Identifying Locations for Best Management Practices in the Middle Fork Whitewater River Sub-Watershed Using the Agricultural Conservation Planning Framework Tool

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Abstract

The goal of the project was to identify potential locations for the implementation of best management practices (BMP) in the Middle Fork Whitewater River Sub-Watershed in Southeast Minnesota. The Agricultural Conservation Planning Framework (ACPF) tool was used to identify areas susceptible to runoff and/or erosion and identify areas to implement BMPs in the form of grassed waterways and contour buffer strips. This project details steps necessary for using a Geographic Information System (GIS) to identify these risk areas by creating assessment matrices. Matrices were created by using the ACPF Watershed Database and the ACPF Toolbox. Watershed data and digital elevation model (DEM) data was used in the ACPF Toolbox to determine land areas more sustainable to runoff and erosion. Areas identified by tools were then compared with aerial imagery to evaluate the number of BMPs found to exist where the ACPF Toolbox predicted at risk land areas to evaluate overall conservation assessment needs in the watershed study area. Results of the project found that in many BMPs already existed in a large number of the higher risk located by the analysis suggesting watershed conservation practices are being utilized. The results can be used by local stakeholders and governments, organizations, and various agencies to better understand watershed needs assessments and build plans for conservation measures.

Introduction

Minnesota is primarily known for its abundance of lakes, but it is also one of the country's main agricultural suppliers ranking sixth in 2017. The state of Minnesota consists of an estimated 87,000 sq. mi. with just over 7,000 sq. mi. of that in the form of water. Water moves and its force can be increased in many ways, especially with Minnesota's extreme weather patterns. The force behind the moving water causes deterioration of land in the form of erosion. Too much water can also cause the land to be oversaturated causing runoff, or streamflow. Surface runoff is a direct result of when rainfall or snowmelt rates exceed infiltration capacity (Brooks, Ffolliott, Gregerson, and DeBano, 2003). With all this water movement, the land is constantly changing over time and there is an impact on the agriculture lands as well. Minnesota's total farmland was calculated at 39,870 sq. mi. in 2017 by the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS). In 1982, NASS started conducting, for the first time, its agricultural census every five years in hopes of allowing individuals to explore trends both national and local. The last census taken in 2017 illustrates that

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the United States has had an 8.8% decrease in total farmlands since 1982. Since 2012, thirty-four states have decreases in acreage of farmlands with an overall 1.6% decrease nationally (USDA, 2017). Minnesota had a decrease of 1.99% in the same five-year time period while also supplying 5% of total U.S. agricultural sales.

Water is not the main source of the decrease in Minnesota's farmland, but its erosive impact can be reduced with proper usage of best management practices (BMPs). To help identify BMPs and needs, the Agricultural Conservation Planning Framework (ACPF) tool was developed. By implementing the use of geographic information systems (GIS), the USDA and the Agricultural Research Service (ARS) created this application to identify potential locations for different types of BMPs (Porter, Tomer, James, Van Horn, and Boomer, 2018). The ACPF Toolbox is currently being used to help local agricultural communities better address their soil and water conservation needs. This may also be summed up with the term water management, meaning the control or movement of water to minimize property damage and loss of life while effectively maximizing water's beneficial usage. Brooks *et al.* (2003) mentions one way to think about watershed management would be to think of it as human activities on a given area of land (the watershed) that have effects on or are affected by water. These activities may present issues in the future regarding the health and stability of the watershed and the surrounding area.

Background

Southeastern Minnesota is located in an area known as the Driftless Area, which encompasses sections of three states. It is a region that is unlike any other zone of the upper Midwest and this is because the 24,000 square miles of the Driftless Area was not impacted by the glaciation during the last ice age. The name Driftless refers to the areas lack of glacial deposits known as "drift." Human occupation in the area extends back to the last ice age, and it has historically been a fertile location for agriculture. The Driftless Area has a very distinct geology because of its history. It is divided into three general landscape units. The first is relatively flat ridges underlain by clay-rich residuum that formed from weathering dolomite bedrock (Juckem, Hunt, Anderson, and Robertson, 2008). The second unit consists of hillslopes with thin soils and built of sand and rock fragments from underlying permeable sandstones (Juckem *et al*., 2008). Lastly the third unit would be valleys and the soil is described as loamy, meaning made up of sand, silt, and clay. The topography supports modern day agricultural needs including organic farms, apple and grape orchards, winemaking, and bee keeping. Corn and soybeans typically dominate the fields here in the Driftless Area and dairy farming remains a popular livelihood for many farming families.

The hydrologic cycle can be defined as the processes and pathways involved in the circulation of water from land and water bodies into the atmosphere and then back. Conservation of mass is a principal that states that inputs such as rainfall, snowmelt and condensation must balance with changes in storage and outputs. This balance, or water budget, is a fundamental concept of hydrology. The hydrologic process effects vegetation and soils and is of particular interest in watershed management. A basic understanding of hydrology is fundamental to the planning and management of renewable natural resources for sustainable use a watershed (Brooks *et al*., 2003).

Soil erosion is the process of dislodgement and transport of particles by the wind and water. Factors that contribute to erosion include climate, topography, soil characteristics, vegetation coverage and land use. Brooks *et al*. (2003) cites that the downstream impacts of erosion depend on the factors that govern sediment transport from watershed surfaces and through the stream channel. The channel system is then forced to adjust to alterations in water flow and the sediment delivery. These channels of rivers and their tributaries are in a constant state of equilibrium and are formed by the flow and sediment over time (Brooks *et al*., 2003). Human activities alter the flow and/or morphology of the stream channels located in a watershed by altering the pace of erosion.

Runoff, or streamflow, results from excess precipitation occurring on watersheds and their stream channels. Brooks *et al.* (2003) state when trying to understand how watershed and stream channel conditions affect streamflow, it is helpful to think in terms of storage and conveyance. Surface runoff is a direct result of when rainfall or snowmelt rates exceed infiltration capacity (Brooks *et al.*, 2003). The rate of infiltration depends on the interaction between three key processes. These include absorption of water into the soil, the storage of water in pore space, and the transmission of water downward through the soil (Ritter, Kochel, and Miller, 2011). These processes suggest that soil moisture is the primary control for runoff because runoff typically occurs when then the soil becomes saturated.

One of the first projects in the Driftless Area that introduced modern agricultural land management practices was conducted in the Coon Creek watershed located in western Wisconsin from 1934 to 1940. It consisted of contour plowing, crop rotation and strip cropping. These practices quickly spread to the rest of the Driftless Area and beyond as agriculturalists noticed improvements in soil and hydrologic conditions (Juckem *et al*., 2008). Conservation practices improved later due to the Conservation Reserve Program (CRP) to reduce erosion. With the implementation of the CRP, conservation practices such as terracing, strip cropping, and reducing tillage led to a reduction in soil erosion rate of nearly 50 % (Mast and Turk, 1999). Agriculturists were paid in exchange for planting permanent vegetation such as various grasses and legumes under the CRP (Mast and Turk, 1999). Since this time, breakthroughs in BMPs have made it easier to control such conditions. BMPs come in many different types depending on what negative impact needs controlled. The three types of BMPs currently in use today are considered vegetative, structural and managerial practices.

For the purpose of the project, suggested vegetative BMPs were only considered, because they are typically used to control erosion and runoff. Specifically contour buffer strips and/or grassed waterways, which can help with the reduction of runoff through which erosion occurs were analyzed. Contour buffer strips are located along topographic contours and used to decrease the length of slopes which allows runoff to accumulate (Porter *et al*., 2018). They are typically strips of perennial vegetation which is sometimes alternated with wider cultivated farming strips (Porter *et al*., 2018). Grassed waterways are seeded with grasses or other suitable vegetation and are positioned to reduce erosion within concentrated flows between hills or along other low-lying areas. Porter *et al.* (2018)

suggests they help in three ways. First, they repress soil detachment by reducing the velocity of the runoff. Secondly, the grassed acts as a protective barrier as it is flattened to prevent gully erosion. Lastly, the root system of the grasses can lead to increased soil strength. Porter *et al*. (2018) also mention grassed waterways are the most common of the BMPs but are under-utilized in the steeper farmed landscapes such as the area selected for the project.

Study Area

The Whitewater River watershed is located in parts of Wabasha, Olmstead, and Winona Counties in southeastern Minnesota. The watershed is then broken down into sub-watersheds. The study area used for the project consisted of the Middle Fork Whitewater River Watershed and is displayed in Figure 1. It is located between Eyota to the southwest, Saint Charles to the southeast, and Elba to the northeast. The area contains Whitewater State Park located in the northeastern portion and consists of 2,700 acres.

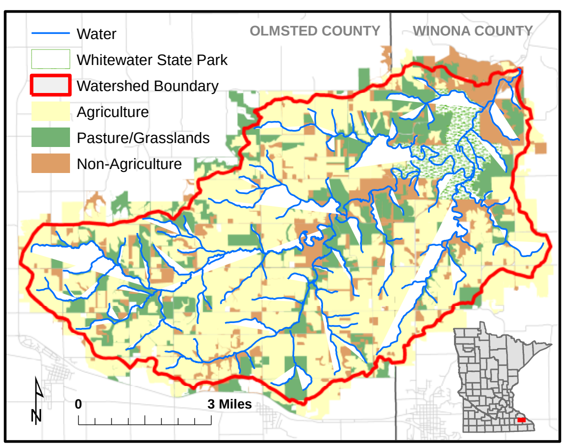

Figure 1. The study area is located in parts of Olmsted, Wabasha and Winona County in SE Minnesota. The Middle Fork Watershed is outlined in red with the actual streams that comprise it in blue. Whitewater State Park is located in the NE section of the watershed. Included is a basic representation of the land use within the study area.

This sub-watershed was selected because of its steep terrain, abundance of agricultural lands, and accessibility for field verification of sites. The total area consists of just under 37,000 acres. The area can be summarized as mostly agricultural with 22,630 total acres mainly in production of corn, sweet corn, and soybeans (Table 1).

Table 1. Itemized breakdown of land use in the Middle Fork watershed. Each category is color coded to its representation in Figure 1.

Agriculture	Total Acres
Corn	21121
Soybean	9998
Sweet Corn	532
Other	444
Pasture/Grasslands	Total Acres
Grasslands	7918
Alfalfa	4013
Other	246
Non-Agriculture	Total Acres
Forested	9553
Developed	2727
Wetlands	152
Barren	27
Open Water	19

Purpose

Increases in human activity and the ever changing climate are causing areas along the flow of water to be susceptible to erosion and/or runoff. With new technology advances, ways of determining these areas are becoming more feasible with added accuracy. The purpose of this project was to use the ACPF Toolbox to identify areas in potential need of BMPs in the Middle Fork Whitewater River Watershed. The product of the tools was a visualization in the form of a map that highlights areas of land at risk of erosion and/or runoff. Specific high-risk fields within the watershed were determined after calculating a risk assessment. Within these areas, analysis was conducted on the suggested BMPs to be implemented. In order to explore overall watershed conservation needs and the effectiveness of the tool, verification of existing BMPs was conducted by the use of aerial imagery or, if accessible, visual confirmation in the field. If a BMP already existed at the location, then one can confirm the accuracy ACPF Toolbox and/or identify areas where a BMP might be considered for additional conservation planning.

Methods

The process of accomplishing the project goals required obtaining the various tools and datasets from multiple sources. One of the key items obtained was the Agricultural Conservation Planning Framework (ACPF) Manual which explained the process and the background processes going on while the tools ran. Once a basic understanding of the concept of the tools was achieved, the tools were then used to locate areas. First the DEM was prepared for the use of the tools. Then a risk assessment of the agricultural fields was developed. This followed with the use of each tool specifically designed for locating sites of both grassed waterways and contour buffer strips. The next step in the process was locating only potential best management practice (BMP) sites within agricultural fields that were deemed "Very High" to "High" risk using the acquired risk assessment. Locations were then observed using aerial imagery or field verification to check if a BMP already exists.

Data/Software

The data used for the project was obtained from the ACPF website and was provided by the USDA. It was located in the ACPF database and is stored in an ArcGIS file geodatabase (FGDB) with a separate FGDB for each HUC12 watershed in the study area. Found within each FGDB, numerous base layers had been developed. These layers include a watershed boundary, 1000 meter buffered watershed boundary, soil data, land-use data, crop history, field boundaries and the USDA NASS Cropland Data (2010-2019). These layers are utilized by the ACPF Toolbox.

Aside from the data provided from the website, a high resolution digital elevation model (DEM) was needed. It is the key data source for many of the tools. It was important to also include enough area in the DEM to allow a 1000 meter buffer to be attached to the watershed boundary. The landscape changes over time and water from various fields may not drain the same direction as they once did. The 1000 meter buffer also allows the tools to reshape the watershed boundary to include added drainage. The DEM was requested from MnTOPO and was received through email. The raw DEM was then run through the first set of tools in the ACPF Toolbox that were designed to prepare the DEM to accurately represent hydraulic flow routing (Porter *et al*., 2018).

In order to run the ACPF Toolbox, certain software needed to be installed. An ArcGIS Desktop version of 10.3 or higher is required. This must include the Spatial Analyst Extension. At the time of the project, ArcMap version 10.7.1 was installed and used. The other software needed is the TauDEM 5.3 Complete Windows Installer. It is a Terrain Analysis package that uses DEMs and was provided at no cost from Utah State University. Once the software was obtained it was uploaded and installed into ArcMap. It was critical to change one geoprocessing setting before working with the data and this was to enable the tools to overwrite the outputs of geoprocessing operations (Porter *et al*., 2018). This mitigates the creation of many outputs from running the same tool with different parameters.

DEM Preparation

The DEM was processed through the D8 Terrain Processing Tool in order to create a filled DEM to calculate the flow accumulation and direction. A flowpath was determined and impeded flows were identified using the Identify Impeded Flow Tool; the output consisted of a depth raster which showed the depth of the backed-up flow (Figure 2). The impediments can be caused by either depressions or false impoundments located on the DEM. Flowpaths that enter a depression located on the DEM simply stop because of no lower elevation for which to travel. False impoundments are typically located on the upslope of bridges and roadways where the tools do not understand water flows under or through culverts (Porter *et al*., 2018).

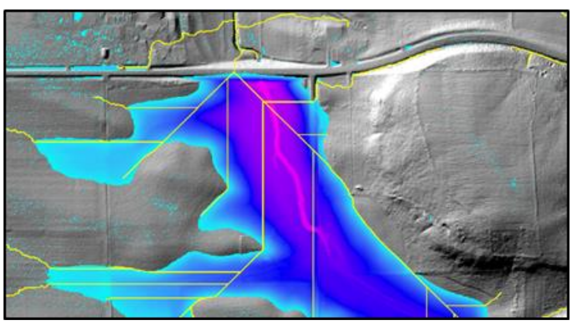

Figure 2. Impeded flow represented by a depth raster created by the Identify Impeded Flow Tool. Flowpath represented in yellow.

The layer created was then updated or fixed by redirecting the flow by cutting into the actual DEM using the Manual Cutter Tool to allow the water to flow under roads or natural features where culverts can be viewed via imagery as seen in Figure 3a and 3b. This same cycle was then processed again until the impeded flows were corrected allowing the future tools to produce more accurate results. After the third run of the cycle, the flowpath was corrected with minimal impeded flows therefor creating a more accurate flowpath.

Figure 3a. Aerial imagery obtained from Google Earth to verify culverts allowing water to flow under roads.

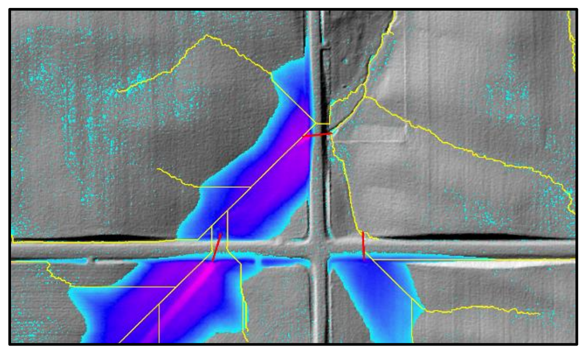

Figure 3b. Impeded flows corrected using the Manual Cutter Tool. The cuts represented in red are then cut into the DEM allowing the flowpath to natural flow through the obstruction. Once ran, the flowpath in yellow will follow the cut lines.

Risk Assessment

With an accurate flowpath determined, the next step was to determine the flow accumulation along the new flowpath. The method chosen for this process was the Area Threshold Tool which applies the area of upstream drainage to a flow accumulation grid. The tool determined this by assigning a value of “NODATA” to grid cells below the threshold and a “1” to those above. The polyline flow network was then created using ESRI’s Stream to

Feature Tool.

The flow network polyline was then reclassified to determine the stream type for each flow segment. In this process streams are either considered perennial or intermittent. This step focused on delineating perennial streams which are important because they define the location of riparian areas. Riparian areas are transitional zones between terrestrial and aquatic ecosystems that are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands (National Research Council, 2002). This step is considered critical in the upcoming risk assessment because it is based on the proximity of the agricultural fields to only the perennial channels, rather than the ephemeral channels (Porter *et al*., 2018).

The perennial flow line was used to then create a stream reach polyline by using the TauDEM software. Also included within TauDEM is the Distance to Stream Tool which uses the stream reach and flow direction to calculate the downward horizontal distance from each grid cell to the channel (Porter *et al*., 2018). The stream reach polyline was then converted into a raster and is the key input for ranking fields in the risk assessment.

The final input needed for the risk assessment is to determine the slopes of the individual fields. The By-Field Slope Statistics Tool generates two outputs: a slope raster and a slope table. These statistics, located in the table, provide information to identify the extent of tile drained fields in the watershed, the relative risk of runoff among fields, and identify fields suitable for runoff control practices such as grassed waterways and contour buffer strips (Porter *et al*., 2018).

The Runoff Risk Assessment Tool was then used to determine areas at "High Risk" of direct runoff (Figure 4). It used the slope table joined to the field boundary feature class and the distance to stream outputs. It cross classifies agricultural fields according the slope and the distance from the stream to determine the risk of runoff (Figure 5). The risk assessment classifies a field at high risk when it is located on steeper slopes near a stream. A low risk field location would be located in an area where runoff practices are not

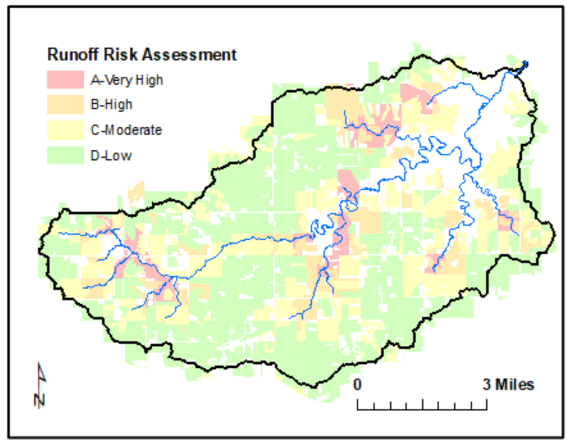

Figure 4. Runoff risk assessment of the Middle Fork Whitewater River watershed. Only areas in red were used to determine existing and new BMP site locations.

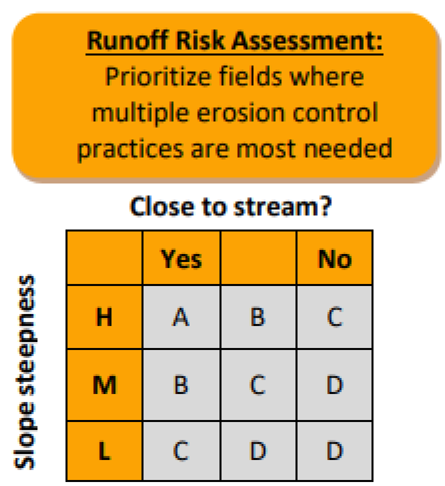

Figure 5. Runoff risk assessment matrix used to determine areas of high risk of direct runoff (Tomer *et al*., 2015).

needed such as a gradual slope far from a stream (Tomer, Porter, Boomer, James, Kostel, Helmers, Isenhart, and McLellan, 2015).

Best Management Practice Siting

With the areas of known high risk runoff identified, the last method in the process was to determine the potential location sites of our chosen BMPs. The two factors the project was looking to manage were soil erosion and runoff of water within agricultural fields. For the purpose of this project and because of the area's size and terrain, grassed waterways and contour buffer strips were selected for BMPs. Each practice had a unique ACPF tool designed to determine these sites.

The tool used for this process of determining areas was the Grassed Waterways Tool. It incorporates a user-defined threshold with a stream power index (SPI) raster. The SPI is a measurement of the erosive power of flowing water (Porter *et al*., 2018). Higher SPI values indicate greater erosive power. It is determined by the following equation, which was obtained from the ACPF Manual produced by Porter *et al.* (2018).

$$SPI = \ln (SCA * \tan \beta)$$

SCA = Specific Catchment Area
β = slope in degrees

For the tool to run, it required the inputs of the calculated SPI raster, the field boundaries, and the created stream. As for the user-decided input, the default of the standard deviation threshold was set at three but was suggested to be increased to the threshold of four to limit the potential sites and only show best suited locations. This then produced an output of the best locations for the installation of grassed waterways (Figure 6).

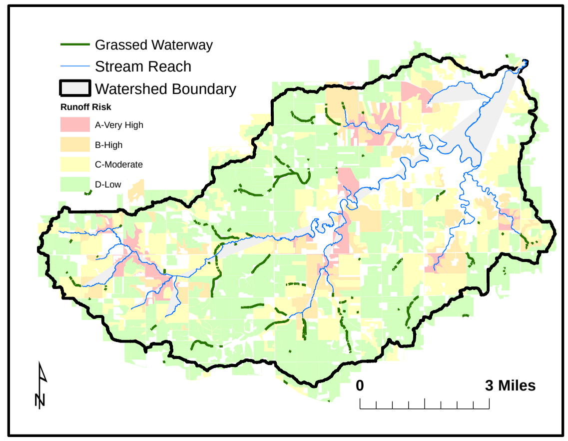

Figure 6. Locations of potential grassed waterway sites overlain on the risk assessment. Key areas of interest will be Very High (red) to High (orange).

The alternative practice for limiting runoff and erosion were the contour buffer strips. The Contour Buffer Strips Tool specifically only runs in areas deemed agricultural based on the field boundary layer. The required inputs were the field boundary layer, slope raster, slope table, DEM, and the D8 Flow Accumulation raster. The user can then choose the z-factor, which is 1 (based on the vertical units of the DEM which is in meters) and the buffer strip width of 15 feet which is the required minimum distance for grasses (30 feet for legumes) as reported by the USDA in a Contour Buffer Strips Factsheet from 2011.

When run, the tool generates a mask of 4-15% slope. Then contours are created for the individual fields where they are based off intervals specifically determined by the slope. Then flowpaths larger than two acres in drainage are removed from the output. This results in contour buffer strips not being sited through concentrated flow pathways, but are rerouted on the sides flanking the drainage ways (Porter *et al.*, 2018). Only contours greater than 100 meters in length are then added with the buffer interval width of 15 feet (Porter *et al.*, 2018). The buffer strips are then smoothed out using a

PAEK (Polynomial Approximation with Exponential Kernel) algorithm which removes sharp angles better for farming operations (Porter *et al*., 2018). The tool however failed during processing. It was suggested to try running the tool through ArcPro, which solved the issue. The potential sites for contour buffer striping suggested by the tools can be viewed in Figure 7.

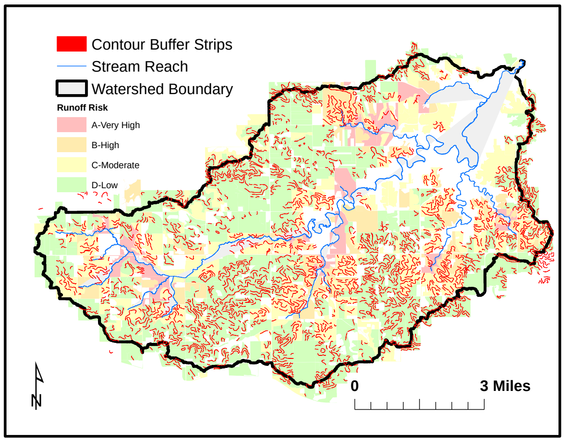

Figure 7. Locations of potential contour buffer strip sites overlain on the risk assessment. Key areas of interest will be Very High (red) to High (orange).

Best Management Practice Site Verification

Once the potential site locations for both the grassed waterways and the contour buffer strips were discovered, only the sites located in a "Very High" or "High" risk area were used in the analysis. This was accomplished by exporting only the higher risk field boundaries and preforming a search by location to select the desired contour buffer strips. Contour buffer strips that were mostly located outside of the higher risk areas were manually removed. The remaining contour buffer strips were then exported into a new feature class for analysis.

The feature class for both the grassed waterways and the contour buffers strips was at first compared to images located on Google Earth. It would be later determined that the imagery used for comparison was from 2015. There were also spots in the imagery that contained cloud cover at some point, but had been replaced with a standard repeating texture of a field. At this point high definition orthoimagry was downloaded from the Minnesota Geospatial Commons website. It was acquired in 2019 and was taken during the agricultural growing season. With the newly acquired imagery the sites were determined to either already have a BMP present or to be a potential site for implementation. There were some sites that could not be determined during this process and were traveled to for field verification.

Summary

The methodology portion of this project consisted of obtaining specialized tools and properly installing them. Data was acquired from the USDA and used in the process of determining the locations of BMPs or potential sites. The manual was downloaded and was thoroughly reviewed in order to accurately locate these sites. A DEM was prepped and cleaned for there to be accurate flowpaths. The flowpaths and the coinciding agricultural fields were then used to determine a runoff risk assessment determined by the matrix built into the tool created by Tomer *et al.* (2015). Once the area of interest was established, two separate tools were used to identify potential sites for grassed waterways and contour buffer strips. The sites located within the higher risk areas were exported out into a new feature class and were verified to either already have a BMP in place or be a location for a future BMP site. Some road-side verification was used in the field to verify sites undeterminable through the areal imagery.

Results

With the use of aerial imagery and some excursions out to certain areas of interest, the final product consists of maps showing the results of the analysis. They depict the sites located within higher risk areas of runoff where best management practices (BMP) in the form of grassed waterways or contour buffer strips may be implemented. As mentioned in the methods section, potential sites were attributed to whether or not there was already a BMP in place. This process of manually determining the existing BMPs proved rather difficult when it came to the contour buffer strips (Image 1). As for the grassed waterways (Image 2), it was fairly easy to distinguish the already existing vegetative feature with the use of the imagery.

Image 1. Contour buffer strip near the intersection of Rt. 39 and Rt. 108 north of Saint Charles in one of the high risk fields.

Image 2. Grassed waterway along 10th St SE just north of Saint Charles in one of the high risk fields.

Grassed Waterways

Through the use of the Agricultural Conservation Planning Framework (ACPF) Toolbox, there were twenty sites determined to be potential locations of grassed waterways within the Middle Fork Whitewater River watershed. These sites were also limited to only areas presumed to be “Very High” or “High” risk from the Runoff Risk Assessment Tool. Of the 20 sites, 19 were determined to already have a grassed waterway implemented leaving one site for implementing the BMP (Table 2). An example of an already existing grassed waterway that aligns with the results of the tools can be viewed in Figure 8. Figure 8 shows that the projected site determined by the toolset aligns perfectly over the already existing grassed waterway. This in fact was true for all 19 of the determined grassed waterway sites.

Table 2. Results of the ACPF Toolbox. It determined one location that would be an acceptable site for a grassed waterway.

Middle Fork Whitewater River Proposed Grassed Waterway Sites	
Total Grassed Waterway Sites	183
High Risk Waterways Sites	20
Sites Without Existing Waterway	1

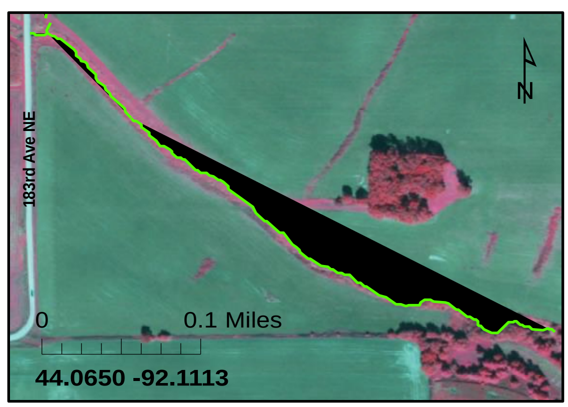

Figure 8. Example of a grassed waterway (green) site determined by the ACPF Toolbox that matched up with an already existing grassed waterway.

The location of the singled out grassed waterway without an already existing waterway is located to the east of 190th Ave NE in Saint Charles (Figure 9). The proposed location was actually located within a tree line along a field boundary. Technically, it was not located on an existing traditional grassed waterway, so it was not included in the existing grassed waterway count.

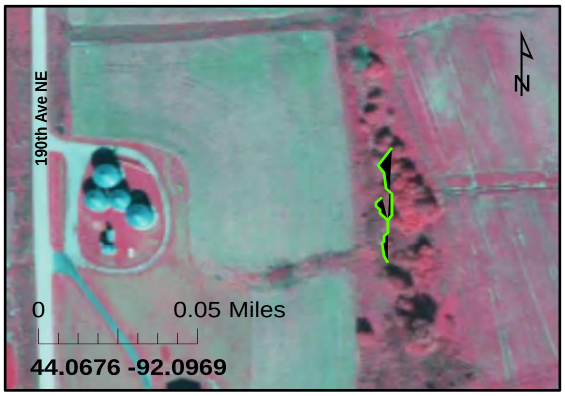

Figure 9. The single location that did not line up with an existing grassed waterway. This was excluded because it was proposed within a tree line. The proposed site appears in green.

The results of the Grassed Waterways Tool were confirmed 95% of the potential sites already contained implementation of grassed waterways. It is also noteworthy to mention that there were another 163 potential sites located outside of higher runoff risk areas. These sites were not verified to contain a grassed waterway, but may present additional sites for conservation efforts to resolve the negative impact of runoff before sites progress to high risk areas.

Contour Buffer Strips

Unlike grassed waterways, contour buffer strips can be placed anywhere along the slope of an agricultural field. Grassed waterways tend to be located in-between hills, which means there is typically a required location to place them. Contour buffer strips are most suitable along uniformed slopes ranging from 4-8 % but can also be used along stepper slopes such as the higher risk locations identified by the tools (USDA, 2011). It was also suggested that the width should be a minimum of 15 feet. Therefore, the current location of this particular BMP may vary arbitrarily from the suggested location based on the ACPF Toolbox.

The results of the Contour Buffer Strip Tool indicated 2,085 potential sites for implementing contour buffer strips. That was narrowed down by exporting out only the locations within a “Very High” to “High” runoff risk area. This brought the number down to a feasible amount of 201 that could be verified either from the aerial imagery or from the field. This however did not go as planned. It became rather difficult to establish whether or not a contour buffer strip was implemented through the imagery and even more difficult from the road-side verification. Another issue that affected the results was that the contour buffer strips tended to be clustered in areas. An example can be seen in Figure 10 showing the clustering located within a “High” risk field. If a contour buffer strip was implemented at each suggested site, there would be minimal space for actual agricultural growth. It was at this point a new method was developed to help identify locations in need of contour buffer striping. This was accomplished by diving the higher risk areas into their individual fields.

The fields that contained suggested sites were selected and exported into a new feature class. They were then scanned for the presence of existing contour buffer strips. If one existed within the field it would be determined to already have the BMP implemented. Under the new method, interest shifted toward finding agriculture fields among the higher risk areas where suggested contour buffer strips were suggested but not currently being implemented.

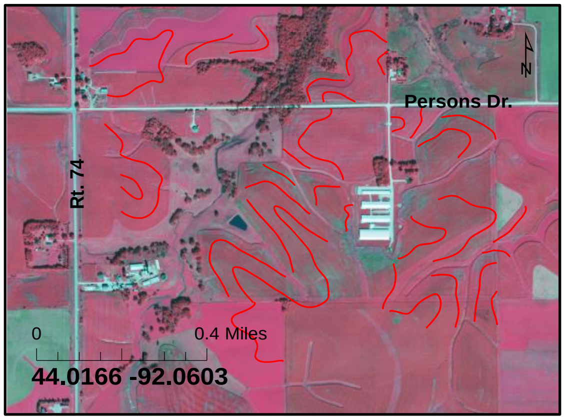

Figure 10. A cluster of contour buffer strips (red) located near the intersection of Persons Dr. and Rt. 74 all within "High" runoff risk assessment agricultural fields.

Under the new method, 32 fields were now contained in the new feature class. These fields were assessed as "Very High" to "High" runoff risk from the assessment. These fields also contain the clusters of the remaining 201 contour buffer strips previously selected from the original method. Using the aerial imagery, the fields were attributed as already containing contour buffer strips somewhere near the vicinity of the proposed site (or sites) or no existing contour buffer strip within the field boundary.

A few of the proposed contour buffer strips actually matched up exactly to the current implemented BMP and an example can be viewed in Figure 11. However most proposed sites contained at least one current contour buffer strip within the field (Figure 12). The results of the analysis show that of the 32 higher risk fields, 14 agricultural fields already implement contour buffer strips to combat runoff and/or erosion. This resulted in 18 fields where contour buffer strips may be implemented to reduce the negative impact of runoff and/or erosion (Table 3).

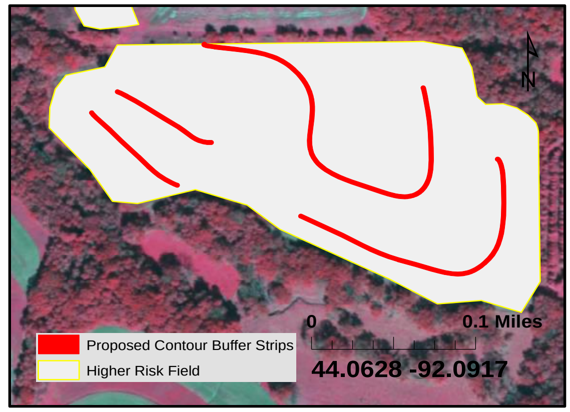

Figure 11. Higher risk assessed field (yellow) containing contour buffer strips represented in red. An example of one of the fields where the proposed strips match up exactly along the already implemented contour buffer strips.

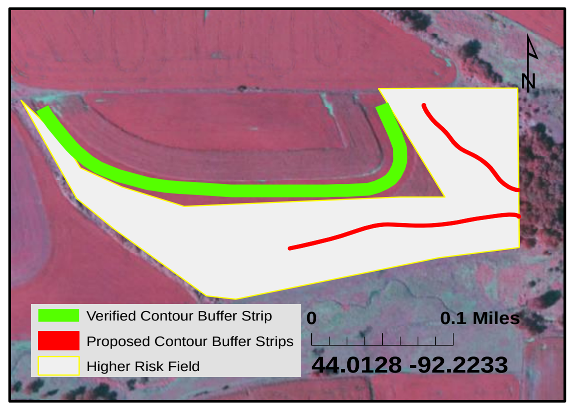

Figure 12. Higher risk assessed field (yellow) containing contour buffer strips represented in red. The proposed sites do not match up with the verified implemented contour buffer strip (green) which borders the field to the north. This was included into the total fields with contour buffer strips because sections are within the field provided from the ACPF Database.

Table 3. Results of the ACPF Toolbox and the Contour Buffer Strips Tool. It determined eighteen fields that could benefit from the implantation of contour buffer strips.

Middle Fork Whitewater River Proposed Contour Buffer Strip Sites	
Total Contour Buffer Strip Sites	2,085
High Risk Contour Buffer Strip Sites	201
Total Agricultural Fields	1,062
Total High Risk Agricultural Fields Containing Proposed Sites	32
Fields Containing Proposed Sites Without Contour Buffer Strips	18

Summary

In order to the narrow down the number of sites to verify, it was decided to limit the potential locations of BMPs to only fields declared “Very High” or “High” risk based on the runoff risk assessment. The results of the grassed waterways showed that 19 of the 20 potential locations already had a BMP implemented. The lone location was located within a tree line and determined to not be an implemented grassed waterway by definition. This area is protecting the soils in other ways, i.e., from the wind, and probably should not be removed for the implementation of the lone grassed waterway.

The narrowing down of the contour buffer strips had to be done in order to make the project feasible. Over 2,000 potential contour buffer strip locations were created with the use of the tool. The amount was then narrowed down further to only look at the actual agricultural fields where the contour buffer strips were proposed. Of those 32 fields, 18 did not contain any sign of contour buffer strips. The following map shows the location of the 18 higher risk fields where the ACPF Toolbox has suggested further research into contour buffer strips for better water and soil conservation within the Middle Fork Whitewater River watershed (Figure 13).

Discussion

The results of the Agricultural Conservation Planning Framework (ACPF) Grassed Waterways Tool performed well in terms of identifying grassed waterway areas and areas in need of grassed waterway best management practices (BMP). From a watershed assessment perspective, at 95% of the proposed sites, a grassed waterway was

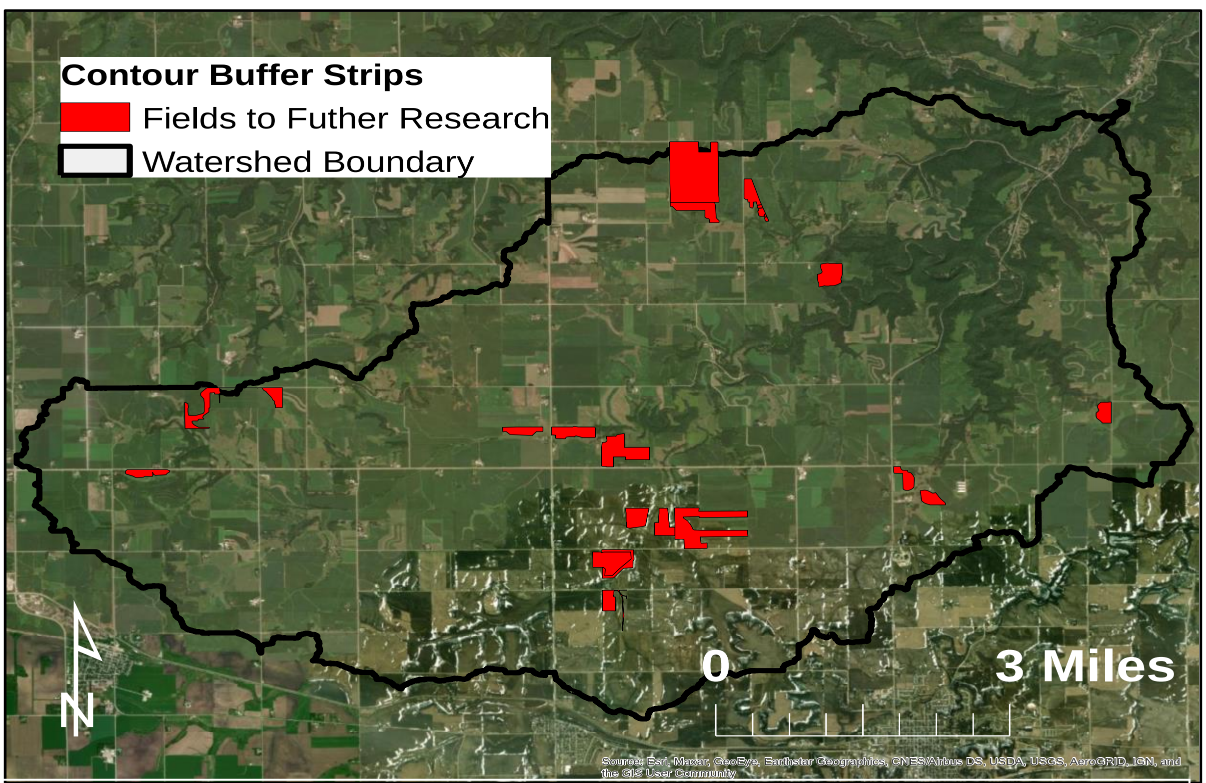

Figure 13. Locations of fields that may benefit from contour buffer strips presented in red.

already implemented. This shows that landowners over the years have been working towards a goal of maintaining good soil and water conservation.

The Contour Buffer Strip Tool found 56% of the proposed fields existing with current BMPs already implemented. This means the watershed could be focusing on additional areas suited for contour buffer strips as part of greater watershed management functions. The fact that of the potential contour buffer strip implemented sites, 56% had a contour buffer strip means over 40% of the areas could benefit from such a BMP, and this could be documented in a watershed needs assessment for conservation funding to enhance protection of these areas.

Contour buffer striping is a unique BMP and its potential may not be the best practice for such an area as the Middle Fork Whitewater River Watershed. Mentioned within a USDA Factsheet on contour buffer strips from 2011, it states "the practice (Contour Buffer Strips) is more difficult to establish on undulating to rolling topography because of the difficulty of maintaining parallel strip boundaries across the hillslope or staying within row grade limits." Landowners at these sites may not have the capability or money to maintain such areas. A few of the fields also appear smaller than most and this would suggest limiting the area designated for growing even more with the implementation of these contour buffer strips. Therefore it would probably not be worth it to some landowners if the growing capacity does not exceed the amount of land used for the contour buffer strips.

It would be interesting to look closely at some of the lower risk areas where BMPs were suggested for implementation. During the time spent driving around evaluating the higher risk sites, the presence of gully erosion became evident in one particular area west of Rt. 74 (Image 3, Figure 14). The area was found to be located within a "Low" runoff risk assessment field in the data. However, it did not show up as a proposed site within the Grassed Waterways Tool results. The tools only suggest sites, but knowing the areas and evaluating the sites with a field visit is just one of the next steps in a project like this. It cannot be stressed enough that the toolbox is supposed to be used along with knowledge

Image 3. Gully erosion present within a "Low" risk assessed field west of Rt. 74 just north of Saint Charles. The red arrow points out the evidence of a future erosion issue. A grassed waterway could potentially prevent the issue.

Figure 14. Aerial image of the erosion present with in the "Low" runoff risk assessed field from Image 3. The red arrow is the gully erosion from the photograph.

of the area of study. Simply depending on the outputs from the toolbox is not suggested. Areas like this in the lower risk areas would be excellent areas for further research to help limit effects of runoff and/or erosion in higher risk areas.

The erosion witnessed from the field verification in Figure 14 was from a road-side photo. Conducting road-side verification or field checks for erosion or BMPs were not as easily viewed from the road. Some of these fields are vast and hidden among tree lines. It is never a good idea for someone to wander off onto the property of someone else. A drone would have been a great way to get the vantage point or angles needed for usable verification images. Even the use of drones along the highway may cause problems among the landowners so it is always best to communicate with them and ask for permission before attempting any sort of drone use.

Conclusions

The purpose of this project was to use the Agricultural Conservation Planning Framework (ACPF) toolbox to conduct a watershed assessment locating higher-risk erosion and/or runoff areas and then numerating identified sites and evaluating if best management practices (BMP) were constructed on those sites. Project results suggested the tools are a great resource for helping to analyze areas in need of conservation practices. Erosion can never truly be stopped. However, correct placement of BMPs can be utilized to help slow the process. The results of this project show that BMPs in the Middle Fork Whitewater River Watershed have been placed in correct areas as identified by the ACPF Toolbox overall. Looking back to imagery from 1991 shows that many of the BMPs have been there for quite a while.

Maybe it is time to take a look at some of these fields not implementing these practices currently. At the same time, one must also realize that the implementation of these practices cost money and time. Therefor utilizing results from tools like the ACPF Toolbox could be a great way to create needs assessments for grant funding for areas that need conservation help. Implementation of BMPs typically remain as voluntary decisions. The few state or local regulations that exist are quite difficult to enforce at the present time. Therefore local conservationists rely on education, technical assistance, and payment or cost-sharing programs to encourage adoption (Olson and Davenport, 2017). The findings can also be used by local conservation planners and/or governments, watershed coordinators, GIS technicians, and various agencies. They can use the findings for transitioning from demonstrations to implementing watershed projects by identifying priority risk areas. It can also be used as a tool to start conversations with various stakeholders on the importance of soil and water health.

It is also important to remember that the key to soil and water conservation is communication. Implementing a BMP in one area can lead to a disturbance further along. It is always important to research the area and talk with local stakeholders, organizations, and agencies before installing any sort of BMP. It can also affect the environment and ecosystems as well. Communication is key in preventing further occurrences or producing new areas at risk. It is good to make sure that the stakeholder knows that their actions have a direct impact on other areas.

Having run through the process of using the ACPF Toolbox, there would be a few things that could have been done differently. First, there is a vast amount of data the tools can produce. This is important to realize the scope of a project and the time needed to complete a thorough investigation of the results. As such, having specific BMPs in mind for a project would streamline the processing. Knowing these things at the beginning, a better model could have been implemented in the process. Time could have been saved by running tools for BMPs and other analyses that was not used in the project. However, designing, processing, and evaluating the entire project provided a good learning experience.

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