How Land-Use Efficiency Affects Nitrogen Loading in NC Watersheds

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Introduction

This research used nitrogen data obtained from the Jordan Lake Nutrient Management Study, coupled with population data, to evaluate land use efficiency and nutrient loading in local watersheds. In addition to this nutrient data, land-use zoning ordinances and parcel data were examined in evaluating the extent and effect of urban development on population. Understanding the relationship between land use efficiency and nutrient loading can better equip municipalities to effectively implement stormwater mitigation and watershed stewardship.

What is land use efficiency?

Land use efficiency, within the scope of this project, is population per unit of nitrogen pollution. Excess nutrients are the primary concern for the health of Jordan Lake. With respect to watershed health, efficiency should minimize nutrient loading.

Hypothesis & Question

Watersheds with greater impervious surface cover (ISC) will have lower per capita amounts of nutrients due to increased population density.

Is there an optimal ratio between population and nutrient loading in a given area that can inform urban development standards?

Methodology

Formulas:

$$\frac{BG\ res\ pop}{BG\ res\ parc} = \frac{Pop}{Res\ parc}(BG)$$

$$(WS\ res\ parc) \times \frac{Pop}{Res\ parc}(BG) = WS\ res\ pop$$

$$\frac{CH\ working\ pop}{CH\ comm\ parc} = \frac{Pop}{Comme\ parc}(CH)$$

$$(WS\ comm\ parc) \times \frac{Pop}{Comm\ parc}(CH) = WS\ working\ pop$$

$$Res\ pop + Working\ pop = Total\ pop\ (WS)$$

$$\frac{Nitro.loading\ (WS)}{Total\ WS\ pop} = Nitro.loading\ per\ capita\ (WS)$$

Results

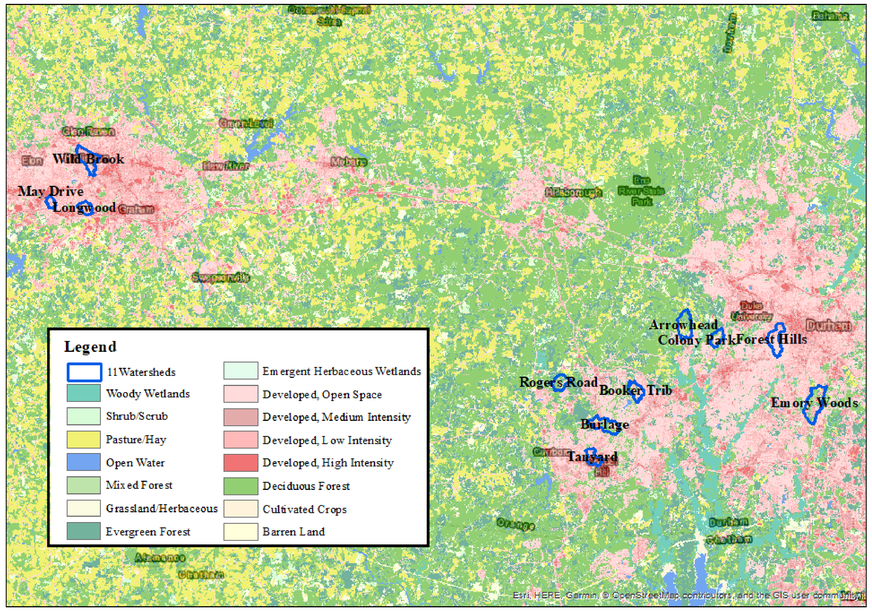

Figure 1. Map of location and cover for each watershed. *ArcGIS*

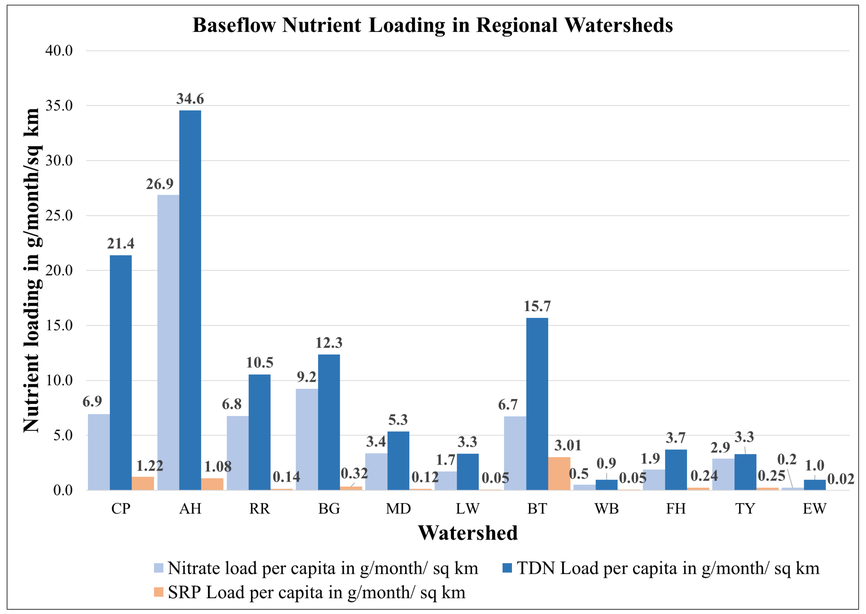

Figure 2. This graph compares nutrient loading per capita among nitrate, total dissolved nitrogen, and soluble reactive phosphorus. Watersheds are listed in order of increasing population. As watersheds increase in population, their land use efficiency also increases.

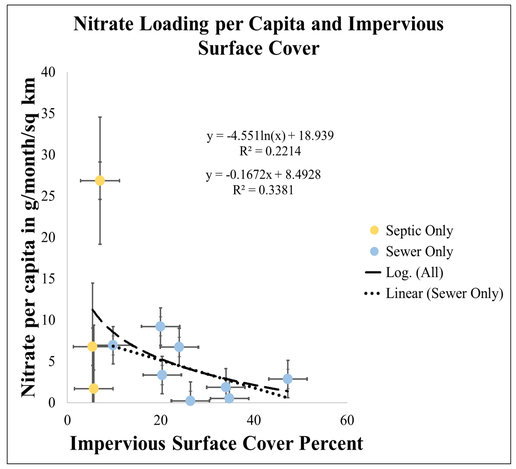

Figure 3. Nitrate loading per capita decreases with increasing impervious surface cover.

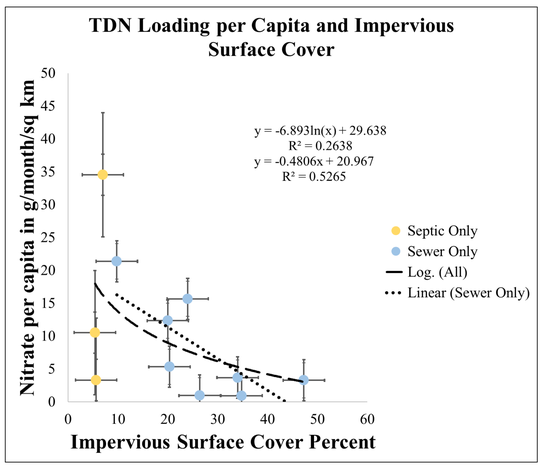

Figure 4. TDN loading per capita decreases with increasing impervious surface cover.

Discussion

- Population per unit of nitrogen serves as an indicator of land use efficiency
- Increased land use efficiency results in decreased nitrogen loading per capita
- Broad analysis of zoning does not indicate impact on nitrogen loading
- Nitrogen loading is lower on a per capita basis in watersheds with more efficient land use

Implications and Future Work

- Account for septic and sewer system differences
- Examine other methods of nutrient loading data; baseflow does not account for stormflow, which is greater in higher density watersheds
- Investigate watersheds and land use efficiency in other municipalities
- Regard zoning as a facet of land use efficiency, not a cause

Resources:

Jordan Lake Nutrient Management Study, (2017). University of North Carolina at Chapel Hill, Environmental Resources Program, NC Policy Collaboratory.
Stone, B., & Bullen, J. L. (2006). Urban Form and Watershed Management: How Zoning Influences Residential Stormwater Volumes. Environment and Planning B: Planning and Design, 33(1), 21–37. https://doi.org/10.1068/b31072.
U.S. Census Bureau; TIGER/Line Shapefiles 2018; (6 June, 2019).
U.S. Census Bureau; American Community Survey, 2013-2017 American Community Survey 5-Year Estimates, Table B01003; generated by Natalie Gauger; using American FactFinder; <http://factfinder.census.gov>; (6 June 2019).
Zoning Ordinances; City of Burlington, City of Durham, City of Graham, Town of Carrboro, Town of Chapel Hill, Town of Elon.

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