Determining Potential Risk Areas for Minnesota Water Features

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Abstract

There are many important water features in Minnesota, but some are under potential threat due to the increase in agricultural pollution of air and groundwater, and infiltration of aquatic invasive species (AIS) (Minnesota Pollution Control Agency, 2018). This study analyzes these risk factors and the existing biodiversity of Minnesota’s water sources to identify potential high risk water features. Using a model that is scaled from 0-24 (low to high risk) it was discovered that over 95% of all water features have some level of threat regarding their natural state, while 15% are at a high risk of invasive species infiltration and pesticide contamination.

Introduction

Aptly named the Land of 10,000 Lakes, Minnesota has an abundant amount of water sources, with over 7,000 square miles of surficial water and the start of the iconic cross-country Mississippi River (Perlman and USGS, 2018). Many water bodies are home to diverse species, and resources for plants, animals, and humans alike, but are increasingly threatened by anthropogenic interference. This study aims to use GIS software to determine the area of Minnesota’s water features that may be under risk for environmental detriment incorporating which locations have the most biological diversity, are prone to invasive species, and are prone to pesticide infiltration.

Methods

This study used ArcGIS 10.4.1 software with access granted by the Environmental Studies Program at Colby College. All maps are projected in the Universal Transverse Mercator NAD83 UTM Zone 15N. The data used to create the map was downloaded from the Minnesota Geospatial Commons, and each layer was then converted to raster. The biological significance layer was divided into three categories of outstanding, high, and moderate. To determine biodiversity level, the variety of fish, amphibians, birds, and plants were incorporated on an ascending scale of 0 - 4 (Figure 1).

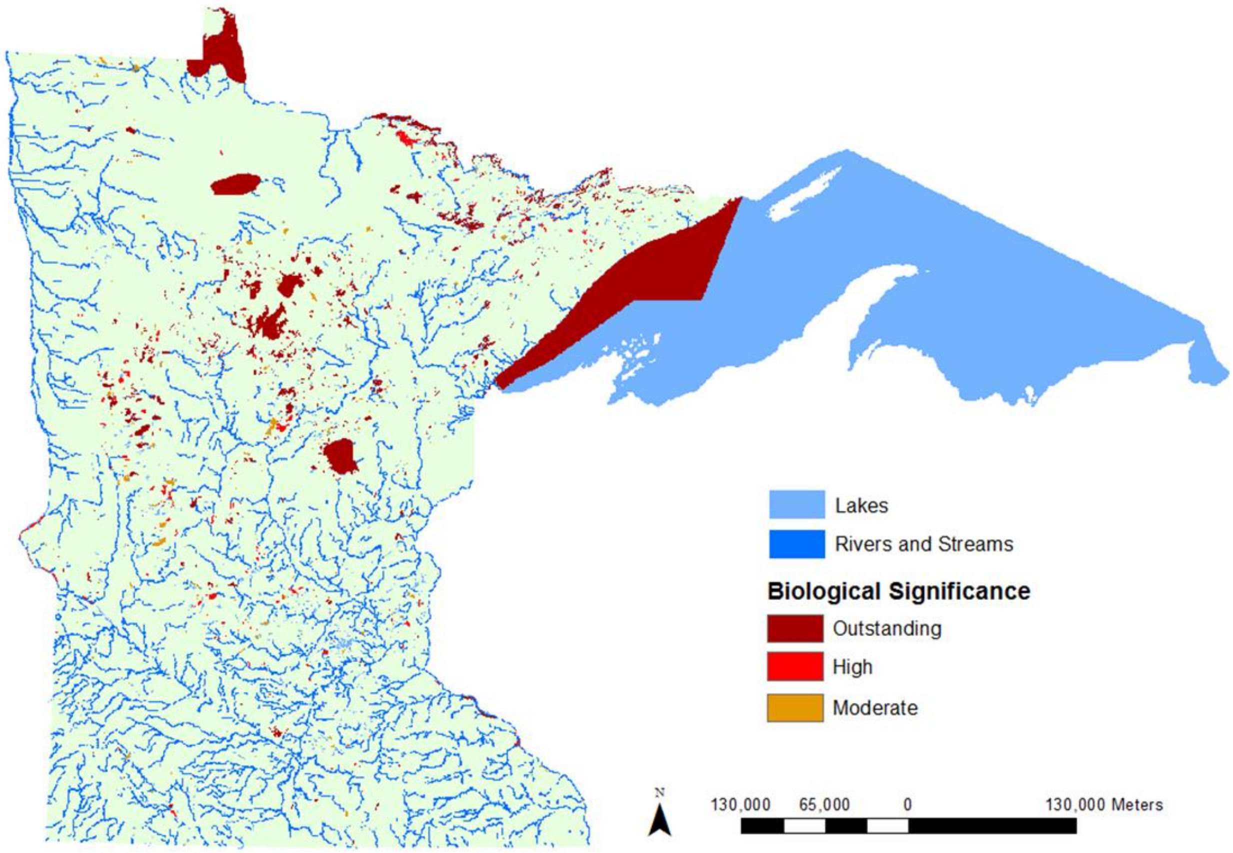

Figure 1. Bodies of water by amount of biodiversity present.

A map was created to show the relationship between location for agricultural pesticides and waters (Figure 2). Pesticide spill points are points of environmental damage due to accidents when using agricultural pesticides, and areas prone to higher pesticide concentrations. A Euclidean distance operation was performed to determine the more at-risk areas in closer proximity to spill sites, incorporating pesticide drift. The values show the broad range of distances from agricultural pesticides when considering other factors such as wind[1] (Figure 2b).

[1] Euclidean Distance Scale
The scale created for this function was based off of Minnesota's weather patterns including wind speed, and the ability for pesticide to drift. Based on size of particles ranging from very coarse to very fine and fog-like, and based on the highest average wind speed in Minnesota being 11 mph, an appropriate range was then calculated incorporating these values and is shown in Figure 2b (Akesson and Yates, 1964). The same distance was applied to Figure 3b to ease analysis in Figure 5. A common distance for pesticide to drift is at least 30 meters (Montana State University, accessed 2018).

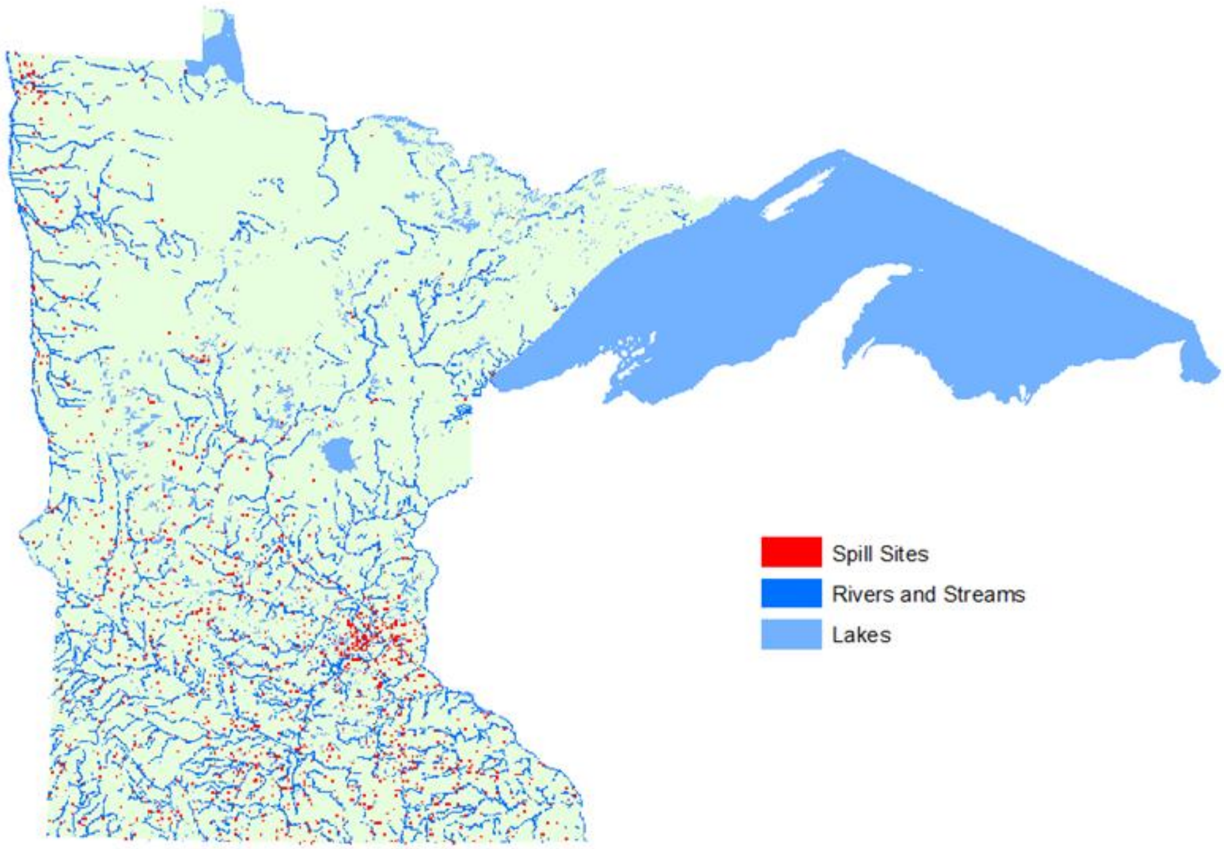

Figure 2a. Known pesticide use areas in relation to bodies of water in Minnesota.

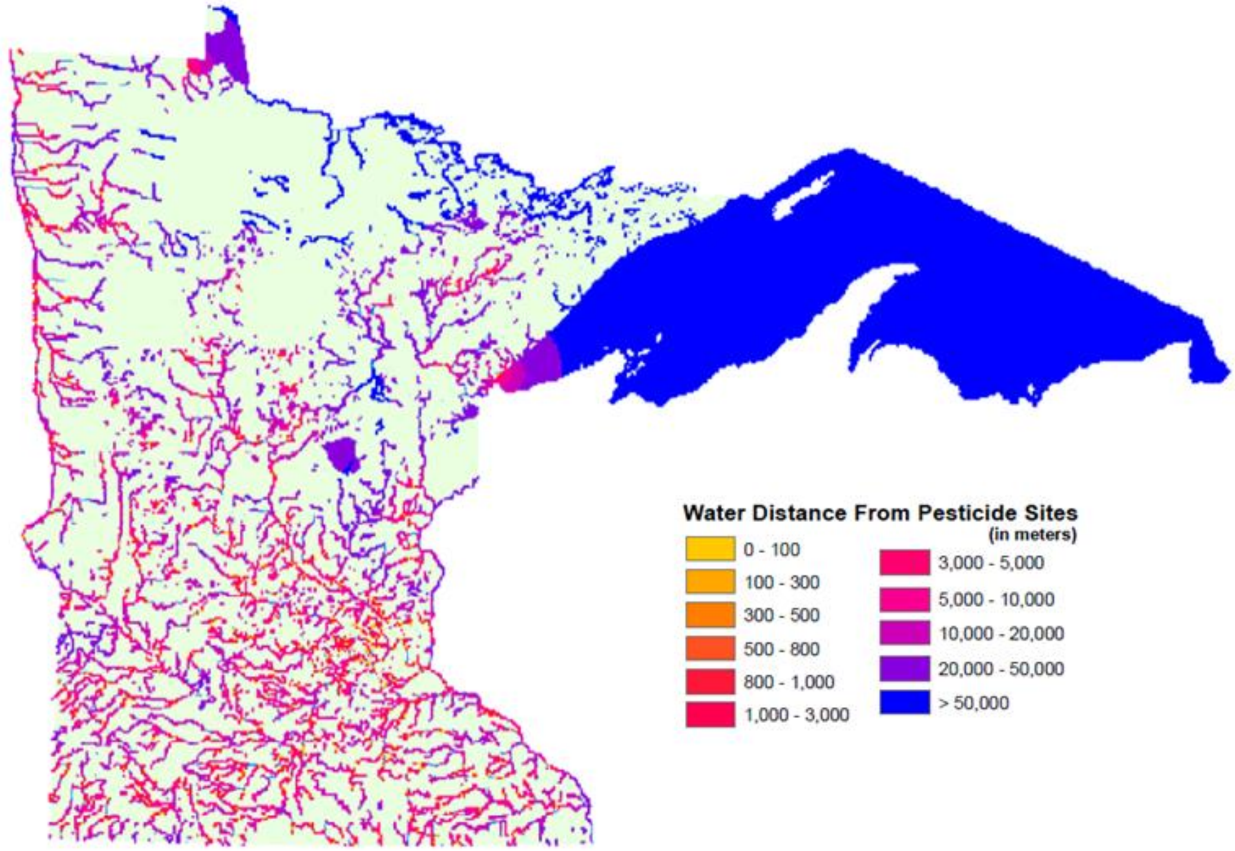

Figure 2b. Bodies of water in relation to proximity to known pesticide use sites.

Another map was created to determine the effect of invasive species on water sources. Another Euclidean distance operation was performed, including the sightings of AIS and having it masked and the processing extent set to the combined water features (Figure 3b).

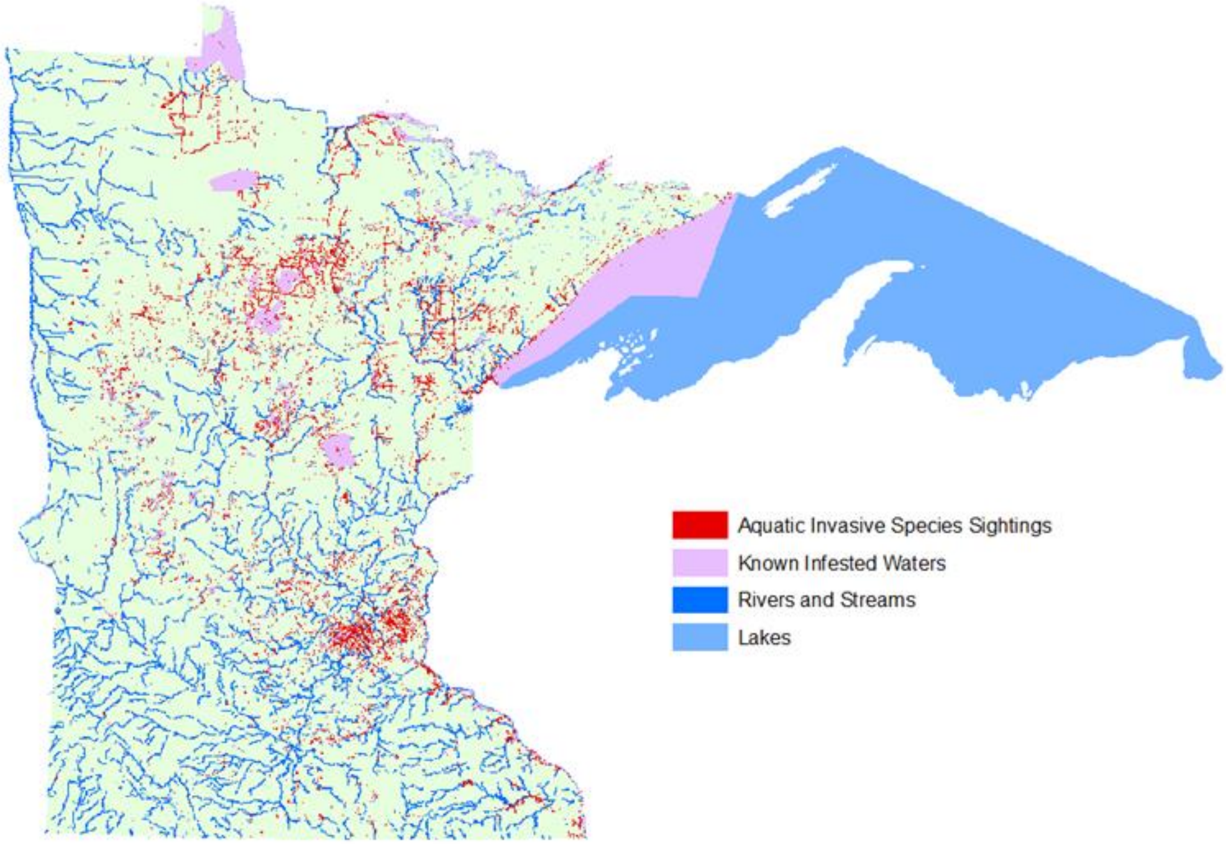

Figure 3a. Sightings of AIS in bodies of water in Minnesota.

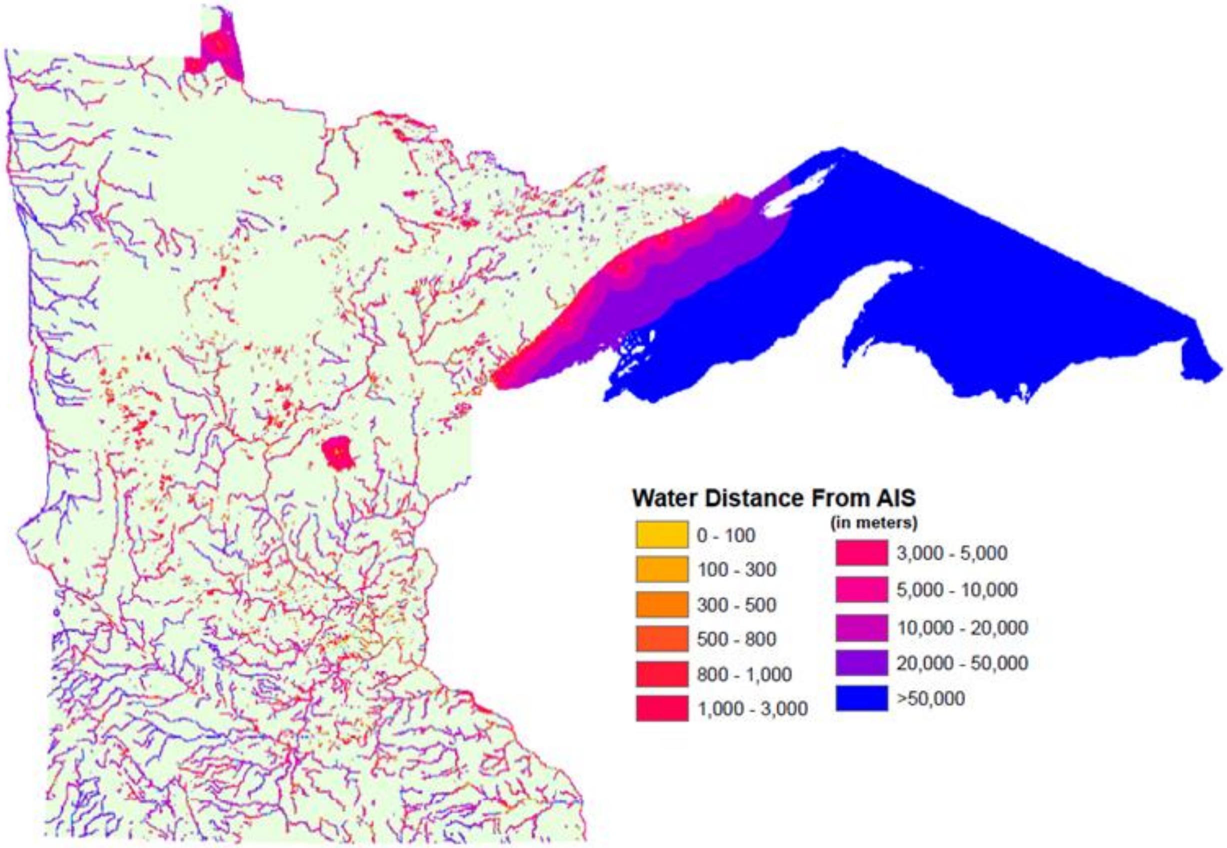

Figure 3b. Bodies of water in Minnesota in relation to proximity to AIS sites.

Lastly, a final map (Figure 5) was created to show the most important areas of focus for water conservation based on the three risk factors displayed in Figures 1-3. This map is the result of combining the three factors; proximity to pesticides, proximity to invasive species sightings, and level of biodiversity of a water feature. A model was developed (Figure 4) to reclassify the three layers to be on the same scale, and added together for analysis. For example, any water feature within 0-100 meters of a risk area was given a value of 11, any feature over 50,000 meters was given a value of 1. The biodiversity raster was scaled between 1 and 3.

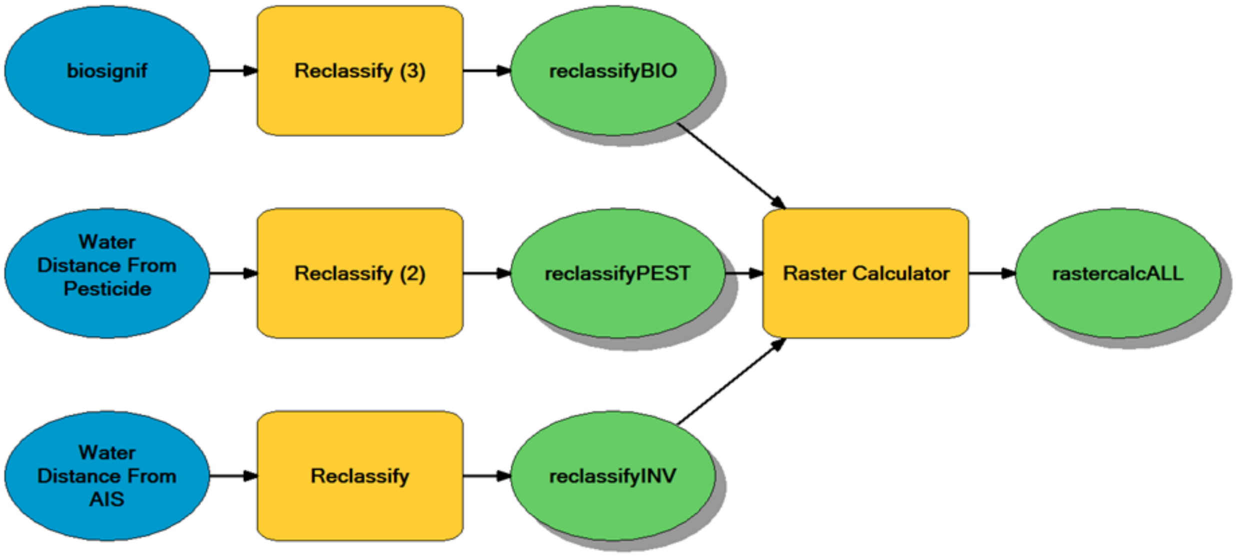

Figure 4. The model used to combine the data from each threat into one raster file.

Results/Discussion

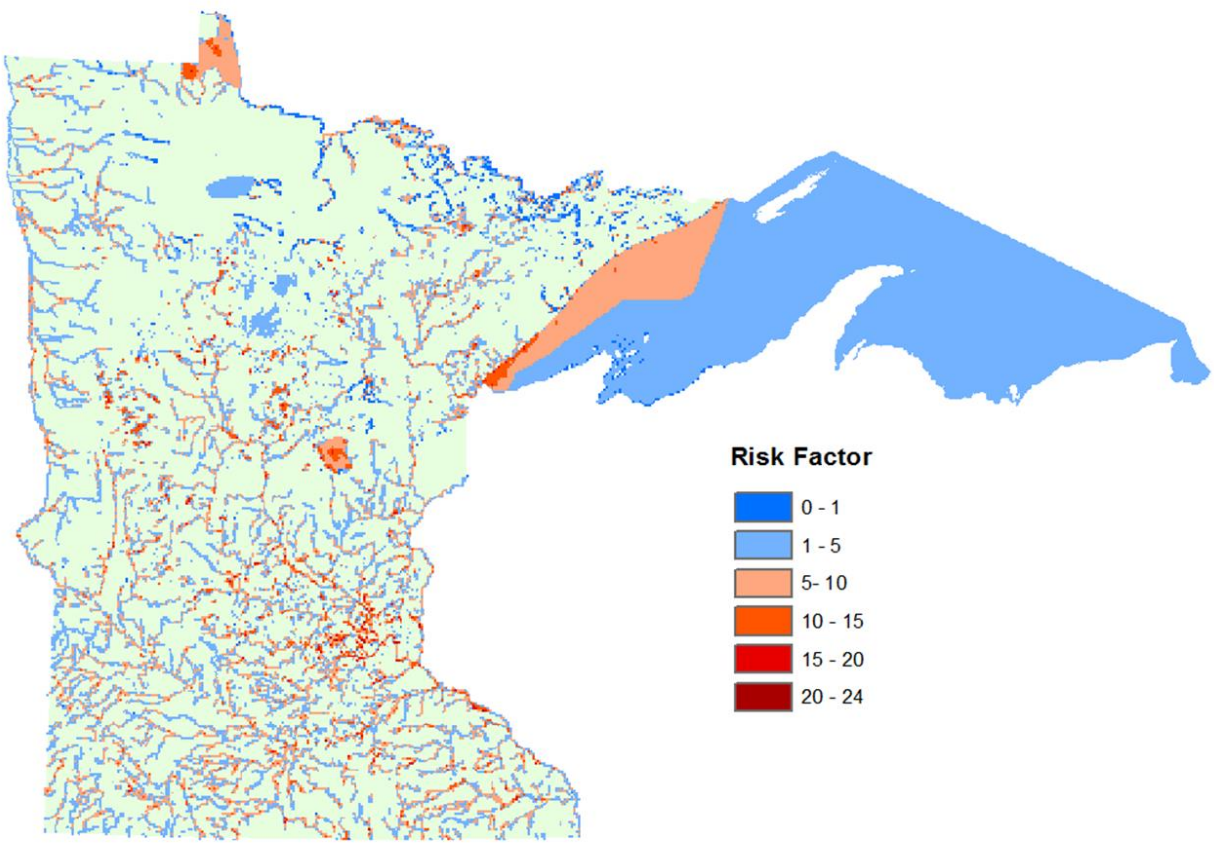

Figure 5. A comprehensive map of all risk factors affecting bodies of water in Minnesota. Level of vulnerability/ risk factor of water features includes whether the feature in question is a significant source

of biodiversity, if it lies in close proximity to an aquatic invasive species sighting, or falls within optimal pesticide drift distance.

The darker red water features in Figure 5 are those that are most biologically diverse, are good hosts for invasive species, and are within range of pesticide drift and contamination. The color ramp displays a range of 0 (lower risk) to 24 (higher risk), based on the added values of each risk factor.

There are 3,475 m^2 of risk areas valued at 10 or above, these areas are shown in darker red. This accounts for 15% of all water sources evaluated. While 15% is a minority, over 95% of all water features have some value of risk. This is important to note, as these risk factors reach nearly every water source and have potential to elevate its conservation needs. Each factor is also easily able to be transferred from location, as pesticides and some species are able to spread quickly either through natural forces or human interference, thus each feature that is currently low may increase in risk value if in proximity to a higher risk feature. Additionally, there are 29 features that are highest risk, valued at 20 and above. According to the model, however, most water features seem to have a moderate risk level, as 43% of features are valued at 5 – 10. All of this information is important to incorporate when considering state water policy by understanding how much protection Minnesota water sources need.

However, this model does not necessarily include all factors or level of risk. There are potentially sources that are worse off than they appear, but were not shown due to the summed nature of all threats. This is not a complete list of all endangered water sources, as while the Euclidean distance and reclassification model are effective, they may be limiting in their calculations. It is important to note that this analysis may not suit all related queries on water issues in Minnesota, due to its relatively preliminary nature. The study completed was done in an introductory course to GIS and thus is not an advanced analysis, but perhaps can be considered a step in the right direction to identifying water issues.

Acknowledgements
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Supplemental Sources

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All data sources and layers are taken from the Minnesota Geospatial Commons.