Killer Crops: A Vulnerability Analysis of Nutrient Pollution in the Chesapeake Bay

Introduction

This project will serve to display the level of nutrient pollution across the Chesapeake Bay. Nutrient pollution, mainly from nitrogen and phosphorus in agricultural runoff, is a major problem in the Chesapeake Bay because excess plant nutrients causes eutrophication and a depletion of dissolved oxygen in the water. Hypoxic water cannot sustain marine life, which is vital for natural water filtration and maintaining a healthy ecosystem. The Chesapeake Bay Watershed encompasses parts of New York, Pennsylvania, West Virginia, Virginia, Delaware and Maryland. This project focuses on the state of Maryland because it is the closest state to the bay and therefore the runoff is the least diluted in river water and groundwater. Since the area is well studied, it is clear that the agricultural fertilizer runoff is the main source of pollution for the bay, but this project will serve to identify exactly where the prevention and remediation efforts should be concentrated in order to reduce Maryland's effect on the bay. Typical remediation techniques include artificial oyster reefs and aquatic vegetation planting, which filter out the nutrients in the water and keep the ecosystem healthy.

Methodology

In order to determine the most vulnerable areas in Maryland in terms of causing nutrient pollution and eventual eutrophication in the Chesapeake Bay, the following ArcGIS methods were performed:

- Proximity near tool on farmland polygons to major rivers in Maryland and to the Chesapeake Bay shoreline
- Raster creations for distance from nearest river, distance from the bay shoreline, and underlying geology
- Raster reclassification to assign scores (0-4) for each distance range and aquifer permeability
- Weighted raster overly with all three rasters to obtain a final vulnerability score
- IDW Interpolation of the dissolved oxygen sample points to obtain a raster masked on the whole bay

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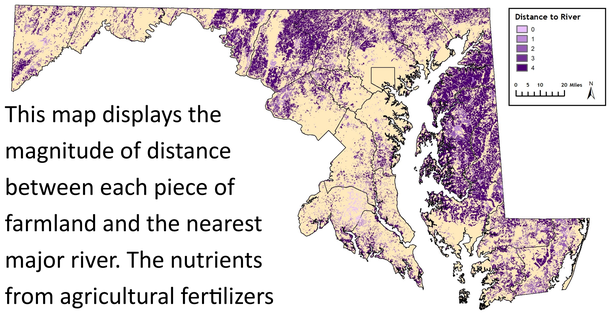
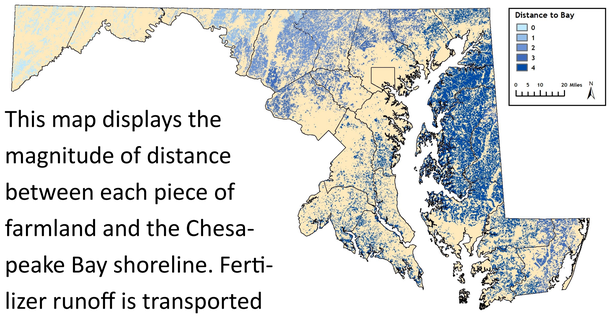
Distance To Rivers



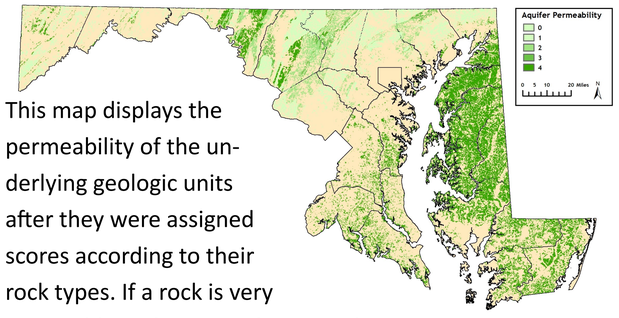
This map displays the magnitude of distance between each piece of farmland and the nearest major river. The nutrients from agricultural fertilizers are washed away by rain into the rivers and groundwater. The closer the source of the pollution is to the rivers, the higher the concentration of contaminants will be upon entering the river.

Distance To Chesapeake Bay



This map displays the magnitude of distance between each piece of farmland and the Chesapeake Bay shoreline. Fertilizer runoff is transported through rivers and groundwater, but the concentration of contaminants are diluted along the way, so the highest concentration of polluted water comes from farmland closest to the bay.

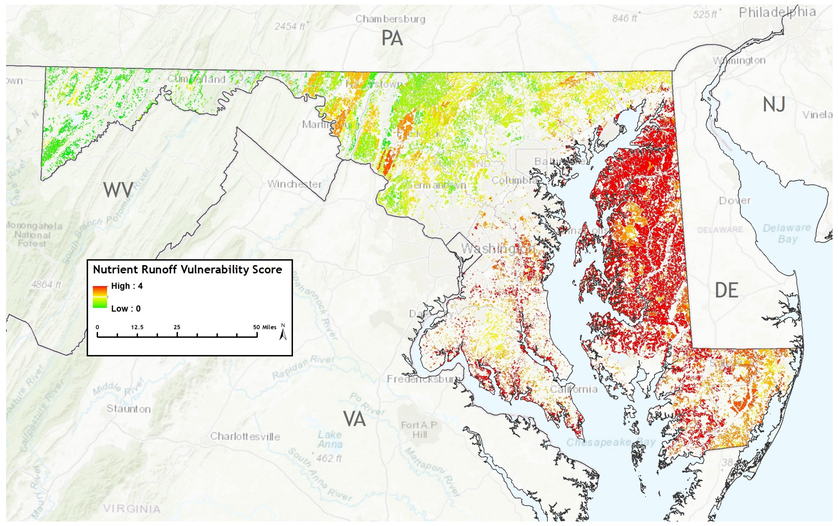
Aquifer Permeability



This map displays the permeability of the underlying geologic units after they were assigned scores according to their rock types. If a rock is very permeable and porous, the groundwater can be transported to the bay quickly, giving the nitrogen and phosphorus less time to be diluted and filtered. The raster is masked by the farmland polygons because Maryland's farmland fertilizer is the pollutant of concern.

Dead Zones

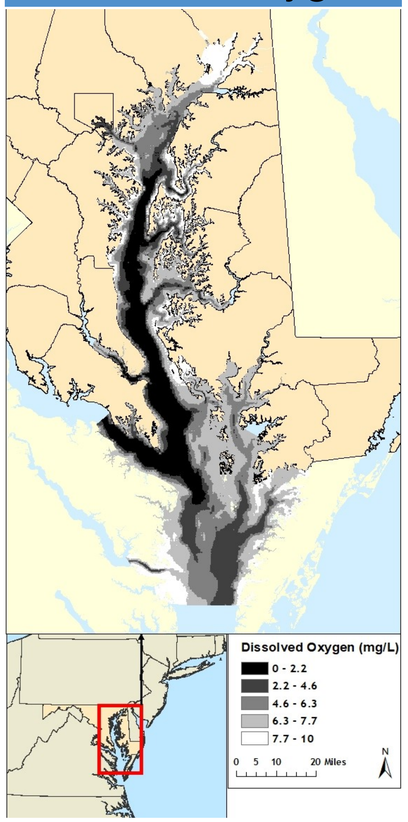
Dissolved oxygen is necessary for almost all marine life to survive in a body of water. Water with levels of dissolved oxygen above 5 mg/L are considered healthy for all sorts of marine life, however if the level is below 5 mg/L, then the space is considered a "dead zone". The figure to the right illustrates the dissolved oxygen concentration at the bottom of the Chesapeake Bay. Since there is less plant life in deeper areas, there is less dissolved oxygen in these areas. There are clearly many dead zones in the bay, which have been linked to the nutrient pollution analyzed in this project.



Results and Conclusions

The figure above demonstrates the weighted overlay for the three pollution vulnerability rasters. The distance to rivers raster shows that most of the farmland in Maryland is relatively nearby to a river , which is reasonable for irrigation purposes. The distance to the bay raster shows that the majority of the farmland close to the bay is on the Eastern Shore (the MD territory on the Delaware Peninsula). Finally, the aquifer permeability raster shows that the fastest flowing aquifers under farmland in the state are also on the Eastern Shore. The weighted overlay of these three rasters results in the final figure above, which confirms that the middle and northern sections of the Eastern Shore are the greatest sources of nutrient pollution in the state. Fertilizer regulations should begin with studies of this area and remediation efforts such as artificial oyster reefs and aquatic vegetation plantings should be focused along the coast of Maryland's Eastern Shore. Oysters and vegetation can filter out these excess nutrients and make the Chesapeake Bay a healthy environment for all marine life once again.

Dissolved Oxygen



Limitations

The main limitation of this project is the assumption that Maryland is the only state affecting nutrient pollution in the Chesapeake Bay. The watershed reaches up to New York, and the majority of the farmland in the watershed is in Pennsylvania and upstate New York. Another limitation is that there is no data on what type of farm is on each farmland polygon. This information could be used to determine how much fertilizer, and of what variety, each farm is actually using. Finally, the aquifer permeability scores only take the permeability of the geologic unit into account, but the elevation gradient and reactions in the runoff and groundwater could change the concentrations of nutrient pollution over distance and time.

Cartographer: Julian Finney

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Data Source: MD Imap 2013

CS: NAD_1983_StatePlane_Maryland_FIPS _1900

Projection: Lambert_Conformal_Conic