The Influence of Urbanization on Stream Quality and Fish Health

*Kate R. Norrid[1, *], B. Graeme Lockaby[2], and Dennis R. DeVries[3]*

[1] Undergraduate Student, College of Forestry, Wildlife, and Environment, Auburn University
[2] Professor, College of Forestry, Wildlife, and Environment, Auburn University
[3]Professor, School of Fisheries, Aquaculture, and Aquatic Sciences, Auburn University

As urbanization increases, stream quality is affected due to the manipulation of waterways to promote fast-draining channels that prevent flooding. As this occurs, stream hydrology is negatively impacted, and it causes unnatural changes in flow frequency and magnitude (Walsh et al. 2005). In addition, human waste runoff into streams pollutes the water, leading to higher levels of pollutants such as *E. coli* and suspended solids. The negative relationship between water quality and the degree of urbanization has been well documented; however, there is relatively little information on how urbanization- related water degradation affects the health and overall physiology of resident aquatic biota.

A small number of studies have been conducted that correlate stream quality and overall fish health (Morse 2005, Menvielle 2006, Helms et al. 2009, Sayer 2012, Nagrodski et al. 2013, Wedge et al. 2015, Iwanowicz et al. 2016), but there remains little information on this critical topic for the lower Piedmont physiographic region of the southeastern United States, a region that is rapidly urbanizing (Wear 2013, Curl and Bell 2021). Our research represents an initial attempt to quantify the specific effects of urbanization-related water degradation on overall fish health within our focal region.

Six total streams, 3 urban and 3 rural, were selected in and around Auburn and Opelika, Alabama. Streams were either 2nd or 3rd order and were associated with watersheds that ranged in size from 130 to 5700 hectares. Indices of fish health and water quality were quantified at each site. Measured water quality metrics included dissolved oxygen, nitrate, phosphate, total suspended solids, and *E. coli*. To quantify fish condition, we collected sunfish (*Lepomis* spp.) from each site using seine nets. These fish were selected for our study due to their abundance in the region and widespread cosmopolitan distribution. Physiological health indices collected from the fish included length-weight ratios (calculated from fish length and weight), hepatosomatic index (calculated from liver weight and fish weight), and gonadosomatic indices (calculated from gonad weight and fish weight). In addition, we extracted otoliths from each fish to determine age, allowing us to quantify population age structures in rural and urban stream systems.

Preliminary results have shown stark differences in *E. coli* levels between land use types (Figure 1). Water and fish data compilation is still ongoing, with statistical analysis in progress. We hypothesize that fish from urban degraded streams will show lower fish condition measures relative to those from forested reference streams and that the urban systems will have altered population dynamics (i.e., younger-biased age structure); however, the extent of these differences is yet to be determined. Once finalized, our results will be of significance to the field of stream conservation because of the evidence linking urbanization, poor water quality, and negative health implications for native aquatic organisms. In addition, they will help fill the current knowledge gap on this subject in the region and give local insight.

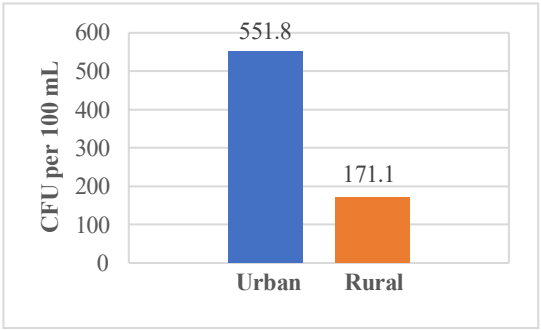


Fig. 1 Means of *E. coli* levels (colony forming units per 100 mL) by land use type.

Statement of Research Advisor

This study, including the hypotheses and general approaches, represents original ideas of Kate Norrid that she developed independently after reviewing pertinent literature. She clearly identified a key gap in the scientific literature pertaining to urbanization effects of surface water and has been responsible

* Corresponding author: krn0009@auburn.edu

for implementing each stage of the study with advice from myself and Dr. DeVries. Kate's insight and creativity on this project show an unusually high level of research aptitude.
- *Graeme Lockaby, College of Forestry, Wildlife, and Environment*

References

Curl, J., and Bell, L. Hydrogeologic Provinces of Alabama. Retrieved August 4, 2022, from https://www.aces.edu/blog/topics/fish-water/hydrogeologic-provinces-of-alabama/, (2021).

Helms, B.S., Schoonover, J.E., Feminella, J.W., "Assessing influences of hydrology, physicochemistry, and habitat on stream fish assemblages across a changing landscape," Journal of the American Water Resources Association, 45(1), pp. 157-169, (2009).

Iwanowicz, D., Black, M.C., Blazer, V.S., Zappia, H., Bryant, W., "Effects of urban land-use on largescale stonerollers in the Mobile River Basin, Birmingham, AL," Ecotoxicology, 25, pp. 608-621, (2016).

Menvielle, E.A., *Relationship of water quality and geochemistry to fish condition factors, isotopic composition, and otolith microchemistry within an urbanized watershed: Onondaga Creek (Syracuse, NY)*, M.S. Thesis, State University of New York, (2006).

Morse, K.J., *The effects of urbanization on the health of fish and benthic macroinvertebrate communities in the Upper Cahaba River watershed*, Ph.D. Thesis, University of Alabama at Birmingham, (2005).

Nagrodsky, A., Suski, C.D., Cooke, S.J., "Health, condition, and survival of creek chub (*Semotilus atromaculatus*) across a gradient of stream habitat quality following an experimental cortisol challenge," Hydrobiologia, 702, pp. 283-296, (2013).

Sayer, A.N., *The influence of land use on fish health and fish communities in wadable streams in South Carolina*, Ph.D. Thesis, Clemson University, (2012).

Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham, P.D., Groffman, P.M., Morgan II, R.P., "The urban stream syndrome: current knowledge and the search for a cure," Journal of the North American Benthological Society, 24(3), pp. 706-723, (2005).

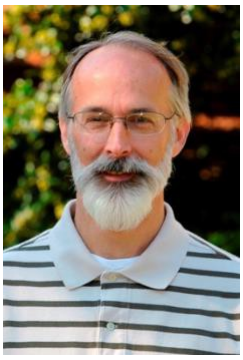
Wear, D., "Forecasts of Land Uses," In D. Wear and J. Greis, Eds., *The Southern Forest Futures Project: USDA Forest Service Tech. Rep. SRS-178*, Asheville, NC: USDA FS Southern Research Station, (2013).

Wedge, M., Anderson, C.J., DeVries, D., "Evaluating the effects of urban land use on the condition of resident salt marsh fish," Estuaries and Coasts, 38, pp. 2355-2365, (2015).

Authors Biography

Kate R. Norrid is a senior-year student pursuing a B.S. degree in Wildlife Ecology and Management at Auburn University. She is interested in studying health from a holistic environmental perspective and plans to work in stream restoration and mitigation following graduation.

Dr. Graeme Lockaby is a professor in the College of Forestry, Wildlife, and Environment at Auburn University. He earned his B.S. and M.S. in Forestry at Clemson University and his Ph.D. in Agronomy–Soils at Mississippi State University. Lockaby's program focuses mainly on the biogeochemistry of forested floodplains and relationships between wetlands and human health.



Dr. Dennis DeVries is a professor and assistant director for research programs in the School of Fisheries, Aquaculture, and Aquatic Sciences at Auburn University. DeVries's program broadly focuses on the interface between basic fields of ecology and applied fields of fisheries and natural resource management.