Wetlands by Design: A Watershed Approach

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EXECUTIVE SUMMARY *(in progress)*

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INTRODUCTION

We envision a future in which wetlands are strategically restored and protected across watersheds to help Wisconsin thrive in terms of our economies, the health and welfare of our communities, and our fish and wildlife habitats.

The Wetlands & Watersheds Explorer, a product of *Wetlands by Design: A Watershed Approach*, guides users toward sites likely to support their wetland conservation goals, such as improving water quality, reducing flood damage, or providing habitat for wildlife.

The Explorer identifies where wetlands are providing these services, throughout all of Wisconsin's watersheds, and where the greatest potential lies to increase these services through wetland restoration. The Explorer, supplemented by field-based planning, can support: prioritizing potential wetland mitigation sites; locating public natural infrastructure projects; developing watershed, wildlife, and water quality plans; and guiding investments by land trusts and other conservation organizations.

While the Explorer can enhance siting decisions, it does not pre-select sites. Rather, it helps to winnow options from the hundreds or thousands found in a watershed to a more manageable handful with the highest service potential. The Explorer provides a starting point for further site assessments that include landowner willingness and other aspects of site feasibility and restorability.

Why wetlands?

Although wetlands cover only a small fraction of the world's land surface, estimated between 5 and 8 percent (Mitsch and Gosselink 2015), they are powerhouses of the natural world. Wetlands play a pivotal role for wildlife; 50 percent of animals listed as endangered and threatened in the U.S. require wetland habitat (Niering 1988). And they play pivotal roles for people, too, as they provide "natural infrastructure" through protection of water quality and quantity, flood reduction, and other ecosystem services.

Wetlands function in a variety of ways (e.g., reducing nutrient loads in streams), and many of these functions provide services that benefit people (e.g., improving drinking water quality). All three terms – functions, services, and benefits – are referred to in this document as "services."

Wetland loss in the U.S. since the 1950s (almost 10 million acres) has translated to the loss of over $80 billion—every year—in renewable ecosystem services (Southwick Associates 2011, based on Costanza et al. 1997). This figure likely underestimates the true economic value of wetlands, as not all wetland services were included in the calculations. Acre for acre, the value of wetlands to the U.S. economy is estimated to be ten times the value of its closest contender, upland forests (Ingraham and Foster 2008). Clearly, continued loss of wetlands will have disproportionately high costs. Through careful planning and design, wetland restoration can return many of these services—and their economic values—to our watersheds.

Box inset: Wetlands and Climate Change

Wetland conservation—both preservation and restoration—presents us with major opportunities to reduce and adapt to the effects of climate change.

Wetlands emit methane, a greenhouse gas, but also store carbon in organic soils and vegetation. In the balance, most wetlands act as carbon sinks. Despite their relatively small global footprint (5-8%), wetlands play a disproportionate role in climate regulation, sequestering an estimated 830 million metric tons of carbon each year (Mitsch et al. 2012a). Wetland restorations can store even more carbon per acre than existing wetlands (Mitsch et al. 2012b) and could provide an effective tool to reduce atmospheric carbon. *Wetlands by Design* prioritizes current and potentially restorable wetlands that have the greatest chance of maintaining and increasing the carbon storage capacity of our landscape.

With ongoing and projected dramatic increases in temperature, intensity and frequency of storms, and other factors related to climate change (WICCI 2011), many aspects of Wisconsin's lands and waters will be fundamentally altered over the coming decades, impacting ecosystem services. For example, agricultural and urban runoff issues are expected to increase, leading to lower water quality (WICCI 2011). The importance of strategically siting wetland restoration and preservation for water quality is only amplified given climate change, and this is true for many of the services wetlands provide. Wetland conservation can help us adapt to ongoing and future effects of climate change.

Why a Watershed Approach?

All wetlands provide important services, whether for wildlife or people, but they are not all important in the same way. There is a great deal of variability in the number, type, and degree of services wetlands. This variability is a result of many factors including the dominant type of vegetation, how water flows through wetlands, the seasonal availability of water, soil characteristics, whether a wetland is connected to a stream or waterbody, and how the surrounding upland is used and its condition. Watershed context and relative position play major roles in how services are distributed among wetlands (Zedler 2003, Zedler et al. 2012). A 5-acre forested wetland at the top of a watershed may be more important for keeping streams flowing during drought than a similar 5-acre forested wetland at the bottom of the watershed. A 2-acre marsh surrounded by cropland is likely much more important for improving water quality than a similar 2-acre marsh embedded in a more natural, forested landscape. Streamside wetlands located above cities can be crucial for flood reduction and public safety, relative to wetlands not connected to streams or those that flow directly into a major waterbody.

In the absence of a watershed approach, it is difficult to consider the broader range of opportunities and compare their relative potential. In a more traditional approach that does not include a watershed perspective, sites may be selected based on field assessments of individual sites, land availability and cost, site accessibility, and other feasibility factors. **These site-level approaches are essential to success and a watershed approach is not intended to replace them**. Instead, a watershed approach complements and improves the site selection process, leading to efficiency, cost-effectiveness, and greater likelihood of generating wetland service returns. To select sites, we recommend combining Explorer results with field-based investigations (Figures 1a and 1b). This holistic approach—encompassing both watershed- and site-level information—capitalizes on the strengths of each scale while minimizing weaknesses. For example, while watershed-scale evaluations are superior at locating areas and sites with the greatest service potential, they rely on statewide datasets that may have known accuracy issues at the site level; site evaluations can help to supplement and clear up data issues.

The term "watershed approach" describes many conservation initiatives that recognize the influence of broader watershed-scale context on sites and processes, including initiatives around groundwater, rivers and streams (B.A. Bohn, 2002), nutrient management, urban runoff, and others. Our application of a watershed approach in Wisconsin is focused specifically on wetlands. From a technical perspective, a watershed approach uses an analytical process to identify ways to support the sustainability or improvement of aquatic resources in a watershed, taking into consideration watershed needs (defined in this project in terms of ecosystem services), as well as the potential of individual sites to meet watershed needs. The Environmental Law Institute's and The

Nature Conservancy's Watershed Approach Handbook provides examples and recommendations for developing a watershed approach within wetland and stream regulatory contexts (ELI and TNC 2014). Region 5 of the Environmental Protection Agency has also developed guidance for integrating wetlands into watershed plans (EPA Region 5 2013)

Figure 1a. Recommended sequence for *finding a site* using Wetlands & Watersheds Explorer

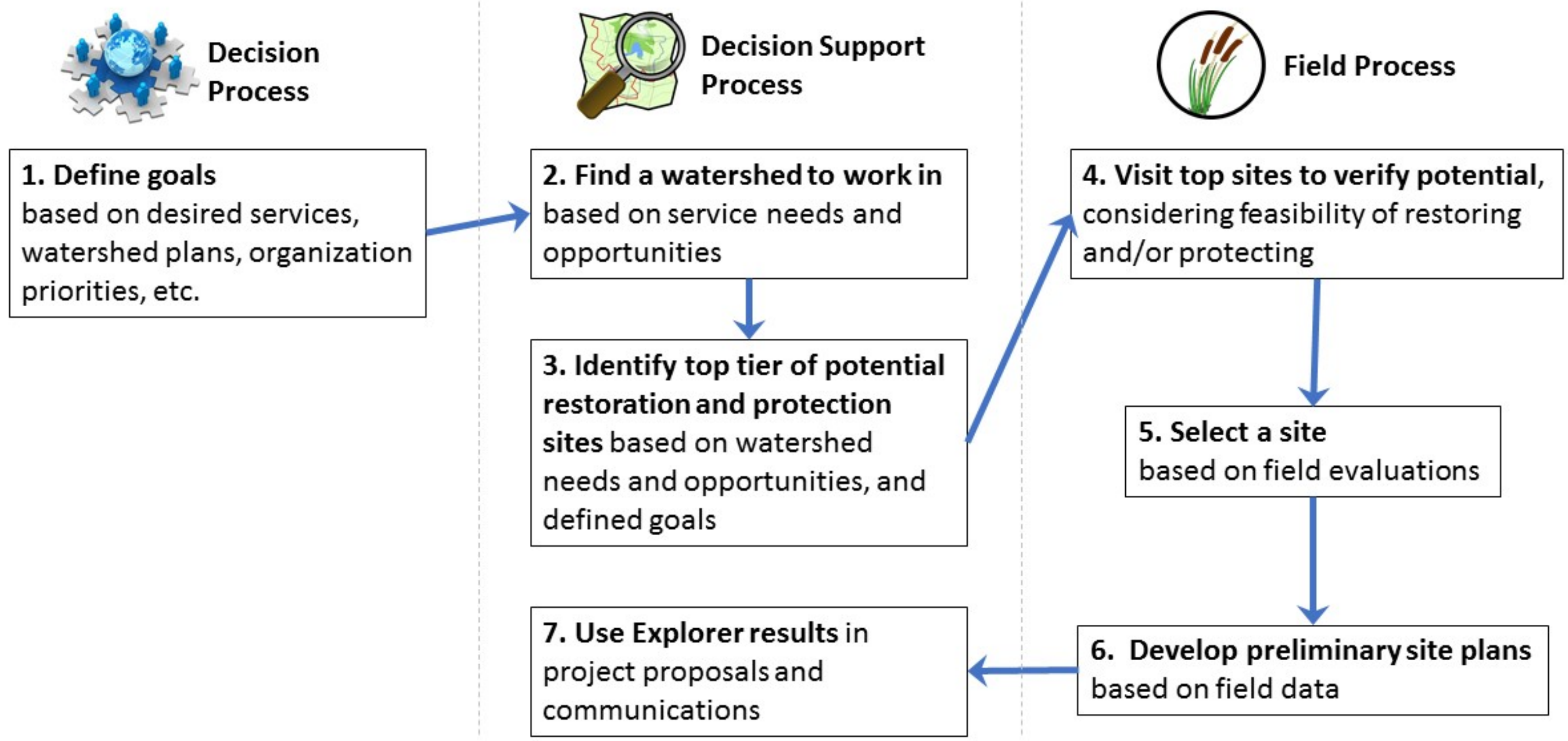
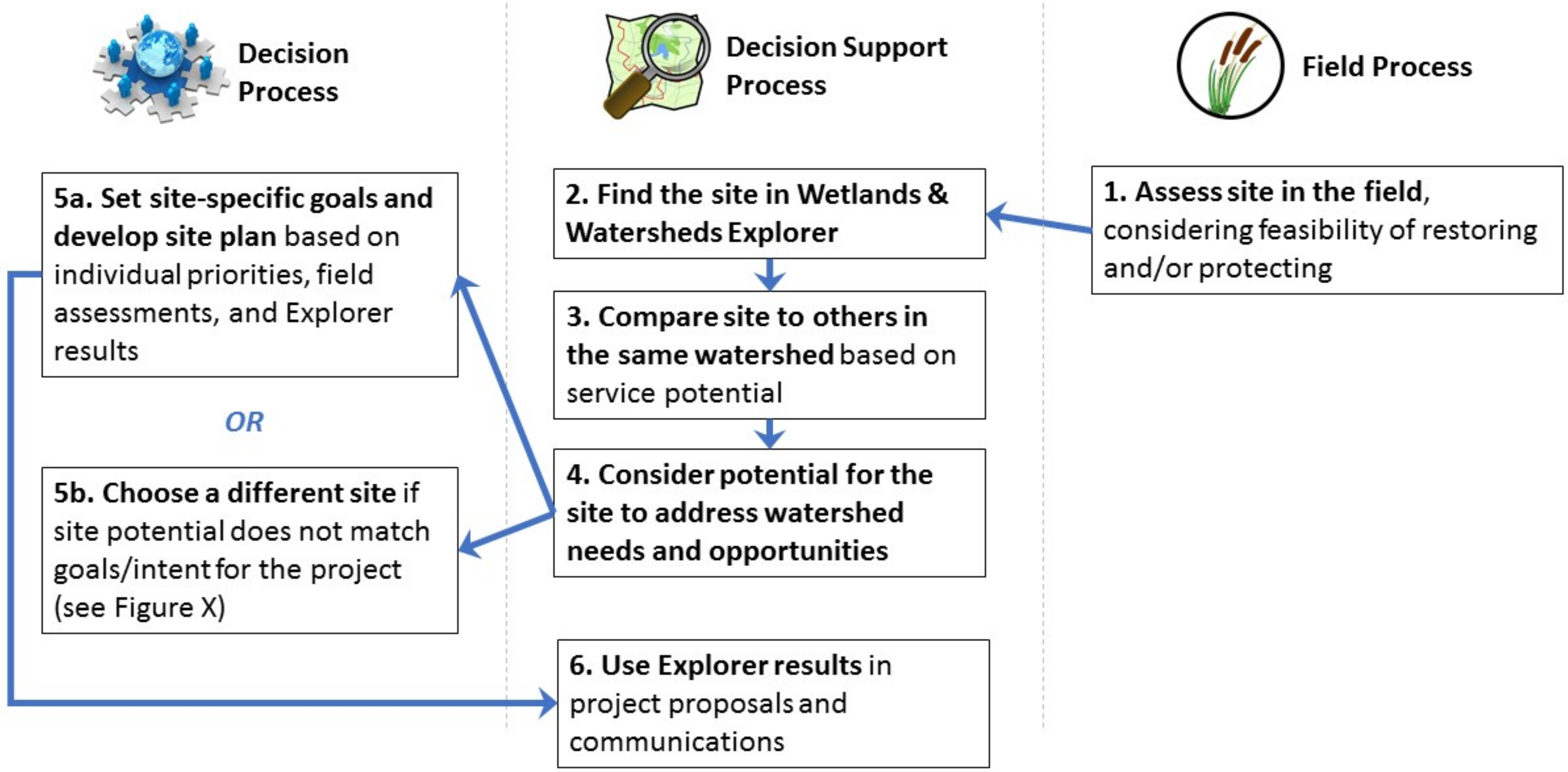


Figure 1b. Recommended sequence for *evaluating a site* using Wetlands & Watersheds Explorer



APPROACH OVERVIEW

History of the Watershed Approach in Wisconsin

Wetlands by Design is the first watershed approach for wetland conservation developed for the entire state of Wisconsin. It draws upon methods and lessons-learned from similar efforts piloted, implemented, and researched in Wisconsin and nationwide (see the Watershed Approach Handbook for overview and examples). Related Wisconsin projects were developed for the Duck-Pensaukee Watershed (Miller et al. 2012), the Milwaukee River Basin (Kline et al. 2006), the Sheboygan River Basin (Miller et al. 2009), a cluster of watersheds on the Stockbridge-Munsee Reservation (Stark and Connor 2013), subwatersheds within the Lower Fox and Des Plaines river watersheds (Tetra Tech 2015), and ongoing work in Lake Superior watersheds (Amnicon and Bois Brule watersheds, Douglas County and St. Mary's Geospatial Services; Marengo River Watershed, Department of Natural Resources and St. Mary's Geospatial Services). Formative work nationally and in other states has included the Army Corps of Engineer's Wetland Evaluation Technique (Adamus et al. 1991), enhancement of National Wetlands Inventory data (NWI Plus; Tiner 2003, 2005), applications of NWI Plus in Michigan (Fizzell 2011) and many other locations (e.g., St Mary's University, GeoSpatial Services), incorporating wetland conservation into watershed planning (EPA Region 5 2013), Oregon's wetland assessment approach (Adamus ____), and Rhode Island's freshwater restoration strategy (Miller and Golet 2001), among others.

In aggregate, these efforts constitute a learning process—an evolution—in watershed-scale wetland planning and assessment, with each building from existing methods and contributing new methods. Contributions of *Wetlands by Design: A Watershed Approach* include an emphasis on the importance of landscape condition and land-use context to wetland service potential; GIS modeling approaches to 'automate' steps typically conducted manually, enabling application at broader scales; separating the 'water quality improvement' service into several constituent parts (phosphorus retention, sediment retention, and nitrogen reduction); new methods to remotely assess whether wetlands have been hydrologically disconnected from streamflow due to stream incision and channelization; and incorporating new datasets such as improved mapping of potentially restorable wetlands (PRW 3.0), new land-use and landcover data (WiscLand 2.0), and the results of Wisconsin's Healthy Watershed Assessment (The Cadmus Group 2014). To advance continued evolution of methods, areas for improvement, data needs, and potential next steps are identified in Appendix __.

Types of Wetland Conservation Opportunities

Wetland resources may be conserved through a variety of activities, which have been grouped into four major categories: preservation, restoration, creation, and enhancement (EPA 2008). There are two kinds of restoration: re-establishment (restoring former wetlands that have been converted to upland) and rehabilitation (restoring current wetlands that have been degraded or impaired). *Wetlands by Design* focuses on wetland preservation and reestablishment. Preservation opportunities were identified from the Wisconsin Wetland Inventory (WWI). Reestablishment opportunities were identified via the Potentially Restorable Wetland (PRW) statewide data layer from WDNR; see Methods section for further information. Current wetlands and potentially restorable wetlands are collectively referred to as 'sites.'

Wetland creation and enhancement opportunities were not identified as part of this project because coarse-scale GIS analyses cannot reliably distinguish the best opportunities. For example, the potential to create wetland hydrology in upland locations is best identified through on-the-ground site assessments. In addition, wetland enhancement involves boosting a service in an existing wetland; this may come at the expense of other services as services are bundled based on factors such as hydrologic regime, and service tradeoffs must be considered (Doherty et al. 2014). Therefore, potential gains in wetland services from wetland enhancement and creation may occur at the expense of other ecosystem services. For example, increasing water levels in an existing wetland to increase habitat for ducks could have a negative impact on other species, and may also reduce flood storage capacity at the site. The methods described below prioritize preservation and restoration (reestablishment) opportunities based on a broad array of services. However, users of this plan should take care to set goals for services that are complementary and tailored to individual sites.

Future updates of the Wetlands and Watersheds Explorer may include wetland rehabilitation opportunities that have been identified in existing datasets (e.g., opportunities to control invasive species such as reed canary grass; Hatch and Bernthal 2008), and those identified as a byproduct of wetland service assessments (e.g., opportunities to restore hydrologic reconnection of a wetland to an associated stream that has been channelized).

Regulatory Context

A watershed approach can be used within a Clean Water Act regulatory context to defend and offset the loss of wetland services in a watershed (NRC 2001). However, the scope of a watershed approach may be much broader, linking mitigation outcomes to local, non-regulatory conservation goals (e.g., flood abatement, habitat preservation, shoreline protection), to the benefit of both. By combining regulatory with non-regulatory conservation resources within a watershed approach, it will be possible to rebuild and sustain the natural infrastructure of our wetlands and watersheds.

Although the vision of *Wetlands by Design* combines goals, intent, and funding across regulatory and non-regulatory contexts, this project has regulatory roots. In 2008 the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps) issued new regulations for compensatory mitigation under §404 of the Clean Water Act (CWA). The "2008 Mitigation Rule" reaffirmed the mitigation sequence for regulatory protection of wetlands: first *avoid* impacts, then *minimize* those that are unavoidable, and finally, if there are no significant adverse impacts, *compensate* for lost resources. Wisconsin's wetland laws generally mirror this federal process. Drawing from recommendations provided in a comprehensive study of compensation effectiveness under the CWA (NRC 2001), the Rule also asserted that compensations (e.g., preservation and restoration actions) must be sited with respect to the context and needs of the watersheds in which they occur. Furthermore, compensation should be accounted for in terms of ecosystem services (e.g., water quality protection, flood abatement, provision of habitat) as well as area. The 2008 Mitigation Rule provided clear guidance on what elements should be considered in a watershed approach, and stated that demonstration of these elements at a proposed compensation site may satisfy the new watershed approach requirement. However, an alternative was provided: to proactively develop a watershed plan that addresses these elements, subject to approval by the Corps District Engineer. Proactive planning enables the selection and advance comparison of top-tier sites across a watershed—a distinct advantage to site-by-site watershed approach justification.

Wetlands by Design: A Watershed Approach and the Wetlands and Watersheds Explorer resulting from this project incorporate and align with requirements of the 2008 Mitigation Rule. Project results can be used to guide investments of the Wisconsin Wetland Conservation Trust (WWCT), the State's in-lieu fee (ILF) wetland mitigation program, and of potential mitigation bank sponsors. Analyses of watershed-scale wetland opportunities and needs can add value to WWCT's Compensation Planning Frameworks (CPF), helping to define watershed-based wetland mitigation goals; in addition, site-specific rankings can help to identify a range of opportunities to meet CPF-defined watershed goals. It is important to note that the Explorer does not rank potential mitigation sites in an absolute sense; rather, it identifies a range of options for potential mitigation applicants to consider and provides information (which must be supplemented by field-collected information) to justify site selection based on watershed context. Release of this report and the Explorer does not imply approval by the Corps, state agencies, or other regulatory agencies. In the context of the §404 program, it is the authority of District Engineers to determine whether a watershed plan is appropriate for use (CWA §332.3(c)(1)).

Assessment Overview

Assessing Watershed Needs and Opportunities

Understanding the relative need for wetland services and opportunities to provide them in a watershed is as important as determining the service potential of an individual site. *Wetlands by Design* began by assessing every watershed across the state to determine the relative decline in wetland services—due to historical wetland loss and alteration—relative to other watersheds in the same 'parent' watershed. This assessment was conducted at several scales: from basins, to watersheds within those basins, to subwatersheds. Services assessed included flood abatement, fish and aquatic habitat, sediment reduction, nutrient transformation, and surface water supply. These services were selected from among a broader array based on assessibility using GIS, relevance to land-use decisions and service needs, and the degree to which they are a product of watershed-scale factors. This last criterion excluded services such as shoreline protection, carbon storage, and wildlife habitat, which are not influenced by watershed properties. In addition, results for the selected services were combined to estimate overall service loss within each watershed.

Watersheds with the greatest historical loss of wetland services were ranked as having 'very high opportunity' for achieving wetland service goals; those that have experienced lesser historical loss of services were ranked as 'moderate opportunity' and 'low opportunity,' accordingly. Watershed opportunities can be matched with user-specific goals, such as reducing floods or improving drinking water quality, to identify the most appropriate watersheds for restoration work.

Assessing Sites: Wetland Service Potential

To prioritize current and potentially restorable wetlands—collectively referred to as 'sites'—we selected a suite of services based on: (1) their relative importance to people; (2) the role they play in maintaining watershed health; (3) the degree to which wetlands, specifically, provide them; and (4) the extent to which we can assess them with available data. Based on these criteria, the following services were selected for assessment in this project: water quality improvement (nitrogen reduction, phosphorus reduction, and sediment retention), flood abatement, surface water supply, shoreline protection, carbon storage, fish and aquatic habitat, floristic quality, and wildlife habitat. A separate methodology was used to rank sites for their potential to provide wildlife habitat (see below).

The range of services provided at an individual wetland, and the extent to which they are provided, is determined by a variety of factors including but not limited to wetland type, hydrology, soil characteristics, watershed position, land-use context, and landscape condition. Data were assessed within three categories, to ensure adequate service assessment, including: 1) *opportunity* for the service to be performed, 2) *effectiveness* of the wetland in providing the service, and 3) the relative *significance* of the site in providing services for people. For example, a site surrounded by steep slopes and impervious surfaces has great *opportunity* to perform the flood abatement service. If that same site is situated in a geographic depression and has dense vegetation, it is likely *effective* at slowing and temporarily storing floodwaters. And if it is situated above developed flood-prone areas, it *significantly* benefits people. The potential for an individual site to provide each service, relative to other sites, was calculated by measuring factors in each of these three categories, and then combining results into a final score.

Sites were ranked as "very high," "high," or "moderate" for each service. Sites were also prioritized for their potential to provide multiple services; this was done via a count of the total number of services provided at "high" or "very high" levels at each site. When selecting sites for restoration, users should consider the range and level of service provision at individual sites in combination with both watershed opportunities (as described above) and user-specific service needs and goals.

Wetlands not prioritized as "very high," "high," or "moderate" for one or more services may still be of value for several reasons: 1) some wetlands (in particular, small sites) were not assessed during this project due to wetland data limitations, 2) numerous wetlands that individually provide services at a low level may, collectively, be of high value within a watershed, and 3) wetlands provide additional services that were not assessed in this approach.

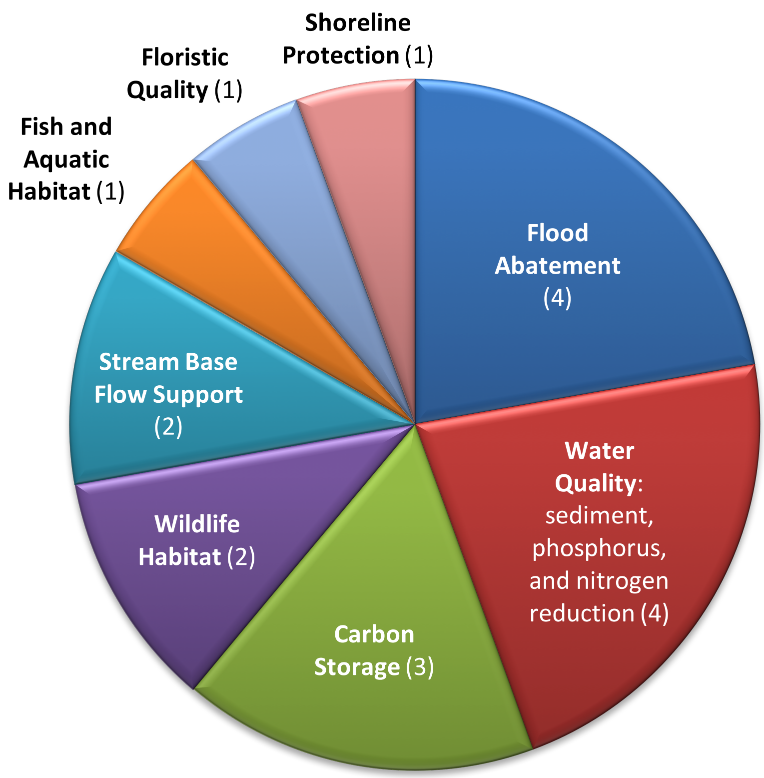
Assessing Wildlife Habitat Potential

The importance of wetlands to wildlife depends on a variety of factors that include, among others, what types of habitats are available, the size of habitat patches, and proximity to other suitable habitats. We adapted the Wildlife Tool (Kline et al. 2006; see also Duck-Pensaukee Watershed Approach, Miller et al. 2012) to identify and rank key habitats relevant to four wetland wildlife guilds (i.e., groups of species that use the same or similar habitats and resources): shallow marsh guild, open water guild, shrub swamp guild, and forest-interior guild. The Wildlife Tool approach recognizes that individual wetlands do not function as islands, but instead as parts of an interconnected system that includes both wetlands and uplands. Therefore "sites" that are prioritized include current wetlands, potentially restorable wetlands, *and* associated upland habitats. In addition to ranking based on the four guilds, sites were also ranked based on their potential to provide habitat for multiple guilds; potentially restorable wetlands were also ranked based on their potential to provide habitat for multiple guilds. The four guilds assessed include: forest interior guild (e.g., Canada warblers, northern flying squirrels), shallow marsh guild (e.g., blue-winged teal, American bitterns), open waters guild (e.g., terns, diving ducks, frogs), and shrub swamp guild (e.g., willow and alder flycatchers).

Climate Change Considerations

In addition to slowing climate change through carbon storage, wetland conservation can also help us adapt to a changing climate. The degree and types of services provided at any given site may be altered by climate change. In addition, the importance of individual wetland services may differ in light of climate change; e.g., as the frequency and severity of flooding increases, the preservation and restoration of sites ranked high for flood abatement become even more important. As part of *Wetlands by Design*, recommendations were made for weighting site rankings for each service, based on an assessment of literature and consultations with experts (unpublished report, P. Moran, 2016). Recommended weightings were not incorporated into site rankings in the Explorer; rather, they are presented here for users to consider in setting priorities for watershed and restoration planning (Figure 2).

Figure 2. Proposed relative weighting of wetland services, in consideration of climate change impacts and climate adaptation potential of wetland conservation.*



*These weights were not applied to ranking of sites in the Wetlands and Watersheds Explorer; instead, they are provided here for users to consider while setting goals and selecting sites.

METHODS

Overview

Specific methods to implement the Approach, described above, fell into the following categories. Although arranged in stepwise format here, many of these steps were overlapping and were conducted iteratively. The steps included:

1. Gathering and integrating datasets
2. Defining and identifying sites: wetland restoration and preservation opportunities
3. Assessing watershed needs and opportunities
4. Assessing sites for wetland service potential
5. Assessing sites for wildlife habitat potential
6. Field validation of results from GIS models
7. Developing a decision support tool to provide data access to users

More information is provided for each of these steps, below.

1. Gathering and integrating datasets

Table M-1 describes the datasets we used, and how they were applied.

2. Defining and identifying sites: wetland restoration and preservation opportunities

Preservation opportunities comprise the current extent of wetlands, as defined by the Wisconsin Wetland Inventory (Wisconsin Dept. Natural Resources, http://dnr.wi.gov/topic/wetlands/inventory.html). Potentially restorable wetlands or "PRWs" (wetland re-establishment opportunities) are former wetlands with the potential to be restored, such as those in agricultural land uses, rather than in well-developed urban areas. Using GIS-data to identify PRWs began in Wisconsin by using a single attribute of soil data, the hydric soil class, and current land use (Kline, et al., 2006). Since then, methods to identify PRWs have evolved to include topography and additional soil attributes related to hydrology (cite WDNR).
Explain briefly or refer to WDNR?

3. Assessing watershed needs and opportunities

Watershed needs and opportunities – defined as declines in wetland services due to wetland loss and alteration since the 1800s – were evaluated by adapting NWI Plus methods (Tiner 20XX) to Wisconsin's wetland data, creating a WWI Plus dataset. In these 'Plus' approaches, existing wetland datasets—containing data about wetland type, size, and location—were enhanced with hydrogeomorphic types of data such as landscape position and water flow path. Enhanced data were then used to determine likely wetland service potential. These methods were used to compare historical service potential to current service potential within each watershed at multiple scales (8, 10, and 12-digit HUCs). The difference between current and historical service provision indicates a functional deficit, which may be interpreted as both ‘watershed needs’ and ‘watershed opportunities.’ Further details are provided below.

> ***Sidebar: info about HUCs***
> - Refer to USGS National Maps; https://water.usgs.gov/GIS/huc.html
> - Add table with #s of the various HUCs in WI, with size ranges; add an example graphic with nested HUCs; how we handled state-line boundaries and developed WHUCs, . .), . . .

WWI Plus: Enhancing the Wisconsin Wetland Inventory

Wisconsin Wetland Inventory data include the size, shape and location of a wetland, and assign a type that describes its vegetation and hydrologic regime (WDNR, 1992). WWI data, considered within the surrounding landscape, is often sufficient for a functional assessment of an individual wetland, but it doesn’t allow assessing wetland services across a watershed, or across any large planning unit.

Landscape level analysis needs an expanded classification of individual wetlands. Other variables, including the positon of the wetland on a 3-D landscape, its connectivity to waterbodies and other wetlands, and the directional flow of water are all characteristics that influence a wetland’s ability and level of effectiveness to perform certain functions. Adding these characteristics as attributes to the traditional WWI wetland types results in an enhanced wetland layer, or WWI Plus.

New attributes describe:

- Landscape position or the relation of a wetland to a waterbody
- Landform or the physical shape of the wetland
- Water flow path, such as inflow, outflow, or through-flow, . . .
- Waterbody type, such as rivers, streams, or lakes

Collectively these new attributes are known as LLWW descriptors, which stands for the first letter in each of the main attributes. USFWS developed dichotomous keys to assign these attributes to mapped wetlands by combining National Wetland Inventory (NWI) maps with other datasets, such as stream flow networks and topography (Tiner, 2011). USFWS also developed regional correlations between the attributes in the enhanced wetland database, or NWIPlus, and several wetland functions (e.g. Tiner, 2003).

This project draws on the USFWS approach beginning with statewide data layers: WWI, the 24K Hydrography Database, and topography based on 30m DEMs. The resolution of our baseline data allowed us to refine and expand earlier Landform and Waterflow Path attributes. In addition, statewide models to identify areas of groundwater discharge (Baker et al., 2003) and entrenched waterways allowed us to add modifiers for some wetlands. Differences between NWI and WWI attributes, such as NWI’s more detailed hydrologic modifiers, required modifying the USFWS methods to develop WWI Plus. Table M-2 lists the LLWW descriptors developed for Wisconsin.

Assignment of the LLWW attributes for each wetland was accomplished by automated GIS-based classifications, and the results were compared to attributes based on field observations at selected wetlands (see Results section).

Again, following the USFWS approach, we developed correlations between the enhanced wetland data and several wetland functions or services. We chose the following five wetland functions based on their importance to people and overall watershed health; the degree to which wetlands, specifically, provide them; and the extent to which we can measure them with available data:

Flood Abatement -- wetlands store excess water due to flood events

Sediment Retention –wetland retain some sediment and nutrients that would otherwise move downstream

Nutrient Transformation – wetlands remove nutrients from the water and convert them into plants, soil, or harmless gas.

Streamflow Maintenance – wetlands contribute water to streams and rivers, especially during dry periods.

Fish and Aquatic Habitat – wetlands support the full life cycle for most fish and aquatic life

Each functional correlation, and how it was used to assign a relative level of functional significance to each wetland, is explained below.

Flood Abatement

Storing floodwater reduces the extent of downstream flooding and lowers flood heights, both of which minimize damage from flooding events. All wetlands store some flood water. Here we identify those wetland types that perform a substantial level of flood abatement. These include wetlands along streams and rivers that can hold excess water until the stream or river can regains its capacity to move this excess water downstream. Wetlands with dense vegetation help to reduce water flow velocity. Ponds that are not artificially drained also provide this function. These depressions collect storm water runoff from adjacent lands, which prevents the water from flooding surrounding areas.

Wetlands of the types listed above are ranked Moderate, rather than High, if they are artificially drained or adjacent to an entrenched stream or river, since they provide flood abatement only during extreme flood events.

Wetlands are excluded if they occur on slopes, and so are unable to retain water; if they lack vegetation; and if they are completely isolated from a stream or river.

<table>
<tr><th>Service Level</th><th>Wetland type Descriptions</th><th>LLWW or DWWI Code Inclusions</th><th>LLWW or DWWI Code Exclusions</th></tr>
<tr><td>High</td><td>Vegetated lentic and lotic wetlands

Island wetlands

Ponds, terrene basin and terrene flat wetlands that have inflow, throughflow, or intermittent throughflow.</td><td>LE***, LR***, LS***

*IL**

PDIN, **PDTH, **PDTI, TEBA*IN, TEBA*TH, TEBA*TI, TEFL*IN, TEFL*TH, TEFL*TI</td><td rowspan="2">*SL, ***IS

TEBA*BI

TEFP*, TEFF*, TEFR*

TEFL*OU, TEFL*OI, TEFL*CI

DWWI Class = F, unvegetated flats</td></tr>
<tr><td>Moderate</td><td>Wetlands with artificial throughflow.

Wetlands associated with an entrenched stream or river.

Terrene basin wetlands with connection intermittent.

Open water wetlands (except Ponds that are ranked "High")</td><td>***TA

****en

TEBA*CI, TEBA*OU, TEBA*OI

DWWI Class = W, open water wetlands</td></tr>
</table>

Sediment & Phosphorous Retention

Sediment and particulate phosphorous are considered together since phosphate ions readily attach to sediment particles suspended in water. Wetland vegetation filters these particles, which then settle out of suspension in slowly moving water. If left undisturbed, the sediment and phosphorous become part of the soil.

The simple mechanical process of sediment removal is most effective in shallow water wetlands since they support dense vegetation in combination with low water flow velocity. Sediment retention increases with the amount of time water remains in the wetland, and with the size of the wetland relative to the inflow rate. Consequently, removal efficiency also increases as the ratio of the wetland area to watershed area increases.

Wetlands ranked High for this service are vegetated, shallow water wetlands able to receive surface water runoff and filter it before discharging to a waterbody. Wetlands ranked Moderate include those lower in the floodplain, where water flow is likely to re-suspend particles; ponds and other open water wetlands; wetlands that are isolated from waterways; and those associated with artificial or entrenched streams.

Wetlands are excluded if they lack surface water inflow, occur on slopes over 5%, or occur within river channels.

Additional factors, which are not part the LLWW assessment, also influence phosphorous retention. Two examples are the wetland soil type and the amount of phosphorus that reaches the wetland. Fine grain mineral soils have more capacity to bind phosphate than sandy soils. Both sediment and phosphorous at high levels can exceed a wetland's retention capacity, lower its effectiveness, and reduce overall wetland quality. These additional factors are considered later in assessing how specific wetlands function.

Service Level	Wetland Type Descriptions	LLWW or DWWI Code Inclusions	LLWW or DWWI Code Exclusions
High	Lentic and lotic basin wetlands having inflow or throughflow intermittent Floodplain wetlands Terrene basin wetlands that have connection intermittent	LEBA*IN, LEBA*TI, LRBA*IN, LRBA*TI, LSBA*IN, LSBA*TI, TEBA*TI *FP** TEBA*CI, LSBA*CI, LRBA*CI	LRIL**, LSIL**, ***OU, ***OI, ***OA, *FR**, *SL**
Moderate	Lentic and lotic basin wetlands having throughflow artificial or throughflow Floodplain Fringe wetlands Lentic and lotic flat wetlands having	LEBA*TA, LRBA*TA, LSBA*TA, LEBA*TH, LRBA*TH, LSBA*TH, *FF** LEFL*TH, LRFL*TH, LSFL*TH, LEFL*TI,	

	throughflow or throughflow intermittent Lentic island wetlands Terrene basin wetlands that are isolated or outflow intermittent All ponds Artificial throughflow wetlands or wetlands associated with an entrenched stream or river	LRFL*TI, LSFL*TI LEIL** TEBA*IS, TEBA*OI **PD1*, **PD2*, **PD3* ***TA, ****en	

Nutrient Transformation (Nitrate & Dissolved Phosphorus)

The most effective wetlands for transforming nitrogen and dissolved phosphorous are those with fluctuating water levels. Where standing water occurs long enough to create anaerobic conditions in the soil, bacteria convert nitrate to harmless nitrogen gas. A fluctuating water table also slows water flow, increases deposition, and promotes nutrient uptake by wetland vegetation. Unlike nitrogen, some phosphorous incorporated into vegetation is released at the end of the growing season as plants senesce, however, some remains in the wetland as plants decompose and add to the soil layer. For both nitrate and dissolved phosphorous, wetlands connected to surface water are in the best landscape positon to reduce nutrient concentrations downstream.

Wetlands are ranked High where they are vegetated and associated with frequent flooding or overbank flow.

Wetlands are ranked Moderate if they are associated with moving water, and consequently have lower retention time than those ranked High; or if they are surrounded by upland, and in a positon to receive nutrients that would otherwise reach a waterway.

Wetlands that lack vegetation, which is essential for nutrient cycling, are excluded. Also excluded are wetlands that have no connection to surface water, or where the wetland/surface water interaction is reduced by hydrologic alterations.

Service Level	Wetland type Descriptions	LLWW or DWWI Code Inclusions	LLWW or DWWI Code Exclusions
High	Vegetated lentic and lotic wetlands that are flat, floodplain, floodplain fringe, or basin	LEFL**, LRFL**, LSFL**, LEFP**, LRFP**, LSFP**, LEFF**, LRFF**, LSFF**, LEBA**, LRBA**, LSBA**	***IS, ****en, ***OA, ***TA

			DWWI Class F, unvegetated flats
Moderate	Fringe wetlands Terrene wetlands	*FR** TE***	

Surface Water Supply (Lakes, Rivers, Streams, & Ponds)

Groundwater discharge sustains water levels in streams, rivers, and lakes during dry periods, which supports aquatic life. Wetlands supply this water where groundwater can flow through the wetland to the waterway. Floodplain wetlands also supply water after storm events by storing water and then slowly releasing it to the waterway once flood waters recede.

Wetlands ranked High for this function include wetlands associated with groundwater discharge, and headwater wetlands, which also have perennial flow to waterways. Headwater wetlands are those adjacent to 1st and 2nd order streams. Wetlands associated with groundwater discharge from the wetland are identified using the DARCY Model (Baker et al., 2003)

Wetlands ranked Moderate are headwater wetlands on intermittent streams, floodplain wetlands, as well as wetlands associated with ponds or lakes that discharge to rivers or streams and that are not already ranked High.

Wetlands that have no outflow to rivers or streams, and non-headwater wetlands with only an intermittent connection are excluded.

Service Level	**Wetland type Descriptions**	**LLWW or DWWI Code Inclusions**	**LLWW or DWWI Code Exclusions**
High	All headwater wetlands except those with an intermittent connection Lentic and lotic wetlands having outflow or throughflow that discharge groundwater.	****hw, not TI LE**OUgw, LE**THgw, LR**OUgw, LR**THgw, LS**OUgw, LS**THgw	***IN, ***IS, ***OI, TE**CI *FL** w/o gw, TEBAOU w/o gw, LSBATH w/o gw

Moderate	Floodplain wetlands. Floodplain fringe wetlands. Fringe wetlands. Terrene wetlands having outflow and that discharge groundwater. Non-headwater wetlands associated with ponds and lakes with throughflow and outflow Headwater wetlands associated with intermittent streams Lentic island, Basins, or Flats with bidirectional flow and groundwater discharge	*FP** *FF** *FR** TE**OUgw **PDTH, **PDOU, **LKTH, **LKOU ***TIhw LEIL*BIgw, LEBA*BIgw, LEFL*BIgw	

Fish & Aquatic Habitat

In addition to fish, aquatic dependent fauna include several turtles, snakes and frogs, muskrat, and many invertebrates, such as dragonflies and mussels. All freshwater species are dependent to some degree on wetlands for part of their life cycle. Fish spawn in marshes bordering lakes, or in riparian forested wetlands during high water in spring, and wetlands are a primary food source for most aquatic species.

Wetlands ranked High are those that are part of, or in close contact with, waterways. These are the shallow water zone of lakes, rivers and stream, and nearby wetlands that are most likely to supply these waterways with the nutrients and organic debris that form the base of the aquatic food web.

Wetlands ranked Moderate are those with artificial or intermittent connections to waterways, and wetlands in the floodplain, but at higher elevations than those ranked High.

Wetlands associated with entrenched rivers and streams, and not hydrologically connected, are excluded.

Service Level	Wetland type Descriptions	LLWW or DWWI Code Inclusions	LLWW or DWWI Code Exclusions
High	Lentic wetlands Fringe wetlands Floodplain fringe wetlands Lotic wetlands with outflow, outflow intermittent, throughflow and throughflow intermittent	LE*** *FR** *FF** LR**OU, LR**OI, LR**TH, LR**TI, LS**OU, LS**OI, LS**TH, LS**TI	****en
Moderate	Lotic wetlands with outflow artificial and throughflow artificial Floodplain wetlands Terrene and lotic basin wetlands with connection intermittent	LR**OA, LR**TA, LS**OA, LS**TA *FP** TEBA*CI, LSBA*CE, LRBA*CI	

4. Assessing sites for wetland service potential (GISRAM)

The relative potential for individual sites to perform each of nine services was determined via a suite of criteria assessed using available spatial data in a GIS environment, referred to as GISRAM. Services assessed include: flood abatement, fish and aquatic habitat, phosphorus retention, sediment retention, nitrogen reduction, surface water supply, shoreline protection, carbon storage, and floristic integrity. Sites were also assessed based on the number of services they are likely to provide at a 'high' or 'very high' level.

Like LLWW, GISRAM relies on remotely sensed data and GIS modeling, and therefore has similar limitations; further assessment and validation in the field is recommended. GISRAM differs from LLWW in considering additional site and context aspects such as soil type, condition of the surrounding landscape, and land-use context. These aspects enhance the ability to compare the relative service potential of individual sites.

Detailed methods for assessing each criterion are presented in Appendix Table M-3, along with underlying rationale for each criterion. This approach is based on methods developed in Rhode Island (Miller and Golet 2001, Golet et al. 2003) and further refined and applied in the Sheboygan River Watershed, Wisconsin (Miller et al. 2009). Criteria were generated from reviews of wetland functional assessment methods developed by Adamus et al. (1991), U.S. Army Corps of Engineers (1995), Miller and Golet (2001), and in consultation with ecologists of partner agencies and organizations.

GISRAM complements, and is informed by, Wisconsin's Rapid Assessment Methodology (WRAM) for wetlands (see "Level 2" of WDNR's assessment methods and tools). These methods have similarities in the types of services assessed and criteria considered for each service. While WRAM may be used to assess the service potential of an individual wetland in the field, GISRAM may be used to comprehensively assess and compare, on a relative basis, all sites across a watershed. WRAM assessments are limited to current wetlands, but GISRAM may also be applied to potentially restorable wetlands. Without a specific restoration plan, however, PRW assessment is limited to criteria that do not involve vegetation type or hydrologic regime.

Ranking sites: Scoring rubric for GISRAM

- For each service at each site, opportunity (O) criteria are combined with Effectiveness (E) criteria to generate scores. The number of O and E criteria answered "yes" is divided by the total possible number of O and E criteria. Scores are then increased by 0.1 for each Social Significance (S) criterion answered "yes."
- For services that increase with wetland size, such as flood abatement, site scores are multiplied by size factors.
- Within each 12-digit HUC, sites were ranked by score quantiles and designated as 'very high,' 'high,' 'moderate,' or 'not applicable' for each service.
- Sites were ranked for their potential to provide multiple services by counting how many of the nine services were provided at a 'very high' or 'high' level.

Using the GIS-RAM Table

The GISRAM criteria developed for each of the nine wetland services are summarized in Appendix Table M-3.

The table headings are explained below:

Code

Each Code identifies a criterion and has three components: the service where the criterion applies; whether the criterion relates to Opportunity, Effectiveness, or Social Significance; and a sequential number.

For example, in the first Code, FA_O1, "FA" indicates the criterion applies to Flood Abatement; "O" indicates the criterion refers to the Opportunity to provide the service; and "1" indicates this criterion is the first in the Opportunity sequence.

Criterion

Brief description of the criterion in terms of relevant ecological factors at a site. A site may refer to a wetland or to a potentially restorable wetland.

For some services, a criterion must be met for a site to provide the service. For example, only wetlands adjacent to waterways can provide shoreline protection. If a service has an essential criterion, it is indicated here in bold. If a service has an essential criterion, and a site does not meet it, the site is not assessed further for this service, and its rank is assigned as Not Applicable.

Rationale

The basis for how the elements of each criterion determine the extent to which a site may provide the service.

Assessment Resource

Some criteria apply to sites that are wetlands and some also apply to sites that are potentially restorable wetland. Assessment Resource identifies the site type(s) where each criterion applies.

Unit of Analysis

A criterion may be based on one of three units of analysis: a polygon; a complex of two or more polygons; or a drainage area or catchment.

Polygon – the unit of analysis is an individual polygon within the WWI or PRW dataset

Complex – the unit of analysis is multiple contiguous wetland or PRW polygons

Catchment – the smallest watershed that includes the assessment resource, a 16-digit Hydrologic Unit

Datasets

Sources and types of data used to determine whether a current or potentially restorable wetland meets the criterion. Table M-1 lists all the datasets used within GISRAM.

GIS-based Criterion

While the rationale for each criterion is based on ecological principles, assessing a site with only remotely sensed data is limited by the types of data available. The GIS-based criterion explains how available data were used to approximate the ecological principles. It also identifies the actual data conditions that determine if a site meets the criterion or not.

The brief table entry is intended to give users, who may not be GIS professionals, a better understanding of how each criterion was applied. It does not provide the detailed GIS process. Many criteria require multiple levels of GIS analysis and model development. One criterion (FA_S1) requires modification of model results based on visual inspection. Appendix M-3 includes the complete GIS analytical process for each criterion in more detail.

5. Assessing sites for wildlife habitat potential (Wildlife Tool)

Many wildlife species require specific habitats and landscape settings, as well as access to a range of additional habitat types seasonally or throughout their life cycle. These factors cannot be readily assessed within GISRAM or LLWW; therefore, the Wildlife Tool was used to rank sites for their relative potential to provide wildlife habitat. Unlike previous applications of the Wildlife Tool, which have focused on species (e.g., Kline et al. 2006, Miller et al. 2012), our statewide application of the Wildlife Tool assesses the potential for wetlands, PRWs, and associated upland habitats to meet the needs of four wildlife guilds:

Forest Interior Guild: Sites were assessed based on their potential to provide habitat for a suite of species that require large forested wetlands or smaller sites embedded within heavily forested landscapes. These include black-and-white warbler, northern waterthrush, and Canada warbler. Associated species are also represented, such as northern flying squirrels.

Shallow Marsh Guild: Sites were assessed based on their potential to provide habitat for American bittern, rails, and blue-winged teal. Adjacent habitats that support these species were also identified (e.g., adjacent upland grasslands provide nesting habitat for teal). Other species associated with this habitat are also represented, e.g., species that require wet meadows.

Open Waters Guild: Sites were assessed based on their potential to provide habitat for terns, grebes, diving ducks, and other species that specialize on open water habitats. Other species associated with this habitat are also represented, e.g., many frogs and aquatic insects.

Shrub Swamp Guild: Sites were assessed based on their potential to provide habitat for species such as willow and alder flycatchers.

These guilds were selected to represent a range of wetland wildlife habitat types. Table M-5, below, shows guild-habitat associations and landscape-scale factors considered and assessed. We developed land cover classes relevant to each guild using several existing statewide datasets: Wiscland 2, Wisconsin Wetland Inventory, WDNR's Reed Canarygrass Cover, and an additional dataset developed to describe roadway corridors (Table M-1). Each landcover class is described in Table M-4.

The first step in developing the Wildlife Tool was to assign a measure of association to each guild-landcover class pair. These associations are listed in Table M-5 based on the following qualitative assessment:

- 3 – primary habitat, essential to most guild members
- 2 – secondary habitat, essential to some aspects of guild members' full-life cycles
- 1 – incidental association between most guild members and cover class, not essential to the full-life cycle
- 0 -- no association between most guild members and the land cover class

Table M-5. Wildlife Habitat Matrix

Land Cover Types		Wildlife Habitat Guilds			
		Open Water	Shallow Marsh	Forest Interior	Shrub Swamp
UPLAND	Urban/Developed, high intensity	0	0	0	0
	Urban/Developed, low intensity	0	0	0	0
	Grasslands and Pasture	0	**2***	0	0
	Forest, evergreen	0	0	1*	0
	Forest, deciduous	0	0	1*	0
	Forest, mixed	0	0	1*	0
	Shrub Land	0	0	0	0
	Cultivated Land	0	0	0	0
LARGE OPEN WATER	Surface Water, rivers	0	1	0	0
	Surface Water, lakes	**3**	1	0	0
WETLAND	Open Water Wetlands	1*	**3**	0	0
	Aquatic Bed/Deep Marsh	**3**	**3**	0	0
	Shallow Marsh <= 5 acres	**2***	**3**	0	0
	Shallow Marsh > 5 acres	**3***	**3**	0	0
	Wetland Meadows	1*	**3**	0	**2***
	Wetland Forest, broad leaved	0	**2#**	**3***	0
	Wetland Forest, coniferous	0	**2#**	**3***	0
	Wetland Forest, mixed	0	**2#**	**3***	0
	Shrub Bog, evergreen	0	0	0	**2#**
	Shrub-carr, deciduous	0	**2#**	**2#**	**3**
	Cultivated flat	0	0	0	0
	Natural flats	0	0	0	0
SPECIAL TYPES	Reed canarygrass	0	1	0	0
	Cattail	**2***	**3**	0	0
	Road corridor	1	1	1	1

*# indicate where spatial criteria are required. These are described below.

For each guild, its association value with a land cover type may rely on its spatial relationship to other land cover types. For example, diving ducks in the Open Water Guild will use a large shallow marsh, only if the marsh is near open water or a deep-water wetland. In Table M-5, these required spatial relationships, or proximity factors, are indicated by an asterisk (*) or a hash-sign (#).

The proximity criteria required to maintain the association values are described below:

Guild	**Asterisk (*)**	**Hash-sign (#)**	**Isolated Habitat due to road corridors**
Open Water	Habitat within 100 m of primary habitat	None	Habitat area > 2 ha
Shallow Marsh	Habitat within 100 m of primary habitat	None	Habitat area > 2 ha
Forest Interior	At least 50% forest cover within 1 km	Habitat is within 100 m of primary habitat	Habitat area > 5 ha
Shrub Swamp	Habitat within 25 m of primary habitat	None	Habitat area > 2 ha

We developed raster-based models for each guild using Table M-5 and the proximity factors. Preliminary results were visually reviewed in selected areas as part of model development. In addition, in selected areas results were compared to known occurrences of wildlife.

Habitat was also ranked for the potential to provide habitat for multiple guilds. For each pixel in the raster dataset, a value of 0-4 was assigned, based on the number of guilds for which the pixel was relevant. For example, a pixel assessed as relevant for 3 of the 4 guilds received a score of 3. All PRWs within 100m of wetlands were considered for their wildlife habitat potential, and received the same score as the associated wetland's 'multiple guilds' score.

6. **Field validation of results from GIS models** (this section under development)

7. **Developing a decision support tool to provide data access to users** (this section under development)

Data Limitations and Considerations

Source data used to develop WWI/PRW Plus and to apply the GISRAM are the primary limiting factor. All wetland mapping has limitations due to scale, photo quality, date of the survey, and the difficulty of photo interpreting certain wetland types. The assessment of services provided by each site is a preliminary one based on additional characteristics also interpreted from remotely sensed data and using best professional judgment to develop assessment criteria.

Such assessments generally have been done in the field, on a case-by-case basis, either by considering observed features or by actual measurement of performance. The preliminary assessments based on remotely sensed information do not seek to replace the need for these field evaluations, which represent the ultimate assessment of wetland services.

For a watershed analysis, however, basin-wide field-derived assessments are not practical, cost-effective, or even possible given access considerations. For watershed planning purposes, a more generalized assessment is worthwhile to identify sites with the potential to provide certain services, especially for those services that depend on many variables or on a site's landscape context. Subsequently, these results can be field-verified to evaluate particular wetlands or potential restoration sites for meeting conservation objectives, or, for regulatory purposes, to assess the potential effects of a project. Additional local data, such as property boundaries, protected lands, or farmland preservation guidelines may also be examined to aid in further evaluations that can supplement the preliminary assessment.

RESULTS *(in progress)*

1. Primary source for results: Wetlands and Watersheds Explorer
2. Example results (find a site vs. evaluate a site results)
3. Statewide/broad-scale observations of trends, issues, and opportunities
4. Field validation
    a. Comparison of LLWW with field-collected data in the Milwaukee River Basin
    b. Comparison of field data with GIS-RAM criteria
    c. Figure: map of field sites
5. Perhaps some other things Tom put into the original draft outline… I'll have to review that

DISCUSSION AND RECOMMENDATIONS *(in progress)*

a. Key Applications for Wetlands and Watershed Explorer
    i. Local Governments -- support for 9 Key Element Plans, natural infrastructure
    ii. Land Trusts -- communicate preservation or restoration value to potential partners and funders
    iii. Compensatory Mitigation Project Sponsors/Regulators – analyze opportunities/support mitigation goals
    iv. Planners-regional planning, parks & open space
    v. Other

b. Conclusions statewide and regionally about conservation opportunities
    i. Wetland Preservation
    ii. Wetland Restoration via re-establishment

c. Climate change considerations– identify items from Patricia's report that apply here
    i. Prioritization of wetlands
    ii. Adaptation strategies

d. Similar Approaches – others doing similar work – describe similarities and differences
    i. St Mary's University / Geospatial Services
        1. Douglas County watersheds, w/ the County, Northflow,…
        2. Marengo River Watershed, w/ DNR
        3. Stockbridge-Munsee
    ii. Michigan DEQ's LLWW Functional Assessment
    iii. Ozaukee County / Andrew Struck's work
    iv. Gary Casper's applications of the Wildlife Tool
    v. Green Bay/Lower Fox Great Lakes AOC
        1. A sister project to *Wetlands by Design*, a partnership of UWGB and TNC titled _______________, is being developed in the Lower Fox River Basin as part of an effort to delist wildlife beneficial use impairments in the Green Bay/Lower Fox Great Lakes Area of Concern (AOC). This project (1) prioritizes wildlife habitats based on their relevance to the AOC and (2) prioritizes wetland restoration opportunities based on their potential to improve water quality for wildlife in the AOC. Lower Fox-specific datasets—field phosphorus levels and tile drainage maps—were used to enhance site rankings for phosphorus reduction.
    vi. Others…

e. Next steps toward advancing methods and implementing on the ground
    i. include wetland re-habilitation opportunities in <u>Wetlands and Watershed Explorer</u>
        1. ditched streams
        2. wetlands with entrenched streams
        3. reed canary grass
    ii. add FQA
    iii. incorporate better data as it becomes available-- higher resolution DEMs, new wetland mapping (scale, within forests, unified with hydro . . .)
    iv. restoration feasibility, site validation/design, …
    v. other

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APPENDICES

Appendix M – Methods Appendices

M-1. Project Datasets (under development)

M-2. LLWW Code Definitions

M-3. GIS Rapid Assessment Methodology (GISRAM)

Appendix X – Feedback from methods reviewers & Wetlands by Design integration/responses (under development)

Appendix Y – Additional resources to implement wetland protection & restoration

(1) Watershed-scale planning & assessment
  (a) TNC/ELI watershed approach handbook
  (b) EPA region 5 wetland supplement…
(2) On-the-ground/field or site-level
  (a) WI Wetlands Association -- restoration guide; ask WWA's input
  (b) …
(3) Funding & technical assistance
  (a) NRCS
  (b) USFWS private lands
(4) Implementation
  (a) What/who to include here?

Tables for Appendix

Table M-1 – Project Datasets (under development)

Layer Name	Data Source	Description	Application
Wisconsin Wetland Inventory (WWI)	Wisconsin DNR http://dnr.wi.gov/topic/wetlands/inventory.html	Wetlands digitized from base maps of 1:24000 or greater. Mapping scale and date vary by county.	LLWW / GISRAM
Potentially Restorable Wetlands (PRW)	Wisconsin DNR Need URL at WDNR, only 2008 listed	Former wetland areas where the current land use can be converted, e.g. agricultural land (2016)	LLWW / GISRAM
WDNR 24K Hydrography Geodatabase	Wisconsin DNR http://dnr.wi.gov/maps/gis/datahydro.html		LLWW / GISRAM
Hydrography 24K Value Added	Wisconsin DNR		

Watershed Boundary Dataset (WBD)	USDA-USGS https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/watersheds/dataset/?cid=nrcs143_021616	Watersheds delineated using USGS topo maps of 1:24000 or greater; accessed _____	LLWW / GISRAM
DARCY Groundwater Movement Model	WDNR [ask Chris for source]	Predicts groundwater recharge / discharge based on soils and topography	LLWW / GISRAM
WI Healthy Watershed Assessment			GISRAM
WI Wind Dataset			GISRAM
. . .			
. . .			
Wiscland 2	Wisconsin DNR http://dnr.wi.gov/maps/gis/datalandcover.html	Landcover data (2016)	GISRAM
SSURGO Soil Surveys	Natural Resources Conservation Service https://websoilsurvey.nrcs.usda.gov/	Digitized from 1:24000 base maps; accessed _____	GISRAM
TIGER Roads		2015	GISRAM
Minor Civil Divisions			GISRAM
		Impaired Waters based 303(d) list (date?)	GISRAM
. . .			

Table M-2. LLWW Code Definitions

LLWW Wetland Code Definitions		
	Code	**Description**
Landscape Position		The relation of the wetland to a water body
Terrene	TE	Not influenced by hydrologic inputs from a stream, river or lake.
Lentic	LE	Adjacent to a lake or within a lake's basin
Lotic River	LR	Periodically flooded by a river (stream order 3 or greater)
Lotic Stream	LS	Periodically flooded by a stream (stream order 2 or less)
Landform		The physical shape of the wetland
Slope	SL	Occurs on a slope >= 5%
Island	IL	Completely surrounded by open water
Fringe	FR	Occurs in the shallow water zone of a permanent stream, river or lake
Floodplain	FP	Occurs on an active alluvial plain along a river or stream
Floodplain Fringe	FF	Encompasses elements of both Fringe and Floodplain
Basin	BA	Occurs in a topographic depression
Flat	FL	Extensive, level wetlands
Waterbody Type		The type of waterbody associated with the wetland
Natural Pond	PD1	Natural waterbody <10 ac
Impounded Pond	PD2	Diked or impounded waterbody <10 ac
Excavated Pond	PD3	Excavated waterbody <10 ac
Natural Lake	LK1	Natural waterbody >10 ac
Dammed Lake	LK2	Dammed waterbody >10 ac
Excavated Lake	LK3	Excavated waterbody >10 ac
Waterflow Path		Waterflow path relative to the wetland
Isolated	IS	Wetland has no obvious surface water connection to other wetlands and waters
Inflow	IN	Receives concentrated surface-water with no outflow
Outflow	OU	Surface-water outflow via natural channels; no channelized inflow
Outflow Intermittent	OI	Surface-water outflow via intermittent channels; no channelized inflow

Outflow Artificial	OA	Surface-water outflow via artificially manipulated or created channels; no channelized inflow
Throughflow	TH	Surface-water inflow and outflow via natural channels
Throughflow Intermittent	TI	Surface-water inflow and outflow via intermittent channels
Throughflow Artificial	TA	Surface-water inflow and outflow via artificially straightened or created channels
Bidirectional	BI	Adjacent to lake; wetland hydrology influenced by changing lake levels
Connection Intermittent	CI	Intermittent unmapped surface connection to a stream, river or lake
Modifiers		
Entrenched	en	A surface-water that is vertically contained within its banks sufficient to reduce its ability to connect with the floodplain
Groundwater	gw	A wetland where groundwater is being discharged or one that receives discharges from an active spring
Headwater	hw	A wetland associated with the origins of a stream such that the wetland contributes baseflow support

Table M-3 GIS Rapid Assessment Methodology (GISRAM)

GIS-RAM: Flood Abatement (FA)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
FA_O1	Site is connected to a lake, stream, or river, OR receives concentrated inflow and/or outflow or is connected through an existing wetland to outflow. **This criterion is necessary to the service.**	Runoff accumulated at a point or channel contributes to more stream flow during storm events. Wetlands connected to streams can help to slow floodwaters.	X	X		X		WWI/PRW Plus	LLWW Functional Significance is High or Moderate = YES
FA_O2	Local topography near a site includes steep slopes.	Steep slopes contribute to rapid runoff and increased stream flow during storm events. Wetlands below these slopes will intercept and slow more stormwater runoff and floodwater.	X	X			X	WWI/PRW, WI DNR 24k VA dataset,	Slopes within the site's catchment exceed the median slope value for the WHUC 10 = YES
FA_O3	Site is in a catchment with high runoff potential	Land cover and soil type in the catchment determine runoff volume.	X	X		X	X	WWI/PRW Plus, WDNR 24K Hydrography Value Added	Site is in a catchment whose runoff Curve Number value exceeds the median Curve Number value for the WHUC 10 = YES
FA_E2	Dominant vegetation of site is dense and persistent	Dense wetland vegetation impedes water flow. Persistent vegetation (e.g. woody plants, robust persistent emergent species) can provide this service even outside of the growing season.	X		X			WWI	Forest, scrub-shrub and persistent emergent marsh wetland types, with modified wetlands (f, g, v and x) excluded = YES
FA_E3	Site is in a topographic depression or floodplain setting	Floodplain wetlands store floodwaters temporarily after storms.	X	X	X			WWI/PRW Plus, Active River Area	Landform = BA, FR, FF, FP, and inside ARA = YES

FA_E4	Internal flow path distance within a site	The longer the flow path within the site, the greater the friction that will slow water movement.	X	X		X		WWI/PRW Plus, WDNR 24K Hydrography Geodatabase	Length of a site's shoreline interface exceeds the WHUC10 non-zero median interface length, with entreched and artifical waterways excluded = YES
FA_E5	Ratio of catchment area to site area	The largest sites, less likely to overflow after a storm, are more effective in storing floodwater.	X	X		X		WWI, WDNR 24K Hydrography Value Added	Wet units that intersect stream/river network used to create the upstream area measures were compared to the area of the catchments above them, wetunits not directly connected to the network were compared to their immediate catchment area. Sites whose ratio is in the most favorable 1/3 of ratios for the WHUC10 = YES
FA_E9	Site is connected to waterways with Strahler Stream Order higher than 2	Wetlands that occur at a lower topographic elevation within the watershed than the contributing uplands will receive more floodwater.	X	X		X		WDNR 24K Hydrography Geodatabase	Stream Order >2 = Yes
FA_S1	Site outflow contributes to downstream developed flood-prone areas	Wetlands that contribute to flood abatement upstream of economically valuable flood-prone areas reduce downstream flood damage.	X	X		X		WWI/PRW Plus, Minor Civil Divisions, Dams, WDNR 24K Hydrography Value Added (HUC-16, topographic network & topology)	Identify all catchments upstream of all of the Cities and Villages in Wisconsin; sites in catchments not upstream of a Dam catagorized with a Potential Hazard of High or Significant = YES.

GIS-RAM: Sediment Retention (SS)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
SS_O1	Site is connected to a surface water directly or through an existing wetland. **This criterion is necessary to the service.**	Wetlands connected to surface water have more opportunity to influence water quality.	X	X		X		WWI/PRW Plus	LLWW Functional Significance is High or Moderate = YES
SS_O2	Lack of vegetated buffer around site	Wetland buffers in natural cover serve as filters for overland flow before it enters wetlands; wetlands lacking such buffers play a larger role in protecting water quality.	X	X	PRW only	WWI only		Wiscland 2	Less that 50% of the landover within 60 m of a site is natural vegetation = YES
SS_O3	Proximity of roadway sediment source to site	Crossing of road right of way over sites and streams; Sediment found on roadways will be washed off during rain events and flow downstream where wetlands are typically located.	X	X		X		WWI/PRW Plus, TIGER Roads (2015)	Wetunit and road within a buffered selection = YES
SS_O4	Predicted Total suspended sediment concentration is high.	Higher runoff volume and velocity is capable of dislodging more sediment as it travels across the landscape resulting in more sediment transport downslope.	X	X		X		Healthy Watershed Assessment, WDNR 24K Hydrography Value Added	Concentration in the complex (area-weighted average of catchment values) exceeds the median concentration for the WHUC 12 = YES
SS_E1	Internal flow path distance within site	The longer the hydrologic path length, the greater the friction provided and this the more effective a wetland is at slowing flow and settling sediment particles. Don't include artificial through flow from NWI + The longer the flow path within the site, the greater the friction that will slow the movement of water and increase its settling ability.	X	X		X		WWI/PRW Plus, WDNR 24K Hydrography Geodatabase	Length of a site's shoreline interface exceeds the WHUC10 non-zero median interface length, with entreched and artifical waterways excluded = YES (Same as FA_E4)

SS_E2	Dominant vegetation of site is dense and persistent	Dense wetland vegetation impedes water flow, causing suspended sediment to settle, even outside of the growing season.	X		X			WWI	Forest, scrub-shrub and persistent emergent marsh wetland types, with modified wetlands (f, g, v and x) excluded = YES (Same as FA_E2)
SS_E3	Site occurs in a topographic depression	Depression wetlands retain water which allows suspended particles to settle.	X	X	X			WWI/PRW Plus	Landform is BA = YES
SS_E4	Ratio of catchment area to site area	Larger wetlands, less likely to overflow, can trap more sediment.	X	X		X		WWI, WDNR 24K Hydrography Value Added	Wet units that intersect stream/river network used to create the upstream area measures were compared to the area of the catchments above them, wetunits not directly connected to the network were compared to their immediate catchment area. Sites whose ratio is in the most favorable 1/3 of ratios for the WHUC10 = YES (Same as FA_E5)
SS_E5	Bank or shoreline upstream or in site is subject to erosion; Stream Power Index (SPI) measures the erosive power of overland flow as a function of local slope and upstream drainage area.	Wetlands or wetlands restored mitigate erosion due to moving water.	X	X	X			USGS - 3D Elevation Program, 10m DEM.	The complex contains an area of SPI(>7) that is greater than the median area of SPI for the WHUC10 = YES

GIS-RAM: Phosphorus Reduction (PR)									
Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
PR_O1	Site is connected to a surface water directly or through an existing wetland. **This criterion is necessary to the service.**	Wetlands connected to surface water have a greater ability to affect water quality.	**X**	**X**	**X**			WWI/PRW Plus	LLWW Functional Significance is High or Moderate = YES
PR_O2	Lack of vegetated buffer around site	Wetland buffers in natural cover serve as filters for overland flow before it enters wetlands; wetlands lacking such buffers play a larger role in protecting water quality.	X	X	WWI, only	PRW, only			Less that 50% of the landover within 60 m of a site is natural vegetation = YES; Same as SS_O2
PR_O4	Stream total phosphorus concentration is high.	Higher phosphorus concentrations in surface waters increases P loading of downstream wetlands.	X	X		X		Healthy Watershed Assessment, WDNR 24K Hydrography Value Added	Concentration in the complex (area-weighted average of catchment values) exceeds the median concentration for the WHUC 12 = YES
PR_O5	High animal unit density	Crop fields near livestock concentrations receive phosphorous as a result of manure spreading.	X	X		X		CAFO permits, Wiscland 2	Site is adjacent to dairy rotation fields that are within 10 miles of a permitted CAFO = YES
PR_O6	Site receives nutrients from a point source	Sites downstream of pollution sources have a greater opportunity to affect water quality than those upstream	X	X		X		WWI, PRW, WDNR 24K Value Added, Wisconsin Pollutant Discharge Elimination System (WPDES) , CAFO permits	Site is on a flowline within a catchment that is downstream of a cathcmernt with a pont source = YES

PR_E2	Dominant vegetation of site is dense and persistent	Dense vegetation slows the flow of water, which increases settling of suspended sediment. During the growing season, dense vegetation also uses dissolved phosphorous for plant growth.	X		X			WWI	Forest, scrub-shrub and persistent emergent marsh wetland types, with modified wetlands (f, g, v and x) excluded = YES; Same as FA_E2
PR_E3	Soil at the site has the capacity to absorb phosphorous.	Fine textured and organic soil types retain more phosphorous than course, sandy soils.	X	X	X			SSURGO Soils	Soil textures of Clay, Clay loam, Sandy clay, Silt, Silt loam, Silty clay, or Silty clay loam within the A or O are prevalent at the site = YES
PR_E4	Site does not have anaerobic conditions	Aerobic conditions increase phosphorous retention in the sediment and the uptake of phosphorus by vegetation	X		X			WWI, SSURGO Soils	Based on the WWI Hydrologic Modifier. Wetland has wet soil (K), or wetland has proplonged standing water (H), but is not formed over organic soil = YES
PR_E5	Site has shallow slope	The lower the slope of a site, the longer it retains water.	X	X		X		USGS - 3D Elevation Program, 10m DEM.	Slope of site is less than the median slope of sites in the WHUC 10 =YES

PR_E6	Ratio of catchment area to site area	The largest sites, less likely to overflow after a storm, are more effective in retaining stormwater runoff, and removing phosphorous either by allowing sediment to settle, or by plant uptake.	X	X		X		WWI, WDNR 24K Hydrography Value Added	Wet units that intersect stream/river network used to create the upstream area measures were compared to the area of the catchments above them, wetunits not directly connected to the network were compared to their immediate catchment area. Sites whose ratio is in the most favorable 1/3 of ratios for the WHUC10 = YES
PR_E8	Site occurs in topographical depression	Depression wetlands retain water longer that sloped or flat wetlands. Longer retention time increases settling of suspended solids and phosphorous uptake.	X	X	X			WWI/PRW Plus	LLWW Landform is BA = YES

GIS-RAM: Nitrogen Reduction (NR)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
NR_O1	Site is connected to a surface water directly or through an existing wetland. **This criterion is necessary to the service.**	Wetlands connected to surface water have a greater ability to affect water quality.	X	X		X		WWI/PRW Plus	LLWW Functional Significance is High or Moderate = YES
NR_O2	Stream nitrate/nitrite concentration is high.	Wetlands with higher levels pollution potential have a greater opportunity to improve water quality than wetlands not receiving such inputs.;	X	X		X		Healthy Watershed Assessment	Concentration in the complex (area-weighted average of catchment values) exceeds the median concentration for the WHUC 12 = YES (Same as PR_O4)

NR_O3	Site receives nutrients from a point source	Sites downstream of pollution sources have a greater opportunity to affect water quality than those upstream	X	X		X		WWI, PRW, WDNR 24K Value Added, Wisconsin Pollutant Discharge Elimination System (WPDES) , CAFO permits	Site is on a flowline within a catchment that is downstream of a cathcmernt with a pont source = YES
NR_O4	High animal unit density	Crop fields near livestock concentrations receive nitrogen as a result of manure spreading.	X	X		X		CAFO permits, Wiscland 2	Site is adjacent to dairy rotation fields that are within 10 miles of a permitted CAFO = YES; Same as PR_O5
NR_E1	Site has seasonally fluctuating water levels	Transforation of nitrate nitrogen to nitrogen gas is most efficient under alternating aerobic and anaerobic conditions.	X	X		X		WWI/PRW Plus	Site is a floodplain wetland (Landform is FR, FF or FP) and not associated with a Lake or Pond = YES
NR_E2	Soil types at the site are rich in carbon	Sites with organic soil types are more effective at denitrification, which depends on the availability of carbon	X	X		X		SSURGO Soils	Soil map units for at least 50% of the area of a site are Histosols = YES; Same as SWS_E3
NR_E3	Dominant vegetation of site is dense and persistent	Dense vegetation slows the flow of water, which increases settling of suspended sediment. During the growing season, dense vegetation also uses nitrogen for plant growth.	X		X			WWI	Forest, scrub-shrub and persistent emergent marsh wetland types, with modified wetlands (f, g, v and x) excluded = YES; Same as FA_E2

GIS-RAM: Surface Water Supply (SWS)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		

SWS_O1	Site is connected to surface waters when baseflow supply is most needed.	Sites that discharge water, even during dry periods, contribute to downstream surface water. Sites with an intermittent connection are typically dry when surface water supply is most needed.	X	X		X		WWI/PRW Plus	LLWW Water Flow Path is not intermittent or isolated = YES
SWS_O2	Site is in a headwater setting	Headwater wetlands are the source of streams.	X	X		X		WWI/PRW Plus	LLWW Headwater modifier is hw = YES
SWS_O3	Site receives groundwater	Wetlands that receive groundwater discharge that water to streams even during dry periods	X	X		X		WWI/PRW Plus	LLWW Groundwater modifier is gw = YES
SWS_E1	Site is in a floodplain setting	Floodplain wetlands supply waterways between storm events by slowly releasing stored water once flood waters recede.	X	X		X		WWI/PRW Plus	LLWW Landscape Position is FP, FF, or FR = YES
SWS_E2	Site is a pond or lake with perennial through flow or outflow	Waterbodies with perennial outflow discharge water downstream	X			X		WWI/PRW Plus	LLWW Waterbody type is Outflow ot Throughflow = YES
SWS_E3	Soil at the site is high in organic material	Organic soils, compared with mineral soils, retain water longer, and release it more slowly, which extends the discharge period.	X	X		X		SSURGO Soils	Soil map units for at least 50% of the area of a site are Histosols = YES
SWS_S1	Site is connected to a stream with impaired baseflow	Streams that are compromised during dry periods by low flow condtions rely on what wetlands remain.	X	X		X		WDNR 24K Hydrography Value Added (Temperature / Flow Model)	Compare the pre-settlement flow with the current annual 90% exceedance flow to represent where baseflow has been depleted. Site's catchment has a the model value less than the median value for the WHUC 12 = YES
SWS_S2	Site's catchment has high capacity wells	Streams that are compromised by groundwater withdrawals are supported by what wetlands remain.	X	X			X	Healthy Watershed Assesment	Site's catchment has groundwater withdrawals greater than the median value for the WHUC12 = YES

GIS-RAM: Shoreline Protection (SP)

Code	Criterion	Rationale	Assessment Resource	Unit of Analysis	Datasets	GIS-based Criterion

			Wetland	PRW	Polygon	Complex	Catchment		
SP_O1	Site is adjacent to or within a river, stream or lake. **This criterion is necessary to the service.**	To protect shorelines, wetlands must be situated along a waterbody.	X	X	X			WWI/PRW Plus, WDNR 24K Hydrography Geodatabase	Site is adjacent to or within 10 m of a river, stream, or lake larger than 10 acres, and does not have an artificial, outflow, or connection intermittent waterflow path outside the floodplain = YES
SP_O2	Site is exposed to a large area of open water	Wetlands along large areas of open water are exposed to wind fetch and dissipate the resulting wave energy.	X	X	X			Wisconsin Wind Dataset, WDNR 24K Hydrography Geodatabase	Developed a model that quantifies the distance of open water from the site along the two most prevailing wind diretions. Model value exceeds the WHUC10 non-zero median = YES
SP_O3	Site connected to a lake used recreationally	Wetlands located on lakes where slow-no-wake protection is limited will mitigate shoreline erosion due to recreational boat activity.	X	X	X			WDNR Lakes	Mississippi River Pools and any Lake larger than 50 acres = YES
SP_E1	Dominant vegetation at the site is dense and persistent.	Banks stabilized by dense root systems are less likely to erode.	X		X			WWI	Forest, scrub-shrub and persistent emergent marsh wetland types, with modified wetlands (f, g, v and x) excluded = YES (Same as FA_E2)
SP_E2	Length of site interface along waterbody connection	The longer the interface between a wetland and a waterbody, the more shoreline protection the wetland provides.	X	X		X		WWI/PRW Plus, WDNR 24K Hydrography Geodatabase	Length of a site's shoreline interface exceeds the WHUC10 non-zero median interface length, with entreched and artifical waterways excluded = YES
SP_S1	Site is located between a developed area and open water	Wetlands that shelter developed areas from shoreline erosion have particular significance.	X	X		X		Wiscland 2	Site meets SP_O1 criterion and is adjacent to urban/developed land cover areas greater than 3600 sq. m = YES

GIS-RAM: Fish & Aquatic Habitat (FAH)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
FAH_O1	Site is connected to a perennial stream or lake. **This criterion is necessary to the service.**	Wetlands connected to perennial surface water have the oportunity to provide fish & aquatic habitat	X	X		X		WWI/PRW Plus	Site is not isolated or entrenched = YES
FAH_E1	Site is inundated in spring	Wetlands flooded in spring provide habitat for reproduction and food chain support	X	X		X		WWI/PRW Plus; Active River Area	Site Landform is BA, FR, FF, or FP and within ARA = YES
FAH_E2	Site is not associated with a waterbody impaired for fish & aquatic life	Viable populations require clean water	X	X		X		Impaired Waters, Clean Water Act 303(d) List	Site is on a waterway not impaired for fish and aquatic life factors (e.g. mercury), or is upstream of an impaired waterway = YES
FAH_E3	Site is accociated with a waterbody bordered by natural landcover	Natural shorelines increase available habitat for fish & aquatic life	X	X		X		Wiscland 2; WDNR 24K Hydrography Geodatabase	Site is adjacent to a waterway whose percent natural cover within 60 meters exceeds the median for the WHUC 12 = YES
FAH_E4	Catchment supports a healthy macroinvertebrate community	Wetlands support the presence of healthy aquatic macroinvertebrates communities	X	X			X	WI Healthy Watershed Assessment	Catchment Macroinvertebrate Index of Biological Integrity (IBI) exceeds the median for the WHUC 12 = YES
FAH_E5	Site is connected to a waterbody with few barriers to fish passage	Wetlands assocaited with barrier-free waterways are more likely to support complete and sustainable populations.	X	X		X		WI Healthy Watershed Assessment	Wetunit associated with waterbody whose Stream Patch Size is greater than the median Stream Patch Size of the WHUC 10 = YES
FAH_S1	Site is associated with a waterbody accessible for public fishing	Wetlands assocaited with waterways accessible to anglers are more likely to benefit the fishing public	X	X		X		WI DNR Lakes/reservoir waterbody dataset	Wetunit is associated with a waterbody that has a public boat landing = YES

GIS-RAM: Carbon Storage (CS)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
CS_E1	Site contains deep peat or muck layers	Peat and muck type soils form when the soilis saturated for much of the growing season, and where buried organic materail decomposes slowly.	X			X		SSURGO Soils	Complex has a soil type within the Histosol Order for at least 50% of its area = YES
CS_E2	Site is dominated by persistent vegetation with high biomass	Carbon storage increases with plant biomass. Plant biomass increases with plant size.	X			X		WWI	Wetlands with trees or shrubs that do not include open water = YES
CS_E4	Site is likely to retain stored carbon	Sites with less water leaving the site lose less material suspended in the water.	X	X		X		WWI Plus	Water Flow Path is Isolated or Inflow = YES

GIS-RAM: Floristic Integrity (FI)

Code	Criterion	Rationale	Assessment Resource		Unit of Analysis			Datasets	GIS-based Criterion
			Wetland	PRW	Polygon	Complex	Catchment		
FI_O1	Site is vegetated. **This criterion is necessary to the service.**	Floristic integrity requires the presnece of vegetation.	X		X			WWI	WWI with current wetcode not Flats or Open Water = YES
FI_O2	Site does not have documented invasives	Wetlands without documented invasive plant species have the potential of higher floristic integrity than those with documented invasions.	X		X			WDNR Invasive Plants Database, WWI	Site is more than 50 m from a documented occurrence of invasive species aassociated with wetlands (reed canarygrass, Phragmites, cattail, purple loosestrife, flowering rush) = YES

FI_O3	Site receives groundwater discharge	Wetlands that receive more groundwater, relative to surface water, tend to receive lower levels of sediment and surface water pollutants that encourgage the spread of invasive plant species.	X			X		WWI Plus	Groundwatermodifier is gw = YES
FI_O4	Dominant landcover near a site is natural vegetation	Natural landcover contributes less to the spread of invasive plant species than does developed or disturbed land.	X				X	Wiscland 2, WWI, WDNR 24K Hydrography Value Added (HUC-16)	Natural landcover within the wetland's catchment exceeds the median valuie for the WHUC 10 = YES
FI_O5	Site not within dispersal zone of invasive plant species	Wetlands outside the dispersal zone of an invasive plant species propagule have less chance to be colonized.	X				X	WDNR Invasive Plants Database, WWI, WDNR 24K Hydrography Value Added (networks)	Lotic or lentic wetlands within catchments with invasive plant species associated with wetlands (reed canarygrass, Phragmites, cattail, purple loosestrife, flowering rush), or within catchments immediately downstream of a catchment with these invasives = YES
FI_O7	Site recognized as high quality plant community	High quality plant communities generally have greater floristic integrity.	X		X			Natural Heritage Inventory, State Natural Areas	Wetlands intersect NHI wetland communities or State Natural Areas = YES
FI_E1	Land cover surrounding the site is dominated by natural vegetation.	Natural land cover around wetlands is a potential barrier to invasive plant species.	X			X		Wiscland2, WWI PRW	Percent natural landcover within 100 m of a sites exceeds the median vlaue for the WHUC 10 = YES