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# Nutrient Farming: A Means to Finance Large-Scale Wetland Restoration

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*Utilizing an economic approach to conservation, Donald Hey, Jill Kostel, and Gary Sullivan propose a financial model for saving and restoring wetlands*

## Abstract

Most human-related environmental problems are widely recognized and their physical, chemical, and biological causes are reasonably well understood. In most cases, neither the cause nor the effect (problem) is assessed economically. We believe that if we as a society are to solve our profound environmental problems, we need to begin to create markets for the products that environmental solutions can offer. For example, wetland restoration could improve water quality, increase biodiversity and wildlife habitat, and provide needed floodwater storage. The Wetlands Initiative has created a restoration strategy, called “nutrient farming,” that encourages large-scale wetland restoration by creating a market that compensates landowners who restore wetlands. The “harvest” will be nutrient (e.g., nitrogen, phosphorus, or carbon) removal credits to be sold to point source dischargers who need to meet stricter water quality standards. To be successful, nutrient farming must be viewed as a business enterprise, an economically efficient means to manage environmental problems. This paper reviews the environmental problems caused by the massive loss of wetlands in the upper Midwest since European settlement, suggests nutrient farming as a vehicle to remedy those problems, and explores the relationship between nutrient farms and biodiversity.

## Introduction: The Problems

Many environmental problems in the Midwest, such as poor water quality, flood damage, and vanishing biodiversity and wildlife habitat are attributable to the loss of millions of acres of wetlands over the past 200 years. Extensive agriculture drain tile systems and narrow, incised outlet ditches have replaced the shallow, vegetated swales and meandering streams that once served as the main surface drainage conduits. Instead of days, it takes only hours for today’s modern drainage systems to efficiently drain the surface and ground water out of the fields into streams and rivers (Hey 2002). Consequently, our altered river systems cost taxpayers billions of dollars in flood damage each year.

Within the Upper Mississippi River Basin agricultural practices, including the application of commercial fertilizers or manure and the production of legumes, are the principal

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source of nitrogen in our rivers and streams (Goolsby et al. 1999). Fertilizer is the largest contributor of nitrogen to the Mississippi River, as the benefits of increased nitrogen fertilizer application and increased crop production have become well established. The highest fertilizer usage and nitrate-nitrogen (NO<sup>3</sup>-N) yields occur in the Corn Belt (Illinois, Indiana, and Iowa). The combination of excessive fertilizer use with rapid agricultural drainage paints a bleak future for water quality.

In 2001, the United State Environmental Protection Agency (U.S. EPA) determined that the nation needs to reduce excess nutrients, such as nitrogen and phosphorus, in receiving water bodies (U.S. EPA 2001). Nutrient overloads are responsible for a number of serious environmental issues in both inland and coastal waters including excessive algal growth, fish kills, increased sedimentation rates, low dissolved oxygen concentrations, and a depletion of desirable flora and fauna. Currently, the nutrient-laden waters reaching the Gulf of Mexico have led to the development of a massive “Dead Zone.” To eliminate the impact of excess nutrients in our water bodies, the national plan calls for all states to write and enact water quality standards for total nitrogen (TN) and total phosphorus (TP) or to adopt the proposed federal criteria. The proposed criteria for Ecoregion VI, the Corn Belt, and Northern Great Plains, are 2.18 mg TN/L and 0.076 mg TP/L (U.S. EPA 2000).

Engineers estimate that the impending water quality standards will cost Illinois ratepayers more than \$5 billion to install the best “concrete and steel” technology available and \$500 million annually to operate these facilities (Zenz 2003). However, this investment can neither produce effluent water that meets the proposed criteria nor will it address regional watershed demand for flood control, suspended sediment reduction, open space, and wildlife habitat.

### **Proposed Solution**

Restored wetlands can provide an ecological solution to the problems of impaired water quality and floodwater storage (e.g., Mitsch and Day 2006, U.S. EPA 1995). Although we know that restored wetlands are desirable, no one has yet developed a financing scheme large enough to effect large-scale restoration. Some state and federal programs, foundations, and private organizations do finance some wetland restoration. However, the cost and the scale of restoration to solve current nutrient and flood storage issues are enormous. It will take an estimated 5-13 million acres of restored wetlands in the Mississippi River Basin to significantly reduce the nutrient load reaching the Gulf of Mexico (Mitsch et al. 2001). Current restoration and conservation programs will contribute just a small fraction to the nutrient management requirement. Market-based or economic strategies are needed to finance this type of large-scale wetland restoration. Simply put, wetlands need to make money.

The U.S. EPA (2004) has been actively supporting the implementation of water quality credit trading programs to improve or preserve water quality. Credit trading programs have been established for different scales of watersheds, ranging from two sources in a minor watershed to multiple stakeholders in the Chesapeake Bay. The two main trading approaches are “cap and trade” systems and offset programs. Cap and trade programs have been implemented in watersheds with multiple point sources, such as municipal and industrial treatment plants, and have improved water quality by setting a limit on the total loading within the watershed from a group of regulated (point dischargers) sources. In an offset program, point sources seek

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offsets, or credits, from unregulated nonpoint sources, such as farmers who adopt best management practices (BMPs) or participate in cooperative conservation programs to improve water quality. With either type of program the exchange of credits allows a water quality goal to be met through the implementation of the most cost-effective nutrient reduction methods within a particular watershed and provides an economic incentive to landowners to implement practices that improve water quality.

The Wetlands Initiative (TWI) has developed an alternative nutrient reduction credit trading strategy that we propose provides a solution for restoring wetlands, improves water quality in our streams and rivers, and overcomes the lack of economic incentive to return land back to floodplain wetlands. This ecological and economic strategy is called “nutrient farming” (Hey et al. 2005a). In comparison to other credit-based programs that focus on watershed trading opportunities between municipalities or point and nonpoint sources, nutrient farming centers on the use of wetlands. Through this strategy, the restoration of floodplain wetlands can be financed by the purchase of nutrient removal credits either through an open market or long-term contracts.

Specifically, nutrient farms are constructed or restored wetlands designed, built, and operated for the primary purpose of removing nutrients, trapping sediments, and storing floodwaters. Rather than growing corn and soybeans, a nutrient farmer “grows” wetlands. The “harvest” is the excess nitrogen and phosphorus removed from the incoming surface water and carbon dioxide, which is removed from the atmosphere. The farmer can manage the land to optimize the natural wetland processes that sequester or remove phosphorus, nitrogen, and carbon. Unlike BMP strategies, nutrient reduction credits can be verified because nitrogen and phosphorus concentrations can be measured at the intake and outfall of the nutrient farm. To quantify carbon sources and sinks, carbon fluxes (i.e., carbon dioxide uptake, greenhouse gas emissions) and carbon content in the vegetation, soils, and sediments are the key measurements needed. Landowners then sell nutrient reduction credits to other crop or livestock farmers, municipalities, or industries that release excess nutrients to surface waters and cannot cost effectively remove these nutrients themselves.

TWI has performed a number of economic studies to demonstrate the efficacy of nutrient farming, including a study to compare the economics of nutrient farming to traditional “concrete and steel” treatment technologies (Hey et al. 2005b) and an analysis of nitrogen trading scenarios in the Illinois River Basin (Kostel et al. 2007). These studies demonstrate that

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large-scale restored wetlands would provide important economic benefits as well as environmental benefits for humans and wildlife; benefits that are unavailable through the use of traditional technologies.

### **Nutrient Farming and Biodiversity**

Although nutrient farms are managed wetlands, we believe the best and most efficient nutrient farms will be those that provide the biodiversity, hydrology, and structure of presettlement wetlands. Nutrient farms function biologically and chemically in the same manner as a natural wetland system. In a 'shallow marsh' nutrient farm system, nitrogen is converted to harmless nitrogen gas (N<sub>2</sub>) by denitrifying bacteria, while phosphorus and carbon are taken up by plants and/or sequestered in wetland organic materials and soils (Walbridge and Struthers 1993; Phipps 1997). These biogeochemical processes are dependent upon effective interactions among the various nutrients, biological agents, and soil elements. All of these interactions are mediated by the appropriate hydrology because nutrients are dissolved or suspended in water that is being transported through the system at a rate and depth that optimizes interaction rates. Moreover, the underlying biogeochemistry functions best under a hydrologic scheme that more closely resembles the floodplain wetlands characteristic of the late 1800s rather than those of today's highly disturbed rivers. Consequently, a well-managed nutrient farm potentially provides better wildlife habitat and functions more similarly to a natural, undisturbed floodplain wetland.

One of the most important and beneficial aspects of a nutrient farm may pertain to its location. The most efficient farms will be built on an existing floodplain that has been disconnected from its river through a system of levees, ditches, and/or drainage. This disconnection has cost our society dearly in the quality of our water, catastrophic flood damages, and vastly diminished wildlife habitat. By reconnecting in a controlled manner, many of these losses can be restored. Much of the levee infrastructure can be readily converted to protect developing wetlands from the fluctuating water levels now characteristic of all major rivers due to land use changes throughout the watershed. Other locations include most areas along an impacted riparian corridor and the dead backwaters and floodplains of streams with steeper gradients.

Ecologists now recognize that functional natural systems are characterized by high levels of biodiversity and conversely that degraded systems are characterized by low biodiversity, a significant presence of invasive species, and reduced functional performance. However, the role of biodiversity in the efficient functioning of a nutrient farm is not well understood and is open to some debate. The role of biodiversity may depend upon the model on which the farm is based, such as a typical treatment wetland versus a biologically rich and heterogeneous wetland. Treatment wetlands are generally not diverse and are run under a homogenous set of conditions to maximize a single function (Kadlec and Knight 1996). For nutrient farming, we believe a biologically diverse wetland will provide a wider range of services and long-term performance at lower cost.

There is little doubt that biologically diverse systems share a number of characteristics that make them functionally superior to less diverse systems. Diverse systems are generally more productive, in that they produce more biomass per area annually

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(Hooper et al. 2005). Diverse systems are more resistant to disturbance because events which impact or stress systems are less likely to result in significant damage or a lasting change in functional performance (Caldeira et al. 2005). Biologically diverse systems are also more resilient because once the system is perturbed, such as from a flood event, it will recover more quickly and reliably. This also makes diverse systems more stable and predictable, primarily because with greater species diversity they possess a wider range of functional attributes (Naeem and Li 1997; Sullivan et al. in publication). This is a type of ecological ‘insurance’, where the functional contribution of an impacted species may be replaced by the contribution of other species that are impacted to a lesser degree or not at all (Yachi and Loreau 1999).

Since nutrient farms are managed systems, developing and sustaining a biologically diverse plant, animal, and microbial community will require an active and strategic contribution to the ecosystem’s dynamic processes. One of the most important of these elements is hydrologic management. Floodplain and marsh communities are adapted to flooding and drying cycles, with the highest levels of diversity and productivity developing under intermediate disturbance regimes (Huston 1994). Drawdowns and flooding events are critical for establishing and maintaining many wetland species (van der Valk 1981; Keddy 2000), with static conditions leading to losses in diversity and/or aggressive species invasions (Kennedy et al. 2002). Further research needs to be conducted to determine the relative importance of such events and the optimal duration and periodicity of their occurrence for the maintenance of an efficient nutrient farm.

One of the most significant challenges to the nutrient farmer will be managing the invasive plant and animal species. Invasive impacts are primarily due to the characteristics that define them as a group; they are early successional species that are very well adapted to disturbance events. In an environment where nearly all natural areas are continuously disturbed by human activities this makes them ideally suited for the invasion and displacement of native species. Invasive species may further enhance their advantage by altering their environment in a manner detrimental to desirable species. It is critical that invasive species be managed if a nutrient farm is to function properly. However, the tradeoffs inherent in any management scheme and the cost of invasive management relative to little or no management remain unknown for many species and circumstances. Invasive species management within the context of a nutrient farm is now an important research topic currently under investigation by TWI.

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Another way that nutrient farms can contribute to biodiversity is the potential to restore and provide critical wildlife habitat. With the massive loss of wetlands throughout the Midwest, there have been dramatic declines in wetland-dependent species, many of which are economically and/or recreationally important (e.g. migratory waterfowl). Habitat loss not only affects all of the species that live in wetlands, but also a far larger number of species that rely on wetlands of one type or another for food, refuge, and/or reproduction, such as the Illinois State endangered Henslow's sparrow (*Ammodramus henslowii*). Exacerbating wetland loss is the general degradation of what remains; nearly all remaining wetlands are fragmented, isolated, and impacted to some degree. Nutrient farms provide an opportunity to reverse these losses before many of the plants and animals dependent upon wetlands disappear locally or regionally. With relatively clean and clear water, the potentially large and biologically rich nutrient farm landscape can provide a resource that is virtually absent throughout the Midwest today; a wide range of habitat niche-space for many of the most rare, threatened, and endangered species throughout the region.

### **Conclusions and Recommendations**

Pilot projects are needed to verify costs, scale-up considerations, and document nutrient removal rates so that nutrient farming will gain acceptance as a nutrient removal technology at a broad scale. TWI is developing a 1,300 acre nutrient farm pilot project along the Illinois River to demonstrate the ability of large-scale wetlands to achieve sustainable nutrient removal while restoring lost habitat and diversity. The success of this pilot project will allow Publicly Owned Treatment Works to take advantage of cost savings and maintain compliance to water quality standards. Nutrient farming provides a strategy that is more appealing than traditional wastewater treatment methods, which provide no additional benefits beyond nutrient reduction and are energy-intensive processes that rely on fossil fuels.

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