A Framework for a Multi-benefit Functional Assessment of Wetland Restoration Opportunities:

Mullet River, WI Watershed

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ACRONYMS

ASFPM Association of State Floodplain Managers
CCAP Coastal Change Analysis Program
CSC Coastal Services Center
NED National Elevation Dataset
NHD National Hydrography Dataset
NOAA National Oceanic and Atmospheric Administration
NRCS Natural Resources Conservation Service
NSPECT Nonpoint Source Pollution and Erosion Comparison Tool
PRISM PRISM Climate Group, Oregon State University
PRW Potentially Restorable Wetlands
SSURGO Soil Survey Geographic database
TNC The Nature Conservancy
USGS United States Geological Survey
UTM Universal Transverse Mercator
WICCI Wisconsin Climate Change Initiative
WI DNR Wisconsin Department of Natural Resources
ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Agricultural and urban development has resulted in the loss of approximately 41% of the original wetlands in the Mullet River Watershed. If not properly managed, runoff can result in non-point source pollution which is a major contributor of phosphorus to the Mullet River. In addition, the loss of wetlands decreases the natural flood storage ultimately increasing the risks of flooding for communities downstream. However, prior studies have determined nearly 2,320 acres of potentially restorable wetlands (PRW) within the Mullet watershed. Through the development of a replicable wetland multi-benefit functional assessment framework, this study aims to prioritize these PRW sites based on their potential to provide both water quality protection and flood abatement services at a watershed scale.

The Nonpoint Source Pollution and Erosion Comparison Tool (NSPECT) was used to model surface water and phosphorus runoff volumes expected to originate from different landuse scenarios. NSPECT outputs were integrated into a Hot Spot Analysis Tool which identified areas within the watershed that were statistically high contributors of nutrients and runoff and should therefore be prioritized as places that might benefit the most from a wetland’s nutrient capture and flood abatement services. Those results were integrated into a broader assessment to evaluate if a PRW met additional criteria to provide multiple benefits. The assessment determined that of the 2,320 total acres of PRW within the watershed, 243 acres (10.5%) have the potential to provide multiple benefits. These sites were incorporated into NSPECT as a “what-if” scenario to estimate the potential impacts of restoration. The scenario assumed that these sites were restored to fully functioning wetlands, thereby changing the existing landuse and associated runoff values. Results indicated that restoration of these multi-beneficial PRW sites could reduce surface water runoff in several HUC 14 catchments within the Mullet watershed by 1% to 14.4% and could reduce expected phosphorus loads anywhere from 1% to 13.8% in some areas. These results and analysis framework can be applied in three primary ways:

1. Integrate Research into On-Going Projects: The results of this study will be used to inform an ongoing project in the region lead by TNC and partners which aims to target agricultural fields for management of soil and phosphorus loss. The recommendations here can also be combined with the outputs of the 2009 functional assessment of existing wetlands to help inform restoration and conservation opportunities on a broader scale.

2. Education and Planning: The derivative maps will be used as communication tools when reaching out to strengthen partnerships with land owners and other stakeholders. The maps simply and effectively highlight areas that have the potential to provide the most benefits if restored. Combining these visuals with outreach regarding runoff regulations, benefits of wetland restoration, and government funded cost share programs will help to encourage land owners and decision makers to implement wetland restoration projects. These results can also be combined with future development plans to determine areas where significant PRW sites might be negatively impacted. Visualizing this relationship will help stakeholders think about opportunities to direct growth toward already developed areas or integrate these valuable wetlands into a park or open space plan.

3. Additional Research: The framework described here could be adapted to evaluate the effectiveness of other best management practices, like filter strips, riparian buffers, and terracing. Research of this nature is necessary for making informed management decisions, and will ultimately promote better land management overall.
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INTRODUCTION

1. Project Scope

Non-point source pollution does not have a single contributor to be held liable for regulating runoff. Therefore, the responsibility to capture and control non-point source runoff requires a cooperative effort between land owners, municipalities, and other key stakeholders. In 2010, the Wisconsin Administrative Codes regarding allowable phosphorus levels in surface waters as well as the performance standards and prohibitions that farmers must comply with were made more stringent (WI NR 102.06, 2010). These changes have motivated areas within the Sheboygan River watershed to more effectively reduce phosphorus discharge from major non-point source contributors like agricultural fields and urban developments.

One example of how these phosphorous regulations are motivating action at the local level is the City of Plymouth, Wisconsin within the Mullet River Watershed (Figure 1). Located in Sheboygan County just fifteen miles west of Lake Michigan, the city is at the center of a landscape dominated by agriculture (Figure 2). Agricultural and urban development has resulted in the loss of about 41% of the original wetlands in this watershed and the removal of riparian vegetation and stream cover. Of high concern to city officials is the Mullet River, a tributary to the Sheboygan River which flows into Lake Michigan.

The City is interested in identifying locations where wetlands can be restored to trap and filter pollution in upstream tributaries, ultimately helping to reduce pollution issues for Lake Michigan. In addition to improved water quality, city officials are interested in prioritizing restoration sites based on the potential for wetlands to provide additional ecosystem services such as surface water storage and flood risk reduction.

To address these needs, the Association of State Floodplain Managers (ASFPM), The Nature Conservancy (TNC), and NOAA Coastal Services Center (NOAA, CSC), partnered with the Sheboygan County Planning Office and the City of Plymouth to identify priority locations for wetland restoration that have the potential to provide both nutrient capture and flood abatement benefits within the Mullet watershed. This framework was based on the multi-objective management (MOM) approach to coastal landuse planning and management outlined in the ASFPM’s No Adverse Impact (NAI) Toolkit. NAI is an approach to management that emphasizes the “do no harm” principle, by encouraging natural resource managers to anticipate both beneficial and adverse impacts of any management strategy (Mauriello et al., 2007). This case study provides guidance on how others within the region can replicate a similar multi-beneficial functional assessment.
The Mullet River Watershed
Nested in the Sheboygan River Basin

Sheboygan River Basin
Mullet River Watershed

Miles
0  50  100

Wisconsin
Rhineland
Wausau
Stevens Point
Wisconsin Rapids
Marshfield
Reedsburg
Reedsburg
Reedsburg
Reedsburg
Reedsburg
Reedsburg
Reedsburg
This map represents a modified version of the Coastal Change Analysis Program (CCAP) landcover dataset. The CCAP 2010 dataset was updated to include ground validated crop type data provided by partners at the TNC WR chapter. As a result, the modified landcover dataset includes several types that are not normally included in CCAP data.

2. Understanding

The goal of this study was to identify areas where wetlands could be restored with relative ease and to develop a framework for prioritizing them based on their ability to offer multiple ecosystem benefits. The criteria used to prioritize sites for wetland restoration in Sheboygan County based on their potential to reduce flood risks and capture nutrients are broadly outlined as:

a. Wetland Characteristics
b. Potentially Restorable Wetlands
c. Connectivity to the River or Floodplain
d. Precipitation Intensity and Frequency
e. Best Management Practices

a. Wetland Characteristics

Wetlands are defined as areas where water covers the soil, or is present near the surface of the soil either all year or for varying periods of time during the year, including during the growing season. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. The types of functions a wetland can perform include flood abatement, water quality, wildlife habitat, fish habitat, heritage values, floral diversity, and shoreline protection (Figure 3).

Due to their storage capacity and ability to slow the speed of flood waters, wetlands can help reduce the severity of floods and associated damage in downstream areas. The ability of a wetland to reduce downstream flooding depends on its size, position within the watershed, and topography. This study assessed all of these factors when determining which areas have the most likely potential to provide multiple benefits in the Mullet watershed.

A 2011 wetland valuation study in Delaware suggested that the potential cost of replacing the natural nutrient removal services of a healthy wetland with additional municipal water treatment would cost $85 per pound ($188/kg) removed of nitrogen and phosphorus combined. This accumulated to an avoided cost of $9,670,000 for the entire 3,132 acre study area, or approximately $3,080/wetland acre (Delaware Department of Natural Resources and Environmental Control, 2011).

Further making the case for the value that wetlands can provide, the Wisconsin Wetlands Association commissioned a study by Earth Economics (eartheconomics.org) in 2012 that found that Wisconsin’s wetlands are worth between $3.2 billion to $152 billion in benefits every year. Learn more in the Rapid Assessment of the Economic Value of Wisconsin’s Wetlands (Earth Economics, 2012) report.
b. Potentially Restorable Wetlands

Although nearly half of Wisconsin’s original 10 million acres of wetlands have been drained, filled, or developed, not all of that wetland acreage is lost forever. Three basic characteristics are used to determine candidate locations for wetland restoration:

- Soil type that indicates wetlands could have existed there previously (≥ 85% hydric)
- Land not currently mapped as a wetland
- Land currently identified in a use that is compatible with restoration techniques (ag)

For this study, a previously developed Potentially Restorable Wetlands dataset was provided by The Nature Conservancy and was ultimately used as the unit of analysis. For those who are looking for similar data sets, the Wisconsin Department of Natural Resources can typically provide guidance on where to find them.

c. Connectivity to the River or Floodplain

Riverine areas, floodplains, and wetlands are extremely interconnected landscape features. Together, they help to mitigate the effects of agricultural development. Rivers are natural conveyance channels that allow large volumes of water to flow through the landscape. When water levels are high or an extreme precipitation event occurs, floodplains provide critical additional storage for excess water. Populated with resilient vegetation, healthy and functioning floodplains help stabilize soils, capture sediments and nutrients, and slow runoff flow. Wetlands trap surface water, recharge groundwater, and capture and filter nutrients. These landscape features normally exist as a naturally occurring system and often function most efficiently together. As a result, a wetland’s connectivity to a river and its floodplain is a critical factor when determining its ability to function at a high level.

d. Precipitation Intensity and Frequency

For the purpose of this study, data on annual precipitation intensity and frequency was used to determine run-off scenarios. Warmer temperatures expected with climate change will lead to less precipitation falling as snow, and more falling as rain. This increased precipitation combined with land use changes that are more susceptible to run-off like urban developments or agricultural fields can increase pollutants in waterways and exacerbate flooding.

To learn more about these projected changes, Wisconsin Climate Change Initiative (WICCI) scientists have "down-scaled" global climate models to project how Wisconsin’s climate has been changing and how it might change in the years to come (Figure 4).

Preliminary runoff estimations derived from increased precipitation scenarios for the Sheboygan River basin suggest that even small increases in rainfall can have significant impacts on local and downstream accumulated phosphorus loads (WICCI,
e. Regulations and Best Management Practices

Best management practice (BMP) is a general term for an action that has shown to provide soil conservation and water quality benefits (Figure 5). BMPs are voluntary actions, meaning landowners and managers can self-select what practices they would like to employ. With respect to agricultural landscapes, best management practices can be divided into three categories:

I. Avoiding:
Avoiding-type BMPs work to prevent pollution from agricultural development and farming. A few common examples are: crop rotation, contour buffer strips, planting cover crops, and implementing nutrient management practices.

II. Controlling:
Controlling BMPs attempt to control the amount or reduce the risk of pollution from agricultural landscapes. Some examples are: conservation tillage, rotational grazing, terracing, and planting vegetation in riparian areas.

III. Trapping:
Trapping BMPs are designed to capture pollutants near their source in an effort to reduce the extent to which they proliferate a watershed. Some examples are: planting filter strips and field borders, constructing sediment control basins, and restoring wetlands.

The framework described in this case study focused solely on wetland restoration. It should be noted that wetland restoration was the appropriate BMP to analyze for this framework because it provides both ecosystems services that project partners expressed interest in while also providing meaningful results at the watershed scale which coincided with the spatial resolution of the data available. Others that attempt to implement this framework will likely need to alter some of the criteria and data inputs to reflect their specific concerns and the most appropriate BMP to address them.
ANALYSIS

In Sheboygan County, the actions taken to identify priority areas for wetland restoration can be generalized into a 6-step process documented in the work flow below (Figure 6).

![Figure 6. Simplified Project Workflow.](image)

1. Site Selection

a. Community Meetings

The first step in this project was to identify where to focus efforts in Sheboygan County. In early 2013, the project team met with the Sheboygan County planner and other key stakeholders to determine needs, opportunities, challenges, and potential data sources. Based on stakeholder input and previous feasibility analyses (Miller, Wagner & Van Helden, 2009), the City of Plymouth, nested in the Mullet River watershed of the Sheboygan River Basin, was selected as the highest priority area of interest for this study. Through this stakeholder engagement, the team was able to determine the two primary ecosystem services that would be evaluated in the multi-beneficial wetland functional assessment: 1) water quality protection/phosphorus capture and 2) flood abatement.

2. Project Development

a. Literature Review

To help inform what data and decision support tools to implement, the principal investigator conducted a comprehensive literature review of similar studies that aimed to assess wetland functions at the spatial scale of this analysis. This review helped determine the tools and data necessary to best meet the project’s goals. This study ultimately referenced several assessments conducted in the region to inform site-selection metrics and criteria (Hatch & Berenthal, 2008; Miller, Wagner & Van Helden, 2009; Miller, Berenthal, Wagner, Grimm, Casper, and Kline, 2012). These references were used to inform the development of the Wetland Multi-Benefit Functional Assessment Matrix which guided the analysis for this project.
One resource of particular importance was a product from the 2009 assessment, a “Potentially Restorable Wetlands” dataset (PRW) which estimated nearly 2,320 total acres of potentially restorable wetlands within the Mullet watershed. This dataset was used as the baseline on which all other analyses were completed during this study (Figure 7).

The 2009 PRW dataset was selected as the focal unit for this study for several key reasons:

1) the original PRW layer was not prioritized. Instead, it was simply designated as restorable wetlands or destroyed wetlands that are under a “restorable” land use (e.g., agriculture, not developed areas) with hydric soils.

2) this dataset already incorporated ag land which is a known contributor of phosphorus in the Mullet and was identified by the stakeholders as a key land use type to target for nutrient capture.

3) prioritizing the PRW would add value to the 2009 assessment that was completed on existing wetlands as these two datasets could be combined to help inform restoration opportunities on a broader scale.

b. Prioritization Criteria Selection

Also compiled during the data collection process was a matrix of criteria (Tables 2a-d) that were ultimately used to prioritize the PRWs identified in the 2009 dataset. These criteria represent measurable parameters related to the key ecosystem services identified by stakeholders; Flood Abatement and Phosphorous Reduction/Water Quality. These criteria were used to score the level at which each PRW may be able to perform the service from low to exceptional. After the functional scores for each service were tabulated, the size of each PRW site was factored in as a multiplier based on literature that supports that wetland size is directly correlated with the magnitudes of the two services evaluated in this study.

3. Decision Support Tool Selection

a. Evaluate Tools

After criteria were identified for the functional assessment, the principal investigator developed a comparative matrix (Table 1) of various decision support tools that measure the impacts of land use changes on pollutants and runoff. Ultimately, runoff analysis was performed using OpenNSPECT, an open-source Nonpoint Source Pollution and Erosion Comparison Tool (NSPECT). NSPECT was chosen because it is freely downloadable, works best at the scale of this study, is broadly applicable, and has a comprehensive user community.
Table 1. Decision support tool matrix.

<table>
<thead>
<tr>
<th>DECISION SUPPORT TOOL MATRIX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>ARIES (Artificial Intelligence for Ecosystem Services)</td>
</tr>
<tr>
<td>HPP (Habitat Priority Planner)</td>
</tr>
<tr>
<td>ISAT (Impervious Surface Analysis Tool)</td>
</tr>
<tr>
<td>InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)</td>
</tr>
<tr>
<td>N-SPECT (Nonpoint Source Pollution and Erosion Comparison)</td>
</tr>
<tr>
<td>SERVES (Simple and Effective Resource for Valuing Ecosystem Services)</td>
</tr>
<tr>
<td>SPARROW (Spatially Referenced Regressions On Watershed attributes)</td>
</tr>
<tr>
<td>WARMF (Watershed Analysis Risk Management Framework)</td>
</tr>
</tbody>
</table>

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## Table 2a.

### WETLAND MULTI-BENEFIT FUNCTIONAL ASSESSMENT MATRIX

<table>
<thead>
<tr>
<th>UNITS OF ANALYSIS</th>
<th>PARAMETER</th>
<th>CRITERION</th>
<th>RATIONALE</th>
<th>DATASET(S)</th>
<th>ANALYSIS PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Potentially Restorable Wetlands (PRW)</td>
<td>Agricultural lands not currently classified as wetlands and soil has a hydric rating</td>
<td>Restorable wetlands or destroyed wetlands that are under a “restorable” land use (e.g. agriculture, not developed areas). Soils with a hydric rating provide enabling conditions for wetlands.</td>
<td>National Agriculture Statistics Service (NASS) 2007 WI Cropland.</td>
<td>Provided by prior analysis completed by N. Miller, J. Wagner, &amp; N. Van Helden, 2009.</td>
</tr>
<tr>
<td></td>
<td>HUC 14 Catchments</td>
<td>Catchment contains PRW and is completely within the bounds of the study area.</td>
<td>The potential of a PRW to provide certain functions depends on the area that drains into that wetland. HUC 14 catchments provide a proxy for this metric.</td>
<td>National Hydrography Dataset (NHD) Plus Catchments (14-digit)</td>
<td>• Clip to study area</td>
</tr>
</tbody>
</table>

### Table 2b.

### SERVICE 1: FLOOD ABATEMENT

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CRITERION</th>
<th>RATIONALE</th>
<th>DATASET(S)</th>
<th>ANALYSIS PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>Slopes within the PRW site's catchment exceed 15%</td>
<td>Steep slopes contribute to “flashy” conditions during storm events. Wetlands below these slopes can help to desynchronize floods</td>
<td>United States Geological Survey (USGS) 2011 National Elevation Dataset (NED) 30m, NHDPlus Catchments</td>
<td>• Calculate slope percent rise from DEM • Select &gt;15% that intersect with catchments</td>
</tr>
<tr>
<td>Floodplain</td>
<td>PRW is located within either the 500yr or 100yr FEMA designated floodplain</td>
<td>Wetlands in the floodplains of streams temporarily hold water from floods, and then release it back into streams during drier periods.</td>
<td>Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM), PRW</td>
<td>• Select PRW that intersect 100 OR 500 year floodplain polys • Select adjacent polys within 5m until no more are returned</td>
</tr>
<tr>
<td>Reduce Risk to Downstream Developed Areas</td>
<td>PRWs that are upstream and connected to the City of Plymouth (flood prone developed area).</td>
<td>Wetlands that are connected to flood-prone developed areas during periods of high flow are particularly significant in abating peak flows.</td>
<td>Plymouth city limits polygon, NHDPlus Catchments, 24K Hydro, PRW</td>
<td>• Buffer town of Plymouth 5mi and select catchments upstream of the city within buffer • Select 24k hydro flow lines that lead into city and select PRW that intersect selected streams • Select adjacent polys within 5m until no more are returned</td>
</tr>
<tr>
<td>NON-sloped, depressional wetland</td>
<td>PRW not located on slopes &gt;5%</td>
<td>Depressional wetlands can temporarily store floodwater more effectively than sloped wetlands.</td>
<td>Slope grid, PRW</td>
<td>• Extract slopes &gt;5% from slope grid • Select PRWs that do not intersect with slope selection</td>
</tr>
<tr>
<td>Impervious surfaces</td>
<td>&gt;10% of PRW site’s catchment is impervious</td>
<td>Wetlands surrounded by impervious surfaces receive large amounts of runoff, more quickly, during storm events.</td>
<td>National Land Cover Data (NLCD)</td>
<td>• Spatial Stats as Table Spatial Analyst tool</td>
</tr>
<tr>
<td>Parameter</td>
<td>Criterion</td>
<td>Rationale</td>
<td>Dataset(s)</td>
<td>Analysis Process</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Runoff Hotspot (L) expected       | PRW that intersect areas that contribute statistically significant amounts of runoff (L) | Areas expected to contribute to significantly high amounts of surface water runoff in (L) could benefit most from the flood abatement and storage services provided by wetlands. | From modeled expected runoff (L) contribution using NSPECT “locaccum” or local effects runoff grid, PRW | • Convert NSPECT output grid “locaccum” to polygon  
• Run “Optimized Hotspot Analysis” tool  
• Extract scores > 0 (significant HOT spots) and select PRW that intersect  
• Select adjacent polys within 5m until no more are returned |
| Table 2c. Service 2: Phosphorous Reduction / Water Quality |                                                                                           |                                                                                             |                                 |                                                                                                     |
| **Parameter**                     | **Criterion**                                                              | **Rationale**                                                                               | **Dataset(s)**                  | **Analysis Process**                                                                                   |
| Headwater connectivity            | PRW adjacent to headwaters (stream order <=3)                               | Headwater wetlands contribute to surface supplies by discharging groundwater and improving water quality for downstream areas. | 24k Hydro, PRW                  | • Extract stream orders <=3 from 24k Hydro to determine “Headwaters”  
• Intersect PRW and headwaters and select adjacent polygons within 5m until no more are returned |
| Prevented plant                   | PRW adjacent to prevented plant areas (areas where it is repetitively too wet for viable crop planting). | Areas that are repetitively designated as “too wet to farm” have enabling conditions for PRW with no loss in ag production as it is already not viable ag land. | Prevented Plant polygon (provided by J. Nelson), PRW | • Select PRWs that intersect with prevented plant areas  
• Select adjacent polygons within 5m until no more are returned |
| High Phos (mg) contribution areas | PRW that intersect areas that contribute statistically significant amounts of phosphorus (mg) | Areas expected to contribute to significantly high amounts of phosphorus (mg) could benefit most from the nutrient capture services provided by wetlands. | From modeled expected phos (mg) contribution using NSPECT “locconc” or local effects pollutant grid, PRW | • Convert NSPECT output grid “locconc” to polygon  
• Run “Optimized Hotspot Analysis” tool  
• Extract scores > 0 (significant HOT spots) and select PRW that intersect |
| NON-sloped, depressional wetland  | PRW not located on slopes >5%                                              | Depressional wetlands can temporarily store floodwater more effectively than sloped wetlands. | Slope grid, PRW                 | • Extract slopes >5% from slope grid  
• Select PRWs that do not intersect with slope selection |
| impervious surfaces               | >10% of PRW site’s catchment is impervious                                | Wetlands surrounded by impervious surfaces receive large amounts of runoff that may carry salts, pet waste, oils, and other surface pollutants. | National Land Cover Data (NLCD) | • Spatial Stats as Table Spatial Analyst tool                                                                 |
| Row Crop                          | Row crops cover >42% of PRW catchment. (Wang et al., 2008).               | Fertilizers applied to row crops can be a significant source of nitrogen and phosphorus. Areas expected to contribute high amounts of nutrients could benefit most from the nutrient capture services provided by wetlands. | NLCD, NHDPlus Catchments, PRW   | • Extract “rowcrop” from NLCD  
• Calculate percentage of row crop area within each catchment and select where row crop >42%  
• Select PRWs that intersect and select adjacent polygons within 5m until no more are returned |
Table 2d.

<table>
<thead>
<tr>
<th>CUMMULATIVE PRIORITIZED RANK</th>
<th>Quartiles: Low Opportunity / Med / High / Exceptional Opportunity</th>
<th>Cumulative values of the rasters for each parameter for both services.</th>
<th>PRW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland size</td>
<td>Multiplier after functions score cumulated. Value 1 if &lt; 2 acres; value 1.5 if &gt;=2 acres AND &lt;= 10 acres; Value 2 if &gt; 10 acres</td>
<td>Wetland size is directly correlated with magnitudes of these services. Size factors taken from (Miller et al., 2012)</td>
<td>PRW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Calculate the area in acres for each PRW and create a histogram of area values to get the relative size breaks
- Reclass on those values; convert to raster

Remainder of this page intentionally left blank.
4. Analysis

a. OpenNSPECT Runoff Analysis

i. Rainfall Parameters

OpenNSPECT, henceforth referred to as NSPECT, uses landcover, elevation, soil, and rainfall data to estimate the runoff volume, flow direction, and flow accumulation of water and pollutants throughout a watershed. The model assumes all runoff is immediate or “flashy,” thus it does not consider evapotranspiration or ground water percolation. In order to develop the precipitation scenario, the user must determine the amount of rain that must fall in order to produce run-off, as well as the number of days in any given year that run-off might be produced.

The precipitation scenario used here was derived from 30 year annual normals data for Sheboygan County, WI acquired from the National Climatic Data Center database. Excel was used to plot the regression line of the Number of Days vs. each Precipitation Threshold which showed a strong logarithmic relationship. The equation of this trend line provided the equation to calculate the number of days of rainfall exceeding any given rainfall amount.

\[
y = -25.79 \ln(x) + 5.6163
\]

\[
R^2 = 0.9954
\]

![Figure 8. NSPECT base precipitation scenario calculation.](image)

Number of Days = \(-25.79 \times \ln(\text{rainfall amount}) + 5.6163\)

Next, the amount of rain required to produce runoff, or the “initial abstraction (Ia),” was estimated based on the dominate soil and land cover characteristics in the study area. This was accomplished by plotting the distribution of land cover classes within the study area, extracting the runoff curve numbers for each type, and calculating a weighted average to get the average curve number for the area (CN). Once the CN was determined to be 0.70 (or 70 scaled from 0 to 100), the Initial Abstraction was calculated. This is the amount of precipitation that must fall before runoff begins. NSPECT uses the following equation to determine this:

\[\text{Ia} = 0.05 \times ((1000/\text{CN}) - 10)\]

where,

Ia = rainfall in inches,
CN = weighted curve number based on all landcover types in study area, scaled 0 to 100,
0.05 = an empirically derived constant from peer reviewed literature
\[ 0.214 = 0.05 \times \left( \frac{1000}{70} - 10 \right) \]

Using this formula, the initial abstract for this study area was determined to be 0.214 inches. By plugging this value back into the regression equation, we get 46 raining days.

\[ 46 = -25.79 \times \ln(0.214) + 5.616 \]

“Raining days” is defined as the number of days on which there was enough rain to produce runoff. Putting it all together, this means that given the distribution of the 30-year average rainfall in Sheboygan County, precipitation over 0.214” will produce runoff on 46 days in a year. These values in combination with the 30yr normal precipitation PRISM raster grid were used to create the “Baseline” runoff scenario for the NSPECT model (Table 3).

### Table 3. NSPECT Input Datasets.

<table>
<thead>
<tr>
<th>Spatial Dataset</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land Use or Land Cover (30m)</td>
<td>NOAA CCAP 2010 updated with local crop type polygons provided by John Nelson with TNC, W</td>
</tr>
<tr>
<td>• Mullet watershed basins</td>
<td>WI DNR</td>
</tr>
<tr>
<td>• 30 yr climatological average precipitation (30m)</td>
<td>PRISM Model</td>
</tr>
<tr>
<td>• Digital Elevation Model (DEM) (10m aggregated to 30m)</td>
<td>USGS NED</td>
</tr>
<tr>
<td>• K-Factor Grid</td>
<td>NRCS SSURGO Database, “kfact” attribute</td>
</tr>
<tr>
<td>• NRCS Hydrologic Soils Group (A, B, C, D)</td>
<td>NRCS SSURGO Database, “hydgrp” attribute</td>
</tr>
<tr>
<td>• HUC 14 Catchments</td>
<td>NHDPlus</td>
</tr>
<tr>
<td>• Potentially Restorable Wetlands (PRW)</td>
<td>John Wagner, TNC</td>
</tr>
</tbody>
</table>

**Tabular Dataset**

| • Curve Number per land use                          | NRCS Urban Hydrology for Small Watersheds                             |
II. Runoff Parameters

NSPECT provides default runoff curve numbers for each land cover class for Coastal Change Analysis Program (CCAP) datasets. While running the model with these default values can still yield useful results, some of the original CCAP land cover classes and runoff curve values were modified to further calibrate the model to the study area. Table 4 summarizes runoff curve number values and USLE/MUSLE cover factor values used in the NSPECT runoff and phosphorus yield calculations in this project. Curve number values and Cover factors for different CCAP classes and soils groups were based on values recommended by NRCS Urban Hydrology for Small Watersheds. The slope length and gradient factor was determined by NSPECT using a combination of pixel size and average gradient determined using the DEM.

Table 4.

<table>
<thead>
<tr>
<th>NRCS Curve Number and Cover Factor by Modified CCAP Class Name</th>
<th>NRCS Hydrological Soil Group</th>
<th>USLE Cover-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified CCAP Class Name</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>High Intensity Dev</td>
<td>0.89</td>
<td>0.92</td>
</tr>
<tr>
<td>Med Intensity Dev</td>
<td>0.77</td>
<td>0.85</td>
</tr>
<tr>
<td>Low Intensity Dev</td>
<td>0.61</td>
<td>0.75</td>
</tr>
<tr>
<td>Developed Open Space</td>
<td>0.49</td>
<td>0.69</td>
</tr>
<tr>
<td>Row Crops</td>
<td>0.67</td>
<td>0.78</td>
</tr>
<tr>
<td>Pasture/Hay</td>
<td>0.39</td>
<td>0.61</td>
</tr>
<tr>
<td>Grassland</td>
<td>0.3</td>
<td>0.58</td>
</tr>
<tr>
<td>Deciduous Forest</td>
<td>0.3</td>
<td>0.55</td>
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<tr>
<td>Evergreen Forest</td>
<td>0.3</td>
<td>0.55</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>0.3</td>
<td>0.55</td>
</tr>
<tr>
<td>Scrub/Shrub</td>
<td>0.3</td>
<td>0.48</td>
</tr>
<tr>
<td>Palustrine Forested Wetland</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Palustrine Scrub/Shrub Wetland</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Palustrine Emergent Wetland</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unconsolidated Shore</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bare Land/Fallow</td>
<td>0.77</td>
<td>0.86</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Small Grain</td>
<td>0.63</td>
<td>0.75</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>0.58</td>
<td>0.72</td>
</tr>
<tr>
<td>Soybeans</td>
<td>0.58</td>
<td>0.72</td>
</tr>
</tbody>
</table>
III. NSPECT Model Outputs

The NSPECT model also allows for two primary types of runoff and pollution calculations; local effects and accumulated effects. The Local effects method removes the influence of upstream cells from the analysis and estimates the pollutants or runoff that originates from each cell. Whereas the accumulated effects are estimates of the pollutant load delivered to or through a cell. The local effects method was chosen for this project because these outputs make it possible to identify areas within the study area that are potentially high contributors of nutrients and/or runoff and should therefore be prioritized as places that might benefit the most from a wetland’s nutrient capture and flood abatement services (Figure 9).

Output datasets that result from running an NSPECT analysis for local effects include:

- Local runoff grid (liters). This grid displays the volume of runoff from each cell in the analysis area.
- Local pollutant grid (milligrams). This grid displays the amount (mass) of the specified pollutant that is coming off of each cell in the analysis area.
- Local sediment load grid (milligrams). This grid displays the amount of sediment (mass) that is eroding from each cell in the analysis area.

IV. NSPECT Post Processing

All NSPECT outputs are produced as tiffs, which do not inherently have attribute tables. This makes statistics calculation difficult so ModelBuilder was used to convert all raw NSPECT outputs to GRID rasters with attribute tables (see Appendix Figure A for model workflow).

b. Hot Spot Analysis

Although preliminary cluster patterns can often be seen in raw outputs from NSPECT, they are not necessarily statistically significant. Applying ArcMap’s “Optimized Hot Spot Analysis” tool isolates only statistically significant spatial clusters of high values (hot spots) and low values (cold spots) (Figure 10). The tool indicates whether the observed spatial clustering of high or low values is more pronounced than what would be expected in a random distribution of those same values. In this study, only the significantly high values were included in the functional assessment (see Appendix Figure b for model workflow).
c. Raster Calculations

The final step in the data analysis process was to prioritize the PRW sites using the Wetland Multi-Benefit Functional Assessment Matrix outlined in Table 2 to evaluate whether or not a PRW met certain criteria to provide multiple benefits. To meet the objectives of the stakeholders, priority should be given to PRWs that could provide both water quality protection and flood abatement benefits. Priority should also be given to sites that have the potential to provide either or both of these services at exceptional to high levels.

1. Prioritizing sites by individual services

1. Assess wetlands using methods described in Wetland Multi-Benefit Functional Assessment Matrix

2. Calculate a score for each service within each wetland polygon (see Appendix Figure C for model workflow).

   a. For each wetland site, divide the number of criteria that have been met for each service by the total possible number of criteria with scores ranging from 0.0-1.0. For example, if assessments reveal that five of the six criteria have been met for a given wetland, then the probability that the wetland could perform the flood abatement service would be 5 ÷ 6 = 0.83.

3. Multiply scores for services by a size factor (see Appendix Figure C). For flood abatement and water quality protection, the magnitude of service is directly correlated to wetland area. Size factors used in this study were determined by plotting a histogram of the acreage of all PRWs to get relative size breaks. Scores ranged from 0.0-2.0 depending on the previously calculated service score (step 2).

   a. PRW <= 2 ac, factor = 1; b. PRW > 2ac AND <= 10 ac, factor = 1.5; c. PRW > 10 ac, factor = 2

4. Determine level of function for each service, for each wetland unit relative to the other wetlands (Figures 11 and 12).

   a. 1st quantile = exceptional; 2nd quantile = high; 3rd & 4th quantile = moderate to low

Figure 10. Example of Optimized Hotspot Analysis output with only significantly high areas extracted.
II. Prioritizing sites by the total number of services performed

6. For each wetland unit, determine the total number of services that are performed at “exceptional” or “high” levels. For example, a site that scores “high” for one service and “exceptional” for another would receive a score of 2.

7. Generate a map of priority wetlands that could provide multiple benefits at exceptional and/or high levels, color-ramped based on the number of services performed (Figure 13).

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Potential for Wetlands to Provide Water Quality Protection Services
Mullet River Watershed

Map created, June 2014 by
Laura Flessner, NOAA Digital Coast Fellow
Copyright The Nature Conservancy &
The Assoc. of State Floodplain Managers, 2014.

Level of Potential

<table>
<thead>
<tr>
<th>Exceptional (5-6)</th>
<th>High (3-4)</th>
<th>Moderate (1-2)</th>
</tr>
</thead>
</table>

HUC14 Catchments
Plymouth Township

This map represents only "Potentially Restorable Wetlands" (PRW) and does not pertain to existing wetlands. PRW are defined as restorable wetlands or destroyed wetlands that are under a “restorable” land use (e.g., agriculture, not developed areas) with hydric soil characteristics.

The numbers next to each level of potential denote how many criteria for that service were met by each site.
Potential for Wetlands to Provide Flood Abatement Services

Mullet River Watershed

Level of Potential

- Exceptional (5-6)
- High (3-4)
- Moderate (1-2)

HUC14 Catchments
Plymouth Township

Map created, June 2014 by Laura Flessner, NOAA Digital Coast Fellow
Copyright The Nature Conservancy & The Assoc. of State Floodplain Managers, 2014.

This map represents only “Potentially Restorable Wetlands” (PRW) and does not pertain to existing wetlands. PRW are defined as restorable wetlands or destroyed wetlands that are under a “restorable” land use (e.g., agriculture, not developed areas) with hydric soil characteristics.

The numbers next to each level of potential denote how many criteria for that service were met by each site.
PRW Sites that Provide Services at Exceptional or High Levels
Mullet River Watershed

This map represents only "Potentially Restorable Wetlands" (PRW) and does not pertain to existing wetlands. PRW are defined as restorable wetlands or destroyed wetlands that are under a "restorable" land use (e.g., agriculture, not developed areas) with hydric soil characteristics.

PRW that perform multiple services should be prioritized as key restoration opportunities.

Map created, June 2014 by Laura Flessner, NOAA Digital Coast Fellow.
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- Purple: 2 Services
- Red: 1 Service
- White: HUC14 Catchments
- Black: Plymouth Township
5. Restoration Impact Analysis

a. NSPECT Management Scenario

The functional assessment determined that of the approximately 2,320 total acres of potentially restorable wetlands within the Mullet watershed, nearly 1,017 acres (almost 44%) were determined to provide at least one service at a high or exceptional level and 243 acres (about 10.5%) were identified as multi-beneficial. Following the assessment, the PRWs that were identified as having the potential to perform both water quality protection and flood abatement services at high or exceptional levels were incorporated into NSPECT as a “what-if” management scenario to investigate the potential impacts of restoration. This management scenario represented a “best case” restoration situation based on the assumption that all multi-benefit PRW sites were restored to fully functioning wetlands, thereby changing the existing land use and associated curve numbers. Raw NSPECT local effects output grids, or the amount of runoff or pollutant expected to originate from each cell, were aggregated by HUC 14 catchment areas for a more intuitive way to view these results (Figure 14). This was accomplished by performing zonal statistics to sum the runoff values within each HUC 14 basin. The summed data were then normalized based on the size of each catchment by dividing the sum (liters of runoff or mg of phosphorus) expected per catchment by the sum of acres per catchment.

b. Reduction Trends

Results from the PRW management scenario were compared to the base scenario to determine the relative impact in terms of surface water and phosphorus reduction. Catchments that showed a reduction of expected phosphorus or surface water runoff were extracted and symbolized from low to high (Figure 15). The potential percent of reduction per catchment due to restoration was calculated by dividing the amount of reduction by the amount originally expected from the base scenario (Figures 16 and 17). Results indicated that restoration of the multi-benefit PRW sites identified by this study could reduce surface water runoff in several catchments within the Mullet watershed by 1% to 14.4% and could reduce expected phosphorus loads by 1% to 13.8% in some areas. Further investigation showed that the highest reductions in both runoff and phosphorus could be achieved with less than 5 acres of PRW restoration. This analysis can help stakeholders identify where within the Mullet watershed multi-beneficial PRW restoration might have the most significant impact with the smallest land use change requirements (Table 5).

However, it’s important to note NSPECT is not a predictive model. This analysis is meant to be used as an educational tool for stakeholder engagement and to provide a preliminary course filter to help guide research and restoration efforts.
Table 5. Acres of PRW restoration necessary to achieve estimated reduction percentages per catchment.

<table>
<thead>
<tr>
<th>HUC14 Catchment ID</th>
<th>Acres per catchment</th>
<th>% of Potential Runoff Reduction</th>
<th>Acres of PRW Restoration Required to Achieve Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>255</td>
<td>309.4</td>
<td>14.4</td>
<td>3.0</td>
</tr>
<tr>
<td>187</td>
<td>311.0</td>
<td>13.6</td>
<td>3.8</td>
</tr>
<tr>
<td>234</td>
<td>739.0</td>
<td>7.3</td>
<td>0.2</td>
</tr>
<tr>
<td>247</td>
<td>474.6</td>
<td>6.3</td>
<td>4.6</td>
</tr>
<tr>
<td>258</td>
<td>667.9</td>
<td>5.9</td>
<td>12.6</td>
</tr>
<tr>
<td>290</td>
<td>591.0</td>
<td>4.2</td>
<td>19.7</td>
</tr>
<tr>
<td>393</td>
<td>901.2</td>
<td>3.6</td>
<td>0.4</td>
</tr>
<tr>
<td>292</td>
<td>3241.9</td>
<td>3.6</td>
<td>13.9</td>
</tr>
<tr>
<td>233</td>
<td>406.4</td>
<td>2.5</td>
<td>0.2</td>
</tr>
<tr>
<td>411</td>
<td>1250.2</td>
<td>2.0</td>
<td>25.6</td>
</tr>
<tr>
<td>289</td>
<td>2150.5</td>
<td>1.8</td>
<td>22.8</td>
</tr>
<tr>
<td>65</td>
<td>270.3</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>211</td>
<td>1400.8</td>
<td>1.4</td>
<td>2.0</td>
</tr>
<tr>
<td>243</td>
<td>2352.6</td>
<td>1.1</td>
<td>3.8</td>
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<tr>
<td>98</td>
<td>398.9</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>271</td>
<td>2903.2</td>
<td>&lt;1</td>
<td>13.9</td>
</tr>
<tr>
<td>311</td>
<td>374.7</td>
<td>&lt;1</td>
<td>0.9</td>
</tr>
<tr>
<td>254</td>
<td>127.0</td>
<td>&lt;1</td>
<td>33.5</td>
</tr>
<tr>
<td>358</td>
<td>1142.1</td>
<td>&lt;1</td>
<td>3.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HUC14 Catchment ID</th>
<th>Acres per catchment</th>
<th>% of Potential Phos Reduction</th>
<th>Acres of PRW Restoration Required to Achieve Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>255</td>
<td>309.4</td>
<td>13.8</td>
<td>3.0</td>
</tr>
<tr>
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<td>667.9</td>
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<tr>
<td>290</td>
<td>591.0</td>
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<td>2150.5</td>
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<td>270.3</td>
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<tr>
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<td>311</td>
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<td>254</td>
<td>127.0</td>
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<td>33.5</td>
</tr>
<tr>
<td>358</td>
<td>1142.1</td>
<td>&lt;1</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Figure 14

Raw NSPECT Model Outputs
Base Scenario - Local Effects Runoff (L)

Zonal Statistics per HUC 14 Catchment
Base Scenario - Local Effects Runoff (L) per Catchment Acre

Base Scenario - Local Effects Phosphorus (mg)

Base Scenario - Local Effects Phosphorus (mg) per Catchment Acre

Expected Runoff (L)  Expected Phos (mg)
High  Low  High  Low

Plymouth Township Boundary

Map created July 2014 by Laura Flessner, NOAA Digital Coast Fellow.
Copyright The Nature Conservancy & The Assoc. of State Floodplain Managers.
Determining Impacts of Multi-Benefit PRW Restoration

Figure 15
Figure 16

Potential Impacts of Multi-Benefit PRW Restoration on Phosphorus Loads

This map represents the potential impacts of a multi-benefit wetland restoration scenario. This management scenario assumes only those PRW found to have the potential to provide BOTH flood abatement and water quality services are restored to fully functioning wetlands. The bar graphs represent the amount of expected phosphorus runoff per catchment acre under base and restoration scenarios. The percentages above each bar graph indicate the estimated percent that phosphorus might be reduced within each catchment by the PRW restoration scenario.

It should be noted that these are general trends of reduction which were not derived from a predictive model. This map is only meant to be an informative and educational tool to help guide stakeholder engagement and research to address stakeholder needs.
Figure 17

Potential Impacts of Multi-Benefit PRW Restoration on Runoff

This map represents the potential impacts of a multi-benefit wetland restoration scenario. This management scenario assumes only those PRW found to have the potential to provide BOTH flood abatement and water quality services are restored to fully functioning wetlands. The bar graphs represent the amount of expected runoff per catchment under base and restoration scenarios. The percentages above each bar graph indicate the estimated percent that runoff might be reduced within each catchment by the PRW restoration scenario.

It should be noted that these are general trends of reduction which were not derived from a predictive model. This map is only meant to be an informative and educational tool to help guide stakeholder engagement and research needed to address stakeholder needs.
6. Ancillary Analyses

a. Parcel Prioritization

An ancillary analysis was performed to identify parcels in Sheboygan County that intersect with PRW with the potential to provide both flood abatement and water quality protection services at high or exceptional levels. Highlighting these parcels can help to target landowners that should be engaged as the siting of wetland restoration projects in the study area progresses (Figure 18).

b. Future Development

This analysis intended to evaluate potential future development pressure on those most valuable PRW found to have potential to provide multiple benefits. This analysis used the City of Plymouth’s 20 year development growth projections to determine areas where future development pressure may inhibit significant PRW sites. Out of the 1,017 acres of PRW that were found to provide at least one service at a high or exceptional level, 257 acres are located within the boundary of Plymouth, WI. Of that, 197 acres (about 77%) could be potentially threatened by future development expected to occur within the next two decades. It was further determined that 120 acres of those threatened were also identified as multi-beneficial by the assessment. This means that almost 78% (120 out of 154 acres) of the most valuable multi-beneficial PRW located within Plymouth could be potentially threatened by future development. Visualizing this relationship can help stakeholders start considering opportunities to avoid growth to protect valuable PRW (Figure 19).

STRATEGY

The primary goal of this study was to provide a replicable framework that can be used to guide the prioritization of restoration of potentially restorable wetlands (PRWs) at a watershed scale. This study incorporated an open-source runoff model, NSPECT, which is widely available, well documented, and relatively easy to run. Although this study implemented ESRI’s Optimized Hot Spot Analysis Tool, this functionality can be reproduced using various open-source GIS platforms, such as the QGIS\(^2\) cluster analysis tools, for those who might not have access to ESRI software.

The results and framework derived from this functional assessment can be employed in three primary ways: 1. they can be integrated into ongoing projects, 2. they can be used as planning and education tools, and 3. they can act as the foundation for further research.

1. Integrate Research into On-Going Projects

The results of this study will be used to inform an ongoing project in the region lead by TNC and partners which aims to target agricultural fields for management of soil and phosphorus loss. The estimated runoff data from this analysis can be used in combination with outputs of SnapPlus (Soil Nutrient Application Planner), a nutrient management planning software, to produce watershed maps showing those fields most in need of management. The recommended PRW sites identified in this study will provide multi-beneficial management options to help promote landowner buy-in.

\(^2\) QGIS v2.4. http://www.qgis.org/en/site/
As the SnapPlus project progresses, the TNC Wisconsin project team will work closely with Sheboygan County, the City of Plymouth, landowners, and other key stakeholders to discuss how the results of these analyses can be implemented effectively in future assessments, planning, and projects. The recommendations here can also be combined with the outputs of the 2009 functional assessment of existing wetlands to help inform restoration and conservation opportunities on a broader scale.

2. Encourage No Adverse Impact Through Community-Wide Education and Planning

a. Educate

The findings of this research will not bring about any significant reduction in flood risk or nutrient capture if they are never implemented. Stakeholder education is necessary to change behaviors and attitudes towards land use and management. The derivative maps will be used as communications tools when reaching out to strengthen partnerships with land owners and other stakeholders and to educate them on the potential benefits of and ideal locations of priority wetland restoration.

The maps simply and effectively highlight the areas that have the potential to provide the most benefits if restored. Combining these visuals with outreach regarding runoff requirements and regulations, the potential benefits of wetland restoration, and government funded cost share programs for wetland restoration projects will help to encourage land owners and decision makers to voluntarily implement wetland restoration projects.

b. Plan and Manage for Multiple-Objectives

Integrating the findings of this functional assessment into future plans will help to ensure that city planners and other local decision makers are managing the landscape for multiple objectives and maximizing the potential benefits. Specifically, the results found here can be combined with future development plans to explicitly determine areas where significant PRW sites might be negatively impacted. Visualizing this relationship will help stakeholders start thinking about opportunities to avoid growth or perhaps integrate these PRW sites into a park or open space plan.

3. Expand Research to Address Additional Best Management Practices

The primary goal of this study was to provide a replicable framework that can be used to guide the prioritization of restoration of potentially restorable wetlands (PRWs) at a watershed scale. The framework described here could be adapted to evaluate the effectiveness of other best management practices, like filter strips, riparian buffers, and terracing. Going forward, this framework could guide the evaluation of many best management practices and provide insight on their effectiveness. Ultimately, this study helps to clearly demonstrate the value of potentially restorable wetlands and can be used to make a more compelling and informed case for funding, restoration, conservation, and stakeholder engagement in the region. Research of this nature is necessary for making informed management decisions, and will ultimately promote better management overall.
Priority Parcels for Multiple Benefit Wetland Restoration
Sheboygan County, WI Parcels Only

Map created, June 2014 by Laura Flessner, NOAA Digital Coast Fellow
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2013 Sheboygan County Parcels

- Green: For Flood Abatement AND Water Quality
- Yellow: For Flood Abatement
- Blue: For Water Quality
- Light Gray: No Data
- Dark Gray Hatched: HUC14 Catchments
- Black: Plymouth Township

Due to data acquisition constraints, the parcel data represented here only includes Sheboygan County 2013 parcel data. However, it should be noted that some PRW are located slightly to the west in Fond du Lac County.

Green parcels intersect with PRW that perform multiple services and should be prioritized as key wetland restoration opportunities.
Figure 19: Potential Development Pressures on Multi-Beneficial PRW

Current Landuse

Projected Landuse in 20 yrs

Map created, July 2014 by Laura Flesner, NOAA Digital Coast Fellow Copyright The Nature Conservancy & The Assoc. of State Floodplain Managers, 2014.

Of 154 acres of PRW within Plymouth that were identified as multi-beneficial by the assessment, 120 acres (nearly 78%) could be potentially threatened by future development expected to occur within the next two decades.
REFERENCES


Figure A. NSPECT post processing Model Builder schematic. This model iterates through all .tiff files in a given folder and projects, clips, exports as a raster GRID, and builds an attribute table with statistics.
Figure B. Optimized Hot Spot Analysis Model Builder Schematic. This tool requires vector polygon inputs so this model first converts the runoff and phosphorus raster GRIDs to polygons, then runs the Optimized Hot Spot Analysis tool to isolate areas of statistically high runoff and nutrient contribution.
Figure C. Raster Calculation Model Builder Schematic. Add all criteria (indexed 0/1) for each PRW for each service. Service 1 = Flood Abatement; Service 2 = Water Quality. The functional score for each PRW is the number of criteria it meets relative to all of the other PRW. Add a Field "Score" type Float. Calculate Field with the number of criteria met / total number of parameters possible for each service (6 criteria per service). Create a lookup table to store the floating point outputs. Multiply the final score by the appropriate wetland size factor.