Do Created Wetlands Replace the Wetlands that are Destroyed?

by Randall J. Hunt

Introduction

Wetlands, once perceived as worthless land, are now recognized as a necessary component of a vital landscape. However, due to draining and filling we have lost many of our wetlands. The loss of wetlands can have undesirable effects on the landscape, such as erosion, flooding, habitat loss and deterioration of water quality. While natural wetland systems are being destroyed nationwide, the wetlands restored or created to compensate for these losses are commonly not evaluated or contain large percentages of non-wetland acreage. At the present time we do not have established methodology that can uniformly evaluate a wetland's function, or that is useful for providing guidelines that enhance wetland restoration/creation success.

Why should we care about wetland loss?

Wetlands are often considered "kidneys of the landscape" because of their role in filtering the effects of surrounding land use, and have widely recognized functions that include storm/flood water retention, shoreline protection, water-quality improvement, and wildlife habitat. In fact, more than one-third of our endangered species are associated with wetlands even though wetlands comprise less than five percent of the landscape! We have lost vast areas of the pre-settlement wetland acreage—more than 50 percent nationally and more than 95 percent in some states. Increasing population, development, farming and landowner's rights have resulted in increasing amounts of our wetland resource being destroyed and have increased the pressure on the wetlands that remain. As demonstrated by the floods of 1993, the loss of wetland functions is becoming increasingly recognized. The effects of wetland loss, however, are poorly understood and wetland research is still considered to be immature.

What is wetland mitigation?

In the broadest sense, mitigation is a process that focuses on: 1) avoiding wetland loss, 2) minimizing the effect of wetland loss, and 3) compensating for unavoidable wetland loss. In general usage, however, mitigation has become synonymous with number 3 and now refers to replacing the function and structure of a destroyed wetland by creating, restoring or enhancing a wetland somewhere else. This mitigation of wetland loss has been mandated by federal law, and there have been numerous large and small wetland mitigation projects in every part of the nation.

Wetlands have many uses, including that as an outdoor classroom.

What are the challenges associated with wetland mitigation?

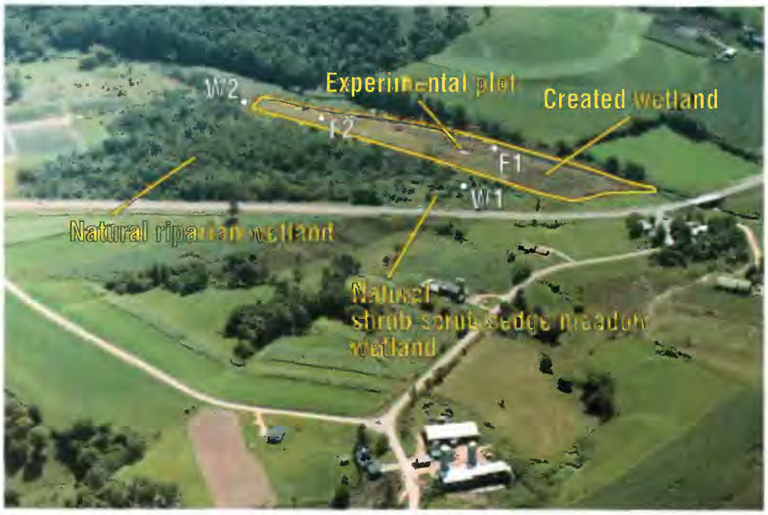
Wetland ecosystems span a large environmental gradient—between occasionally wet uplands to shallow lakes. As might be expected over such a large range, no "universal truths" apply to all wetlands, or to wetland mitigation projects. It has become apparent that we are lacking basic wetland research techniques that can easily assess: 1) the functions occurring within the wetlands, 2) the role that destroyed wetlands played in the greater watershed/ecosystem health, and 3) the extent to which mitigation wetlands compensate for lost wetland systems. In the midst of the pursuit to create and restore, wetland scientists are becoming aware that the many unknowns make it virtually impossible to provide definitive guidelines for successful wetland assessment and design.

What are some of the issues surrounding wetland mitigation?

It is not widely accepted that mitigation projects are successful. Although the current wetland permit programs assume that wetland loss is being ameliorated, no long-term, interdisciplinary research shows unequivocally that a created wetland has fully replaced the lost function resulting from a wetland's destruction. Secondly, there is a concern that created wetlands do not provide in-kind compensation. That is, many hard-to-create wetland types (such as fens, bogs and sedge meadows) are being replaced with common, easy-to-create wetland types (cattail marsh), or the "quality" of the resulting mitigation wetland is not equal to the wetland that was destroyed. A third concern is that placing mitigation projects in areas distant from the destroyed wetland will result in the wetland functions being replaced in

Wetland studies require intensive instrumentation and labor to properly characterize the hydrology, soils and vegetation.

Wetlands span a large range of "wetness"—from occasionally wet meadows and prairies to shallow lakes.



Site description: *The site is located in the unglaciated region of Wisconsin that is characterized by steep slopes and narrow valleys that promote localized ground-water discharge and the formation of river bottom wetlands (fig. 1). The natural wetland consists of a natural shrub-scrub/sedge meadow wetland dominated by sedges, willow and alder and a riparian wetland dominated by alder, american elm and black ash. During the summer of 1991, an adjoining upland agricultural field was excavated to compensate for a wetland being filled by a road construction project. A sedge meadow was the target for the wetland creation, and the field was excavated to depths that were specified on the basis of pre-construction water levels in 72 wells on the site. Salvaged marsh surface (wetland topsoil from a destroyed wetland) was obtained from the on-site project and from a highway project off-site. During the growing season, the ground-water level is generally 0.5 to 1.5 feet below ground surface. As a result of their landscape setting, surface water is not important to either the natural or constructed wetlands.*

Figure 1. Aerial view of the Wisconsin Department of Transportation/U.S. Geological Survey wetland creation site near Wilton, Wisconsin one year after construction. Within the created wetland are experimental plots where design parameters (for example, depth to ground water) were varied. The locations of intensively instrumented sites in the natural and created wetland are also shown.

areas away from where they are needed and/or in areas that are not wetland deficient. Finally, there is great interest in mitigation "banks"—large wetland restoration or creation projects that can serve as compensation credit for wetland losses elsewhere in a given region. While many people agree that large, intact wetland acreage is desirable, there is some concern that mitigation banking projects will not provide meaningful mitigation of the cumulative effects of widely distributed, small-acreage wetland loss.

Evaluation of Wetland Creation: A case study

The U.S. Geological Survey and the Wisconsin Department of Transportation have cooperatively funded an eight-year study that has focused on both evaluation and design of wetland creation projects. Our work focused on 1) the appropriateness of traditional techniques in wetland investigations, and 2) interdisciplinary evaluations of how the constructed wetland compares to the adjacent natural analogue.

1) Do traditional techniques for investigating hydrologic problems work in wetlands?

Scientists commonly investigate hydrologic questions by determining how much water is moving through a system, and what that water is carrying. This understanding is then used to characterize how the system functions, and how it interacts with the surrounding landscape. Our work focused on evaluating how well these traditional methods work in wetland investigations.

Measuring water flows: Traditionally, a relation called Darcy's law has been successfully applied to ground-water problems in non-wetland areas. Darcy's law relates the flow of ground-water to the strength of the pressure driving the system (the gradient) and how easily the water can flow through the material (the material's hydraulic conductivity). Our work has demonstrated that in many cases this

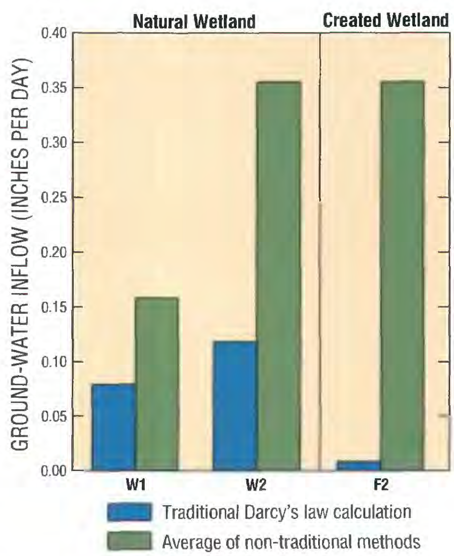


Figure 2. The blue bars represent the values of ground-water flow estimated by using traditional Darcy's law calculations. The green bars represent the inflow measured by innovative methods and demonstrate that traditional approaches can significantly underestimate inflow to wetlands.

simple relation underestimates the amount of ground-water flow in wetlands (fig. 2) because of the uncertainty in characterizing the hydraulic conductivity of the sediments. The innovative techniques used in our work included an isotope mass balance, a model of heat and water flow, and a numerical water balance model; these techniques are described in the article referenced at the end of this fact sheet. This level of understanding will likely be needed elsewhere, especially to answer those questions that require knowledge of ground-water-wetland interaction.

Measuring wetland water quality: A wetland's ability to retain and transform potential contaminants is often cited as an important wetland function to preserve. In most studies, a well with a 1- to 3-foot long open interval is dug into the wetland and pumped to obtain a water sample. We compared

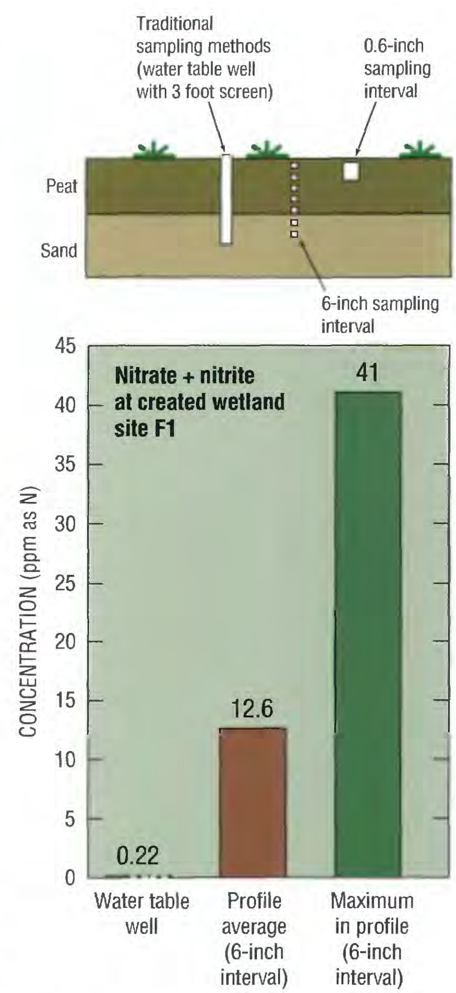


Figure 3. Three different sampling scales used to investigate water quality in the natural and created wetlands showed that very large differences in constituent concentration can be measured depending on the amount of the subsurface sampled. Again, traditional methods appropriate in other hydrologic investigations may not be appropriate for work in wetlands.

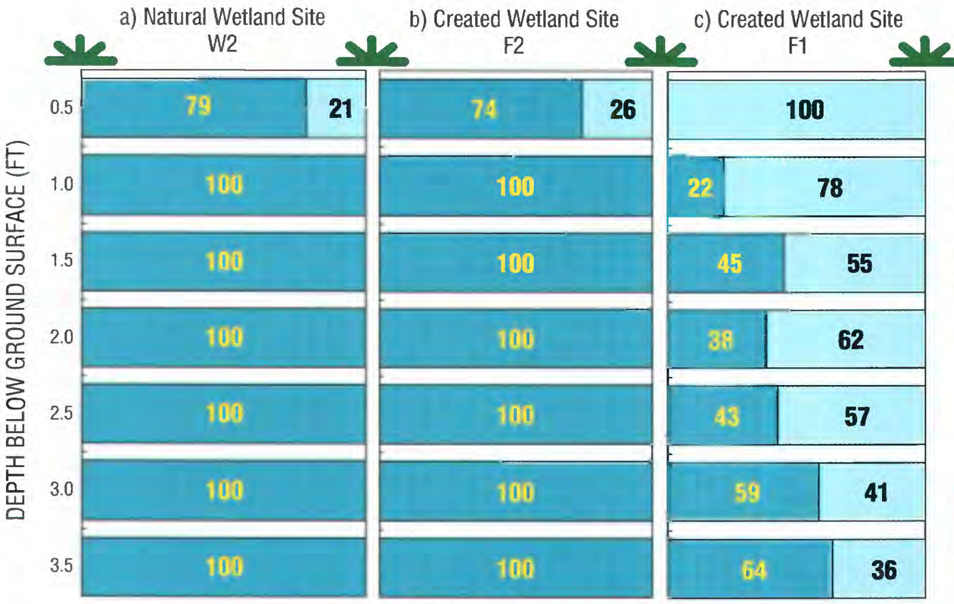


Figure 4. Assessing whether you've created the appropriate hydrology at a created wetland can be difficult. By analyzing the water molecule we can identify the sources of water at different depths in the wetlands. This approach shows that areas of the created wetland have the same ground-water source (a and b). Other areas of the created wetland (c) depend on rain water to maintain water levels and are expected to be drier in times of drought.

traditional sampling from such a well to *in-situ* sampling profiles that divided the well's 3-foot long open interval into 6-inch and 0.6-inch intervals (fig.3). As shown in Figure 3, concentrations of dissolved chemical constituents (in this case nitrate + nitrite) measured in the samples from a water table well can be more than 50 times lower than the average concentration present in the subsurface. This difference is a result of water entering the well from preferential flow zones rather than uniformly from the entire interval sampled by the well's screen. The 0.6-inch sampling interval also showed dramatic geochemical changes vertically—concentrations of some constituents in the root-zone soil water differed by a factor of more than 1000 in water samples collected just 3 inches apart. Variability was present to some degree in each of the constituents measured. Clearly, our evaluations of wetlands—be they for wetland function analysis or assessing the effectiveness of wetlands for wastewater treatment—would be fundamentally flawed if this small-scale variability is ignored.

Salvage marsh surface (SMS) is excavated from the wetland that is to be filled and is stockpiled for application over the created wetland. SMS is a critical element for providing the appropriate hydrological and chemical environment for wetland plant establishment.

2) Is the created wetland similar to the natural wetland next to it?

The simple answer is "in some ways yes, but in other ways no". We looked at the system from the perspective of the essential components of wetlands—the water, the soils, and the vegetation.

Water: We used water tracers (naturally occurring stable isotopes of water) to identify sources of water to the wetlands. In the natural wetland (fig. 4a) and in some areas of the created wetland (fig. 4b), ground water is the predominant source of water; this represents a successful creation of the natural wetland hydrology at the site. In other areas of the created wetland, however, the major source of water is rain (fig. 4c). Because the timing and availability of these two water sources is very different, we can expect that the two areas in the created wetland will respond differently to environmental stresses such as drought. This difference in water source also indicates that wetland hydrology can vary significantly over small distances, and that the hydrology may be as variable as the associated vegetation

While aesthetically pleasing, significant differences remain between the created wetland and the adjacent natural wetland five years after construction.

Wetland creation involves costly earth moving, making it a more expensive alternative than wetland restoration.

Figure 5. The type of wetland targeted for a creation or restoration can have a large effect on the success of the project. The Wisconsin Department of Transportation/U.S. Geological Survey restoration site targeted a shallow-water marsh (a relatively easy wetland type to restore). This resulted in a higher wetland success rate at the restoration site than at the creation site when evaluated as percent of site acreage.

community. Finally, the hydrologic results of this study demonstrate that even a high density network of wells and long-term pre- and post-construction monitoring cannot guarantee that we will have sufficient understanding of the system to create a hydrologic regime needed for a sedge meadow wetland. This difficult-to-obtain hydrologic knowledge is crucial for developing in-kind compensation, and needs to be considered when assessing the appropriate mitigation strategy for destruction of hard-to-replace wetland types.

Soils: The organic salvaged marsh surface (SMS) was only thinly spread on top of the created wetland mineral soil, therefore the soils on the created wetland are more mineral (therefore more dense) than those in the natural wetlands. This difference resulted in a 4° C increase in the root-zone temperatures of the created wetland. This has large implications for wetland seed germination and survival of certain wetland plants. The addition of off-site SMS also caused large deviations from water chemistry seen elsewhere on the site. These deviations demonstrate that SMS provides a suitable chemical substrate for wetland seed germination and survival, as well as a moist physical substrate. Areas that contain the off-site salvaged marsh surface, however, may never have the same wetland plant composition as the on-site natural wetlands due to these large differences in soil water chemistry.

Vegetation: After five years, it appears that the vegetation communities present in the created wetland are not any more similar to the natural wetlands than those observed initially after wetland construction. The areas of the created wetland where on-site salvaged marsh surface was applied were distinctly different not only from the natural wetland, but also from the areas of the created wetland that had salvaged marsh surface obtained from off-site. Recently, the two areas of the created wetland have become more compositionally similar, but are still very different from the natural wetland. These results demonstrate that the adage "get the water right and the wetland will follow" may not always hold, and that many factors may come into play in wetland development and persistence.

Study Schedule, Products and Future Work

This study was initiated in 1989 and is planned for completion in September 1997. One scientific journal article detailing the use of innovative methods for investigating natural and constructed wetland hydrology has been published and two others are planned as this fact sheet goes to press. Additional work focusing on quantifying evapotranspiration and trace metal cycling in wetlands are ongoing.

How does the wetland creation compare to wetland restoration?

We also investigated how wetland restoration (restoring a wetland that was once drained or filled so that it once again functions as a wetland) compares to wetland creation in this same area of Wisconsin. The wetland restoration consisted of converting a drained corn field to shallow water marsh (fig. 5) and wet meadow—the types of wetlands found in the area. Shallow water marshes are considered easier to construct than the sedge meadow attempted at the created wetland site. This fact notwithstanding, the main conclusions of our comparison show that:

1) The construction cost for the restored site was one-fifteenth the cost of the created wetland. The high cost of earth moving required to create a wetland where one has never existed makes it likely that the costs of wetland creation will always be higher than wetland restoration.

2) Restoration implementation time was much shorter (two weeks) than wetland creation (six months) due primarily to the larger scope of work required for wetland creation.

3) In a 1993 delineation of the wetland creation and restoration sites, 60% of the created site would have been delineated as wetland and 100% of the restored site was wetland.

Published Articles

Hunt, R.J., D.P. Krabbenhoft, and M.P. Anderson. (1996). "Groundwater inflow measurements in wetland systems." Water Resources Research. 32(3): 495–507.

Hunt, R.J., D.P. Krabbenhoft, and M.P. Anderson. (1997). "Assessing hydrogeochemical heterogeneity in natural and constructed wetlands." Biogeochemistry. 39: 271–293

Hunt, R.J., T.D. Bullen, D.P. Krabbenhoft, and C. Kendall. (in press)."Using stable isotopes of water and strontium to investigate the hydrology of a natural and a constructed wetland". Ground Water.

For more information, please contact:

Randy Hunt
U.S. Geological Survey
8505 Research Way
(608) 821-3847
rjhunt@usgs.gov
www: http://wwwdwimdn.er.usgs.gov

Layout and illustrations: Michelle Greenwood
U.S. Department of the Interior
U.S. Geological Survey
Fact Sheet FS-246-96