Summer 7-10-2024

Geospatial Analysis of Hydrologic Nitrogen in Ohio Using Terrain Ruggedness Index (TRI) and Terrain Position Index (TPI)

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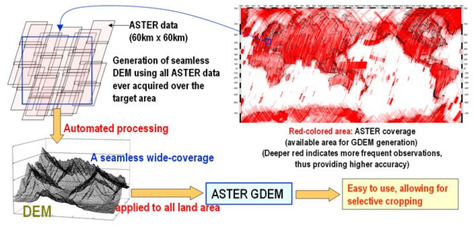
Introduction

- Hydrologic nitrogen in ecosystems can significantly impact water quality. Excessive nitrogen, often originating from agricultural runoff, wastewater discharge, and industrial activities, can lead to eutrophication – the over-enrichment of water bodies with nutrients, resulting in excessive algal growth and depleted oxygen levels. This study aims to use geospatial analytics to identify areas in Ohio that are more susceptible to high nitrogen levels due to their topographic characteristics.
- Terrain Ruggedness Index (TRI) and Terrain Position Index (TPI) are two key metrics derived from Digital Elevation Models (DEMs) that can help characterize the landscape. TRI measures the variability in elevation of adjacent parts of a DEM, while TPI compares a data point in a DEM to its neighbors. By analyzing terrain ruggedness and position, we can statistically identify locations more likely to have higher nitrogen levels.
- Nitrogen tends to flow towards areas with lower elevations relative to their neighbors. By using geospatial techniques to identify points on the DEM with lower TPI and TRI values, we can locate areas that could have higher nitrogen runoff compared to others. If left unchecked, hydrologic nitrogen can cause disastrous consequences for ecosystems, as evidenced by the algal blooms in Lake Erie caused by nitrogen runoff from fertilizers.

Methodology



- Digital Elevation Models (DEMs) for Ohio were obtained from the United States Geological Survey (USGS). Additionally, Topographic Position Index (TPI) and Terrain Ruggedness Index (TRI) values were included in the DEM.
- The data was then processed in R using dplyr and base R functions.
- In the dataset, there were thousands of repeated values for the same points, these values were eliminated using the unique function in R.
- To identify areas with higher susceptibility to nitrogen runoff, the dplyr and ggplot2 packages were used. The created visualizations help interpret the spatial distribution of susceptibility to nitrogen runoff. By mapping the DEM metrics, potential runoff hotspots were identified.

Results

Figure 1:

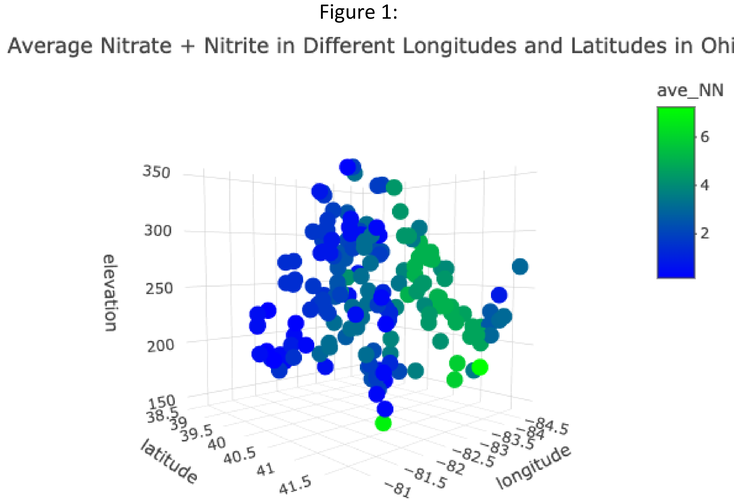


Figure 1 shows the dispersion of Nitrate + Nitrite at different points indicated by the longitude, latitude and the elevation features of the graph. In this case, the concentration of Nitrate + Nitrite is skewed toward the right hand side

Figure 2:

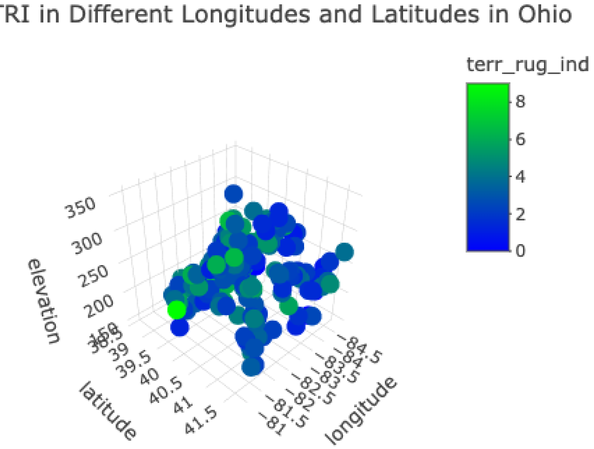


Figure 2 shows the TRI levels in different areas in Ohio. In this case, the high TRI levels are mostly on the left side of the graph with an exception of a few outliers. This shows an inverse correlation between TRI and concentration of Hydrologic Nitrogen

Figure 3:

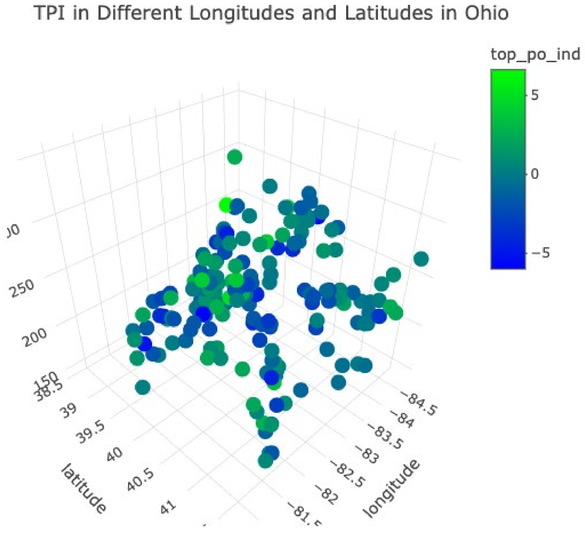


Figure 3 shows the TPI levels in different areas in Ohio. However, there is little to no correlation between this variable and average Nitrate + Nitrite.

Conclusion

The geospatial analysis of hydrologic nitrogen in Ohio using Terrain Ruggedness Index (TRI) and Terrain Position Index (TPI) revealed a notable correlation between TRI and average nitrogen levels, indicating that areas with higher terrain variability tend to have elevated nitrogen concentrations.

In contrast, no significant correlation was found between TPI and ave_nn, suggesting that relative elevation position within the landscape does not significantly impact nitrogen levels. These findings underscore the importance of considering terrain ruggedness in predicting and managing nitrogen runoff.

Future research should focus on incorporating additional environmental variables, such as land use patterns and soil types, to enhance the predictive accuracy of nitrogen susceptibility models.

Moreover, improving data resolution adding more aspects to the project such as fertilizer use or different elements that connect to hydrologic nitrogen. Enhancements in data collection methods and broader study that would cover the entirety of the US instead of Ohio could further refine the understanding of hydrologic nitrogen dynamics and support the development of mitigation strategies.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant No. 2133576
This work made use of the High Performance Computing Resource in the Core Facility for Advanced Research Computing at CaseWestern Reserve University.

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Thrust Interactions