

Boat Run: The Impact of Land Use Change on Water Quality in the Lower Delaware River

INTRODUCTION



The Delaware River has been renowned for its poor water quality since the first industrial revolution in late 1800's. The river, particularly the "Boat Run" stretch from just north of Trenton, NJ to the mouth of the Delaware Bay, runs through what was once the center of steel production in the United States, and was treated as a sewer for so long that by the end of World War II, it was considered dead. When large industry started moving out of the area in the 1970's and 1980's, and water quality standards began to be published and enforced by the Federal Clean Water Act, the river saw a significant increase in water quality, bringing Boat Run almost to fishable standards. Significant restrictions were put on townships discharging wastewater into the river. These restrictions have become harsher with time, as the area has become increasingly dependent on the tourism and recreation industries. The water needs to meet federal standards and additionally appear clean enough to remain a popular destination.

Water quality is dependent on dissolved oxygen (DO) levels. Adequate DO concentrations in water are necessary to maintain aquatic life. Levels are affected by various contaminants: various nutrients and organic matter that get into the water require oxygen to decompose, which decreases the amount of DO in the water. Some nutrients encourage the growth of aquatic plants which are decomposed by bacteria that use up the supply of oxygen in the water. These contaminants come from various point and non-point sources, including waste-water discharge and storm water runoff, which will pick up contaminants from the land surface it flows over. It is expected that land use in the surrounding watersheds will have an eventual impact on the water quality of the Delaware River, and that changes in land use can be correlated to changes in water quality. This project tests that assumption by determining the most significant land use change in the area in the past 15 years, tracking the change in levels of the pollutant most closely associated with that land use, and analyzing the subsequent impact on DO levels in the lower Delaware River.

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METHODS

Determining Most Significant Land Use Change

The Delaware Valley Regional Planning Commission provides shapefiles of land use coverages for the area for 2000 and 2015, both of which were converted to rasters. The Reclassify tool was used to sort the uses into common categories. Those rasters were then converted back into polygons, and summarized to determine the area each use covered in each year. This data was exported to Excel, and the percent coverage was calculated and plotted for both years, as shown in the below graph.

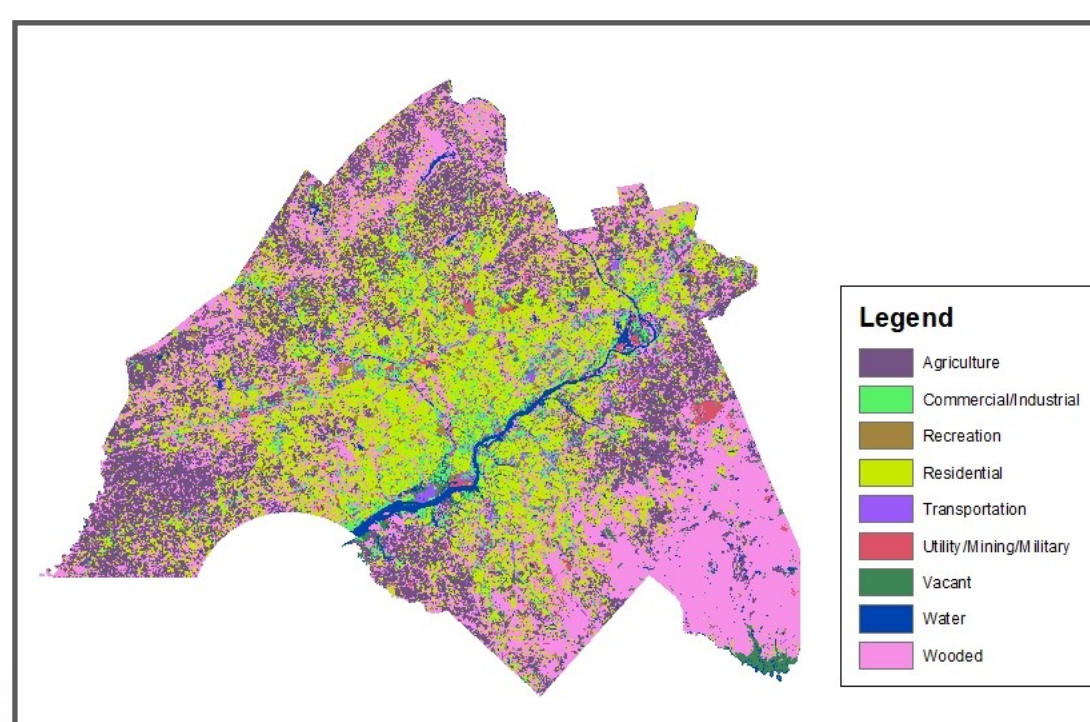
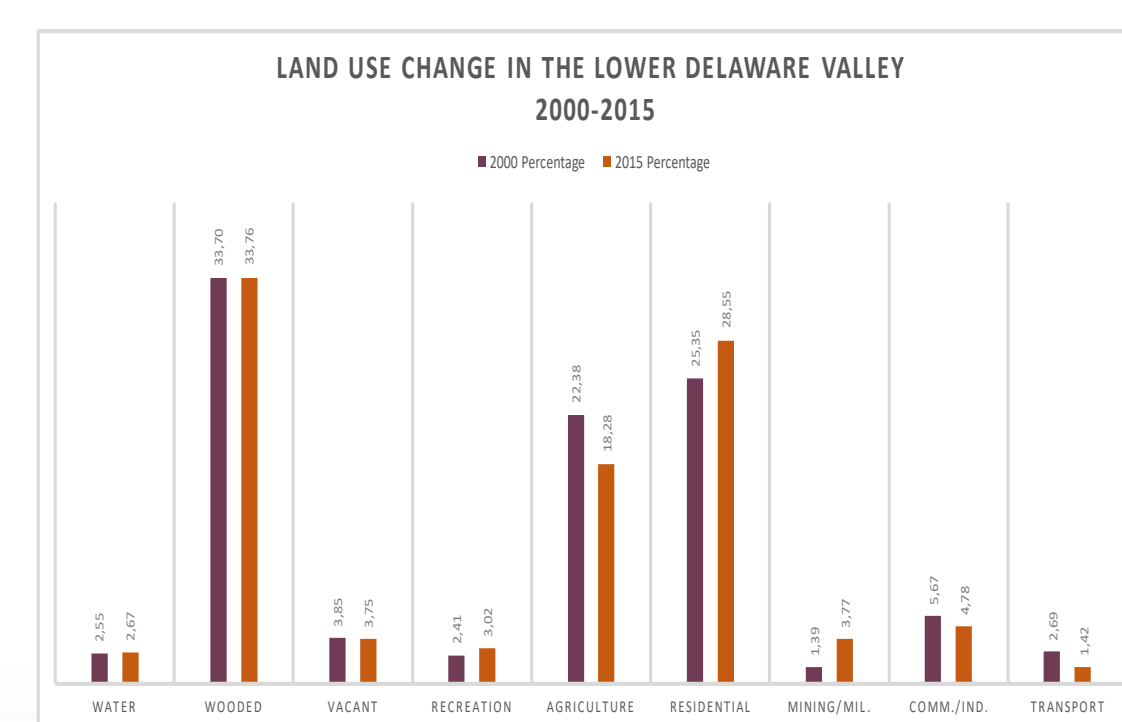


Figure 1: Categorized Land Use Raster for 2000



Determining Specific Use Change on a Watershed Scale

Given that the most significant land use change was in Agriculture, the Reclassify tool was used again to create Boolean rasters of agriculture use for each year. The Raster Calculator tool was used to create a Boolean raster showing area that changed from agriculture use to something else. These rasters were converted back to polygons to determine the area of both the 2000 raster and the change raster. Location queries were used to assign a Watershed field to the agriculture polygons. Summary tables of both layers were created and joined, and the Field Calculator was used to determine the percent agriculture change in each watershed.

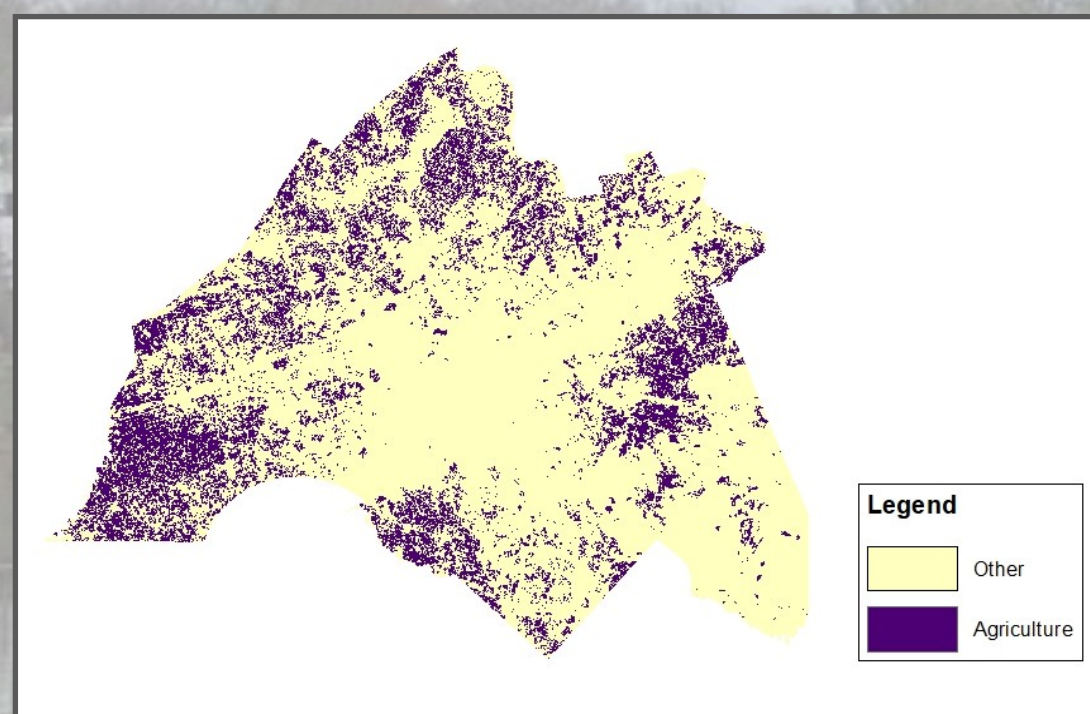


Figure 2: Agriculture Coverage in 2000

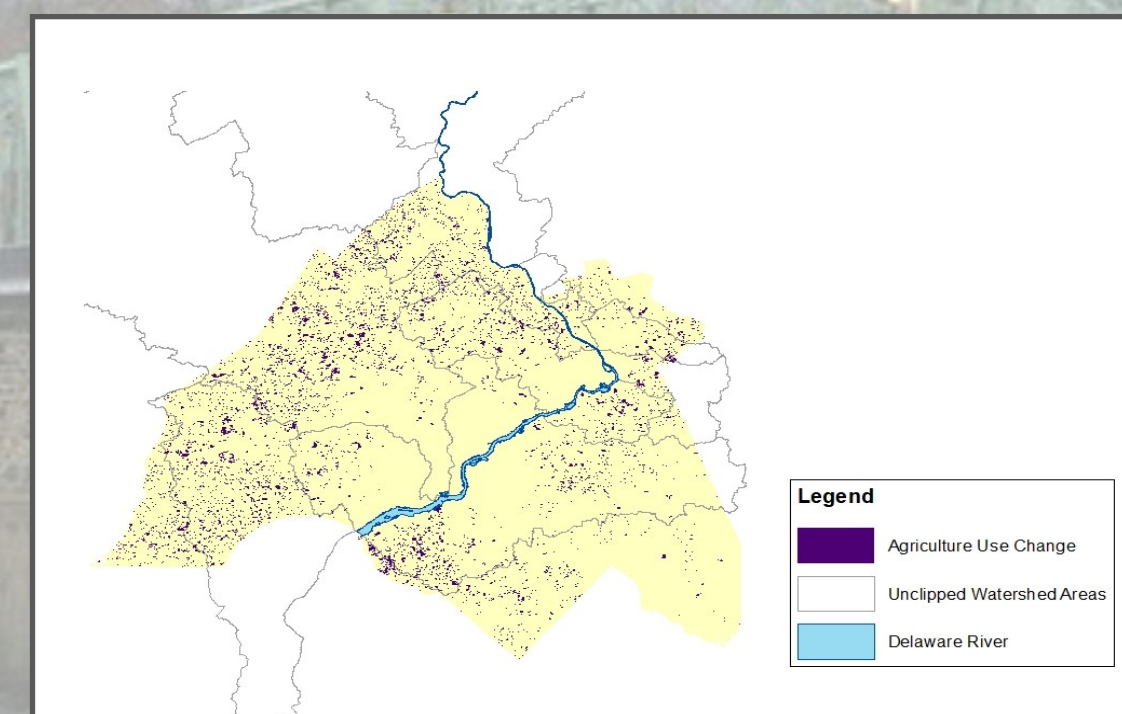
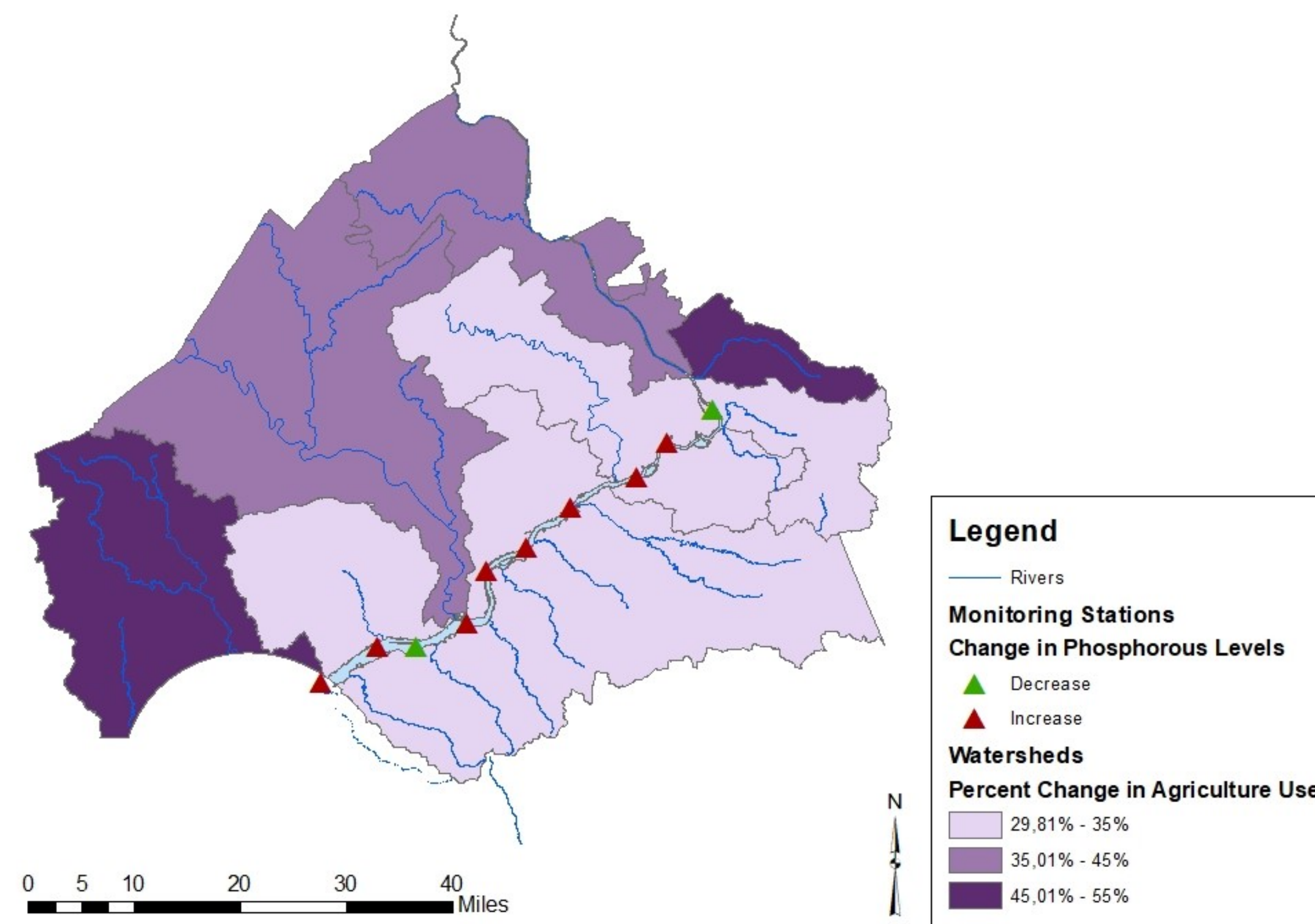
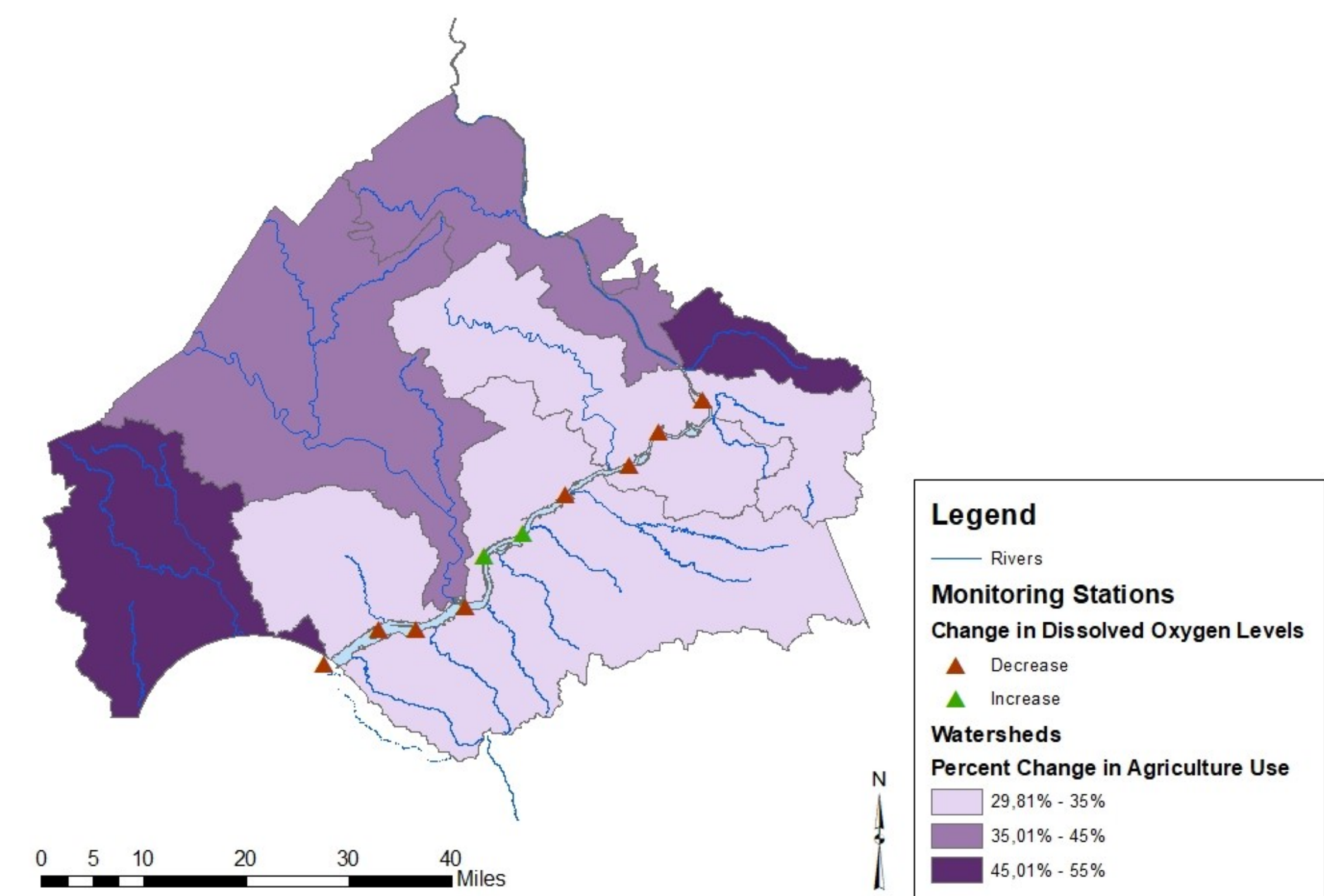


Figure 3: Agriculture Coverage Change

Change in Agricultural Use and Phosphorous Levels, 2005-2015



Change in Agricultural Use and Dissolved Oxygen Levels, 2005-2015



RESULTS

Since agriculture was determined to be the most significantly changed land use, decreasing by 4.1%, phosphorous, a nutrient pollutant associated with agriculture use due to its presence in fertilizers and manure and regularly reported in water quality tests, was tracked along the Boat Run stretch of the Delaware River. Average phosphorous concentrations were determined for each monitoring station in both 2005 and 2015, as was a percent change. After classifying each monitoring station by its percent increase or decrease, it was determined that the monitoring stations showing a percent decrease in phosphorous levels were those directly downstream of the watersheds showing the larger percent decrease in agricultural land use. This result was expected, and confirmed the hypothesis that decreasing agricultural use could be correlated to decreasing phosphorous levels. One outlier to this result was the Brandywine-Christina Watershed—the most southwest watershed—which showed a large decrease in agriculture use but did not show a decrease in phosphorous levels in the monitoring station immediately downstream. This is likely the case because a significant portion of this watershed lies outside the analyzed county boundaries. There are also more monitoring stations downstream of that watershed that were not analyzed, so it is possible those areas showed a decrease in phosphorous levels.



There did not, however, appear to be an increase in dissolved oxygen concentrations as a result of decreasing phosphorous levels. While this result is unexpected, it is not unreasonable. While agriculture showed the largest decrease as a percentage of land use, residential use showed the largest increase. Increasing residential use not only means more people living in the area leading to an increase in municipal wastewater being discharged into the river, but also implies that more surfaces will be either paved or covered with a roof, increasing storm water runoff into the river. This change is likely associated with an increase of other pollutants (organics or nutrients) that are affecting the dissolved oxygen levels more than the decrease in phosphorous. The percent decrease in dissolved oxygen levels is not detrimental: no monitoring station saw a decrease greater than 10%. The lowest average dissolved oxygen concentration in the Boat Run stretch was ~7 mg/L, which is the suitable level for trout spawning determined by the DRBC.

CONCLUSION

In order to more fully analyze the effect of land use change on water quality, this project would have to be expanded to examine the impact of every land use change on every pollutant or nutrient monitored in the river. It would also be useful to divide the watersheds into smaller sub-watersheds, which would more accurately determine which land areas are feeding which monitoring station. Overall, the water quality of this portion of the Delaware River is good: the dissolved oxygen levels over the past ten years are consistently above the standards to sustain fish life, showing a drastic improvement since the passing of the Clean Water Act. Using data from those years, one would likely see the rapid deindustrialization of the area correlate with decreasing levels of organics and other pollutants coming from industrial effluents and a significant increase in dissolved oxygen levels. That data, both for land use and water quality, is not available to the public. The river today appears to be maintaining levels achieved from an intense period of policy change and clean-up efforts. It is important for the economic and environmental well-being of the area that as it becomes more developed residentially, the water quality in the river stay above federal standards. With that rationale in mind, it is likely that the many planning commissions and water authorities throughout the area and along the greater stretch of the river will continue monitoring water quality and reinforcing quality standards well into the future.

References and Data Sources

- Kauffman, G. J., Jr. (2010). The Delaware River Revival: Four Centuries of Historic Water Quality Change From Henry Hudson to Benjamin Franklin to JFK. *Pennsylvania History: A Journal of Mid-Atlantic Studies*, 77(4), 432-465. doi:10.1353/pnh.2010.0008
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