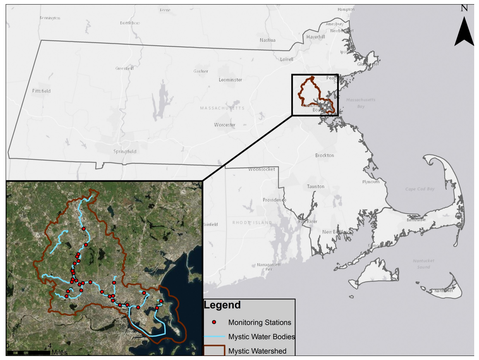
Risk Analysis and Model of Phosphorus Loading In The Mystic River Watershed

Introduction

This project looks at phosphorus levels in the Mystic River Watershed in Massachusetts, the location of which is shown below. The Mystic River Watershed is one of the most populated watersheds in Massachusetts, and has a long history of industry. Today, it is mostly used for recreation, but high phosphorus levels are impairing that use. Phosphorus is necessary for plant life, but at excessive levels it can cause eutrophication (a reduction in dissolved oxygen in water bodies, caused by excessive organic matter). This leads to algal blooms that are a danger to human health, and also kills off important aquatic species such as river herring. Other studies have quantified how much phosphorus different land uses add to a water body (EPA 2014). This analysis uses this information, as well as land use data and measured phosphorus levels, to rank the risk of phosphorus loading from land within the watershed.



Methodology

Three risk maps were aggregated using a raster calculator to find the areas of highest risk to the river, which are shown to the right. The phosphorus loading map was weighted twice as much as the other two maps, since it has a more direct impact on phosphorus levels on the river. The methodology for the creation of the risk maps is shown to the right, under the heading for each map.

Phosphorus levels were also modeled using the inverse distance weighting method, with data from monitoring stations along the river.

Limitations

One limitation of this analysis was that there is very little data available about the transport of phosphorus through a watershed, so the distance buffer was a fairly rough approximation of how distance affects phosphorus transport. There are also other factors that contribute to phosphorus loading, such as septic system use and combined sewage overflows, for which there was no available spatial data.
The model of phosphorus within the river is based exclusively on inverse distance weighting, so it could be improved with consideration of phosphorus removal processes and rates

References and Sources

Publications

"Alewife Brook Combined Sewer Overflow (CSO) Control." City of Somerville, Somerville, 30 Oct. 2017, www.somervillema.gov/cso.

Data Sources

"LANDUSE2005_POLY_MID." MassGIS.
Andy Hrycyna, Mystic River Watershed Association.
"Methods to Calculate Phosphorus Load Reductions for Structural Stormwater Best Management Practices in the Watershed." EPA.
"WATERSHEDS_ARC" MassGIS.
"IL_2012_ARC". MassGIS.

Elizabeth White for CEE 187 at Tufts University, 12/7/2017

Projection: NAD_1983_StatePlane_Massachusetts_Mainland_FIPS_2001

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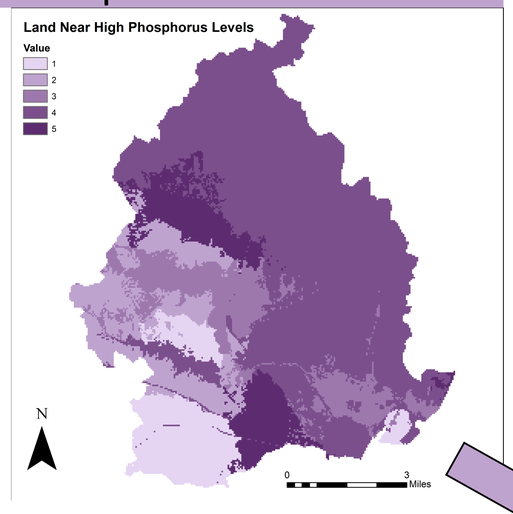
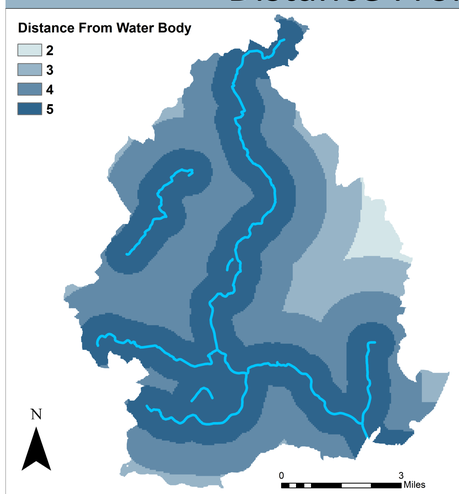
Distance to High Phosphorus Levels In River

This map considers which land areas are closest to the areas of the river with the highest phosphorus levels. These land areas therefore contribute most directly to areas of the river most in need of remediation. The land areas are ranked, with 1 being areas closest to the lowest phosphorus levels in the river, and 5 being areas closest to the highest phosphorus levels in the river.



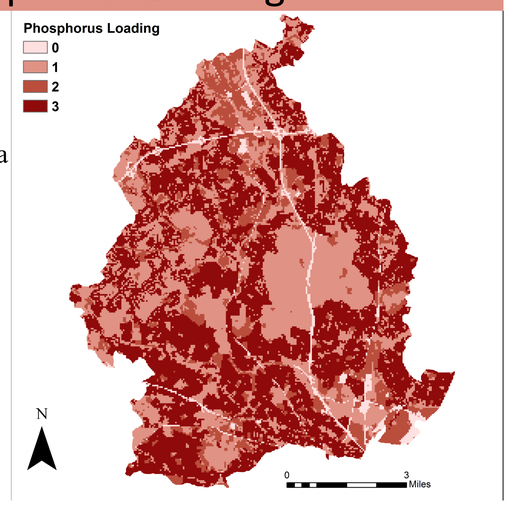
Distance From River



This map considers phosphorus entering the water bodies through stormwater runoff. Stormwater carries high amounts of phosphorus, therefore contributes significantly to phosphorus loading risk. The areas closest to the river load the most phosphorus due to runoff, and are ranked the highest for risk, while the areas furthest from the river are ranked the lowest.

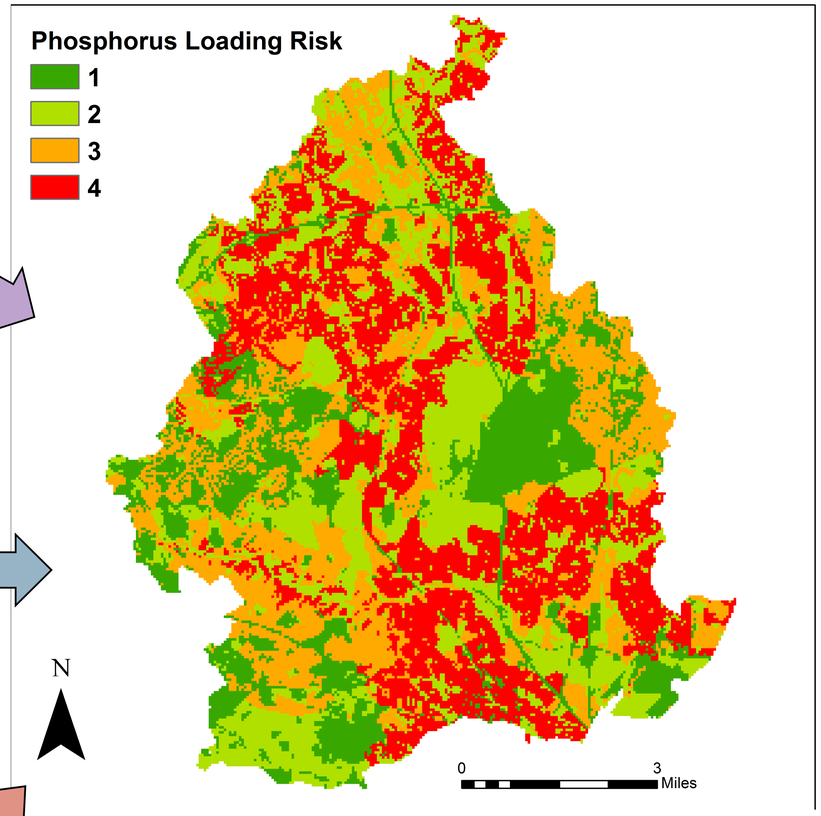
Phosphorus Loading

This map considers how much phosphorus is loaded by each area based on land use. This was done by joining a land use map with data about how much phosphorus each land use type contributed. The phosphorus loading was then ranked, with 3 loading the most phosphorus and 0 loading no phosphorus.



Results and Conclusions

A major result of this spatial analysis shown below is that land areas very close to the river are generally the most damaging to the river's phosphorus levels, although not uniformly. These areas should be addressed first when trying to reduce phosphorus in the Mystic River. Area specific remediation could involve permeable pavement, increased street sweeping, or decreased use of fertilizers.



The model of phosphorus in the river shown below clearly shows areas that are in most need of remediation, and are at highest risk for eutrophication. The model correlates strongly with known information about the river– the Mystic Lakes have a much higher volume of water than most of the river, for example, and therefore have a much lower concentration of phosphorus. Alewife Brook has a large number of combined sewage outflows (Somerville 2017). These outflows carry extremely high levels of phosphorus into the brook, which is also shown in the model.