A Watershed Approach to Wetland Services: Prioritizing Wetland Restoration in the Upper Rock River Basin, Wisconsin, USA

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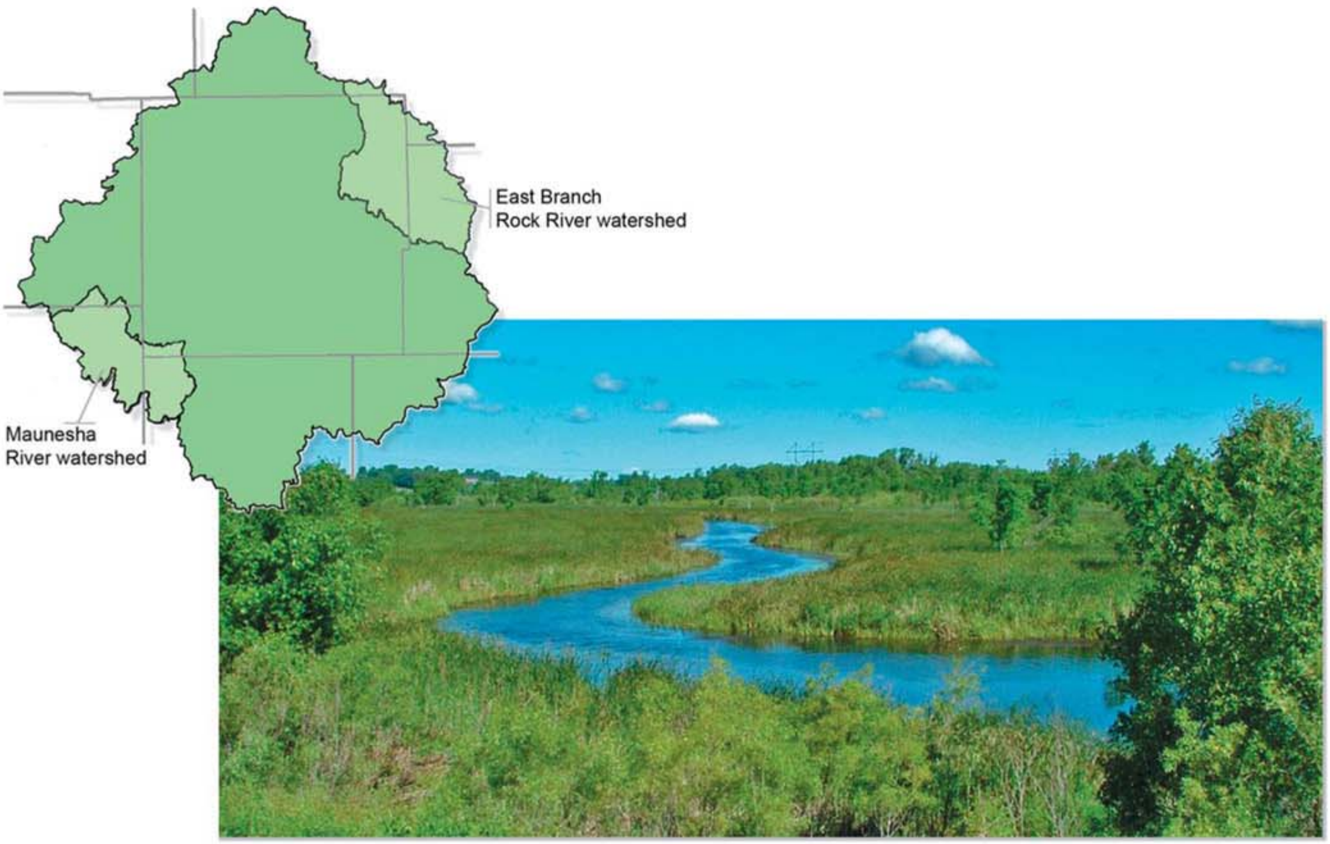

Water Resources Management Practicum 2004
Gaylord Nelson Institute for Environmental Studies
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The Water Resources Management Practicum is a regular part of the curriculum of the Water Resources Management (WRM) Graduate Program at the University of Wisconsin-Madison. The workshop involves an interdisciplinary team of faculty members and graduate students in the analysis of a contemporary water resources problem.

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Figures

Table

Preface

The Water Resources Management (WRM) Practicum is a requirement for completion of the Master of Science degree in Water Resources Management in the Gaylord Nelson Institute for Environmental Studies (The Nelson Institute). For the 2004 WRM Practicum nine students spent the 2004 spring and summer semesters developing a watershed-based prioritization strategy for wetland restoration. Environmental Defense funded this project through its Center for Conservation Incentives and The Nelson Institute at the University of Wisconsin–Madison.

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Executive Summary

Development in Wisconsin has resulted in the loss of important landscape processes due to wetland drainage and degradation (Houlahan and Findlay, 2003; Richardson and Gatti, 1999). These disturbances have greatly reduced the landscape's natural ability to provide flood attenuation, sustain base flows, recharge groundwater, improve water quality, and support a diverse ecosystem. Restoration is a tool for ecosystem management that attempts to reestablish ecologic and hydrologic processes of former or degraded wetlands.

Because a wetland is dependent on its water sources and also has an impact on downstream resources, a strategy for wetland restoration should be approached at the watershed scale. The strategy should take into account the functioning of existing wetlands, conservation of important wetland resources, and the potential of former wetlands to provide services. Factors such as landscape position, species richness, and hydrologic regime need to be assessed to optimize wetland services (National Research Council, 2001). Each site has individual characteristics, and trade-offs may need to be made to optimize wetland functions. For example, a site used to improve poor water quality by trapping sediments and nutrients may eventually compromise its ability to support a high level of species richness. A watershed-based approach can accommodate this limitation by basing the selection of individual restoration sites on optimal service delivery.

The 2004 Water Resources Management Practicum was given the task of developing a watershed-based strategy for wetland restoration considering ecological services (hydrologic support, water-quality improvement, and biodiversity enhancement) as well as investigating a means to implement such a strategy. Our proposed goal was to identify potentially restorable wetlands for the Upper Rock River Basin in southeastern Wisconsin and to develop a scheme that would rank the basin's wetlands on the basis of their potential ability to perform these ecological services. We defined potentially restorable wetlands as lands with hydric soils that are not currently mapped as wetlands. In the Upper Rock River Basin, most of these lands are privately owned and used for agriculture.

Several entities are involved in providing funds and technical expertise, but Farm Bill conservation programs (e.g., Wetlands Reserve Program and Conservation Reserve Enhancement Program), which offer participatory incentives to encourage conservation and restoration of natural nonpoint source pollution controls and former wetlands, are the best-endowed sources for wetland restoration. Collectively, these programs are the greatest source of funding for wetland restoration on agricultural lands. However, programmatic and land-use realities offer major challenges to implementing a watershed-based strategy, for the following reasons:

- Most wetland restorations are not effectively providing multiple wetland functions (National Research Council, 2001).
- Property boundaries and landowner objectives limit restoration options.

- Farm Bill conservation programs rely on voluntary participation.
- Restorations focus on overall acreage rather than wetland function.
- Influential economic and social factors act as disincentives to participate in conservation programs.
- Pursuing strategic wetland restoration is difficult because of lack of resources.
- Data sharing between various entities is not coordinated.
- Availability of geographic information system (GIS) data to the public is limited.

The examination of various wetland-mitigation projects was useful in developing our strategy. In particular, our review of wetland mitigation projects revealed two important ideas regarding wetland functions and placement. First, many replacement wetlands are not functionally equivalent to reference wetlands (National Research Council, 2001; Bedford, 1996; Mitsch and Wilson, 1996). As a result, the importance of conserving existing wetland resources and the use of adaptive management should be emphasized. Second, a study of wetland mitigation came to the conclusion that use of a watershed-based approach to wetland conservation and restoration is more likely to result in self-sustaining wetland ecosystems (National Research Council, 2001). In effect, only restoration activities coordinated at the watershed scale can maximize potential wetland function and, in turn, services to society.

The Upper Rock River Basin, located in southeastern Wisconsin, encompasses the headwaters of the Rock River, and glacial drumlins are the dominant landforms within the basin. Land use is mainly agricultural, resulting in high nutrient and sediment loads to aquatic systems within the basin. During the development of our strategy, we found that focusing on an area as large as the Upper Rock River Basin was problematic given our time constraints and the level of familiarity we wished to achieve with our study area. Therefore, we reduced our focus to two representative watersheds: the East Branch Rock River and the Maunesha River.

Our method of study included the evaluation of several past studies, GIS data analysis, interviews with various local restoration practitioners and decision makers, and field checking of available data concerning the East Branch Rock River and Maunesha River watersheds. We concluded the following about the basins:

- The majority of existing and potentially restorable wetlands within the East Branch Rock River and Maunesha River watersheds fall into two broad geomorphic categories: inter-drumlin and former lake-bed wetlands.
- The majority of the hydric soils of the Upper Rock River Basin are connected and very few isolated hydric soil areas of significant size exist.
- Several large wetland complexes (groupings of several wetland types into a larger wetland area) are present in the East Branch Rock River and Maunesha River watersheds. The Wisconsin Department of Natural Resources (WDNR) has identified these areas as important wetland resources and they are currently our best opportunity for creating and preserving diverse wetland habitat.

- Water-quality issues plague the Upper Rock River Basin. As a result, existing wetland systems are being degraded. Water-quality improvement is of high priority to basin managers.
- Many wetlands, restored and not restored, in the East Branch Rock River and Maunesha River watersheds are hydrologically disconnected from their associated stream or river and have impaired hydrologic functions.
- Wetland hydrologic support functions, specifically flood attenuation, are not identified as a major need within the East Branch Rock River and Maunesha River watersheds.

We believe these findings highlight the importance of conserving important existing wetlands and improving the quality of water entering these wetlands. Meeting these needs can be realized partly by placing restored wetlands within the watershed at strategic locations to optimize ecological services. This dictates a strategy based on the following:

- improvement of water quality upstream of major wetland complexes,
- expansion of existing wetland complexes, and
- restoration of the hydrologic connectivity within existing systems.

Wetland-restoration design techniques include best management practices such as riparian wetland buffers targeting major hydrologic flow paths to streams and ditches, pocket wetlands placed at outlets of active drain tile systems, and wetlands at the base of drumlin slopes to intercept large runoff volumes. Additional benefits of our strategy would include increased spatial connectivity and habitat corridors, diversification of habitat types, and the protection of hydrologic support services.

We foresee the keys to successful implementation of our strategy to be basinwide coordination between stakeholders, unhindered participatory incentives, and full commitment to adaptive management. We recommend coordination of a collaborative watershed-based effort between local communities and institutions. Additionally, we propose that implementation of our strategy include, where appropriate, addressing the causes of and accommodating the consequences of the various challenges mentioned above.

- The Wetlands Reserve Program (WRP) should be adjusted to include assessments of wetland services provided by restoration projects. At the national and state levels, equal weight should be given to services such as potential water-quality improvement and increased biodiversity as well as hydrologic support services. Overall success of the WRP should be measured by increased ecological services in addition to the number of acres restored.
- At the federal level, sufficient funds should be allocated to agencies to form partnerships using a watershed-based approach. Funds would be increased for program outreach, education, data sharing, long-term monitoring, and adaptive management.

- The Wisconsin use-value tax assessment for agricultural lands should be reformed to remove the tax disincentives for wetland restoration.
- The state of Wisconsin should make the completion of a statewide digital/GIS database that includes layers such as an updated wetland inventory, reed canary grass and invasive species coverage, mitigation sites, and soils a priority. The state should also initiate an effort to make these data layers readily available to various entities attempting to plan and manage water resources on a watershed scale.
- Community efforts are needed to create visions for individual watersheds and to educate landowners about the significance and functions of properly restored wetlands.

Several general ideas became apparent to us in our development of a prioritization strategy for wetland restoration. To provide ecological functions that are valued by society, wetland functions must be viewed at a watershed scale. Detailed, local knowledge is a necessary component of proper assessment of a watershed's ecological conditions. This watershed assessment must be evaluated at a scale consistent with the benefits that wetland restoration will deliver. Wetland-restoration objectives can be more clearly established through a community visioning process that aims to conserve and enhance resources deemed important from scientific and societal viewpoints.

Introduction

Historic and current land uses, such as urban development and conversion to agricultural lands, have destroyed or degraded many wetlands worldwide, resulting in the loss of key wetland functions (Moser et al., 1996). As a result, wetland restoration has become an increasingly important issue in ecosystem management. By definition, wetland restoration is the act of taking a former or degraded natural wetland and reestablishing the related ecologic and hydrologic processes and functions (Society of Wetland Scientists, 2000).

Current wetland-restoration strategies focus on site-scale projects or specific species enhancement rather than on wetland functions within the context of a watershed. These methods have reduced wetland diversity, replacing a landscape that historically contained a variety of wetland types with more homogeneous wetland communities (Steel, 2004). Restoration methods have not been entirely effective in the creation of well established, functioning wetland systems that support flood reduction, biodiversity enhancement, and water-quality improvement (Zedler, 2003, 2000; Mitsch and Wilson, 1996; National Research Council, 2001). Typically, created wetlands are not considered to function as effectively hydrologically and/or biologically as naturally occurring wetlands (Mitsch and Wilson, 1996; Bedford, 1996). The restoration of wetland systems has often been addressed by focusing on one primary function for ease of management. This practice has resulted in the oversimplification of the complex relationships found in wetlands.

Figure 1. *Location of the Upper Rock River Basin within Wisconsin. The Maunesha River and the East Branch Rock River watersheds are also shown.*

Therefore, to restore key wetland functions within a watershed, a strategic watershed-based approach is needed (Zedler, 2003; Bedford, 1996; National Research Council, 2001). The 2004 Water Resources Management Practicum was assigned the task of developing a watershed-based prioritization strategy for wetland restoration to provide the following ecological services: hydrologic support, water-quality improvement, and biodiversity enhancement. Our proposed goal was to identify potentially restorable wetlands for the Upper Rock River Basin in southeastern Wisconsin (fig. 1) and to develop a scheme that would rank the basin's wetlands on the basis of their potential ability to perform these ecological services. The process we developed can be applied to other watersheds; however, the resulting strategy is specific to our case study and will vary from one watershed to the next.

Watershed approach to wetland restoration

As more has been learned about the various functions of wetlands and the role wetlands play in the landscape, a new approach to restoration planning and management has begun to emerge. This method has been termed the watershed, or landscape, approach to wetland restoration (Zedler, 2003; Crumpton, 2001). This approach takes a holistic view of a defined watershed by understanding how wetlands function at different locations within the landscape. Strategic placement of wetland restoration based on such an understanding can optimize the creation of habitat for biodiversity, water quality, and hydrologic support. (See green text box on the following page for a description of these wetland functions.)

A watershed approach to wetland restoration has several key components. Although we cannot define an exact method to such an approach, we have outlined the major steps.

1. Define the restoration goal

Defining the overall goal of the wetland-restoration project in a watershed is the most essential step (Bedford, 1996). Ecologic and hydrologic characteristics, in combination with social desires, should be considered when establishing the restoration goal. Once this goal has been established, restoration objectives should be created to guide the development of the restoration strategy.

2. Define the spatial scale

When looking at a watershed, it is critical to define spatial scale. Scale is highly dependent on the identified objectives of the restoration. Many questions still remain as how to define the limits of a landscape to determine effectively the impacts of wetland restoration within the defined area and on downstream resources. Political boundaries should not be used to determine the extent of a watershed approach application (Lamb and Thomas, 2004). Current strategies have placed much emphasis on the U.S. Geological Survey's (USGS) hydrologic units as well as larger ecoregions (Preston and Bedford, 1998). Those scales may still be too large to understand entirely a complex system and prioritize restorations effectively without overgeneralizing the landscape. The National Research Council (2001) Committee on Mitigating Wetland Losses recommended that the scale of analysis be adjusted to fit the wetland and watershed functions under consideration instead of accepting one universal scale.

Roles of wetlands in the ecosystem

Wetlands have attributes of terrestrial and aquatic environments. These ecosystems are defined by the hydrologic inundation regime or degree of saturation, the characteristic hydrophilic vegetation, and the presence of hydric soils. Due to these unique landscape features, wetlands serve many environmental functions that fall into three main categories: hydrologic support, water-quality improvement, and habitat to support biodiversity (Zedler, 2003).

Hydrologic support

The term *hydrologic support* refers to ecosystem functions such as base-flow augmentation, groundwater recharge, water-supply potential, flood-flow attenuation, and shoreline erosion protection (Ogawa and Male, 1983; Mitsch and Gosselink, 2000). However, it can be a wetland's impact on the extent and magnitude of flooding that receives most attention. Flood attenuation by wetland systems can be achieved through water storage, increased evapotranspiration, and reduced runoff (especially in the case of isolated wetlands that reduce the watershed drainage area). Of these flood-control factors, water storage is the most important (Potter, 1994). Short-term storage delays and reduces flood peaks; long-term storage of captured water reduces flood volumes (Potter, 1994). However, this storage must be temporary, meaning that the wetland must drain to make the additional volume available for storing future flood events.

Water-quality improvement

Wetlands significantly impact water quality and have been shown to reduce the concentration of many pollutants, including nitrogen, phosphorus, suspended sediment, biochemical oxygen demand, trace metals, trace organics and pathogens (Woltemade, 2000). Improvement in water quality is linked to many chemical, physical, and biological processes that are often associated with wetlands (Mitsch and Gosselink, 2000). Although all wetlands will provide water-quality services to a certain degree, two main factors have been shown to influence greatly the benefits of water-quality treatment: location within the watershed and the ratio of contributing area to wetland area. Location is important because the wetlands must intercept a significant amount of the contaminant(s) of concern and be connected to open-water ecosystems to have an impact on downstream water quality (Crumpton, 2001; Craft and Casey, 2000). Wetlands that are large in relation to their contributing area will have longer retention times and provide greater water-quality benefits (Woltemade, 2000).

Habitat and biodiversity

Wetlands are considered to be one of the most productive ecosystems on Earth and are home to a large array of plants, animals, and microorganisms (Mitsch and Gosselink, 2000). The species supported by a given wetland depend on length of inundation period, pH, soil types, water sources, and water quality. Many organisms are dependent on wetlands during all or part of their life cycle. It has been estimated that 43 percent of all threatened and endangered species are associated with wetland habitats, including species of plants, mammals, birds, reptiles, amphibians, mussels, fish, and insects (Niering, 1988).

3. Assemble and synthesize available data

The next step requires the assembly of the available data to help better understand the watershed, the analysis of key features within the area, the identification of related problems, and an understanding of the function of the existing wetland or potential wetland site in the context of the entire landscape. This involves evaluating a variety of spatial and temporal scales using tools such as geographic information systems (GIS), interviewing local resource agents working within the basin, and performing field investigations.

The placement of a wetland within a watershed can affect its function; therefore, it becomes necessary to identify viable locations for wetland restoration. One should also assess existing wetlands to determine how they are currently functioning. Knowing the extent to which a wetland is providing a valued function can help identify sites for protection and enhancement.

It is also important to identify human impacts on the landscape. These impacts include the destruction of wetlands through drainage for agricultural conversion or filling for development and the degradation of others through channelization, dam construction, introduction of invasive species, and nonpoint and point source pollution. Understanding the effects of such impacts can provide valuable insight to wetland-restoration planning.

4. Develop a prioritization strategy

Developing a strategy for prioritizing potential wetland-restoration projects in accordance with restoration objectives is an excellent way to lend structure and focus to the restoration effort. Prioritization criteria that support the desired functions and objectives must be determined. Using these criteria and the assembled data for the selected area, a number of potential wetland-restoration or enhancement sites can be prioritized. This information can be used to make decisions regarding the project selection and money allocation that aid in meeting the restoration objectives.

5. Incorporate adaptive management

One factor that contributes significantly to the progress of a restoration effort is the long-term management of the project. As mentioned previously, wetland-restoration techniques have resulted in restored wetlands that are functionally inferior to their natural counterparts (Zedler 2003, 2000; National Research Council, 2001). An adaptive management approach is ideal for addressing this type of uncertainty because it uses management as a tool for gaining critical knowledge and continually incorporates this knowledge into the management plan (Johnson, 1999).

Previous studies incorporating the watershed approach

Watershed-based approaches have been applied in many studies attempting to prioritize wetland-restoration sites for a single objective; most commonly, that objective is water quality, biodiversity enhancement, or flood attenuation (Schweiger et al., 2002; Smith et al., 1995; Brooks et al., 2002; Boyd and Wainger, 2002; Richardson and Gatti, 1999; Llewellyn et al., 1996). Questions still remain regarding the generalizations made, the scales used, and the practical applicability of each method. The following are some of the concerns we have identified in relation to these published studies:

- Because many of these researchers relied solely on GIS and digital data, they have conducted analysis at a scale too large to evaluate effectively the potential function of a restoration site or the functionality of an existing wetland.
- Many of the approaches did not integrate local knowledge of a watershed or its wetland systems.
- Complex, costly, and time-consuming methods have been used in many of the studies to evaluate the criteria used to prioritize restoration sites; many of these methods have not been adopted as a common practice.

Our intention was to develop a watershed approach to wetland restoration that integrates local knowledge of ecosystem services, incorporates the use of GIS with management on a scale consistent with the evaluation of wetland function, and is cost effective to implement. Once overcoming the obstacles outlined above, additional challenges exist in the successful implementation of a watershed-based wetland-restoration strategy.

Implementation challenges

A large percentage of wetland restorations takes place on private land. Several state and federal programs financially and technically support these projects (see Appendix 1 for a list of program goals and Web sites). Farm Bill conservation programs are the best-endowed sources of funding for wetland restoration, providing the greatest opportunity to implement wetland restoration in agricultural landscapes. The Wetlands Reserve Program (WRP) alone provides approximately six million dollars annually to wetland restoration within Wisconsin (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004). Other programs include the U.S. Fish and Wildlife Service (USFWS) Partners for Wildlife, and the Wisconsin Department of Natural Resources (WDNR) Glacial Habitat Restoration Area.

These programs have made great strides in restoring wetlands to the landscape, but there is room for improvement in restoring wetland services to the landscape. We identified several challenges to implementation of a watershed-based wetland-restoration strategy that are largely programmatic in nature, making them difficult to overcome.

Emphasis on the restoration of a single wetland service

Current restoration practices at individual sites are typically guided by objectives that aim to provide a single service while assuming that other services will be provided consequentially. For example, parts of the Upper Rock River Basin fall within the North American Waterfowl Management Plan's Upper Mississippi River Joint Venture area and the WDNR's Glacial Habitat Restoration Area; both programs emphasize restoration of habitat. These programs restore wetlands designed specifically for waterfowl habitat, which usually do not reflect the historic wetland landscape in terms of location and diversity. Scrapes, which are small depressions providing open water for breeding pairs, are the typical waterfowl habitat restoration technique. Although they provide valuable habitat for desired waterfowl species, scrapes may not provide any ancillary benefits such as water-quality improvement (Crumpton, 2001).

Focus on acreage rather than restoration quality

National programs place emphasis on restored wetland acreage as a measure of success and do not typically take into account restoration quality. This discourages programs from allocating the necessary resources to manage for multiple objectives and operate fully functioning systems at each individual site. The emphasis on restored wetland acreage was reinforced through the "No Net Loss" policy established in 1989 (Heimlich et al., 1998). However, the objective of maintaining current acreage, or the status quo, is not sufficient because degraded, mitigated, or restored wetlands may not provide the same services as fully functioning wetlands (Heimlich et al., 1998). The WRP has a limited amount of funds available for investment in each site. A larger share of funds is often allocated to acquisition of restorable land rather than restoration (Natural Resources Conservation Services, n.d.).

Five predominant wetland types—wet meadow, shallow marsh, introduced herbaceous, open water, and shrub carr—account for 70 percent of the restorations in Wisconsin (Steel, 2004). With a decrease in the diversity of wetland types being restored and a lack of post-restoration monitoring, the question remains as to the quality of the services provided by these systems.

Lack of funding for monitoring and management

Conservation programs may fail to appropriate sufficient funds and resources to the management and monitoring of restoration sites (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004). Adaptive management and determining the success of restoration efforts is dependent upon comprehensive monitoring before and after restoration on-site and statewide. Follow-up restoration maintenance and monitoring are often secondary to the acquisition of acreage, which is considered top priority because it ensures annual program funding. In an effort to address this issue, Wisconsin was the first state to hire a full-time staff member to monitor the efforts of the WRP, and funds have been acquired for the repair and enhancement of earlier restoration sites (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004). The Natural Resources Conservation Service (NRCS) has made commendable advancements in monitoring and management of individual restoration sites since the WRP's inception, but the limited resources allocated to these actions may not be sufficient to implement wetland restoration strategically on a landscape scale.

Conflicts between manmade and natural boundaries

Political boundaries

Political boundaries occasionally follow streams or rivers, but rarely follow watershed boundaries. The inconsistency between political and natural boundaries presents several challenges to the management of water resources, including wetland restoration. Separate governmental entities have different interests, values, and resources, which could make it difficult to collaborate on wetland-prioritization strategies and coordinate their execution on a watershed scale.

Private property boundaries

The partitioning of the rural landscape into small parcels presents one of the most serious challenges to restoring functional wetlands. Most historic wetland complexes span multiple property boundaries and have been parceled out to several landowners, making it difficult to restore these wetlands to their previous acreage. Situations can arise in which only one individual owning part of a former or degraded wetland would pursue restoration, but the adjacent owners would continue their current land use. For legal reasons landowners must ensure that the restoration will not cause flooding on adjacent property and, in the case of drained agricultural land, must guarantee that the drainage system remains functional for all other landowners. These constraints result in piecemeal restoration and compromise wetland function (Art Kitchen, U.S. Fish and

Figure 2. *In Dane County, Wisconsin, a Wings Over Wisconsin wetland project, a former mint farm, is now overgrown with willows. Berlin Road bisects the restoration site and must be maintained for public safety. (Photograph, July 1, 2004.)*

Wildlife Service, verbal communication, 2004).

Utility and transportation corridors

Many utilities and transportation corridors intersect large wetland complexes due to lower investment costs associated with the purchases of this land (Robert Vanderclute, Association of American Railroads, verbal communication, 2005). The establishment of these corridors and their upkeep have greatly impacted the hydrologic connectivity of wetland sites, the regeneration of native biota, and the aesthetic quality of large wetland complexes (Findlay and Bourdages, 2000; Knutson et al., 2000; Trombulak, 2000).

Because utility and transportation corridors were established prior to environmental regulations and they are responsible for providing essential community services, it is difficult to remove or revoke rights to these properties to restore wetland hydrology. For example, adjacent to Deansville Marsh, a township road (Berlin Road) must be maintained for public safety and emergency services. This road divides a recent Wings Over Wisconsin restoration site and has impeded restoration efforts for years. The site (shown in fig. 2 and described in grey text box on the facing page) is currently covered with willow trees and is considered by some as an example of an impossible restoration (Kevin Connors, Dane County Land Conservation Department, verbal communication, 2004).

Voluntary enrollment in major restoration programs

Many wetlands in the Upper Rock River Basin are on agricultural lands. Therefore, Farm Bill conservation programs have the potential to play an important role in restoring wetlands. These programs provide two means for farmers to participate: cost sharing and easements. Either mechanism of conservation requires voluntary participation on the part of the landowner. The agencies charged with enrolling landowners in conservation programs typically focus on working with those who are interested instead of identifying high priority restoration sites and reaching out to the owners of these areas. The NRCS is limited in the time and money that can be allocated to pursue participants, and must rely on landowners who contact them for wetland restoration. This makes it difficult to restore wetlands strategically on a watershed scale.

Restoration gone wrong—The Deansville marsh mint farm

The Deansville marsh in northeastern Dane County, Wisconsin, has been manipulated over the past century by stream channel straightening of the Maunesha River and the installation of surface ditches to facilitate farming of the fertile wetland soil. This land has a place in Wisconsin history as the first state wildlife area, designated in 1928 (Steve Falter, Capital Water Trails, verbal communication, 2004). During the 1970s, the Wisconsin Department of Natural Resources began purchasing the former marshland with the hope of someday restoring the system to its original function. In 1994, a large parcel of land adjacent to the Maunesha River became available. Theodore Vale, the owner of a mint farm on the southeast corner of Deansville Marsh, was eager to retire and became interested in restoring this former wetland. Working in cooperation with the Dane County Land Conservation Department (LCD), NRCS, WRP, and WDNR, planning for the project was initiated and a WDNR Stewardship grant was awarded (Dennis Johnson, Wings Over Wisconsin, written communication, 2004).

One minor detail became a major roadblock to the wetland restoration: Berlin Road. The community and municipal authorities in the town of Medina were committed to maintaining the more than 100-year-old dirt road that crossed the mint farm property for providing emergency services and reducing local transportation costs. However, if the wetland was restored and water pumping (which was critical for controlling water levels in the mint field) ceased, the one-lane road would be flooded. Searching for a possible solution, Kevin Connors of the Dane County Land Conservation Department contacted the Wisconsin Department of Transportation (WDOT) and proposed a partnership between the WRP restoration project and the WDOT wetland mitigation activities. After additional meetings a compromise was reached: Wings Over Wisconsin would purchase the property with the help of the WDNR stewardship grant and the wetland would be restored with the aid of NRCS, WDNR, and LCD technical support. In return, WDOT agreed to reconstruct the township road and would receive credit for mitigating wetland losses; the township would perform any necessary maintenance to keep the road in operation. It seemed like the perfect solution to balance environmental restoration and human services.

The land purchase came off without a hitch. However, the work to maintain Berlin Road encountered many setbacks. Over a 2- to 3-year period, roadwork was completed only to see the road sink into the marsh. Planning and assistance through the WRP program also lagged behind while waiting for Berlin Road to stabilize. Several years passed without management of the farmland, and willows took over. By the time restoration plans could be constructed, trees were several feet tall and completely blanketed the fields. A willow burn was attempted, but to no avail. Several of the partnering groups insisted that standing water remain in the wetland, eliminating the possibility of pumping the water to perform more work (Kevin Connors, Dane County Land Conservation Department, verbal communication, 2004). The road had to be protected, which meant that the water level could not be raised to flood out the willow. Money became an issue and eventually work came to a halt. Today, the former mint farm stands as a monument to the persistence of the willow.

Economic disincentives for participation in conservation programs

Conservation programs offer economic incentives and protection of land-use rights to farmers, such as cost sharing and easements, in exchange for the development rights to marginally productive farmlands. These incentives are intended to entice landowners to enroll in various programs. However, even if farmers have marginally productive land, several key disincentives can offset standard incentives.

Use-value tax assessment

The current Wisconsin use-value tax structure serves as a disincentive for landowners to participate in several important Farm Bill conservation programs that focus on wetland restoration (Kevin Connors, Dane County Land Conservation Department, verbal communication, 2004). Agricultural lands restored to wetlands under the WRP, Partners for Wildlife program, and Wildlife Habitat Incentives Program (WHIP) are assessed as undeveloped lands under official use-value tax definitions. However, wetlands restored under the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Nonpoint Source Water Pollution Abatement Program, Environmental Quality Incentive Program (EQIP), and Water Bank Program are taxed as agricultural lands.

Although lands designated as undeveloped are assessed at 50 percent of fair market value (Wisconsin Department of Revenue, 2004), in many districts agricultural lands are taxed at a lower rate. For example, undeveloped lands in Dane County are taxed at approximately $12 per acre; agricultural lands are taxed at $3-$4 per acre (Kevin Connors, Dane County Land Conservation Department, verbal communication, 2004). In Columbia County the difference in the tax rate between undeveloped and agricultural lands can be more than $34 per acre (Erin O'Brien, Wisconsin Wetlands Association, verbal communication, 2004). Even with an assessment on undeveloped lands, taxes may still be greater for restored wetlands. If a landowner is trying to decide whether to participate in the WRP, the prospect of having to pay significantly higher taxes can act as a major disincentive—especially for larger sites.

Other disincentives for enrollment

Economic factors are the primary reason for farmers not to participate in the WRP or CRP (Lant et al., 1995). Even though some former wetlands tend to be marginally productive or profitable, removing land from production is a difficult decision for many farmers. Hydric soils can provide much-needed moisture to crops in a relatively dry year. Flexibility in the acreage available for farming can help make economic decisions easier. A study by the Soil and Water Conservation Society showed that farmers tended not to participate in the WRP because of economic concerns and the use of permanent easements (Despain, 1995).

Several additional disincentives also deter participation in conservation programs. A cumbersome application process and landowner distrust of the government can dissuade enrollment. Misunderstandings of how restoration will affect property taxes can occur. Insufficient time and money are allocated to the implementation of conservation programs (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004). As a result, restoration practitioners who are charged with implementing multiple Farm Bill programs may favor certain programs due to individual biases. The result of uneven application of management techniques may not be optimal or strategic (Steel, 2004).

Lack of data coordination and availability

With the large number of agencies and groups that take part in restoration projects, the coordination of strategies, tools, field data, and other information that could assist practitioners in the restoration process is difficult. A lack of coordination of data can be a problem due to difficulties in assessing the current and predicting the future conditions of Wisconsin's wetlands. For example, every agency that has a wetland-restoration program keeps a record of restored acreage. An acreage sum reported by each agency would result in an overestimation because many projects involve more than one agency and these projects would be counted more than once. This has been recognized and a more accurate compilation was attempted by the WDNR and NRCS, but did not reach completion (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004).

Data may not be readily available to practitioners and interested individuals. Some information may be easily accessible at no cost; other information may be difficult to locate and access or expensive to obtain, particularly detailed information. In many cases, information is offered at no charge to the general public for use by stipulating the intended use of the information. For example, Rhode Island's GIS Web site (http://www.edc.uri.edu/rigis/) allows access to some information from various agencies, including wetland data, at no charge; other information may be obtainable with payment of a fee. The Wisconsin Wetlands Inventory GIS data are available with the payment of $15 per Public Land Survey System Township (http://www.dnr.state.wi.us/org/water/fhp/wetlands/documents/digital.pdf).

Available information is not always complete or current. Updating wetland information in the state of Wisconsin is limited due to a lack of adequate funding and staffing. The WDNR is authorized by the state legislature to update the Wisconsin Wetlands Inventory every ten years. However, the state estimates that the WDNR has the resources to do so only every 24 years (WDNR, 2004a). A statewide qualitative and quantitative assessment of Wisconsin's wetlands is not possible within the current structure.

Case study area

The Rock River Basin in Wisconsin is a 3,777 square mile watershed, which is divided into the Upper Rock River Basin and the Lower Rock River Basin. The town of Fort Atkinson, Wisconsin, serves as the outlet point distinguishing the Upper Rock River Basin from the Lower Rock River Basin watersheds. The Rock River Basin is a headwater tributary to the Mississippi River, extending from southeast and south-central Wisconsin into northern Illinois.

The Upper Rock River Basin comprises an area of approximately 1,890 square miles in the eastern ridges and lowlands of south-central Wisconsin (fig. 1) (Martin, 1932; Johnson, 2002). The basin encompasses the headwaters of the Rock River as well as 76 miles of the main channel, which begins in Horicon Marsh at the confluence of the East, South, and West Rock River branches (Johnson, 2002).

The Upper Rock River Basin is in the region of the state that was significantly shaped by the Wisconsin Glaciation more than 10,000 years ago. Some of the unique glacial features in the basin include kettles, moraines, and most notably, large drumlin fields, which cover much of the basin. Drumlins are small, elongated hills of glacial till that run parallel to the direction of glacial retreat (Cox, 1979). They may be as long as 2 km and reach heights greater than 50 m and widths of 500 m (National Snow and Ice Data Center, n.d.).

Oak savannahs, deciduous forests, wetlands, and prairie were the historically dominant ecosystems of the Upper Rock River Basin. The extent of hydric soils in the basin, as determined from GIS analysis, suggests that nearly 40 percent of the land area once supported wetland ecosystems. However, today only 16 percent of the total land area is classified as wetland, indicating a 60 percent loss of wetland area.

Current land use in the Upper Rock River Basin is dominated by agriculture (fig. 3). The basin is one of the most agriculturally productive areas in Wisconsin; dairy and cash crops are the main agricultural commodities (University

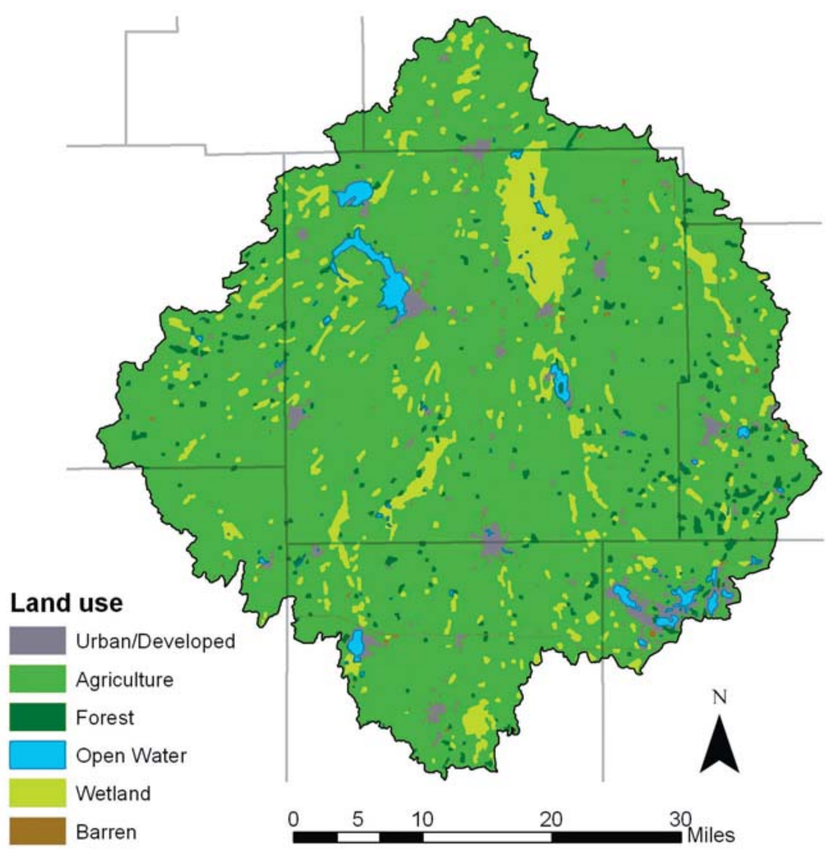

Figure 3. *Current land use of the Upper Rock River Basin.*

of Wisconsin–Extension, n.d.). As of 2002, 41 percent of the farms in the Upper Rock River Basin have switched to conservation tillage practices; the other 59 percent still use conventional plowing techniques (Johnson, 2002), which disturb more of the soil profile and reduce ground cover, leaving more farmland susceptible to erosion.

Within the basin, land that has traditionally been agricultural is being used for commercial operations, cash cropping, and urban development. Small, individual dairy operations are being converted to larger, more commercial operations; the types of crops grown are changing from feed crops, such as alfalfa, to cash crops, such as corn and soybeans, which leave the soil more susceptible to erosion; and productive agricultural land is being used for commercial and residential development (Johnson, 2002; Nancy Paul-Drummy, University of Wisconsin–Extension, verbal communication, 2004).

The Upper Rock River Basin has been the focus of many studies conducted by the University of Wisconsin and many other agencies. The interest in the basin can be linked to the presence of many important wetland resources within the basin, including Horicon Marsh. Horicon Marsh is the largest wetland complex in the Upper Rock River Basin and is a national wildlife refuge and a state wildlife area. This wetland complex is designated as a "Wetland of International Importance" and a "Globally Important Bird Area" and was internationally recognized by the Ramsar Convention in 1990 (Moser et al., 1998). In addition, the wetland provides nesting and migration habitat for 268 species of birds, including many common wetland and upland birds and some of Wisconsin's rarest birds (Wisconsin Department of Natural Resources, 2004b). Some of the interest in studying the Upper Rock River Basin can also be attributed to water-quality concerns and the Rock River's contribution of nitrate to the Gulf of Mexico, which has been identified as a cause of salt-water hypoxia leading to the "Dead Zone" at the mouth of the Mississippi River (Turner et al., 1994; Zedler, 2003).

Methods for strategy development

We incorporated a watershed approach into the development of our strategy for prioritizing wetland restorations to optimize the three main wetland services to the watershed. Because we were tasked with developing a strategy for a dynamic system, our process was not linear, but rather an adaptive process and was often redirected as new information was gathered and presented.

We began by assembling all available data for the Upper Rock River Basin. This included a variety of GIS data such as watershed and watershed boundaries for the Upper Rock River Basin, soils, roads, orthophotographs of all counties within the Basin, state and federal public lands, a digital elevation model, impaired water bodies, hydrography, and the Wisconsin Wetlands Inventory (see Appendix 2 for a complete list of GIS layers and their sources). This digital database provided a means of visualizing the physical characteristics of the basin and allowed us to extrapolate information such as the extent of hydric soils and existing wetland complexes within the basin. By overlaying these datasets, we were able to determine roughly the extent of potentially restorable wetlands within the Upper Rock River Basin. These areas were defined as regions of hydric soil that are not currently mapped as wetland. Only locations within these areas were considered as potential sites for wetland restoration because we assumed these areas historically supported wetland ecosystems.

We also reviewed other data sources, including the Upper Rock River State of the Basin Report (Johnson, 2002) as well as individual watershed reports compiled by the Wisconsin Department of Natural Resources (2002). These reports provided insight into a variety of characteristics and trends in the basin and included information about wetland resources, endangered and threatened species, and issues affecting water quality. Another valuable report was created by Earth Tech, Inc. (2000), which summarized the results of intense water-quality modeling that provided important information about sediment and nutrient loading from smaller watersheds within the entire Rock River Basin in Wisconsin. That report allowed us to determine the major sediment and nutrient sources within the Upper Rock River Basin. Other studies done in conjunction with the University of Wisconsin–Madison were available, including quantification of the extent of reed canary grass coverage in wetlands within the Upper Rock River Basin and surrounding area (Bernthal and Willis, 2004), a summary of the impact of the WRP on wetland restorations in Wisconsin (Steel, 2004), and an evaluation of stream water quality in the Rock River Basin (Potter et al., 2000).

After we began to develop a general understanding of the key characteristics of the Upper Rock River Basin, we realized that the issue of scale needed to be addressed. Originally, the entire basin was to be considered for the development of a wetland-restoration strategy. However, we determined that the basin as a whole was too expansive to evaluate the watershed effectively without overgeneralizing the system. Therefore, we chose two watersheds, the East Branch Rock River and the Maunesha River (table 1), to develop a restoration strategy that could be extended to the entire basin.

Table 1. *Summary of physcial characteristics of the Upper Rock River Basin, the Maunesha River watershed, and the East Branch Rock River watershed*

Watershed	Total area[1] (acres)	Hydric soil area[2] (%)	Wetland area[1] (%)	Number of threatened/ endangered species[3]	303(d) Impaired waters list[4]		Public lands[5]	
					Rivers and streams (miles)	Water bodies (acres)	State (acres)	Federal (acres)
Upper Rock River	1,212,723	41	16	131	245	35,048	43,536	21,860
Maunesha River	80,608	37	12	22	32	—	4,271	—
East Branch of the Rock River	114,820	34	14	25	30	—	7,108	—

Sources: [1] WDNR Wisconsin Wetlands Inventory, [2] WDNR Digital Soils Data, [3] WDNR Natural Heritage Inventory (n.d.), [4] WDNR Digital Impaired Waters Data, [5] WDNR Digital Public Lands Data (See Appendix 2 for more information about data sources.)

We further investigated the representative watersheds and visited our case study watersheds to confirm visually the GIS information on hydric soils as well as familiarize ourselves with the condition of existing wetlands.

As a result of our interviews with basin resource agents, we became familiar with the role of existing wetland-restoration programs in the area and gained insight to the implementation and funding of these programs. Basin resource agents also presented the goals for each of the programs and suggested current challenges to restoration and areas where more information could improve future wetland restorations. Additionally, they provided insight to not only the biophysical needs, but also the social desires of the basin communities with regards to wetland resources.

Field investigations gave us a better understanding of the needs and challenges being faced within the basin. Field trips with various resource agents allowed us to view the results of previous wetland restorations. These trips allowed us to see the geographic distribution of restoration sites from current restoration programs. We were also able to assess visually current land use, hydrologic connectivity, and non-native species in existing wetlands within the basin.

Synthesizing the geospatial information, past studies and reports on the basin, interviews with local resource agents, and observations made during field trips within the basin, allowed us to determine some of the key biophysical needs within the Upper Rock River Basin. We also gained insight into the social issues affecting wetland resources. This knowledge helped us formulate an overall restoration goal for the basin. Our strategy to prioritize wetland restorations within the basin was developed with several key objectives to help attain this goal.

Biophysical observations

Looking at the available data, we made several key observations regarding the biophysical characteristics of the Upper Rock River Basin.

1. Many existing and potentially restorable wetlands within the East Branch Rock and Maunesha River watersheds fall into two geomorphic categories: inter-drumlin and former lakebed wetlands.

Broad wetland types within the glacial landscape most likely included palustrine, lacustrine, and riverine wetlands, as classified by the USFWS classification system (Cowardin et al., 1979). To define more precisely the wetland characteristics within the Upper Rock River Basin, we established our own wetland types, consisting of what we have termed "inter-drumlin" wetlands and "former lakebed" wetlands. We based these wetland terms on a wetland's genesis by considering the basic geomorphic processes that resulted in their unique landscape position.

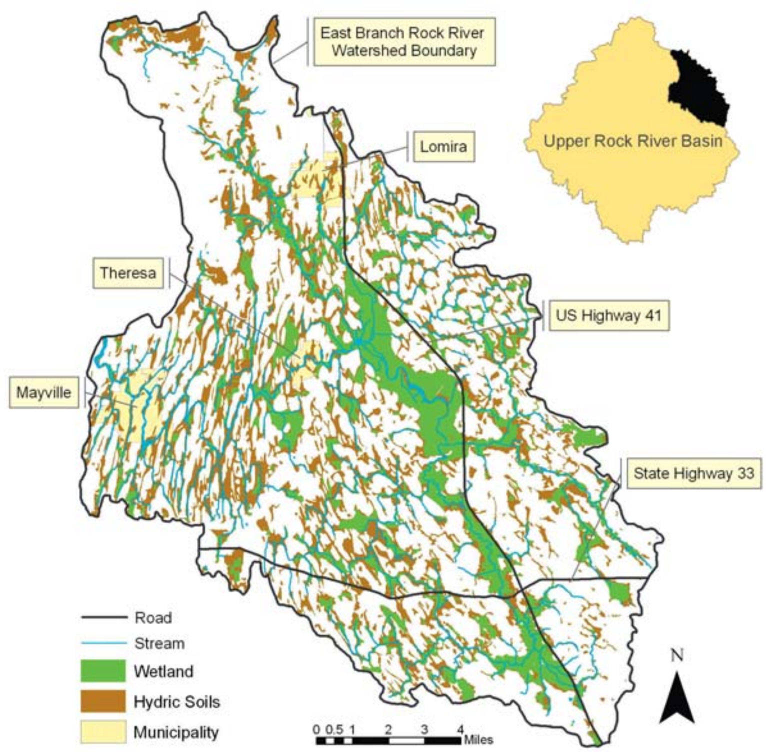

Figure 4. *Comparison of hydric soils and existing wetlands in the East Branch Rock River watershed. Inter-drumlin wetlands are especially apparent in the western half of the watershed and are seen throughout the Upper Rock River Basin.*

The areas between drumlins typically consist of hydric soils resulting from glacial sediment deposits and organic soil accumulation as water flowed through these valleys as glaciers receded and released sediment-laden water. These inter-drumlin wetlands form a connected network of hydric soils, displaying the pathways of historic water flow. Many of these areas contain rivers, streams, and artificial drainageways. These inter-drumlin wetland networks, as seen in figure 4, dominate the East Branch Rock River and Maunesha River watersheds.

Where several of these inter-drumlin wetlands meet, pockets of hydric soils may have been deposited as a result of larger lake systems that slowly drained and naturally converted to former lakebed wetlands. Due to the size of these large wetland complexes, it was often difficult to drain them successfully for agricultural production and they remain a unique resource in Wisconsin's glaciated landscape. An example of a former lakebed wetland is Horicon Marsh.

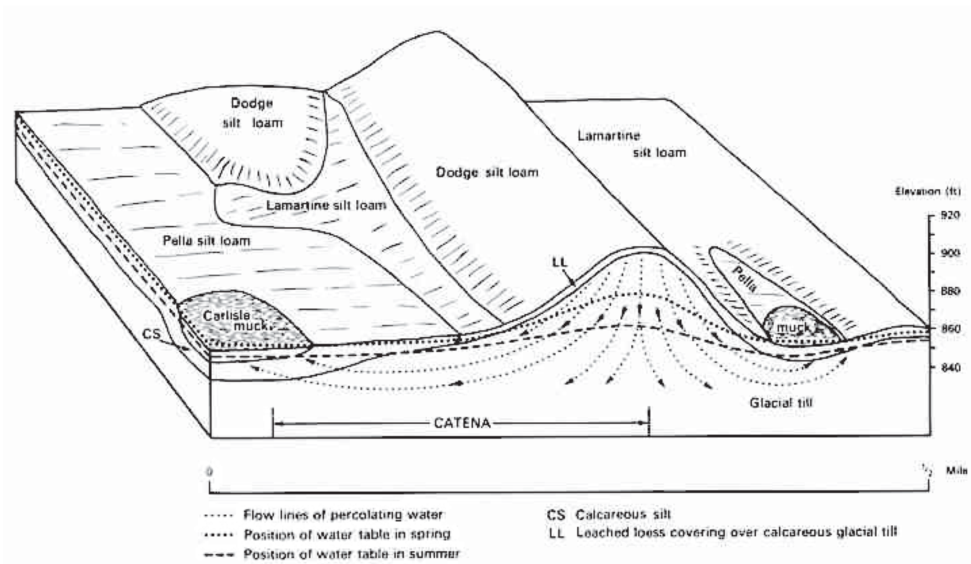

Figure 5. *Cross section of drumlin and flow paths discharging to create inter-drumlin wetlands (Hole, 1976).*

Many riparian wetlands within the Upper Rock River Basin can be considered inter-drumlin wetlands due to the correlation between drumlin valleys and natural water flow paths. Former lakebed wetlands can also encompass riparian wetlands that were once glacial lakebeds as well as lacustrine fringe wetlands. In addition, what appears in some cases to be riparian wetlands may in fact be the result of ditching that creates artificial stream systems that can be interpreted as natural streams when using GIS analysis alone. However, a GIS analysis was useful in determining that some commonly restored wetland types within the basin were most likely not historically present within the East Branch Rock River and Maunesha River watersheds, leading to our second conclusion:

2. Very few areas of unconnected hydric soils exist in these two watersheds.

The pattern of hydric soils within the East Branch Rock River and Maunesha River watersheds indicates that most hydric soil regions are currently interconnected. Hydric soil patterns generally form continuous chains of wetland soil or are linked by natural waterways. This is mostly due to the Wisconsin Glaciation, which carved long, narrow drumlin fields into the landscape, created small lakes by temporarily blocking drainage ways, and connected these areas with drainage flow paths. A cross section of a drumlin and associated flow paths and wetlands can be seen in figure 5.

In addition, glacial maps of the Upper Rock River Basin display a continuum of inter-drumlin aerial wetland characteristics that follow the path of glacial retreat. Along moraines and the extreme edges of the glacier's course, inter-drumlin wetlands are typically shorter and smaller in area. They also may have historically contained fewer natural water outlets than their northern counterparts and as a result underwent more extensive ditching (Quentin Carpenter, University of

Wisconsin–Madison, verbal communication, 2004). This suggests that isolated wetlands may have existed in these regions for part of the year. However, it is our general conclusion that these semi-isolated wetlands represent a very small part of the watershed and their restoration is not a priority.

3. Many wetlands (restored and not restored) in the East Branch Rock River and Maunesha River watersheds have weak hydrologic connections.

Historically, the streams of the Upper Rock River Basin received much of their flow directly from precipitation and groundwater discharge, with very little contribution from surface runoff (K.W. Potter, University of Wisconsin–Madison, verbal communication, 2004). Water most likely flowed through the wetland complexes through a series of shallow, interconnected lakes and meandering streams that did not have well defined channel cross sections. Since then, many of the wetland systems in the Upper Rock River Basin have been altered by human activity and land-use change, either directly, by stream channelization, channel incision, tile drainage, or drainage ditches or indirectly by sediment accumulation. This is true of systems that have been converted to farmland as well as wetland restorations that have not filled ditches or eliminated recent sediment deposits that now form a more defined stream channel. These practices result in a former wetland receiving more flow from overland runoff and not from the distribution of precipitation and groundwater over its surface. In addition, the effect of ditches, channelization, and tile drainage is rapid transport of any water that comes into contact with the wetland downstream, reducing retention time in the wetland area. These factors alter the natural hydrologic regime by short-circuiting water through the wetland.

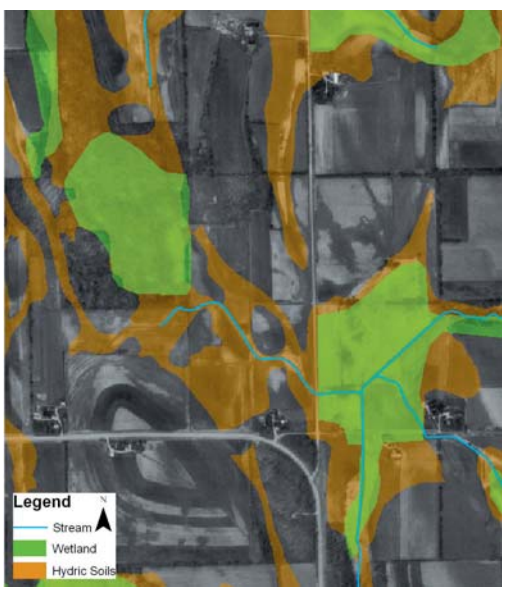

Figure 6. *Poor inter-wetland connectivity. Hydric soils that are no longer wetland connect the wetland complex on the left to the complex on the right. Restoration of those hydric soils could improve the hydrologic connectivity between the complexes as well as create a wildlife/habitat corridor.*

Wetland connectivity is a necessary component for providing biodiversity enhancement, water-quality improvement, and hydrologic support (Mitsch and Gosselink, 2000). For this report, wetland hydrologic connectivity is defined in two ways—relating either to inter-wetland or intra-wetland hydrologic connections. Hydrologic connectivity is viewed as a positive aspect of a wetland and refers to having intact natural flow paths that increase the residence time of water throughout a wetland. Good hydrologic connectivity increases the contact area of water interacting on the land surface.

Inter-wetland hydrologic connectivity refers to the extent that wetland systems are linked to adjacent wetland systems, considering the historical degree of connectivity. Examining wetland maps and performing field reconnaissance to determine if one wetland area is part of a larger wetland

Figure 7. *Dorn Creek Marsh, in Dane County, Wisconsin, an example of a wetland that has good intra-wetland hydrologic connectivity. Note how the channel of the meandering stream on the left disappears in the wetland. This lets water come into direct contact with the wetland, allowing for sedimentation and nutrient processing, which can improve water quality, as well as providing opportunity to store and delay water. (Photograph, July 7, 2004.)*

complex are ways to evaluate such connectivity (fig. 6). Human influences on land use and property-boundary restrictions are possible causes of inter-wetland disconnection, which can negatively impact nutrient flow through a wetland system, reduce a wetland's ability to store and recharge water, and eliminate wetland habitat (DeBusk, 1999; Mitsch and Gosselink, 2000; Richardson, 1994).

Intra-wetland hydrologic connectivity is more specific to an individual wetland and involves determining the hydrologic connection that the wetland has to its water sources (fig. 7). The presence of deep drainage ditches is an indication that a wetland is poorly connected; water inflow (by rainfall, groundwater seeps, and overland flow) is quickly routed to surface drainage systems. Tile drainage can have a similar affect on subsurface flow. Streams that are poorly connected to riparian wetlands will inundate their adjacent wetland floodplain less often (less than once every 1 to 2 years), thus bypassing the water-quality treatment services as well as the hydrologic support benefits provided by the riparian wetland. This negatively affects the organisms that rely on flooding as part of their life cycle. In addition, a poorly connected wetland will be inundated with stream water only in large storm events, reducing its ability to store water and sustain base flow during low flow conditions.

Figure 8. *The straightened Maunesha River (seen as the diagonal line of trees in the photograph) through Deansville Wildlife Area. Historic stream meanders can be seen on the left side of the existing channel. Water flowing down the channelized Maunesha River rarely comes in contact with its floodplain and the surrounding wetland is thus hydrologically disconnected from the adjacent area. (Photograph, June 26, 2004.)*

Deansville Wildlife Area in Dane County is an example of a large wetland complex that is poorly connected to the Maunesha River, which flows through it. Within this system, the Maunesha River has been straightened and channelized, and many ditches drain surrounding farmlands within the complex (fig. 8). As a result, the river rarely comes in contact with its floodplain.

4. Several large wetland complexes have been identified as important wetland resources within their communities.

As previously mentioned, the glacial landscape of the Upper Rock River Basin supports large wetland complexes. Several of these existing wetlands and wetland complexes have been identified and protected by the WDNR and the federal government as important wildlife habitat within and downstream of the East Branch Rock River and Maunesha River watersheds (fig. 9). Among these are Horicon Marsh, Allenton Wildlife Area, Theresa Marsh Wildlife Area, Deansville Marsh, Waterloo Wildlife Area, and Mud Lake State Wildlife Area. Much time and money have been invested in the protection and enhancement of these wetland complexes.

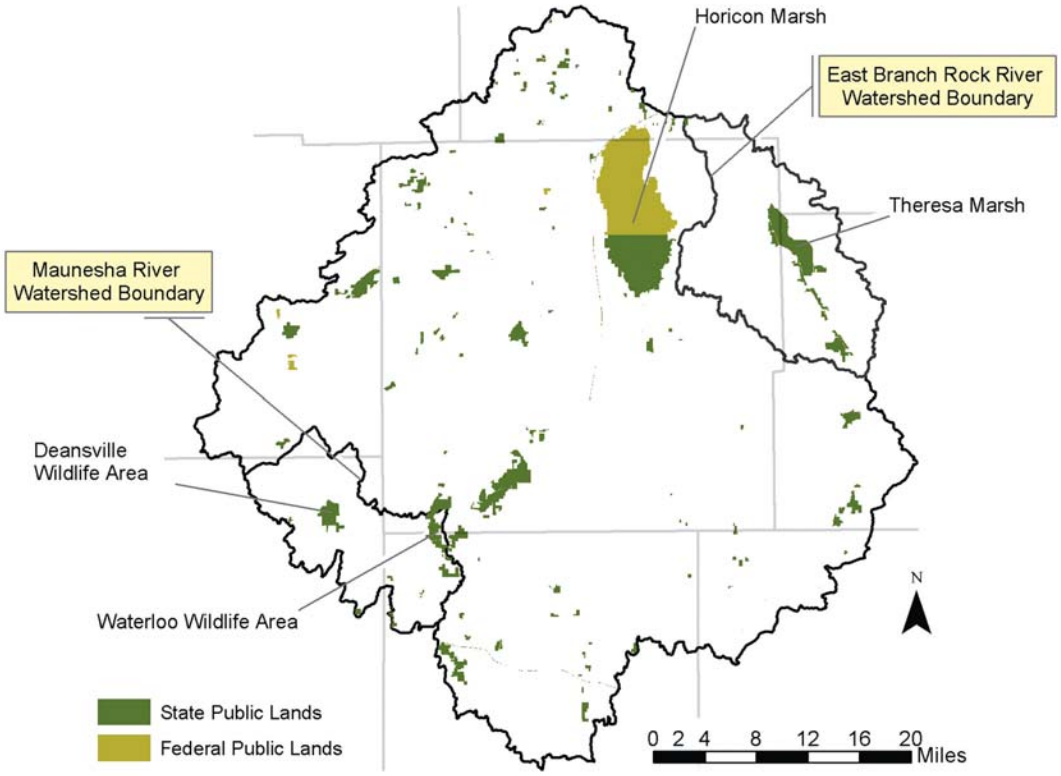

Figure 9. *State and federal lands in the Upper Rock River Basin.*

5. Water quality has been degraded in the Upper Rock River Basin, and water-quality improvement is a high priority to basin managers.

Runoff containing excess sediment and nutrients from agricultural lands is the major pollutant source in the basin; however, runoff from developing areas is gaining importance (Johnson, 2002). The Upper Rock River Basin is experiencing increased population growth as the largely rural landscape slowly converts to suburban development. Increased development typically means less pervious area, more stormwater runoff, decreased infiltration and groundwater recharge, and increased soil erosion and sedimentation from construction sites.

The natural topography of the region can contribute to sediment and nutrient loading. In both study watersheds, drumlins are prominent features in the landscape. Compared to other landscape features within the watersheds, drumlin slopes are relatively steep, and when farmed, are susceptible to soil erosion.

Modeling of phosphorus and sediment loading in the Rock River Basin indicated that the East Branch Rock River watershed contributes 12,591 tons of sediment and 102,008 lbs of phosphorus annually; the Maunesha River adds 8,658 tons of sediment and 62,987 lbs of phosphorus to the Rock River system (fig. 10) (Earth Tech, Inc., 2000). These two sources account for 33 percent of the sediment and 20 percent of the phosphorus loads within the entire watershed.

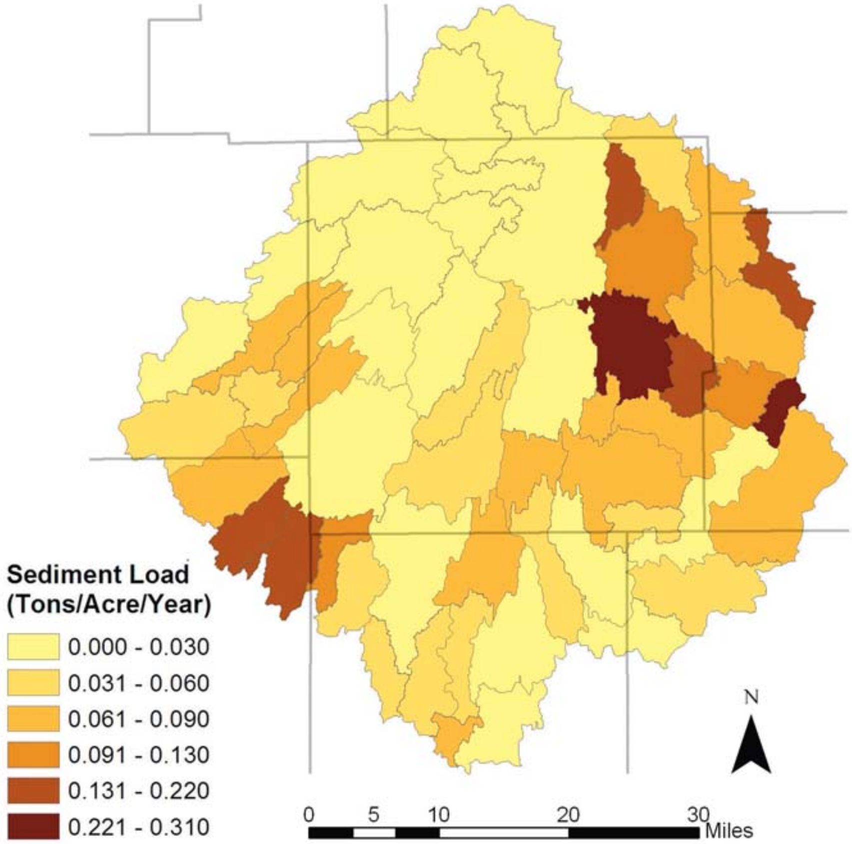

Figure 10. *Sediment loading from the Upper Rock River Basin, as determined by modeling done by Earth Tech, Inc. (2000).*

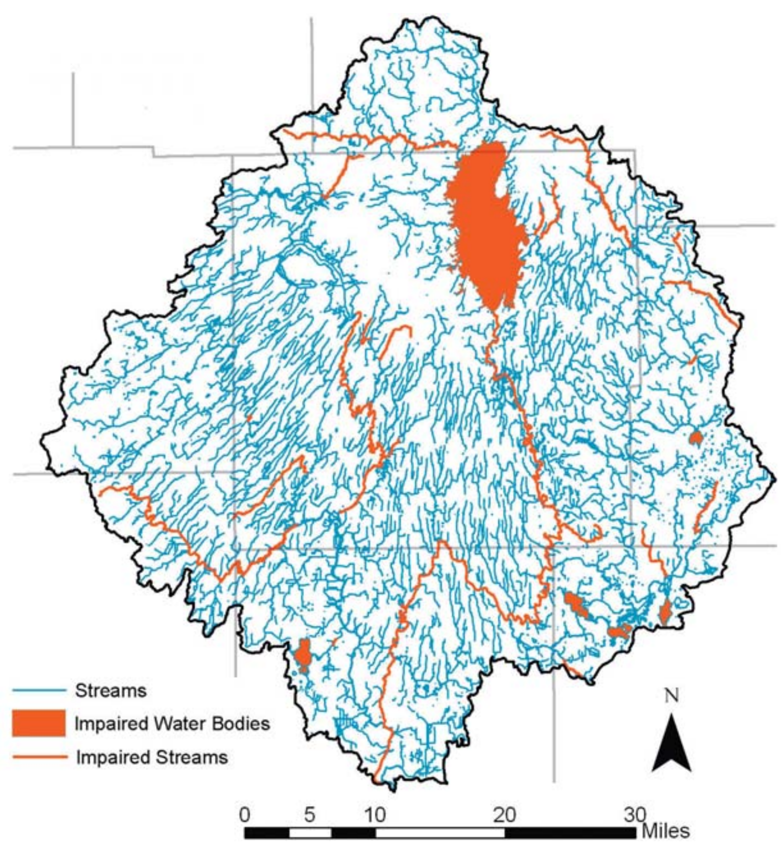

Figure 11. *Impaired water bodies and streams of the Upper Rock River Basin.*

Of the 1,346.7 miles of waterways in the Upper Rock River Basin, nearly 250 miles (18.6%) of rivers and streams are on the U.S. Environmental Protection Agency 303(d) list, which identifies significantly impaired rivers, streams, and water bodies and the causes of degradation (fig. 11). These water bodies include Kummel Creek, Kohlsville River, and sections of Wayne Creek and Limestone Creek. Although the East Branch Rock River is classified as a Class 2 trout stream in its upper reaches, downstream it becomes a major source of sediment and nutrients draining into Horicon Marsh.

Basin managers have identified poor water quality as a major impediment to wetland restoration in the Upper Rock River Basin. Most outreach efforts concentrate on educating landowners about nonpoint source pollution, installing conservation practices, and utilizing nutrient management. The most useful tool for resource agents in the Upper Rock River Basin would be a set of guidelines for selecting conservation projects based on their ability to improve water quality (Nancy Paul-Drummy, University of Wisconsin–Extension, verbal communication, 2004).

6. Existing wetland systems are being degraded by poor water quality.

As the result of land-use and management practices within the watersheds, excessive sediment and nutrient loading is degrading the ability of existing wetlands to serve as diverse biological habitats. Elevated nutrient levels can lead to eutrophication, which alters the vegetative composition and decreases dissolved oxygen levels, thus adversely affecting aquatic life (Cwikiel, 1997). Sediment trapping plays an important role in protecting downstream water quality, but is extremely undesirable in wetlands that are highly valued for habitat and biodiversity.

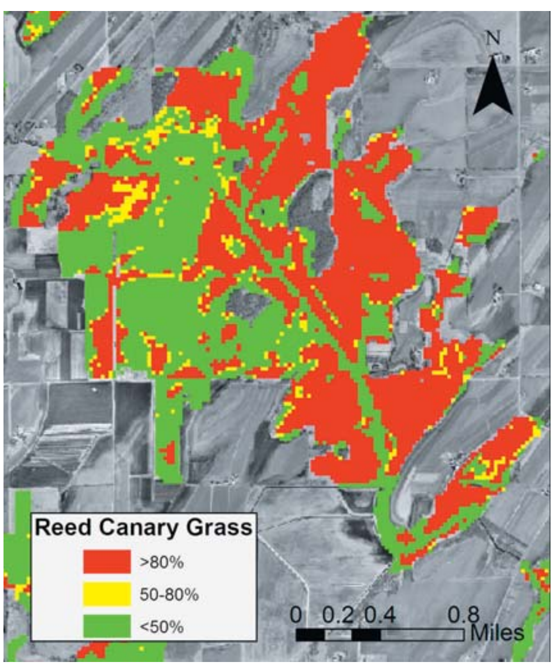

Figure 12. *Reed canary grass coverage in Deansville Wildlife Area (Bernthal and Willis, 2004).*

Areas such as Horicon Marsh, once recognized for its quality and abundance of habitat, have now become nutrient and sediment sinks dominated by monotypic and invasive species such as reed canary grass *(Phalaris arundinacea)* and cattails *(Typha* spp.) (James Congdon, Wisconsin Department of Natural Resources, verbal communication, 2004). These species weaken the wetland's ability to provide diverse habitat to fauna and can out-compete native fauna. Since 1994, the USFWS has been managing water levels in Horicon Marsh in an attempt to prevent a monoculture of non-native cattails. Other wetland complexes, such as Deansville Marsh, are dominated by monotypic stands of reed canary grass as shown in figure 12.

7. Flood attenuation is not a significant motivation for wetland restoration in the East Branch Rock River and Maunesha River watersheds.

Wetlands perform several hydrologic functions that potentially benefit humans and ecosystems, including attenuation of flood flows, maintenance of low flows, and recharge of groundwater. However, the flood-storage benefits of wetland restoration in the Upper Rock River Basin watershed are likely to be much smaller than the water-quality and habitat benefits. Flooding is not a major economic issue in the watershed (Donna Haugom, Jefferson County Emergency Management, written communication, April 15, 2004). Chronic flood problems are limited to agricultural fields on drained wetlands and isolated floodplain sites in small population centers. The "health" of streams in the watershed is much more limited by excessive sediment and nutrients than by persistent low flow. Because most of the restorable wetlands are in stream valleys where the water table is high, restoration is not likely to have much effect on groundwater recharge. Therefore, we have not targeted hydrologic functions as a restoration objective.

Protecting and enhancing the watershed resources of the Upper Rock River Basin

The overall restoration goal we identified for the Upper Rock River Basin includes the protection and enhancement of important watershed resources. Within the basin, several large wetland remnants support (or have the potential to support) a diversity of plants and animals, but these areas are experiencing diversity loss due to eutrophication and/or contaminants. To restore basin areas properly, the quality of water entering the systems must be improved to limit phosphorus and sediment accumulation in the marsh areas.

After consulting with various federal, state, and local entities as well as community members, we selected the following wetland complexes as important watershed resources for the East Branch Rock River and Maunesha River watersheds: Horicon Marsh, Theresa Marsh, Deansville Marsh, and Waterloo Wildlife Area (refer to fig. 9 for the locations of these wetland complexes).

To attain our restoration goal, we developed three restoration objectives with the needs of the East Branch Rock River and Maunesha River watersheds in mind. These objectives provide the framework of our restoration strategy:

- Improve water quality upstream of important watershed resources
- Restore hydrologic connectivity within existing wetland complexes
- Expand the area of existing wetland complexes to their historical limits

Our strategy can be used to implement these wetland-restoration objectives and to serve as a guideline for selecting potential wetland-restoration sites. This strategy identifies wetland complexes within the watershed that will best function to provide wetland services, provides recommendations for prioritizing potential locations for restoration projects, and suggests conservation and wetland-restoration practices that could be implemented.

Restoration objective 1. Improve water quality upstream of important watershed resources

We have identified poor water quality as the main cause of degradation to the systems. Therefore, the first issue that must be addressed is the quality of the water entering those wetlands. We recommend the following guidelines for prioritizing wetland restorations within the Upper Rock River Basin to function as water-improvement wetlands.

Identify point and nonpoint pollution sources upstream of the resource

The WDNR Upper Rock River Management Plans (2002) lists seven known and permitted point sources for the East Branch Rock River watershed and six permitted point sources for the Maunesha River watershed. The WDNR enforcement of Clean Water Act regulations is a critical first step in ensuring pollution point sources meet state discharge requirements. Ensuring that point sources meet national discharge standards is an essential step to improving water quality, but wetland restoration may not be an effective method of reducing point source pollution.

While resolving point sources, attention should also be given to targeting specific areas of high pollution nonpoint source loading. Earth Tech, Inc. (2000) completed hydrologic nonpoint source modeling for the entire Rock River Basin, using the soil and water assessment tool (SWAT) model (Neitsch et al., 2002). This modeling calculated the load of phosphorus (in pounds and pounds/acre) and sediment (in tons and tons/acre) transported by surface runoff on an annual basis for individual watersheds. Watersheds with the highest sediment and/or phosphorus loads as determined by this, or a comparably reliable modeling analysis, should be the focus of water-quality improvement through wetland restoration and conservation practices.

The WDNR has compiled a list of impaired waters under Section 303(d) of the Clean Water Act, and modeling can be used to identify sources of degradation and plan for pollution reduction. We recommend that watersheds identified as significant contributing areas—that is, landscape areas or features that have been identified as sources of water pollution (nitrate, phosphorous, sediment, or other constituents) that exceed locally established thresholds—through hydrologic modeling and the 303(d) list be given priority for wetland-restoration projects to improve water quality.

Address project sites within significant contributing areas

Individual site ranking

The hydrologic modeling performed by Earth Tech, Inc. (2000) produced watersheds in the Upper Rock River watershed ranging from 2 to 113 square miles in area. From this watershed modeling, "significant contributing areas" (watersheds that have relatively high nutrient and sediment loading) can be identified and individual restoration sites selected. In selecting which sites to restore first, it is desirable to target areas that will provide the greatest benefit given the available restoration resources. We suggest a method primarily based on the ratio of wetland area to drainage area, while considering the rate of soil erosion from the contributing area and a corresponding sediment-trapping efficiency. Our method also makes headwater restoration a priority in areas where high nutrient and sediment loading exist. Some studies (Alexander et al., 2000; Peterson et al., 2001; Seitzinger et al., 2002) showed that headwater areas are most critical for water-quality improvement. See Appendix 3 for a sample-ranking sheet of individual wetland sites.

Practices

Conservation practices. The next step in improving water quality upstream of important watershed resources is installing conservation practices and implementing restoration. Wetland restoration should be used as a water-quality improvement tool only after addressing source problems such as nutrient management and excessive soil

Figure 13. *Jefferson County, Wisconsin, a wetland-restoration site designed, constructed, and managed by the Madison Audubon Society. Dave Musolf is seen in the foreground. (Photograph, April 22, 2004.)*

erosion. Conservationists embody this concept in the motto: "Keep the soil in its place and the water where it lands" (Kevin Connors, Dane County Land Conservation Department, verbal communication, 2004). Using conservation practices such as contour farming, strip cropping, and conservation tillage is encouraged as part of an approved conservation plan for agricultural lands.

If agricultural land in significant contributing areas is being taken out of production to create vegetated upland buffers, wetland restoration could be used without implementing additional conservation practices. In cases where wetland restoration for water-quality improvement is considered feasible and beneficial, the ideal situation would be to restore all hydric soils on the site to the historic wetland community or wetland system that they can best support. After deciding upon wetland restoration as a water-treatment tool for an individual site, we suggest the following wetland-restoration techniques for appropriate areas within the Upper Rock River Basin.

Extensive biologic/hydrologic restoration. Striving for complete biologic and hydrologic restoration of a wetland site would be the most desirable option for most potential sites. Currently, extensive biologic restoration is more common than hydrologic restoration, most likely because of the complexities inherent in restoring the original hydrologic conditions of a site. Hydrologic restoration can include methods such as ditch filling, tile drain removal, and channel reconstruction (see Thompson and Luthin, 2004, for a thorough guide on wetland-restoration methods). However, it is very difficult to determine accurately a wetland's historic hydrologic connections, and hydrologic restoration is far from being a perfected science. Biologic restoration can include aspects of hydrologic restoration, but focuses more on restoring the vegetative habitat of a wetland complex. Restoration methods can include preparation techniques of tillage, herbicide application, and burning, and planting techniques involving dispersal of native seeds or starter plants. Adaptive management of the site is also desirable, and planning can be quite intensive. For example, a recent Madison Audubon restoration in Jefferson County, Wisconsin (fig. 13), required more than 2,000 hours of volunteer time with five seed mixes and multiple habitat

Figure 14. *Maunesha River riparian areas flooded in the early summer of 2004. These floodplain areas would be classified as riparian wetlands for restoration. (Photograph taken downstream of the town of Waterloo, June 26, 2004.)*

Figure 15. *Drain tile outlet discharging to a ditch or stream (Photograph from National Soil Tilth Laboratory, 2004).*

zones, including open water, wet mesic, mesic, and dry mesic (David Musolf, Madison Audubon Society, verbal communication, 2004).

This option strives to create the highest quality and most functional wetland by restoring hydrologic connections and native plant species, but may require extensive time and financial resources. In addition, site constraints may prevent the restoration of all hydric soils on an individual property, in which case we suggest consideration of the wetland-restoration practices described below.

Riparian wetland buffers. Construction of riparian wetland buffers could help prevent sediment and nutrients generated on agricultural fields from entering the water system and being transported downstream, and would be most effective when used in conjunction with other best management and conservation practices (National Association of Conservation Districts, 2003). Therefore, in the absence of complete restoration of hydric soils, riparian wetland buffers (areas adjacent to streams that are occasionally inundated) may be the most beneficial use of restoration resources (fig. 14). These buffers would be especially important in headwater areas of the Upper Rock River Basin, where runoff volumes are greater due to the relief of the area. Construction of riparian wetland buffers would involve removing drainage through the wetland and promoting sheet flow of water that contributes to the wetland.

Wetlands at the base of drumlin slopes. By restoring wetlands at the base of the slopes, runoff from drumlins could be intercepted and directed around agricultural land at the base of the slope, trapping nutrients and sediment from upslope while reducing soil erosion within the fields below. Grassed waterways are currently used as a conservation practice to reduce sediment loading from drumlin slopes by creating a channel parallel to the length of the drumlin that quickly transports surface water (Kevin Connors, Dane County Land Conservation Department, verbal communication, 2004). This alternative involves replacing grassed waterways with low-lying wetland areas to promote sheet flow, provide water storage and recharge, and enhance denitrification. The restoration of wetlands at the base of drumlin slopes may also provide wildlife corridors with greater species diversity and abundance than grassed waterways. This practice is specific to landscapes characterized by drumlins.

Constructed wetlands at the end of tile drains. To make the land arable, much of the farmland within the Upper Rock River Basin has been tiled for drainage. These tile systems are not only effective at moving water from farm fields but are also responsible for carrying nutrients, particularly nitrate, to downstream resources (fig. 15). To improve water quality, small wetlands can be constructed at the outlet of active tile drain systems or along the ditches to which these systems drain. Creating these small wetlands and intercepting tile drainage may reduce nitrate concentrations via denitrification (Kadlec, 1994; Woltemade, 2000).

Restoration objective 2. Restore hydrologic connectivity in existing wetland complexes

Many of the systems in the Upper Rock River Basin have been altered by human activity, either directly or indirectly, most commonly by stream channelization, incision of channels, ditching within the system, accumulation of sediments, and intersection by transportation and power corridors. We recommend restoration of hydrologic connectivity in existing wetlands to provide wetland services of water-quality improvement, biodiversity, and hydrologic support.

In the case of the Upper Rock River wetlands, some recommendations for hydrologic restoration include the elimination of ditches within the system, the removal of spoil banks created during the channelization process, restoration of the original stream channel, the removal of accumulated sediment along the stream banks, and the lowering of the lands adjacent to incised waterways to increase the frequency of contact between the water and its floodplain. Improving hydrologic connections where roads and other features (such as railways and power lines) are present may not always be possible. However, when looking at restoration sites, avoiding such features would be optimal.

Water-quality improvement

Wetland disconnection limits the potential for nutrient processing and sedimentation that can occur in a wetland. If wetland hydrologic connectivity is restored and the incoming water is of poor quality, this wetland restoration must be viewed as creating a treatment wetland. In this case, a strategy similar to the one described in Restoration Objective 1 can then be used to determine if an existing disconnected wetland should be restored. Additional considerations should include estimates of the biologic integrity of the existing site and consideration of the effect that incoming water will have on the site.

Biodiversity enhancement

Restoration sites should be selected on the basis of the anticipated ecological value that an individual wetland would possess. Although restoring hydrologic connectivity in some wetlands may degrade the resource, attempting to re-establish the natural inundation regime could further enhance wetland systems that have relatively good source water quality. Flooding of hydrologically connected riparian wetlands can input nutrients that are essential for plant growth. These nutrients can also act as important biological indicators for fish that utilize riparian wetlands for spawning and rearing habitat (Mitsch and Gosselink, 2000; Junk et al., 1989). Wetlands next to an existing wetland with high biodiversity should be given priority, as is discussed in Restoration Objective 3.

Hydrologic support

Wetlands have been promoted for years as a means of providing hydrologic support functions such as base-flow augmentation, groundwater recharge, water supply, and flood protection (Ogawa and Male, 1983). Potter (1994) stated that for flood protection, storage is the most important mechanism to consider. Short-term storage can delay and reduce flood peaks; long-term storage reduces flood volumes. In addition, increasing wetland storage has the potential to pond water and increase evapotranspiration losses (Potter, 1994). However, when a wetland has been hydrologically disconnected from its tributary stream, these potential hydrologic functions do not exist. Therefore, restoring hydrologic connectivity in riparian areas can provide water storage, which may in turn recharge groundwater, increase atmospheric and plant uptake, and provide flood protection for downstream areas.

Restoration objective 3. Expand existing wetland complexes

Restored or created wetlands may not be functionally equivalent to their natural counterparts (Zedler, 2003, 2000; National Research Council, 2001). Therefore, it is critical to enhance and expand existing wetlands to improve their functionality, rather than creating new wetlands with unknown function potential. Restoring land able to support a wetland ecosystem surrounding an existing wetland remnant expands the area of land available for wetland habitat to support biodiversity. These wetlands may also create wildlife corridors to nearby wetland areas or create interconnected wetlands. Another benefit of restoring lands surrounding a highly valued resource is the removal of lands that could potentially be pollutant sources, creating a buffer around the resource. Much of the agricultural land surrounding wetlands is on hydric soils, indicating that those lands were historically wetlands prior to their conversion to agricultural land. Many of these lowlands on hydric soils are only marginally productive as farmland (Zedler, 2003), and these lands could provide an excellent opportunity for wetland restoration.

We recommend that potential restoration sites adjacent to existing wetlands be given higher priority than isolated sites. Isolated sites have the potential to create habitat that may be especially important for rare species (Tiner et al., 2002); however, the restoration of isolated wetlands does not complement our restoration goal of protecting and enhancing downstream valued resource. Restoring sites that provide a series of connected wetland complexes will enhance biodiversity (Tiner et al., 2002) among these areas and provide water-quality benefits that can be realized downstream as well as within the wetland.

Summary of prioritization strategy

The concepts discussed in this section offer some guidelines for prioritizing wetland restorations within the Upper Rock River Basin to improve water quality to large, existing wetland complexes and enhance biodiversity within those systems. The restoration objectives we selected, while not yet validated, may provide these services within the landscape.

Our strategy is specific to the Upper Rock River Basin, but a similar method could be applied to other watersheds considering wetland restoration. Although the restoration objectives and prioritization strategy will be different for each watershed, some basic principles can be utilized.

- Consider a watershed approach.
- Develop an understanding of the watershed resources and values to the community.
- Determine your watershed restoration goal(s).
- Identify obstacles to address (e.g., poor water quality).
- Develop restoration objectives to achieve your goal and overcome obstacles.
- Prioritize sites according to those objectives.

The use of strategically placed wetland restorations throughout the watershed cannot solve all of the Upper Rock River's identified problems. However, when used in conjunction with other agricultural conservation practices, urban stormwater best management practices, and construction-runoff controls, wetland restoration could be an important tool with the ability to make significant water-quality improvements. Such improvements will not only have an impact on the Rock River system, but also on many of the wetland resources, improving wetland habitat and supporting species biodiversity.

Recommendations for implementation

Restoration techniques suggested by the scientific community may be difficult or impossible to implement. Politics, institutions, and economics interact in ways that consistently frustrate the best intentions of scientists. We foresee the largest barriers to achieving successful implementation of our watershed-based strategy to include a lack of basinwide coordination and adaptive management. Although restoration many times has proved useful in protecting and conserving important water resources at individual project sites, future efforts must fully take into account ecosystem interactions on a landscape scale.

Any attempt to coordinate efforts on basinwide scales throughout the state would have to include innovative, multifaceted approaches that effectively bring people with varying interests together. Over the last several decades, societal values on the environment have been expressed through a general increase in regulatory actions. The debate over the appropriate degree of implementing environmental regulation has helped divert attention away from the fact that the basic goals expressed in the Clean Water Act are fully engrained in our society and governmental institutions. "Fishable, swimmable, drinkable waters" are goals that are increasingly talked about when referring to finite water resources continuously threatened by increasing urban populations and conflicting land uses.

In the relative long term, our society will most likely favor stricter regulation of nonpoint source pollution—much like point source pollution before it. We will not speculate on whether this would become reality through the implementation and enforcement of current legislation or the passage of further legislation. But as greater pressures are placed on our water resources over time, nonpoint source pollution will increasingly become a focal point and the measure by which we evaluate our efforts to protect water resources.

The successful implementation of our strategy must occur over a relatively long period of time. Efforts to coordinate a wetland-restoration strategy are not something that would occur overnight. We propose the incorporation of our strategy within the institutional framework of the Upper Rock River Basin and the State of Wisconsin by considering current and long-term regulatory environments.

Implementation under potential future regulatory requirements

Section 303(d) of the Clean Water Act delegates to the states responsibility for determining the amount of various pollutants a water body can receive, without violating water-quality standards, and allocating that amount among pollution sources through the total maximum daily load (TMDL) program (U.S. Environmental Protection Agency, 2004). According to the Association of State and Interstate Water Pollution Control Administrators (2001), the estimated average cost of developing TMDLs over the next 15 years will be between $670 million and $1.17 billion a year, the states bearing the majority of these costs. The states, including Wisconsin, have been slow to implement the unfunded mandate from the U.S. Environmental Protection Agency due to these high costs and the ongoing controversy of the efficiency and quality of the science behind the process. However, litigation in recent years has pressured the states to proceed to implement the TMDL program that has long taken a back seat to National Pollution Discharge Elimination System permitting (National Research Council, 2001).

The establishment of TMDLs has been forced upon several states by lawsuits brought by citizens claiming neglect of responsibilities under the Clean Water Act. Although the decisions by courts in this matter are reasonable given the intent of the Clean Water Act, a reactive policy by the state in regard to pollution control is not ideal. A comprehensive, proactive policy would allow states to gain the upper hand in complying with present and future regulations at a lower overall cost. However, in many cases, the political will to deal with nonpoint source pollution does not appear to exist. Lower long-term cost—the incentive to taking a proactive approach—is paradoxically what states are avoiding in the short-term.

With the continuation of federal pressure to meet ambient water-quality standards, the state has the option to allocate sufficient funds to nonpoint source pollution abatement programs or to require landowners to bear a greater majority of the costs. Wisconsin administrative rules NR 151 and ATCP 50, which restrict polluted runoff, include a 70 percent cost-share provision. Currently, the state has very little financial leverage, making the goals in these administrative rules unattainable. Regardless of political intentions, legal noncompliance has resulted. Wisconsin also lacks the resources to establish TMDLs across the state, much less to provide funds for cost sharing that would be needed to implement TMDLs. Ongoing financial problems for the state may place the onus upon landowners to meet nonpoint source pollution standards.

To account for the lack of funding by the state, alternative sources of cost sharing must be sought more aggressively. Monies from the Farm Bill programs, such as CREP, qualify as eligible cost-share and provide the potential to make up the shortfall in funding from the state. Here lies an opportunity to implement technical strategies, such as tile drainage interception and the creation of riparian buffers on marginal farmland. The management practices encouraged by Farm Bill programs may greatly assist both the landowner and the state in attaining water-quality standards. Another factor favoring the increased use of Farm Bill programs in environmental policy is the fact that the federal government has been moving away from the traditional price supports for agriculture (Heimlich et al., 1997). Farm Bill conservation programs can help serve as the carrot in the case of the presence of a stick, such as increased regulation of nonpoint source pollution.

The change in land tenure in the Upper Rock River Basin may have far-reaching impacts on the long-term management of agricultural lands. Greater development pressures from the larger urban communities within and surrounding the basin along with the reluctance of younger generations to farm have contributed to the Upper Rock

River Basin's transition to larger scale farming. The population majority in urban centers may not be sympathetic to new large-scale landowners they do not know. As fewer individuals come to own the majority of agricultural land, state or local governments may decide to plan and zone agricultural lands to protect valued water resources. Larger-scale landowners are usually afforded increased flexibility in the use of their land, making them more able to set aside marginal lands and rely on production from more suitable soils.

Before increased regulatory actions become a reality, research in the form of monitoring must be implemented to assess properly the state of water resources in the Upper Rock River Basin. This would help determine available options regardless of outside pressures and may save the state money in the long-term. If the restoration of wetland services helps attain a goal of improved water quality, then the effectiveness of our strategy can be modeled and subsequently used as a method for site prioritization. (The blue text box on the following pages provides additional suggestions for strategy implementation in the Upper Rock River Basin).

Preemptive implementation within the current institutional framework

Although the potential for mandatory federal regulation exists, it is advantageous for communities to seek solutions to management objections prior to such directives. Local communities and landowners may lessen the impact of state and federal mandates that require high public and private expenditures by seeking local, creative solutions. An inclusive watershed approach to planning would help minimize nonpoint source pollution and allow for the implementation of prioritization strategies already outlined.

A watershed management approach focuses on areas that are defined hydrologically, rather than by political boundaries, and it seeks to incorporate social, economic, and ecological interests. This requires a coordinated effort on the part of all stakeholders, who are ultimately responsible for collaborating on restoration objectives, implementing a plan, and monitoring results.

Collaboration

The current federal and state agencies play an integral role in the protection and restoration of wetlands. The past collaboration of these public agencies in acquiring, managing, and monitoring wetland restorations has been an effective means of stretching monies and enticing individuals to participate in programs such as the WRP. However, we have identified a need for more locally led collaborations to create a vision for individual watersheds and to educate landowners about the significance of restored wetlands. This need results from an incongruence of political and watershed boundaries, the conflicting objectives of managers at a statewide basis, and the voluntary nature of the programs. A localized initiative including agencies and general interest groups, such as the Rock River Coalition, could further identify restoration objectives at smaller scales, to prioritize, and conduct outreach and education.

Additional opportunities to implement strategy within the Upper Rock River Basin

Combine efforts to improve water quality and restore wetlands

The use of strategically placed wetland restorations cannot solve all of the Upper Rock River's water-quality issues. However, when used in conjunction with other agricultural conservation practices, urban stormwater best management practices, and construction runoff and point source pollution controls, we believe that wetland restoration could play a key role in improving water quality. Restoration would not only have a positive influence on river systems within the basin, but also on other aquatic ecosystems, corresponding wildlife habitats, and overall species biodiversity.

Invest a specified percentage of mitigation fees to the enhancement of important wetland resources in Wisconsin

For example, the Wisconsin Department of Transportation (WDOT) could offer 10 percent of accrued mitigation fees for cost-sharing with wetland restoration and management efforts initiated by the Wisconsin Department of Natural Resources. This strategy would allow the state to place more money towards the protection of important multiple-use wetlands. The WDOT would be an ideal candidate for such a venture because of its constant need to mitigate for the loss of various wetlands throughout the state. Because mitigation wetlands can take up to 20 years to achieve functional equivalency with natural wetlands (National Research Council, 2001), greater benefits may be attained much sooner through the enhancement of existing wetlands rather than the creation of new wetlands.

Incorporate wetland restorations into new development

Most land within the Upper Rock River Basin is currently in agricultural production, but land use is shifting near urban centers. Conversion to residential development is common in areas along the basin boundary closest to the cities of Madison, Milwaukee, and Fond du Lac. New residential developments and other land-use conversions can provide excellent opportunities for wetland restoration or wetland preservation. Currently, Wisconsin attempts to comply with the Clean Water Act (404d) by maintaining laws (NR 151, ATCP 50) that make wetland drainage due to development more difficult. However, we realize that a combination of economic forces and lack of environmental consciousness can cause communities to support development that does not take wetland conservation or services into account.

Alternative development styles, such as cluster development, look at valued natural and cultural resources and clusters the development around those areas, preserving the valued areas. Cluster development has many ecological benefits, including a reduction of impervious areas, a reduction in soil erosion, and the protection of green space and stream buffers. Prairie Crossing, a residential development in Grayslake, Illinois, provides an excellent example of how ecologically minded planning can be successful in the preservation of natural prairie and wetland habitat. Prairie Crossing is a residential development that aims to improve water quality through a designed stormwater-management system, incorporating source controls and restored prairie and wetland landscapes (Apfelbaum et al., 1994). Wetland restoration and other management tools can help diminish negative impacts to water quality and conserve valued aquatic ecosystems.

Create wetland-protection districts

Wisconsin is lacking local special purpose districts whose primary objective is to address water-quality issues at watershed scale. Minnesota has special purpose districts called watershed protection districts (WPD) that deal with water-quality issues. The state statutes define their power and role. They can be formed to specifically address water quality. These districts are typically overseen by a board of managers that is appointed by the board of commissioners of the counties involved. The WPDs may be granted the ability to levy taxes.

These districts or a similar body of government could assist in a variety of capacities in the implementation of techniques suggested in this report and compensate for the current lack of state and federal resources. The WPDs could facilitate the creation of watershed plans for their entire jurisdiction or watersheds within, utilizing a visioning approach to identify objectives and strategies. The resulting plan may result in greater coordination efforts within the watershed to restore and manage wetlands and adjacent uplands impacting water quality. The watershed plan created by the WPD may identify sub-basins contributing a large proportion of sediment and nutrients to the system. These sites would become areas of high priority for monitoring and the application of buffers and pocket wetlands. The WPD staff may assist in the implementation. For example, one objective of the WPD may be to support the NRCS and the Farm Service Agency in application of Farm Bill Programs. Technical assistance from the WPD may help the NRCS compensate for the lack of technical funding allocated for staff. The Red Lake Watershed District in Minnesota began an effort similar to this in 2002 and may be a useful template (http://www.redlakewatershed.org/projects/Silver%20Creek%20Buf%20Guideline-Descrip.pdf).

Initiating coordination

Efforts to prioritize and implement restoration objectives through coordination may be initiated by agency managers in the basin, or it may be necessary to create a new organization such as a nonprofit or a special interest district. An umbrella organization should be identified to implement the variety of techniques for prioritization that we have suggested and compensate for the current lack of state and federal resources. For instance, the formation of a special interest organization or a special district could fulfill the lead role and oversee the creation of a watershed plan to restore and manage wetlands and adjacent uplands impacting water quality.

These needs have been identified in the Upper Rock River Basin. In the past there has been an effort by the Rock River Coalition and others to seek funding for a coordinator, who could oversee this effort. A coordinator would assist the NRCS to allocate more efficiently resources made available through the Farm Bill programs. In the past, federal and state agencies have not had the resources to assist financially in supporting such a position. Alternative sources of funding should be identified. These sources might include the formation of special interest districts given the authority to levy taxes, federal nonpoint source grants, or the local Resource Conservation and Development, Inc.

It is a common assumption in the process of watershed resource planning that the scale should be synonymous with that of large previously delineated watersheds, such as the WDNR basins. However, the scale under consideration when determining a plan is dependent upon the objective of the project. For example, if the protection of Horicon Marsh is the primary objective, it is necessary to focus resources within the contributing watershed and avoid a generalization of techniques. By identifying specific projects and concentrating on specific objectives within the larger basin, local benefits may be more apparent in the near future.

Identifying restoration objectives

The potential for providing waterfowl habitat is one of the greatest determining factors for the allocation of WRP funds, the most influential source of wetland-restoration funding in the Rock River Basin (Alice Klink, Natural Resource Conservation Service, verbal communication, 2004). Although the NRCS has restored, on average, 10 percent of their sites to open water, local NRCS agents have strived to achieve 25 percent open water at each restored site. This is reinforced partly by the fact that each potential WRP site is ranked and awarded a greater number of points for providing waterfowl habitat (Alice Klink, Natural Resource Conservation Service, verbal communication, 2004).

As we have discussed, wetlands designed specifically for waterfowl habitat do not adequately serve to improve water quality or improve biodiversity. The primary goal of wetland restoration within the Upper Rock River Basin should not be providing habitat for waterfowl, but rather improving water quality. However, past wetland-restoration practices have focused primarily on site-specific acquisition and the creation of waterfowl habitat. Due to limited resources, techniques of restoration have become generalized. The generalization of restoration techniques often results in the restoration or creation of predominately five wetland community types within the entire state of Wisconsin (Steel, 2004). The failure to consider watershed processes or a site's position in the landscape has resulted in created wetlands that are open bodies of water with fringe vegetation, areas plagued by invasive species, or wetlands that are still hydrologically disconnected. The full array of restoration objectives within a basin must be recognized and implemented to prevent the homogenization of wetlands on the landscape. Otherwise, the overall purpose of restorations will be jeopardized by the primary goal of providing waterfowl habitat.

A local collaborative effort is needed to identify wetland restorations with multiple applications beyond that of providing waterfowl habitat alone. Local efforts are also needed to assist agencies in reassessing the objectives of current restoration programs. A group or individual should facilitate the composition of watershed plans for their watershed on a smaller scale. A citizen advisory council could be created to ensure that the interests of the stakeholders are addressed in the creation of the plan. All stakeholders should participate in the creation of a vision for the watershed. Watershed groups should identify the primary needs of the watershed for improving water quality and/or biodiversity based upon the concerns of the stakeholders. Collectively, watershed organizations can then apply political pressure for funding at a state and national level. Lobbying efforts can also focus on the creation of a strategic plan for restoration and the application of Farm Bill programs.

Prioritization

Farm Bill conservation programs create prioritization criteria to identify the desired functions and objectives of restoration activities. Looking at these criteria, the NRCS should re-evaluate the priorities that are given to each criterion to better allocate funds to address the most important aspects of restoration activities.

The ranking criteria should place a greater emphasis on the importance of restoring wetlands to address water-quality issues rather than waterfowl habitat. A higher priority should not be given to sites that could result in more open water, but to the hydrologic function of a site. For example, the connectivity of a site should be considered during the original site analysis. As described previously, there should be a greater focus on the capacity of a restored wetland to intercept nutrients. For instance, the NRCS may focus their resources to utilize wetlands and or buffers to intercept tile drainage, reducing nitrate discharge at the source. Unique landscape features may also influence site rankings. In the case of the Upper Rock River Basin, a higher priority should be given to sites at the base of the drumlin slopes. The field ranking criteria must have a degree of flexibility to allow field agents to take the needs and objectives of individual catchments into consideration.

The WDNR plays a large role in the creation of wetlands statewide. The NRCS often collaborates with the WDNR in acquisition of easements that focus on resource areas identified by the WDNR. In areas that are part of the Glacial Habitat Restoration Area within the Upper Rock River Basin, the WDNR has concentrated on open water restorations to provide habitat to waterfowl populations deemed significant by the state and participants of the North American Waterfowl Conservation Plan (Tim Grunewald, Wisconsin Department of Natural Resources, verbal communication, 2004). It is also the responsibility of the WDNR to identify areas to be restored or preserved that are critical to the protection of water quality. The WDNR's Land Legacy Program, which is currently in draft form, identifies areas of high management and acquisition priority. The Upper Rock River has been identified for its potential to provide increased recreational services. The Land Legacy Program project area might give the NRCS and others incentives to focus efforts in these areas due to the opportunity to partner with the WDNR. The WDNR should use these opportunities to concentrate on nonpoint source pollution.

Outreach and education

Outreach and education are important tools to entice voluntary participation within a watershed. Outreach and education efforts of local field agents and interested organizations have shown to have an influence on the adoption of restoration techniques, participation in voluntary programs, and other conservation practices. This is evident in observing the distribution of WRP sites across Wisconsin (fig. 16). The high density of WRP sites in Columbia and Marquette Counties is due to the proactive efforts of resource agents (Steel, 2004).

The importance of outreach and education has also been supported in the case of the paired watershed project conducted in the Mackinaw River Watershed in Illinois. There, a preliminary study conducted by The Nature Conservancy found that "focused outreach has significantly increased acceptance and installation of best management practices. During four years of focused outreach, the Bray Creek watershed had significantly higher implementation rates for grass waterways, filter strips, and strip-till farming acreage than the reference watershed" (Herkert, 2003).

A greater emphasis should be placed on allocating appropriate funds and creating policies that encompass outreach and education as a primary goal. Outreach and education is stated as a primary objective of the U.S. Fish and Wildlife Service (2003) Partners for Wildlife Program. However, this priority is not reflected in practice, due to a lack of allocated resources. It is a similar scenario with the WRP. Wisconsin originally planned to have seven teams of engineers and biologists distributed in field offices statewide. The responsibilities of these teams would include interacting with landowners who may potentially enroll land. However, within recent years the federal administration has encouraged outsourcing and contracting with private industries, preventing the creation of federal positions. Outsourcing activities have required that NRCS and WDNR partner in the hiring of biologists (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004). Currently, it appears that outreach and education have become a lesser priority when working on restoration projects as agencies are faced with these challenges.

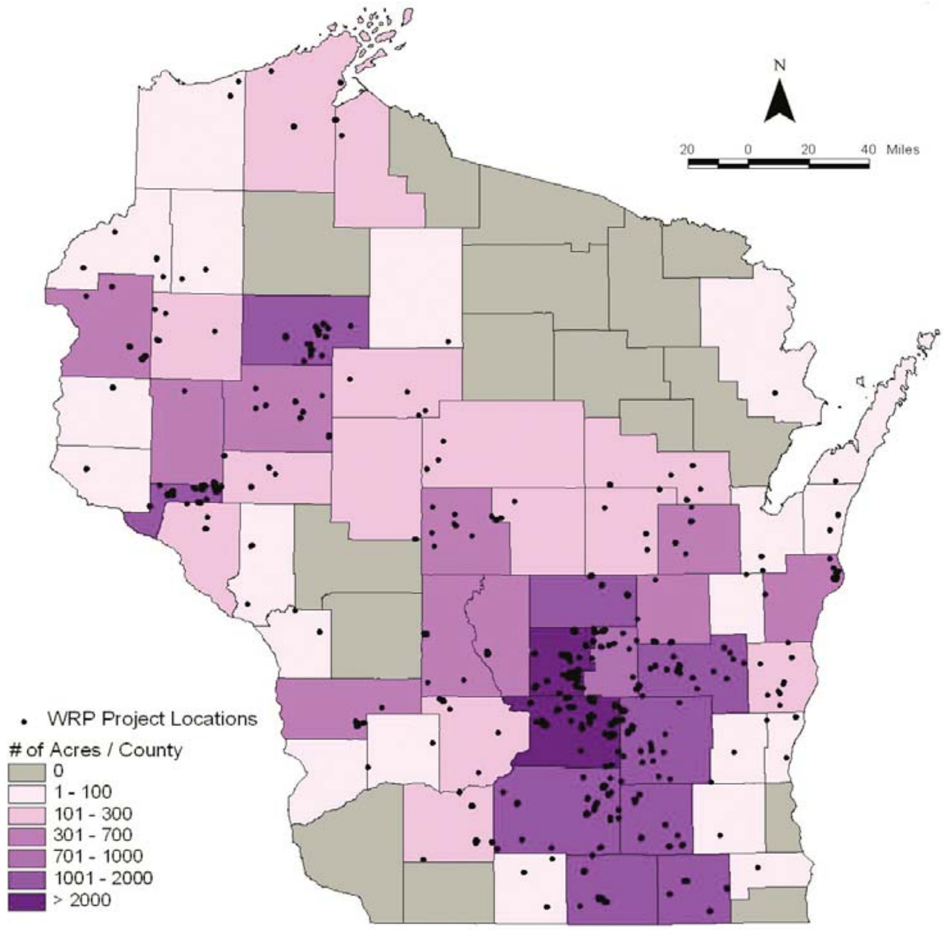

Figure 16. *Wisconsin Reserve Program projects by county, 1994–2002 (Steel, 2004).*

Outreach and education may take many forms. Within the Rock River Basin, there is an effort by the USFWS, WDNR, Lake Sinnissippi Association, Rock River Headwaters Incorporated, the Mayville School District, Main Street Mayville Incorporated, and the Wisconsin Humanities Council to document the cultural value of the Rock River and Horicon Marsh (Hoy and Weinstein-Breunig, 2003). This effort, called the Sense of Place Project, is a cross-generational sampling of the values of the Mayville community, their perspective of their surrounding water resources, and their vision for the future. This effort, which was facilitated by cultural geographer Geri Weinstein-Breunig, was intended to raise awareness within the community of their connection to their surroundings and give them a sense of ownership. Collaboration activities such as this may serve as a foundation on which to build stewardship.

Participatory incentives

After prioritization is determined on the basis of community-identified objectives, how can landowners be convinced to participate? The voluntary nature of easement programs makes it difficult to place wetlands strategically within the landscape. Economic and social incentives are needed to enroll a sufficient number of participants. There has been significant research on adoption of conservation practices within the agricultural community, yet the question of why people adopt practices is yet to be resolved completely (Lockertz, 1990). In places in the Upper Rock River Basin, a lack of incentives or a disincentive for enrollment of lands into easements has influenced the decisions of landowners to participate in restoration activities (James Congdon, Wisconsin Department of Natural Resources, verbal communication, 2004).

In Wisconsin there is little economic incentive for agricultural landowners to restore wetlands. One option for overcoming this obstacle would be to amend the use-value assessment property tax to designate WRP and Partners for Wildlife restoration sites as agricultural land. This may remove the previously mentioned tax disincentive in many districts, which acts to hinder landowners from choosing to enroll moderately productive farmland into certain conservation programs. The Wisconsin Wetlands Association and others are currently evaluating the extent to which taxes create economic disincentives to wetland restoration in various tax districts and are evaluating a suite of policy and program alternatives that attempt to replace economic disincentives with policies that reward good conservation practices (Erin O'Brien, Wisconsin Wetlands Association, personal communication, 2004).

The lack of economic incentives is not solely to blame for the lack of enrollment. Other social factors that are not commonly understood may influence the acceptance of management practices within a community (Nowak and Cabot, 2004; Luzar and Jane, 1999). Other disincentives include a cumbersome application procedure, a lack of understanding of the programs, frustration and/or mistrust of the government, and the requirement of removing land from production (Herkert, 2003; Art Kitchen, U.S. Fish and Wildlife Service, verbal communication, 2004; Angela Rusch, Wisconsin Department of Natural Resources, verbal communication, 2004).

Education and outreach could help solve these issues over time. It is important that agencies allocate time and effort to increase environmental awareness within the target project area; for example, prior to the implementation of a program, agency staff could become acquainted with local landowners and how they perceive the program (Luzar and Jane, 1999). Local agents and advocates of restoration must build a strong level of trust within a community. It can be advantageous to concentrate on a larger objective, such as water-quality improvement. This prevents the community from forming a perception that a program's purpose is solely to set aside their property (Kevin Connors, Dane County Land Conservations Department, verbal communication, 2004). Wetland restoration will only be effective if it is combined with best management practices on the land.

Monitoring and adaptive management

Complex ecological systems are constantly changing to fluctuating environmental conditions. These changes in ecosystem composition must be frequently monitored to prevent invasive species infestation, additional human impacts, and degradation of the community. To be able to maintain a restored site, it is important to use a process, such as adaptive management, that incorporates science and social interests to achieve continued management and monitoring (Meffe et al., 2002).

Adaptive management focuses on the use of participation and sustained monitoring to alter management and restoration plans as a system changes and to minimize uncertainty that may exist at the initial time of implementation (Meffe et al., 2002). By using scientific knowledge as well as public input, a system is created that provides benefits to all groups interested in the restoration project. This process aims to include all individuals interested in a particular restoration site, from scientists to local landowners, to incorporate all the ideas for the use of the site.

The Rock River Coalition's citizen monitoring effort provides a opportunity to apply a more adaptive approach to prioritizing for wetland restoration. Local citizen monitors currently collect biological, chemical, and physical data for streams in the Upper Rock River Basin. These efforts should be continued and used as a model for other basins in the state. In addition, efforts should focus on assisting the NRCS and WDNR to monitor specifically the effects of wetland restoration. For example, monitors could estimate sediment load by taking light-meter readings on streamwater samples collected below restoration sites. This would provide a measure of the fine particles, which have been identified as the major transport mechanism for phosphorus in the Rock River Basin (Potter et al., 2000). Information from these readings can be used to monitor past restorations or identify sites where buffers, pocket wetlands, or larger easements may be pertinent. Also, citizen-monitoring efforts can expand their focus to include wetlands statewide. The Rock River Coalition has posted a request for proposals for the development of volunteer wetland-restoration monitoring protocols and a program plan. If they are successful, there may be an opportunity to derive a protocol for other sites.

Interagency coordination of data management would be useful in an effort to adopt a more adaptive approach and to identify trends statewide. The NRCS and the WDNR have attempted to create a common data bank for wetlands information to comprehend the quality and quantity of wetlands within the landscape. However, the attempt to create a common repository was unsuccessful (Alison Peña, Natural Resources Conservation Service, verbal communication, 2004). We suggest that sufficient time and money be allocated to the creation of a priority database that includes natural, restored, and mitigated wetlands. A common information bank would help identify trends that are affecting the state's wetlands and would serve as a valuable tool for adaptive management.

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Appendix I

Wetland Conservation Programs

Coastal Zone Management Program

The Coastal Zone Management Program was created in 1972 and is administered by the National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management. The program is available in 34 states and the United States territories that have coastal regions. The program focuses on the protection, restoration, and enhancement of coastal resources. Wetland restoration, habitat improvement, and pollution control are some of the conservation activities that are applied to protect coastal resources.

Web site: http://coastalmanagement.noaa.gov/czm/

Conservation Reserve Program

The Conservation Reserve Program (CRP) was created in 1985 and is a voluntary conservation program administered by the Farm Service Agency. The goals of the CRP focus on the protection of topsoil, groundwater, and species habitat.

Web site: http://www.nrcs.usda.gov/programs/crp/

Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program was authorized in 1996 and is administered by the Farm Service Agency. The program addresses environmental degradation occurring around rivers and streams. The program attempts to remove agricultural land surrounding water features from production to protect water quality and enhance wildlife habitat.

Web site: http://www.fsa.usda.gov/dafp/cepd/crep.htm

Conservation Security Program

The Conservation Security Program (CSP) is a voluntary conservation program that began in 2004. It is administered by the Natural Resources Conservation Service. This program focuses on rewarding agricultural producers who have worked to implement conservation protection methods. The CSP provides government assistance in implementing conservation practices that conserve, protect, and improve soil, water, air, energy, plant and animal life and other conservation practices.

Web site: http://www.nrcs.usda.gov/programs/csp/

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) was created in 1997 and is a voluntary conservation program administered by the National Resource Conservation Service. The program is available to landowners in the United States and its territories. The EQIP works with agricultural and livestock operations to prevent environmental degradation. Conservation activities focus on reducing nonpoint source pollution, soil erosion, and air pollution.

Web site: http://www.nrcs.usda.gov/programs/eqip/

Glacial Habitat Restoration Area

The Glacial Habitat Restoration Area (GHRA) is a project operated by the Wisconsin Department of Natural Resources that focuses on the restoration and management of wildlife habitat for waterfowl. The goal of the GHRA is to restore 38,600 acres of waterfowl nesting cover and 11,000 acres of wetlands within four counties in Wisconsin: Columbia, Dodge, Fond du Lac, and Winnebago. The state of Wisconsin is purchasing important lands as well as offering long-term easements to landowners to secure lands for the project.

Web site: http://www.dnr.state.wi.us/org/land/wildlife/hunt/hra.htm#Glacial

Partners for Wildlife

The Partners for Wildlife program was created in 1987 and is implemented by the U.S. Fish and Wildlife Service. Restoration activities emphasize the protection of threatened, endangered, and federal trust species through the restoration and protection of fish and wildlife habitats. Wetland restoration and habitat improvement are the primary conservation activities used to protect these natural resources.

Web site: http://partners.fws.gov/

Wetland Reserve Program

The Wetland Reserve Program (WRP) is a voluntary conservation program created in 1996 and administered by the National Resource Conservation Service. The WRP is available to landowners in the United States and its territories. The WRP focuses on the protection of the environment by reducing soil erosion and improving water quality by creating and restoring wetlands and wildlife habitat.

Web site: http://www.nrcs.usda.gov/programs/wrp/

Wildlife Habitat Incentives Program

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program that has been administered by the National Resource Conservation Service since its inception in 1998. The program is available to landowners in the United States and its territories. Habitat restoration, habitat management, and species protection activities are the primary focus of WHIP. Restoration activities through WHIP focus on the improvement or installation of upland, wetland, riparian, and/or aquatic habitats to provide beneficial wildlife habitats.

Web site: http://www.nrcs.usda.gov/programs/whip/

Appendix 2

Geographic information system database layers

Data layer	Source of data	Originator	Publisher	Location	Date
Dane County Soils	WDNR	Dane County	NRCS	Madison, WI	1996
Dodge County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	1998
Columbia County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	2001
Green Lake County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	1998
Fond du Lac County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	1998
Jefferson County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	1997
Washington County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	2002
Waukesha County Soils	WDNR	NRCS	NRCS	Fort Worth, TX	2003
Dane County Orthophoto	WDNR	USGS	USGS	---	2000
Dodge County Orthophoto	WDNR	USGS	USGS	---	1992
Columbia County Orthophoto	WDNR	USGS	USGS	---	2000
Green Lake County Orthophoto	WDNR	USGS	USGS	---	1992
Fond du Lac County Orthophoto	WDNR	USGS	USGS	---	1992
Jefferson County Orthophoto	WDNR	Jefferson County	Ayres Associates	---	1996
Washington County Orthophoto	WDNR	SEWRPC	Ayres Associates	---	1995
Waukesha County Orthophoto	WDNR	SEWRPC	Ayres Associates	---	1995
DNR Managed Lands	WDNR	WDNR	WDNR	Madison, WI	2003
Wisconsin 30-m DEM	WDNR	USGS	USGS	Reston, VA	1998
Wisconsin Hydrography	WDNR	WDNR	WDNR	Madison, WI	2003
Wisconsin Trout Streams	WDNR	WDNR	WDNR	Madison, WI	2002
Wisconsin Wetlands Inventory (WWI)	WDNR	WDNR	WDNR	Madison, WI	Varies by County
Wisconsin Impaired Streams (303d)	WDNR	WDNR	WDNR	Madison, WI	2004
Wisconsin Imparied Water Bodies (303d)	WDNR	WDNR	WDNR	Madison, WI	2004
Wisconsin Roads	WDNR	US Census Bureau	OLIS, WI-DOA	Madison, WI	2000
Wisconsin Watershed Boundaries	WDNR	WDNR	WDNR	Madison, WI	1992
Phosphorous and Sediment Loading	Earth Tech, Inc.	WDNR	WDNR	Madison, WI	2002
Reed Canary Grass	WDNR	WDNR	WDNR	Madison, WI	2004
WISCLand Land Cover Data	WDNR	WDNR	WDNR	Madison, WI	1998

Appendix 3

Wetland Restoration Site Prioritization Considerations: A Logic Sheet for Guidance in Developing Project Priorities

This logic sheet is provided as a starter reference for further research and development of these concepts. In general, this system concentrates on prioritizing project sites based on the ability of a wetland site to trap sediment and function as a treatment wetland. The primary considerations are ratio of drainage area to wetland area, soil loss, sediment trapping efficiency, location within the watershed, and degree of hydrologic connectivity.

It is important to differentiate between these treatment wetlands and relatively pristine wetlands that have established biodiversity or have potential to do so (e.g., wetlands that are not dominated by invasive species). Treatment wetlands may be used to improve water quality before water enters a more biodiverse wetland, but the biodiverse wetland itself should not be used as a water-quality treatment site.

***Step 1.** Identify the project area, including upstream drainage area and wetland restoration area. (Include detailed maps.)*

Contributing area ______________________________

Wetland restoration area ______________________________

Ratio of contributing area to wetland area ________________

***Step 2.** Perform a soil loss calculation for the contributing watershed.*

Gather the following information for your area of interest to determine the soil loss from a site using the Revised Universal Soil Loss Equation (your local land conservation or Natural Resources Conservation Service personnel may be able to aid you in this process):

A (average soil loss, tons per acre/year) = **R * K * LS * C * P**

Factor Symbol	Factor	Definition
R	Rainfall-runoff erosivity	Rainfall intensity in every storm (droplet size) * 30 minutes
K	Soil erodability	This factor measures the susceptibility of the soil to erosion
LS	Slope length and steepness	Length and slope from top of slope to toe of slope
C	Cover management	Evaluation of land use
P	Support practice	Evaluation of conservation practices

From Natural Resources Conservation Service (1996).

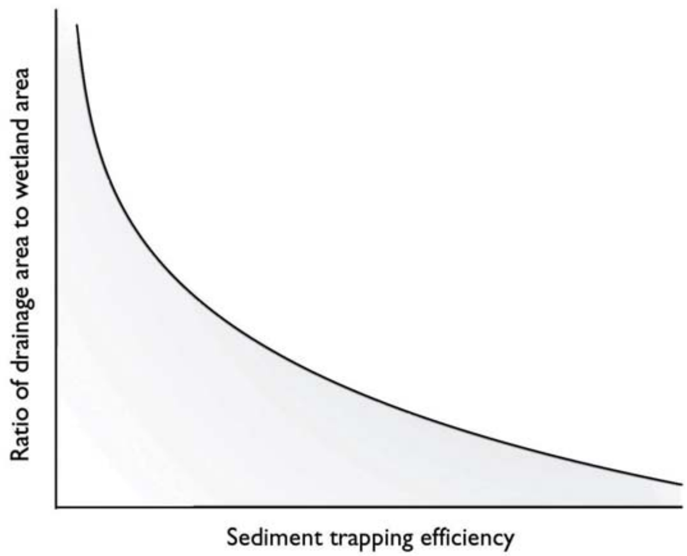

Figure A3.1. *Example of a sediment trap efficiency curve.*

More complex algorithms can be utilized to estimate the amount of phosphorous associated with this sediment or approximate the nitrogen delivery to the wetland area.

Step 3. Estimate sediment trapping efficiency for your watershed.

In general, as the ratio of drainage area to wetland area decreases, the ability of that wetland to trap the sediment delivered to it will increase. This observation is supported by literature (Woltemade, 2000; Jansson et al., 1994) and may result in an exponential decay curve such as the one in figure A3.1.

The data to support this analysis would have to come from transport modeling of the watershed or from literature (in the absence of site-specific data). However, once obtained, this simple graph could be used to determine minimum and maximum thresholds for sediment trapping and the corresponding area ratios. In general, sites that have a lower drainage area to wetland area ratio should be given higher priority.

Step 4. Prioritize headwaters.

Give greater consideration to sites that are located at the headwaters of stream networks. Studies by Alexander et al. (2000) and Peterson et al. (2001) indicated that headwater streams (those located in the upper reaches of the stream network) may be most important for regulating water chemistry due to their large surface-to-volume ratios.

Step 5. Prioritize hydrologic connectivity.

A wetland-restoration project may have a greater chance of becoming functional if it has suffered fewer disturbances compared to a similar site. Consider "ranking" sites into three (or more) groups of hydrologic connectivity. Riparian wetlands with streams that are entrenched either by natural erosion processes or artificial ditching would be considered the lowest level of connectivity. A wetland with mid-range connectivity is one that does not have entrenched channels, but rather contains a natural, meandering stream that has not experienced ditching. The highest level of wetland connectivity would be characterized by the absence of a defined channel over part of the system.

Level I (Good)—no channel over part of the wetland system

Level II (Average) —natural, meandering channel with no ditching or entrenched reaches

Level III (Poor) —entrenched channel, by natural erosion or artificial drainage

We recommend that restoration priority be given to Level I sites, followed by Level II and then Level III sites. The presence of existing connectivity may increase the likelihood of achieving your restoration goals. However, it could also be argued that those sites in level III should be given higher priority because they offer the most opportunity for improvement.

Any given wetland may migrate between these classes, either through time or space along the stream path. This creates a non-linear system, in which each section of wetland must be individually evaluated and wetland connectivity should be determined on the basis of the entire riparian reach. The use of aerial photography, current and historical, is helpful for examining the wetland's connectivity and must be followed by field investigation.

Step 6. Add the rankings from steps 1–5 and determine the high priority sites.

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