River: Model Documentation, Draft Final Report.
Anaerobic	A situation in which molecular oxygen is absent (or effectively so) from the environment.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Assessment Model	A model that defines the relationship between eco-system and landscape scale variables and functional capacity of a wetland. The model is developed and calibrated using reference wetlands from a reference domain.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Assessment Objective	The reason an assessment of wetland functions is conducted. Assessment objectives normally fall into one of three categories: documenting existing conditions, comparing different wetlands at the same point in time (e.g., alternatives analysis), and comparing the same wetland at different points in time (e.g., impacts analysis or mitigation success).	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Assessment Team (A-Team)	An interdisciplinary group of regional and local scientists responsible for classification of wetlands within a region, identification of reference wetlands, construction of assessment models, definition of reference standards, and calibration of assessment models.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Baseline Study	An inventory of a natural co-unity or environment that may serve as a model for planning or establishing goals for success criteria. Synonym: reference study.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Benefits	Outcomes associated with changed outputs described in terms of their relative value; the outcomes and changed outputs are a result of the Corps project or action being discussed. Example: diversity of stream invertebrates, water clarity, migratory habitat in riparian zones.	Planners Core Curriculum

Created Wetland	The conversion of a persistent upland or shallow water area into a wetland through some activity of man.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Criteria	Standards, rules, or tests on which a judgment or decision may be based.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Degraded Wetland	A wetland altered by man through impairment of some physical or chemical property which results in a reduction of habitat value or other reduction of functions (i.e., flood storage).	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Disturbed Wetland	A wetland directly or indirectly altered from a natural condition, yet retaining some natural characteristics; includes natural perturbations.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Direct Impacts	Project impacts that result from direct physical alteration of a wetland, such as the placement of dredge or fill.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Drained	A condition in which the level or volume of ground or surface water has been reduced or eliminated from an area by artificial means.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Ecological (Functional) Lift	The difference between future with project (FWP) and future without project (FWOP).	Pruitt defined (used in USACE and USEPA. 2008. Compensatory Mitigation for Losses of Aquatic Resources; Final Rule. 33CFR 325and332 and 40CFR230.

Ecological Indicators	Parameters that characterize and quantify ecosystem integrity and measure ecosystem response to proposed design alternatives (Gentile et al., 2001; Kandziora et al., 2012; van Oudenhover et al., 2012). Defined as specific, measureable, discrete, but not necessarily independent variables that can be used to quantify the condition or state of the socially-relevant endpoints, and have known or hypothesized responses to stressors (Gucciardo et al., 2004; Harwell et al., 1999; Kandziora et al., 2012). The standard of judgment or rules on the basis of which the alternative decisions are ranked according to their desirability; a generic term including both the concepts of attributes (i.e., measurable quantities or qualities associated with an object in a GIS) and objectives (Burks-Copes 2012 - Sunrise River Report (draft).	Gentile et al., 2001; Kandziora et al., 2012; van Oudenhover et al., 2012; Gucciardo et al., 2004; Harwell et al., 1999;
Ecosystem	A biotic community, together with its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole, unified through life processes. Ecosystems are hierarchical, and can be viewed as nested sets of open systems in which physical, chemical and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration and rehabilitation can be directed at different-sized ecosystems within the nested set, and many encompass multi-states, more localized watersheds or a smaller complex of aquatic habitat.	Burks-Copes, K. A. 2012. A Community-based Ecosystem Response Model for the Cottonwood Riparian Forests of the Missouri River: Model Documentation, Draft Final Report.
Ecosystem-based Management (EBM)	A systems-level methodology to deliver ecosystem goods and services to humans by means of natural capital conservation, preservation and restoration (Gregory et al., 2012a; Kareiva et al., 2011; McLeod and Leslie., 2009). Return on investment under an EBM paradigm is directly attributed to the improvement of an ecosystem's integrity and measured in terms of ecosystem response to a variety of proposed changes via ecological indicators. Thus EBM takes into account all the interconnected and complex ecological, social, and economic factors affecting an	Gregory et al., 2012a; Kareiva et al., 2011; McLeod and Leslie., 2009

	ecosystem's integrity, and focuses the inevitably limited stakeholder resources on those options to alter (i.e., restore, recover, preserve, intervene, etc.) current conditions with the intent of improving ecosystem integrity, thereby sustainably producing ecosystem goods and services.	
Ecosystem Function	Ecosystem functions are the dynamic attributes of ecosystems, including interactions among organisms and interactions between organisms and their environment (SERI 2004). Some restoration ecologists limit the use of the term "ecosystem functions" to those dynamic attributes which most directly affect metabolism, principally the sequestering and transformation of energy, nutrients, and moisture. Examples are carbon fixation by photosynthesis, trophic interactions, decomposition, and mineral nutrient cycling. When ecosystem functions are strictly defined in this manner, other dynamic attributes are distinguished as "ecosystem processes" such as substrate stabilization, microclimatic control, differentiation of habitat for specialized species, pollination and seed dispersal. Functioning at larger spatial scales is generally conceived in more general terms, such as the long-term retention of nutrients and moisture and overall ecosystem sustainability.	Burks-Copes, K. A. 2012. A Community-based Ecosystem Response Model for the Cottonwood Riparian Forests of the Missouri River: Model Documentation, Draft Final Report.
Ecosystem Goods & Services	The concept originated with Westman (1977) who suggested that the social value of benefits provided by ecosystems could potentially be quantified such that society could make more informed decision regarding policy and management. The concept that nature contributed materially to both the personal well-being of the populace and the health of the market economy offered a unique perspective, suggesting a bridge could be made between economic and ecological assessments. The idea rapidly evolved over the next several years (refer to Fisher et al. 2009 and references therein) culminating in a series of definitive papers with formative definitions including: 1) the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life	Burks-Copes et al (2013 in review). An Ecosystem-based Approach to Mainstreaming Ecosystem Services into USACE Operations and Maintenance Projects. ERDC TN-DOER-Tx September 2012.

	(Daily 1997), 2) the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza et al., 1997), 3) the benefits people obtain from ecosystems [Millennium Ecosystem Assessment (MEA), 2005] 4) the components of nature, directly enjoyed, consumed, or used to yield human well-being (Boyd and Banzhaf 2007), and 5) the aspects of ecosystems utilized (actively or passively) to produce well-being (Fisher et al. 2009). As the years and research surrounding the topic evolved, the definitions were honed into a seminal concept – one that advocates a valued production of goods and services by natural capital (i.e., indispensable resources essential for human survival and economic activity provided by the ecosystem) (Kareiva et al. 2011). The key points are that: 1) ecosystem goods and services must be ecologically-based phenomena, 2) that these benefits do not have to be directly utilized by consumers, and 3) their value is simply a way to depict their importance or desirability to the consumers. Defined in this manner, ecosystem goods and services are generated by functioning ecosystems whose components or processes generate products or provide intangible commodities that are then consumed or utilized by humanity either directly or indirectly. Ecosystem function is based on a combination of ecosystem structure and processes.	

Ecosystem Integrity	An attainment of reference-like conditions (SERI 2004). Ecosystem integrity is in effect “system wholeness, including the presence of appropriate species, populations, and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes” (Dale and Beyeler, 2001). Thus, an ecosystem has integrity when its dominant characteristics (i.e., composition, structure, function and processes) occur within its natural range of variation (reference conditions) and is sustainable when it is resilient (i.e., it can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions).	Burks-Copes and Kiker - phd
Ecosystem Process(es)	Physical, chemical, or biological actions dynamically transforming matter and energy in the system (i.e., photosynthesis, transpiration, biogeochemical cycling, succession, colonization, etc.).	Burks-Copes et al (2013 in review). An Ecosystem-based Approach to Mainstreaming Ecosystem Services into USACE Operations and Maintenance Projects. ERDC TN-DOER-Tx September 2012.
Ecosystem Structure	Ecosystem structure is equated with biological or physical features on the landscape (i.e., those indispensable components of natural capital such as biomass, flora, fauna, soils, water, etc.)	Burks-Copes et al (2013 in review). An Ecosystem-based Approach to Mainstreaming Ecosystem Services into USACE Operations and Maintenance Projects. ERDC TN-DOER-Tx September 2012.
Enhanced Wetland	An existing wetland where some activity of man increases one or more values, often with the accompanying decline in other wetland values.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Functional Assessment	The process by which the capacity of a wetland to perform a function is measured. This approach measures capacity using an assessment model to determine a functional capacity index.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Functional Capacity	The rate or magnitude at which a wetland ecosystem performs a function. Functional capacity is dictated by characteristics of the wetland ecosystem and the surrounding landscape, and interaction between the two.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Function Values	Values determined by abiotic and biotic interactions as opposed to static measurements (e.g., biomass).	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoraton: The Status of the Science. Island Press, Washington, D.C.
Geospatial	That branch of physical geography which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc. The investigation of the history of geologic changes through the interpretation of topographic forms (USACE 2005). The external structure, form, and arrangement of rocks or sediments in relation to the development of the surface of the Earth (Titus 2009).	SERDP RC-1701 Final Report - Burks-Copes & Russo 2013.
Goal	A goal is defined as the end or final purpose. Goals provide the reason for a study rather than a reason to formulate alternative plans in USACE planning studies (Yoe and Orth 1996). A goal is considered a description of generally agreed upon desired outcomes, and is by its very nature generally defined in broad contexts. Goals are clarified by objectives and endpoints (USACE 2010).	Burks-Copes, K. A. 2012. A Community-based Ecosystem Response Model for the Cottonwood Riparian Forests of the Missouri River: Model Documentation, Draft Final Report.
Habitat	The environment occupied by individuals of a particular species, population, or co=unity.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Hydric Soil	A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. Hydric soils that occur in areas having positive indicators of hydrophytic vegetation and wetland hydrology are wetland soils.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Hydrogeomorphic Wetland Class	The highest level in the hydrogeomorphic wetland classification. There are five basic hydrogeomorphic wetland classes: depression, Riverine, slope, fringe, and flat.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Hydrologic Regime	The distribution and circulation of water in an area on average during a given period including normal fluctuations and periodicity.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoraton: The Status of the Science. Island Press, Washington, D.C.
Hydroperiod	The annual duration of flooding (in days per year) at a specific point in a wetland.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Hydrology	The science dealing with the properties, distribution, and circulation of water both on the surface and under the earth.	Environmental Laboratory. (1987). "Corps of Engineers Wetlands Delineation Manual, "Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Indirect Impacts	Impacts resulting from a project that occur concurrently or at some time in the future, away from the point of direct impact. For example, indirect impacts of a project on wildlife can result from an increase in the level of activity in adjacent, newly developed areas, even though the wetland is not physically altered by direct impacts.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

In-Kind Replacement	Providing or managing substitute resources to replace the functional values of the resources lost, where such substitute resources are also physically and biologically the same or closely approximate those lost.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoraton: The Status of the Science. Island Press, Washington, D.C.
Invasive Species	Generally, exotic species without natural controls that out-compete native species.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Jurisdictional Wetland	Areas that meet the soil, vegetation, and hydrologic criteria described in the "Corps of Engineers Wetlands Delineation Manual" (Environmental Laboratory 1987) or its successor. Not all wetlands are regulated under Section 404.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Management Measure	A management measure is a specific feature or activity that addresses one or more planning objectives.	Principles and Guidelines (1983), Planning Guidance Notebook (2000)
Mean Higher High Water (MHHW)	The arithmetic average of the elevations of the higher high waters of a mixed tide over a specific 19-year period.	Brian Voigt. 1998. Glossary of Coastal Terminology. Washington Department of Ecology, Publication No. 98-105
Mitigation	Restoration or creation of a wetland to replace functional capacity that is lost as a result of project impacts	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Mitigation Banking	Wetland restoration, creation or enhancement undertaken expressly for the	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and

	purpose of providing compensation credits for wetland losses from future development activities.	Restoration: The Status of the Science. Island Press, Washington, D.C.
Mitigation Plan	A plan for replacing lost functional capacity resulting from project impacts.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Monitoring	Periodic evaluation of a mitigation or voluntary restoration site to determine success in attaining goals. Typical monitoring periods for wetland mitigation sites are three to five years.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Natural capital	Natural capital is comprised of features on the landscape (e.g., flora, fauna, soils) that interact (through ecosystem processes such as nutrient cycling and carbon sequestration) performing functions (e.g., water purification, waste assimilation, barrier formation, etc.) that generate services humans can either directly or indirectly utilize (e.g., clean water, flood protection, erosion control, storm surge attenuation, recreation, etc.).	Burks-Copes et al (2013 in review). An Ecosystem-based Approach to Mainstreaming Ecosystem Services into USACE Operations and Maintenance Projects. ERDC TN-DOER-Tx September 2012.
Objective	A statement of the intended purposes of the planning process; it is a statement of what an alternative plan should try to achieve. More specific than goals, a set of objectives will effectively constitute the mission statement of the Federal/non-Federal planning partnership. A planning objective is developed to capture the desired changes between the without- and with-project conditions that when developed correctly identify effect, subject, location, timing, and duration (Yoe and Orth 1996). Objectives identify effect, subject, location, timing, and duration (USACE 2010).	Burks-Copes, K. A. 2012. A Community-based Ecosystem Response Model for the Cottonwood Riparian Forests of the Missouri River: Model Documentation, Draft Final Report.
Organic Matter	Plant and animal residue in the soil in various stages of decomposition.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed.

		B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Out-of-Kind Replacement	Providing or managing substitute resources to replace the functional values of the resources lost, where such substitute resources are physically or biologically different from those lost.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Performance Measure (aka performance metric, metric, indicator)	A performance metric is designed to measure how well a specific feature or asset performs relative to its intended purpose(s). The key to selecting good metrics (i.e., ecological end points) is to consider the problem context, the study goals and objectives, and then select end points at the relevant and appropriate spatial and temporal scales. These indicators will likely require regionalization (i.e., refining and honing based on latitude, longitude, and seasonal configuration). In other words, flood damage avoidance is only important to that section of the populace currently threatened by flooding, recreation value decline with travel distance, and water availability is only important to farmers during the growing season.	Per Ty Wamsley & Burks-Copes et al (2013 in review). An Ecosystem-based Approach to Mainstreaming Ecosystem Services into USACE Operations and Maintenance Projects. ERDC TN-DOER-Tx September 2012.
Performance Target (aka performance standard)	Specific criteria (often thresholds) that indicate when explicit, goals and objectives have been met. Here, criteria are also discussed in terms of ways to assess or think about goals and objectives (USACE 2010).	
Plan (i.e., Alternative, Alternative Plan, or Solution)	A set of one or more management measures functioning together to address one or more planning objectives (Yoe and Orth 1996). Plans are evaluated at the site level with HEP or other assessment techniques and cost analyses in restoration and rehabilitation studies (Robinson, Hansen and Orth 1995).	
Plant Community	All of the plant populations occurring in a shared habitat or environment.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Project Alternative(s)	Different ways in which a given project can be done. Alternatives may vary in terms of project location, design, method of construction, amount of fill required, and other ways.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland

		Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Project Area	The area that encompasses all activities related to an ongoing or proposed project.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Project Target	The level of functioning identified for a restoration or creation project. Conditions specified for the functioning are used to judge whether a project reaches the target and is developing toward site capacity.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Quantitative	A precise measurement or determination expressed numerically.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Reference Conditions	Reference conditions, and more specifically reference sites, function as physical representations of the ecosystem's range of character whose attributes are both observable and measureable (SERI, 2004). These standards of reference make it possible to establish a likely range of variability for particular measures of ecosystem integrity, facilitating the development of relational indices for ecosystem response models. The sites themselves can serve as templates for rehabilitation designs and specifications, as well as offer benchmarks or performance targets to measure the progress of recovery efforts and stimulate adaptive management responses (Miller et al., 2012).	SERI, 2004; Miller et al., 2012

Reference Domain	All wetlands within a defined geographic area that belong to a single regional wetland subclass.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Reference Standards	Conditions exhibited by a group of reference wetlands that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the regional wetland subclass. By definition, highest levels of functioning are assigned an index of 1.0.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Reference Wetlands	Wetland sites that encompass the variability of a regional wetland subclass in a reference domain. Reference wetlands are used to establish the range of conditions for construction and calibration of functional indices and to establish reference standards.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Region	A geographic area that is relatively homogeneous with respect to large-scale factors such as climate and geology that may influence how wetlands function.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Rehabilitation	Conversion of an upland area that was previously a wetland into another wetland type deemed to be better for the overall	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the

	ecology of the system.	Science. Island Press, Washington, D.C.
Restored Wetland	A wetland returned from a disturbed or altered condition to a previously existing natural or altered condition by some action of man (i.e., fill removal).	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Site Potential	The highest level of functioning possible, given local constraints of disturbance history, land use, or other factors. Site capacity may be equal to or less than levels of functioning established by reference standards for the reference domain, and it may be equal to or less than the functional capacity of a wetland ecosystem.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Stressors	The physical, chemical, and biological changes that result from natural and human-caused forces and effect other changes in ecosystem structure and/or function. Stressors have associated time dimensions and usually can be quantified (i.e., nutrient loading rates, water quality degradation, shifts in population dynamics, etc.). Stressors may affect a single resource or component, or the stressor may act on multiple ecosystem components, so that stressor effects may be limited or widespread.	
Targets (aka endpoints or performance criteria)	Readily observable, usually quantifiable, events or characteristics that can be aimed for as part of a goal or objective. Targets are a subset of the broad set of indicators, which are prior identified system characteristics that can provide feedback on progress toward goals and objectives (USACE 2010).	
Tidal	A situation in which the water level periodically fluctuates due to the action of lunar and solar forces upon the rotating earth.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Trade-offs	Used to adjust the model outputs by considering human values. There are no right or proper answers, only acceptable ones. If trade-offs are used, outputs are no longer directly related to optimum habitat or wetland function (Robinson, Hansen and Orth 1995).	Burks-Copes, K. A. 2012. A Community-based Ecosystem Response Model for the Cottonwood Riparian Forests of the Missouri River: Model Documentation, Draft Final Report.

Transect	A line on the ground along which observations are made at a given interval.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Watershed	The geographic area that contributes surface runoff to a common point, known as the watershed outlet.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Water Table	The upper surface of groundwater or that level below which the soil is saturated with water. The saturated zone must be at least 6 inches thick and persist in the soil for more than a few weeks.	Kusler, J.A. and M.E. Kentula. 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.
Wetlands	In Section 404 of the Clean Water Act "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a pre-valence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." The presence of water at or near the surface creates conditions leading to the development of redoximorphic soil conditions, and the presence of a flora and fauna adapted to the permanently or periodically flooded or saturated conditions.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Wetland Ecosystems	"Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Corps Regulation 33 CFR 328.3 and EPA Regulations 40 CFR 230.3). In a more general sense, wetland ecosystems are three-dimensional segments of the natural world where the presence of water at or near the surface creates conditions leading to the development of redoximorphic soil conditions, and the presence of a flora and	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

	fauna adapted to the permanently or periodically flooded or saturated conditions.	
Wetland Functions	The normal activities or actions that occur in wetland ecosystems, or simply, the things that wetlands do. Wetland functions result directly from the characteristics of a wetland ecosystem and the surrounding landscape, and their interaction.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
Wetland Restoration	The process of restoring wetland function in a degraded wetland. Restoration is typically done as mitigation.	U.S. Army Corps of Engineers. 2016. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States. ed. B.A. Pruitt, R. D. Rheinhardt, C. V. Noble. ERDC/EL TR-16-__. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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