Impacts of a Forested Park and Reservoir on Stream Nutrient Loads in Southwest Ohio

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Introduction

Pollution from agricultural runoff in the Midwestern US has led to eutrophication in freshwater and coastal systems (Carpenter et al. 1998; Bernot et al. 2006; Stets et al. 2020). Despite efforts to combat nonpoint source pollution, many agricultural watersheds in the US continue to exhibit elevated nutrient concentrations. Although widespread conversion to agricultural land cover has contributed to eutrophication in many Midwestern watersheds, remaining forested areas may improve water quality in streams and decrease downstream transport of nutrients.

Within Midwestern regions dominated by agricultural land use, many small forested areas, frequently centered around a man-made or natural lake, exist in fragmented locations. Studies have shown riparian vegetation can limit runoff of excess nutrients into stream systems (Phillips 1989; Mayer et al. 2007; Hill 2019). In addition, reservoirs can retain nutrients (Vanni et al. 2011; Powers, Tank and Robertson 2015), although they can also be a source of nutrients during times of year when streams are delivering smaller loads (Williamson et al. 2019). Less commonly studied are transitions from agricultural land cover to forested land cover, and the relative impacts of streams and reservoirs in a linked catchment system.

Research Questions

1. Do changes in Total Nitrogen (TN), Total Phosphorus (TP), Nitrate (NO_3^-), Soluble Reactive Phosphorus (SRP), nitrite (NO_2^-), and ammonium (NH_4^+) loads differ between streams and Acton Lake within Hueston Woods State Park?

Hypothesis 1a.) The streams and Acton Lake combined will result in a significant decrease in nutrient loads within Hueston Woods State Park.

Hypothesis 1b.) The decrease in loads for all nutrients will be greater in the lake than within the streams due to increased residence time within the lake.

2. Do storm events or vegetation cover (NDVI) affect changes in nutrient loads in the study streams or Acton Lake?

Hypothesis 2a.) Changes in nutrient loads within the study streams and Acton Lake will decrease during storm events due to decreased residence time.

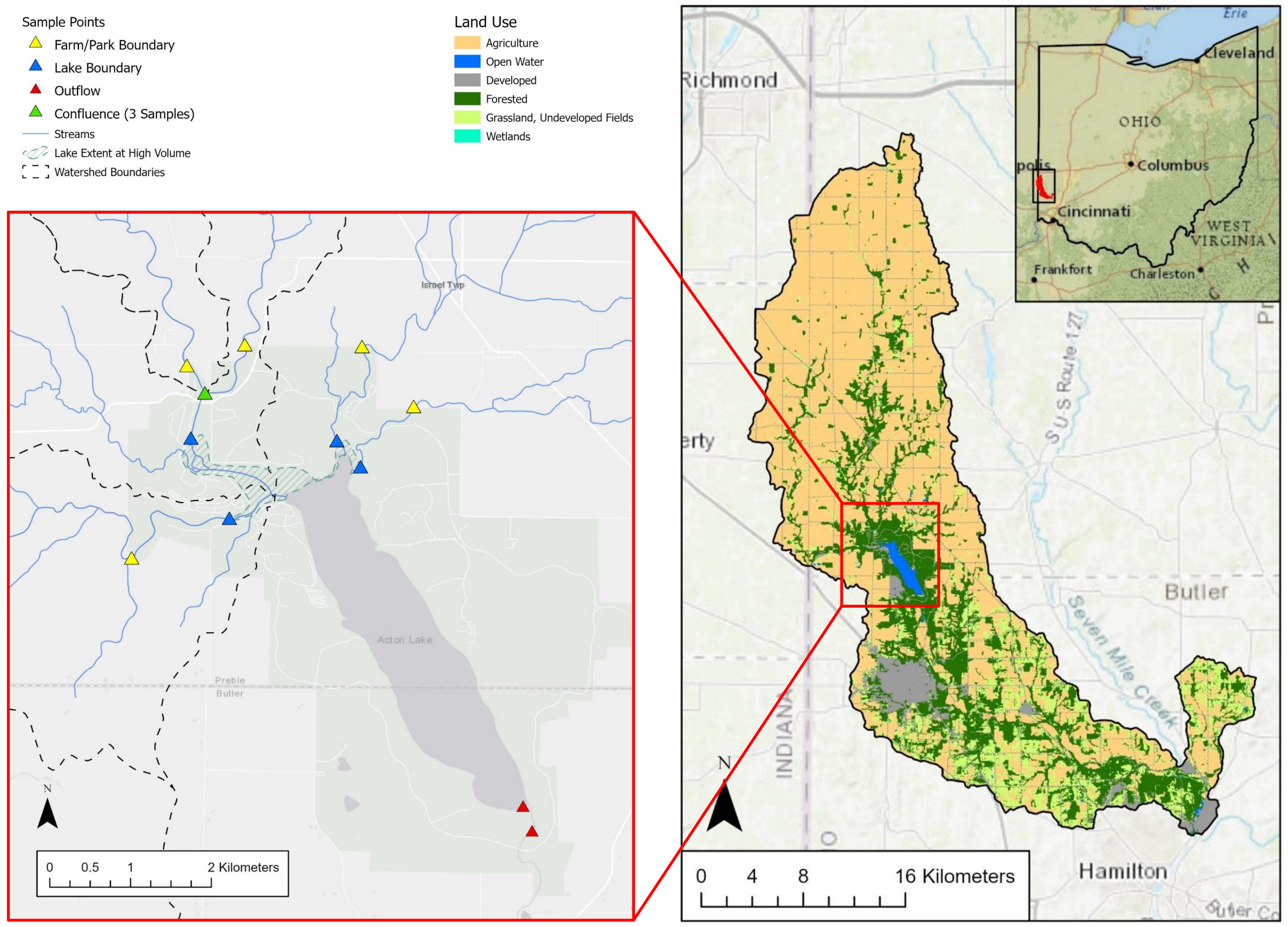
Hypothesis 2b.) Increased NDVI within the park boundary will correlate with larger decreases in nutrient loads.

Study Site

This study will be conducted within Hueston Woods State Park, a small, forested area within an agriculturally dominated watershed in Southwest Ohio. Over 80% of land cover within the watershed consists of soy and corn crops. The underlying geology is comprised of glacial till with poorly drained soils, and tile drained agricultural practices are common. Climate in the region is strongly seasonal, with most precipitation occurring during winter and spring.

Little Four Mile Creek, Four Mile Creek, Marshall's Branch, and Deer's Ear are the four main streams in the watershed and account for >90% of the watershed's land area that drains into Acton Lake. The streams differ in sub-watershed area and are comprised of plane-bed, pool-riffle and occasional step-pool morphology (Rech et al. 2018). Each stream flows across the park boundary roughly a mile before entering the lake, at which point it is surrounded by riparian and forested land cover.

Acton Lake is a hypereutrophic reservoir at the center of Hueston Woods State Park. Constructed in 1956, the lake is 625 acres with a maximum depth of 30' and flows out through a spillway dam at the southern end.



Methods

- Water samples will be collected by hand biweekly at 14 sample sites (see map) for 2 years beginning December 2019.
- Samples will be filtered through a glass NVSS microfiber filter and processed with a Lachat autoanalyzer for concentrations of TN, TP, NO_3^-, SRP, NO_2^-, and NH_4^+.
- Manual discharge measurements will be taken to calibrate Onset HOBO automatic water level loggers operating for the duration of the study in each stream and for stage measurements taken below dam outflow.
- Additional discharge measurements at sample sites will quantify stream discharge gain or loss within park boundaries.
- Nutrient concentrations will be multiplied by stream discharge to quantify nutrient loads at the time of sample collection.
- Additional information on independent variables will be collected for modeling change in loads within the system:
  - Stream morphology surveys will quantify residence time within each stream.
  - Satellite imaging and ground surveys will determine NDVI and potential vegetation uptake within stream corridors.
  - Dissolved Organic Carbon (DOC) and Total Suspended Sediment (TSS) concentrations will be quantified for each water sample.
- ANCOVA will be used to model change in loads from park boundary to the lake confluence for each stream and change in loads from streams/lake confluence to the dam outflow.
- Data collection is currently ongoing and will finish in December 2021

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