Agriculture and Lake Erie Algal Blooms

An Intervention Suitability Analysis

Introduction

Lake Erie has had increasingly problematic algal blooms, growing in size, intensity, and frequency (Patel, 2017). Algal blooms are caused by an excess of nutrients, specifically nitrogen and phosphorus. Increased algae density turns the surface water a mucky blue-green and causes outbreaks of cyanobacteria, which can produce cyanotoxins (US EPA, 2013). The blooms impact Lake Erie's ecosystem, regional tourist economy, and drinking water (Patel, 2017).

The nutrient pollution is in part due to nonpoint agricultural runoff. Rain causes nutrients from fertilizer and manure sources to runoff into Lake Erie tributaries, eventually flowing into the lake. The Western Lake Erie sub region spans three states: Michigan, Indiana, and Ohio (Figure 1). The area is dominated by an agricultural landscape and contains the Maumee River, the largest Great Lake tributary. This Intervention Suitability Analysis aims to identify the areas in the Western Lake Erie sub region that have the most intensive agricultural practices and are oriented to be impactful sources of nitrogen and phosphorus runoff—therefore most suitable for intervention.

Figure 1: Western Lake Erie Region.

Cartographer: Molly Bailey

Tufts University, Introduction to GIS 101

May 6, 2019

Projection: North America Albers Equal Area Conic

Data Sources: USGS, USDA NASS, Sierra Club, ArcGis Online

References: Patel, J. K., & Parshina-Kottas, Y. (2017, October 3). Miles of Algae Covering Lake Erie. The New York Times.; US EPA, O. (2013, March 12). The Issue [Overviews and Factsheets].; Image: Allen, J., & Simmon, R. (2011, October 5). Toxic Algae Bloom in Lake Erie. NASA Earth Observatory from Wikimedia Commons.

Data

The 2017 Census of Agriculture, from US Department of Agriculture/National Agricultural Statistics Service was used to formulate a county-level table of: cropland acres; farm operations; and inventories of cattle, hogs, sheep, and chickens to be summed for livestock totals. The 2012 Census was used to gather cropland acres and calculate difference from 2017. Concentrated Animal Feeding Operations (CAFOs) were downloaded as a table from the Sierra Club.

The United States Geological Survey (USGS) was a source for: polygon shapefiles of the Western Lake Erie region and HUC8 sheds from the Watershed Boundary Dataset and county-level estimates of nitrogen and phosphorus 1987-2012 for attributes 'farmP2012' and 'farmN2012' from a data release. A county polygon shapefile with FIPS codes was retrieved from ArcGis Online.

Methodology

I used ArcMap 10.6.1 to perform the analysis. I used display XY data to add the CAFOs as a layer using table provided latitude, longitude. I executed kernel density of CAFO points by square kilometers and then reclassified by five natural breaks for new values of 1-5 for low-high. I joined the data tables including data of cropland, farms, county-level fertilizer, and livestock to county boundaries using the 5-digit FIPS codes. I executed polygon to raster (30 sq. km) for the following attributes: self-calculated crop difference and livestock totals, crop acres 2012, farm P 2012, farm N 2012, farms 2017, HUC8 sheds. I reclassified the raster values using five natural breaks and assigned new 1-5 values low-high. HUC8 sheds were reclassified with Maumee Basins receiving a five to others 1.

I used an unweighted raster calculator to sum the eight inputs (Figures 2-9) and then reclassified the outcome using five natural breaks to reassign final new values 1-5 for low-high.

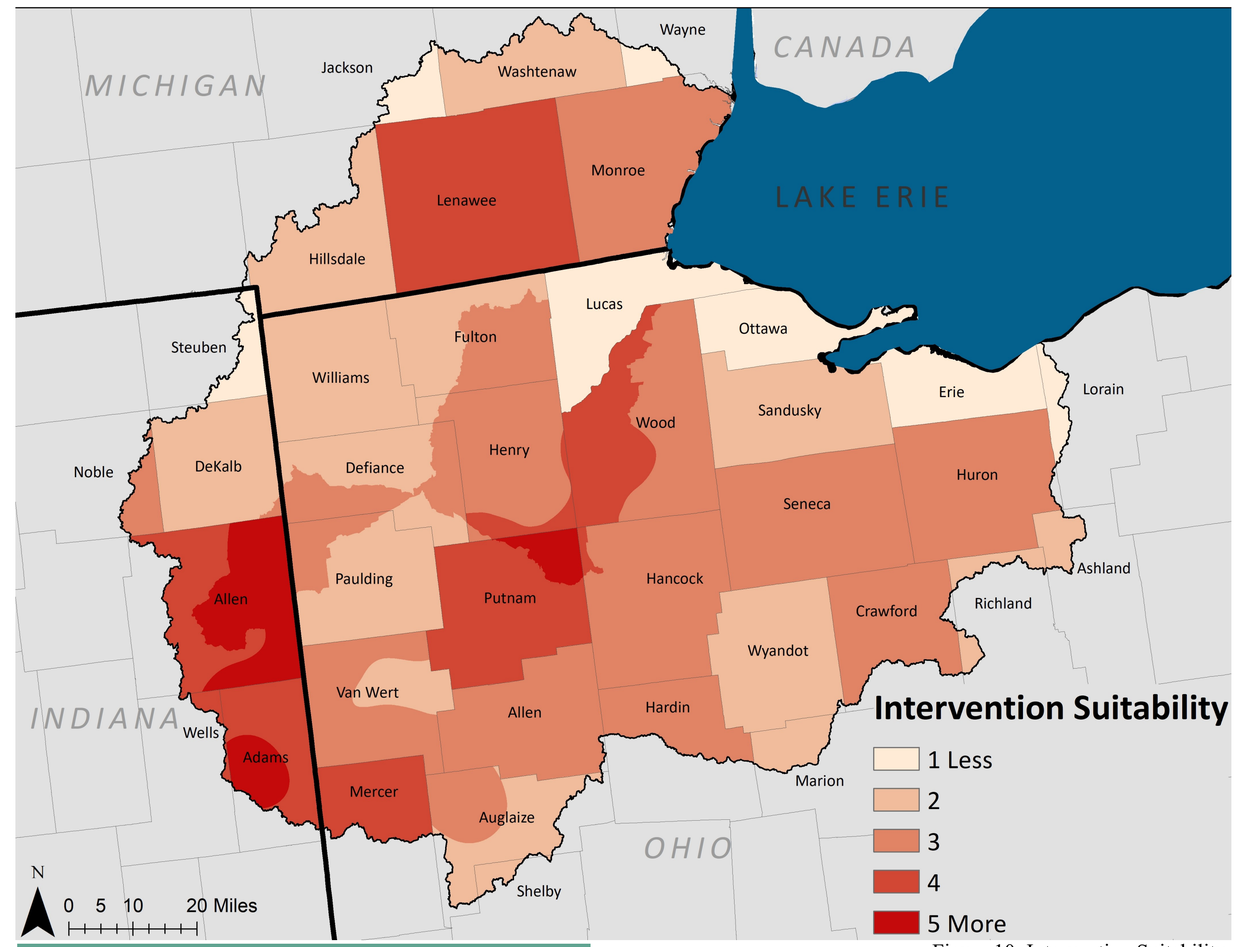

Figure 10: Intervention Suitability.

Results

The analysis of both cropland and livestock agricultural practices show different geospatial distributions across the Western Lake Erie region. Cropland and fertilizer use (Figures 2-5) is relatively more continuous throughout the region. Livestock and animal operations (Figures 6,7) are more intensive in the western part of the region. Number of farms (Figure 8) corresponds to the counties with increased cropland (Figure 2) and livestock (Figure 6), and the Maumee River basins (Figure 9) run through the center, with the lower basin closer to the lake larger in size.

The areas most suitable for intervention (Figure 10), most intensive agricultural practices, are pockets within Adams and Allen counties in Indiana and Putnam county of Ohio. Values of four are in all three states: Lenawee county of Michigan, Mercer, Putnam, and Wood counties Ohio, and Adams and Allen counties Indiana. Lucas county has relatively low agricultural activity, indicating the pollution is coming from upstream.

Discussion

The widespread agricultural practices of the Western Lake Erie region indicate that a multi-state intervention effort is needed to ultimately contain the nitrogen and phosphorus nutrient pollution contributing to Lake Erie's algal blooms. This analysis connects the broader research on agricultural causes of nutrient pollution to specific counties to promote a local focus. It will prove useful for environmental and agricultural policy makers to properly focus and align their efforts.

Cropland Acres per County, 2012

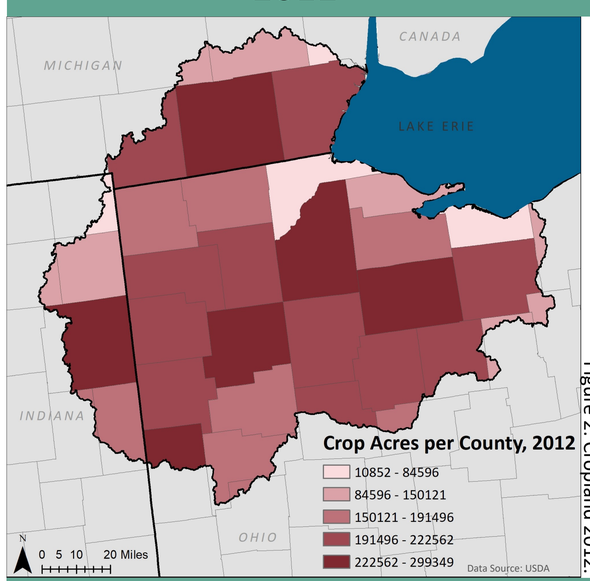

Figure 2: Cropland 2012.

County Estimates of Phosphorus Fertilizer for Farm Use, 2012

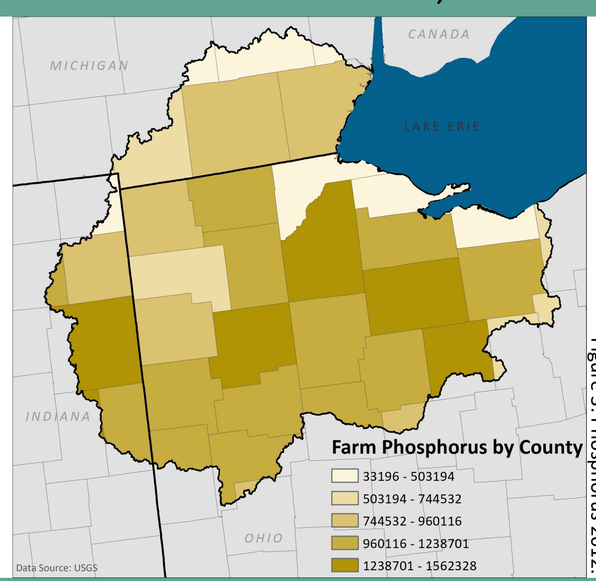

Figure 3: Phosphorus 2012.

County Estimates of Nitrogen Fertilizer for Farm Use, 2012

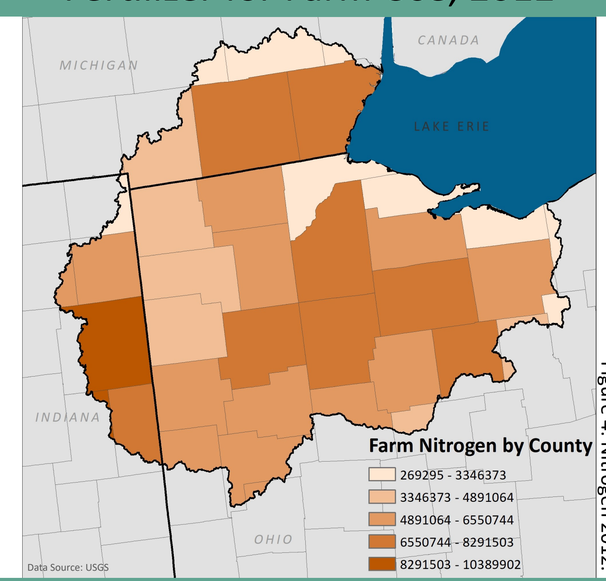

Figure 4: Nitrogen 2012.

Change in Cropland Acres per County, 2012 to 2017

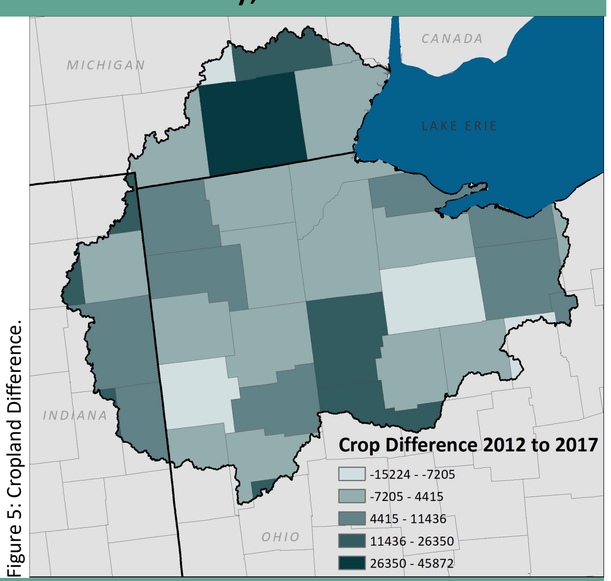

Figure 5: Cropland Difference.

Livestock Totals per County, 2017

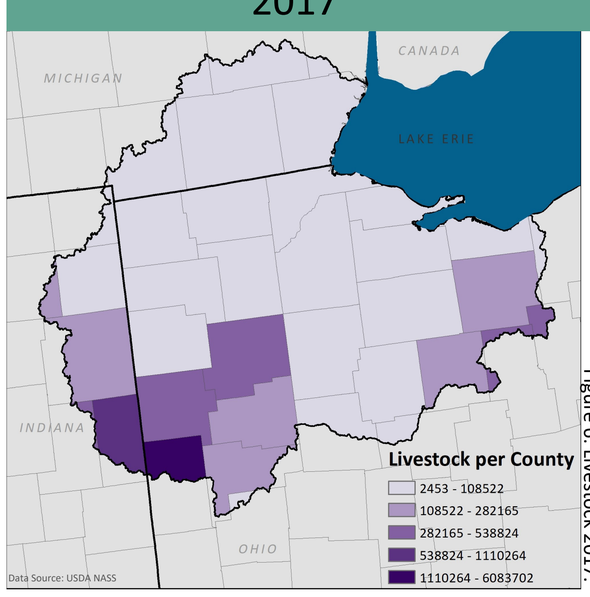

Figure 6: Livestock 2017.

Density of Concentrated Animal Feeding Operations, 2015

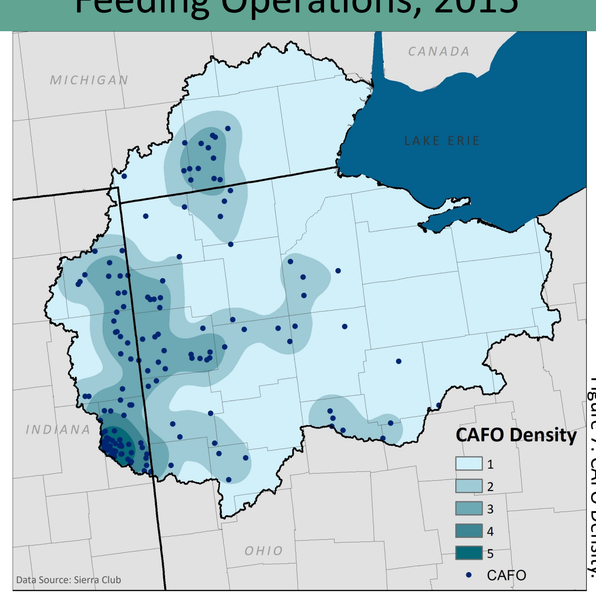

Figure 7: CAFO Density.

Number of Farm Operations per County, 2017

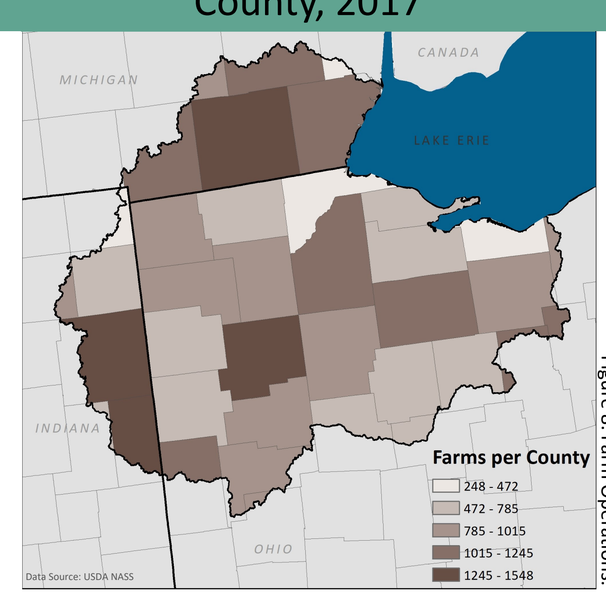

Figure 8: Farm Operations.

HUC8 Maumee River Basin Designation

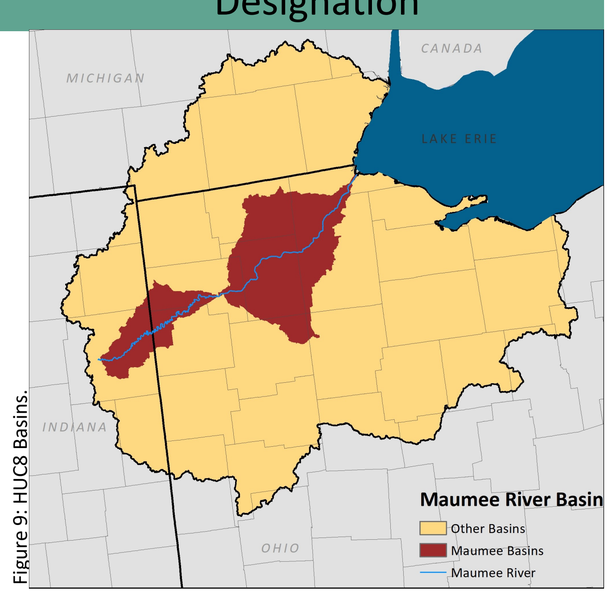

Figure 9: HUC8 Maumee River Basins.