RESULTS FROM SIX YEARS OF COMMUNITY-BASED VOLUNTEER WATER QUALITY MONITORING BY THE UPPER OCONEE WATERSHED NETWORK

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Abstract. The Upper Oconee Watershed Network (UOWN), an Athens, GA-based non-profit volunteer organization, was organized in 2000 with the mission to improve water quality in the Upper Oconee River basin through community-based advocacy, monitoring, and education. Quarterly monitoring of both reference and impaired stream segments form the basis for achieving all three of UOWN's mission objectives. UOWN has developed a model for engaging the public in quarterly monitoring and in the larger annual River Rendezvous events. Quarterly monitoring not only tracks long-term trends in targeted stream segments, but also has resulted in the discovery and remediation of acute incidences of pollution. Six years of data collection revealed high levels of contamination in urban streams as evidenced by high conductivity and bacterial numbers, and potential limitations when using quarterly water quality monitoring to assess the health of Piedmont streams.

INTRODUCTION

Volunteer watershed monitoring groups serve an important function in protecting water quality by promoting a sense of watershed stewardship among citizens and by collecting important water quality data. According to the Georgia River Network website (www.garivers.org), there are at least 63 watershed groups in Georgia alone. While the approaches taken by each group to fulfill their mission may vary, all struggle with the issue on how best to improve the quality of their waters of concern given limited resources.

The Upper Oconee Watershed Network (UOWN), based in Athens, GA, was incorporated as a non-profit in 2000 and uses quarterly monitoring events as the basis for advocacy and education. UOWN also engages the public in a yearly River Rendezvous event to collect samples from 100 or more different sites in a single morning. Previous analyses of UOWN's quarterly data in relation to land use revealed a correlation between development in the watershed and water quality impairment (Conners et al. 2001, Wenner et al. 2003). The purpose of this study was to expand the study to 17 quarterly sites in the Upper Oconee River basin over a period of four to six years to assess seasonal and land use trends on physical, chemical and biological water quality indicators (conductivity, turbidity, pH, nitrate, phosphate, fecal coliform, and *Escherichia coli*).

METHODS

Data collection

Stream and river sites within the Upper Oconee River basin (USGS Cataloging unit 03070101) were sampled four times each year in January, April, July, and October for between four and six years. Teams of volunteers, led by a Georgia Adopt-A-Stream (GA DNR, 1997) certified team leader, visited each quarterly site to collect water samples that were kept on ice to be tested according to established protocols. Volunteer labs (Dr. Dwight Fisher and Dr. Deanna Conners) processed the bacterial samples within six hours. Numbers for fecal coliforms were determined using the membrane filtration method (APHA et al. 1992), and counts of *E. coli*, Enterococci, and total coliforms were determined using fluorometric methods (IDEXX Laboratories, Westbrook, ME). Bacterial numbers are expressed as colony forming units (cfu) or most probable number (MPN) per 100 ml. Conductivity and pH were measured with an Oakton pH/CON 10 series meter and turbidity was measured using a LaMotte 2020 meter. A Hach DR 890 colorimeter was used to analyze nitrate (NO_3-N) and phosphate (PO_4) concentrations. Precipitation data were obtained on-line from the USGS North Oconee at College St. station (USGS0217770).

Data analysis

Seven parameters including precipitation, conductivity, turbidity, *E. coli*, fecal coliforms, nitrate, and phosphate were analyzed from the quarterly data from 17 sites (Table 1) for the period of April 2000 through July 2006. Sites were selected to reflect a range of land use designations (i.e., rural, suburban, urban, or river). Urban streams are located in the urban core of

Athens and are impacted by dense development, impervious surfaces, industrial areas, and sewer lines. Suburban streams are located outside of the urban core and are impacted by suburban-style development, industrial areas (Trail Creek), and sewer lines. Rural streams are located in the agriculturally zoned "Greenbelt" or in the state botanical garden (Orange Trail Creek) and are typically relatively undisturbed by development above the sampling site, although two sites (Orange Trail Creek and Shoals Creek) are impacted by agricultural uses. No sewer lines are associated with rural streams. River sites include one on the Middle Oconee upstream of the urban core and two sites on the North Oconee (above and below a wastewater treatment plant) within and below the urban core. For each site and variable, seasonal (winter, spring, summer, fall) means and standard errors were determined across years. Pearson's correlation coefficients among variables were determined using the SAS statistical software (SAS Institute Inc., Cary NC).

RESULTS

When considering stream type, urban streams had higher conductivity than suburban, rural or river sites, with average readings twice as high as rural or suburban streams (Fig. 1A). Also, conductivity readings generally were highest in the fall. Rivers had considerably higher turbidity readings than the streams (Fig. 1B). Numbers of fecal coliforms (Fig. 1C) and *E. coli* (Fig. 1D) were highest in suburban and urban stream types, especially in the spring and summer, while rural streams tended to have the lowest bacterial counts. Nitrate levels were highest in urban and rural streams (Fig. 1E) while phosphate levels were variable across seasons and site (Fig. 1F).

Table 1. UOWN sites for this study sorted by land use designation. Site location indicated by latitude and longitude.

Site Classification and Site Name	Latitude	Longitude
Rural		
Bear Creek Tributary	33°58'06"	83°29'50"
Shoal Creek	33°58'09"	83°18'14"
Orange Trail Creek	33°54'11"	83°22'47"
Sandy Creek	33°58'50"	83°22'55"
Suburban		
Cedar Creek	33°55'27"	83°19'15"
McNutt Creek	33°55'36"	83°25'40"
Trail Creek	33°57'16"	83°21'57"
Hunnicutt Creek	33°57'27"	83°26'16"
Urban		
Brooklyn Creek	33°56'51"	83°23'58"
Barber Creek	33°58'01"	83°23'26"
(upstream, downstream)	33°58'09"	83°23'18"
Brickyard Creek	33°58'31"	83°23'35"
(upstream, downstream)	33°58'35"	83°23'24"
Pulaski Creek	33°58'04"	83°22'46"
River		
North Oconee (above)	33°57'19"	83°22'04"
North Oconee (below)	33°55'55"	83°21'35"
Middle Oconee	33°57'28"	83°26'19"

A number of significant correlations were observed among pairs of variables in the data set. Turbidity (r = 0.17, P = 0.0106, n = 222) and log-transformed *E. coli* counts (r = 0.25, P = 0.0002, n = 206) were correlated significantly with precipitation recorded within 24 hours of the sampling period (Fig 2). Log-transformed counts of *E. coli* and fecal coliforms were correlated with each other (r = 0.44, P < 0.0001, n = 209). Counts of *E. coli* (r = 0.40, P < 0.0001, n = 241) and fecal coliforms (r = 0.17, P = 0.0076, n = 235) also were correlated with turbidity. None of the correlations involving conductivity were significant at $P \leq 0.05$.

DISCUSSION

Conductivity, an indicator of dissolved contaminants such as nutrients or chemicals, was significantly higher in most urban streams. These streams drain the highly urbanized areas of Athens. A variety of contaminants enter streams from the surrounding impervious surfaces during storm flows and from groundwater and point source discharges during low flow. Turbidity and bacterial numbers were positively correlated with precipitation within 24 hours of the sampling event. Storm water run-off from high flow events, when compared to low-flow events, can substantially increase sediment transport and bacteria levels in Upper Oconee River basin sites (Eggert et al., 2005). Turbidity readings from river sites remained consistently higher during both low-flow and high-flow events, and across seasons, indicating the cumulative effects of upstream erosion and historical sediments.

Nitrate and phosphate concentrations were high in many urban streams, indicating the variety of contaminants entering these streams. High nitrate levels are also a problem in some rural streams, especially in a stream system in the State Botanical Garden that drains the University of Georgia (UGA) swine farm operations. In the North Oconee River, there were consistently elevated levels of phosphate and bacteria, when compared to phosphate and bacteria levels at the upstream site, at a site just below an antiquated and near-capacity wastewater treatment plant that the county has scheduled for replacement within 5 years.

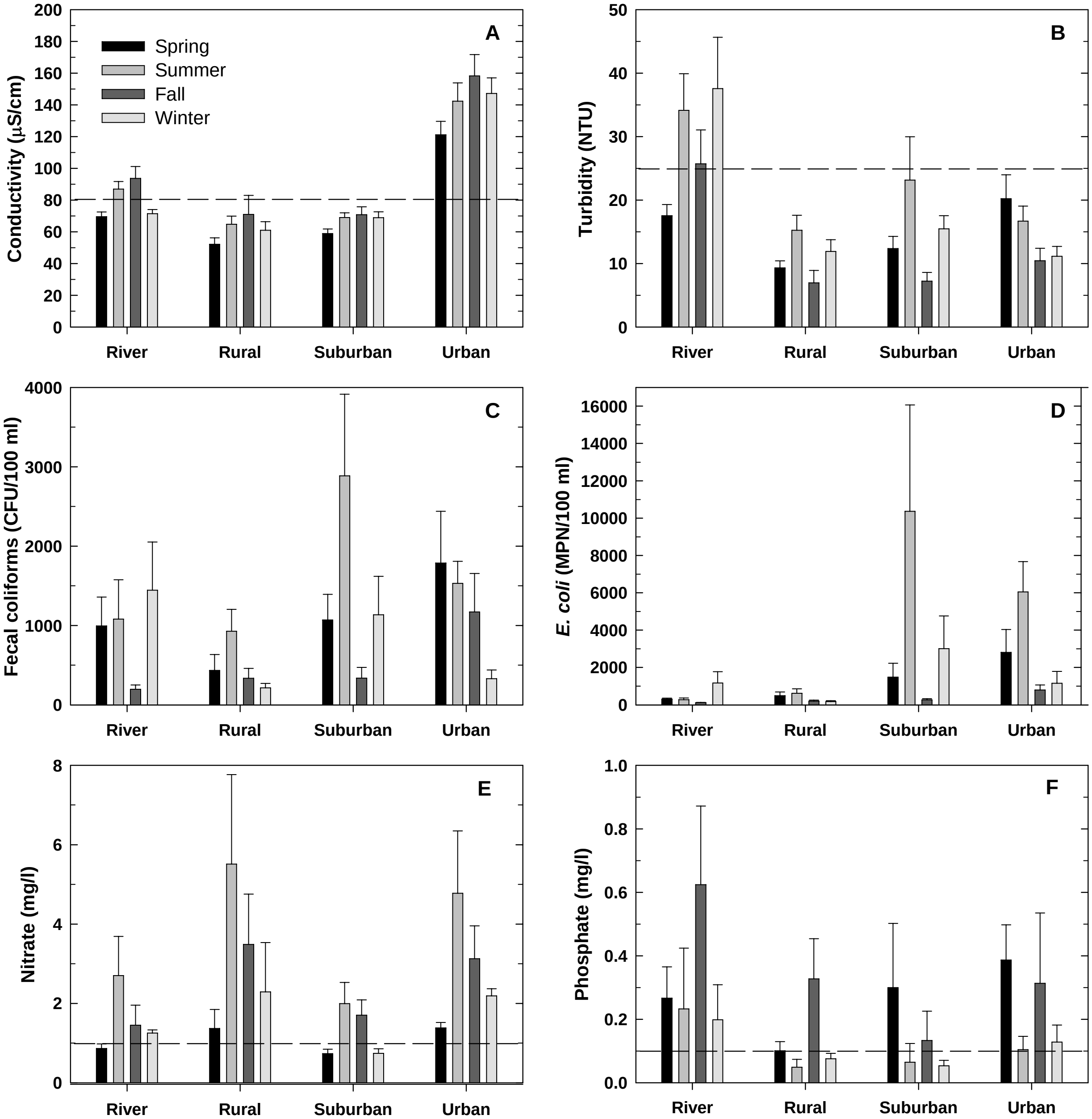

Figure 1. Seasonal averages and standard errors (*n* = 15-30) for six water quality variables measured at 17 sites in Athens-Clarke County. Each site was classified according to the general land use designations of rural, suburban, urban, or river. Horizontal lines indicate UOWN and Georgia water quality thresholds.

Fecal coliform standards (<200 cfu/100 ml May through October, <1000 cfu/100 ml November through April, GWQC) were violated in many streams when sampling occurred within 24 hours of significant (>0.25 cm) precipitation. High bacterial numbers may be attributed to animal waste (domestic and wild) in storm water run-off (Carroll and Rasmussen, 2005). Bacterial numbers were generally lower during low-flow events (Fig. 2). Rural streams on average had acceptable bacterial numbers during times of low-flow, but often urban and suburban streams contained high numbers of bacteria during low-flow. These high numbers were generally associated with active sewage leaks. Most of the urban and suburban streams have sewer line easements along much of their reach resulting in periodic sewage discharges from blockages or breaks. Based on the findings from quarterly monitoring, UOWN detected and reported several sewage leaks (Carroll and Rasmussen, 2005). Most sewer failures were quickly corrected but for some the source of the contamination was elusive

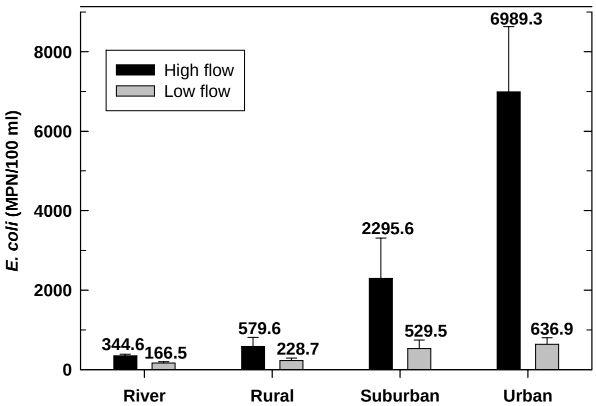

Figure 2. Mean numbers of *E. coli* bacteria measured at 17 sites when precipitation within 24 hrs. was >0.25 cm (High flow, 4 dates) or <0.25 cm within 48 hrs. (Low flow, 4 dates). Sites are classified according to land use designations.

resulting in consistently high numbers of bacteria at some stream sites.

New standards using *E. coli* as an indicator are currently being proposed by the EPA, but have not been accepted by the GA EPD. *E. coli* bacteria are a subset of fecal coliforms. The correlation between fecal coliforms and *E. coli* in this study was to be expected, although *E. coli* numbers often exceeded the number of fecals. This may be due to the use, in this study, of the IDEXX method for *E. coli*, which is a more sensitive test than the membrane filtration method commonly used for fecals. Therefore, standardization of testing methods should be a consideration when establishing bacterial thresholds in water.

Only 14% of the 70,150 stream and river miles in Georgia are monitored for water quality, and of that percentage nearly 60% do not meet water quality standards (Georgia River Network). Several of UOWN's quarterly sites are on the TMDL 303(d) list of impaired waters. Volunteer groups such as UOWN can assist local governments by providing water quality data and identifying potential water quality impairments, although UOWN lacks the resources to complete extensive surveys of local stream segments. Future directives for UOWN include developing a cooperative program with Athens-Clarke County to track and remediate sources of contamination in impaired stream segments.

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