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NUTRIENT DYNAMICS OF THE LUMBEE RIVER BASIN POST-HURRICANE MATTHEW: CLOSING THE DATA AVAILABILITY GAP FOR BASIN RESIDENTS

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WRRI Project # 17-01-W

Progress Report
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Prepared by:
Ryan Emanuel (faculty PI) and Justine Neville (student PI)

Project Overview

In October 2016, Hurricane Matthew brought unprecedented flooding to the Lumbee River basin in Southeastern North Carolina. Peak discharge at the USGS stream gage near Boardman, NC (Station Number 0234500) exceeded 1000 m^3s^{-1}, more than double the peak discharge following Hurricane Floyd, which had been the basin's worst flood in living memory (Figure 1). Regional flooding was widespread across the basin, especially southwest of downtown Lumberton, NC (Figure 2). Observations from the southwest side of Lumberton suggest that massive amounts of sediment were transported down the main stem of the Lumbee River before being deposited in neighborhoods close to or within the floodplain (Figure 3).

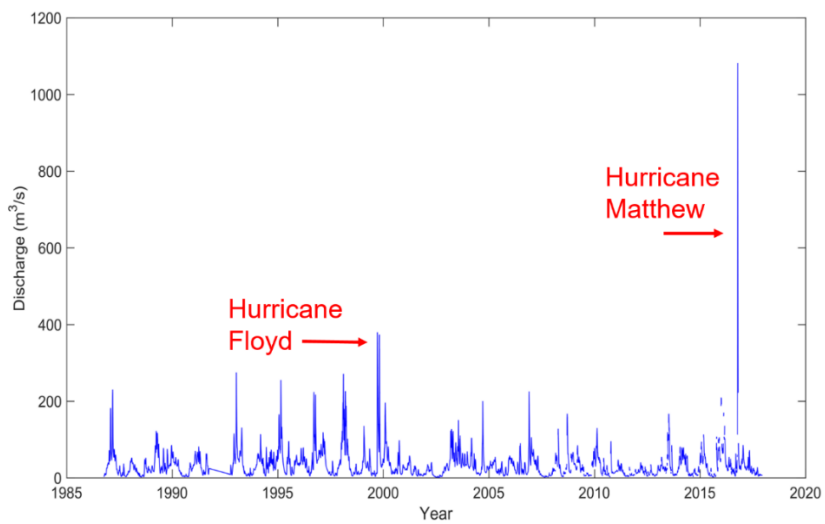

Figure 1: Hydrograph of Lumbee River (USGS Station 0234500) showing flood peaks following Hurricane Floyd (1999) and Hurricane Matthew (2016).

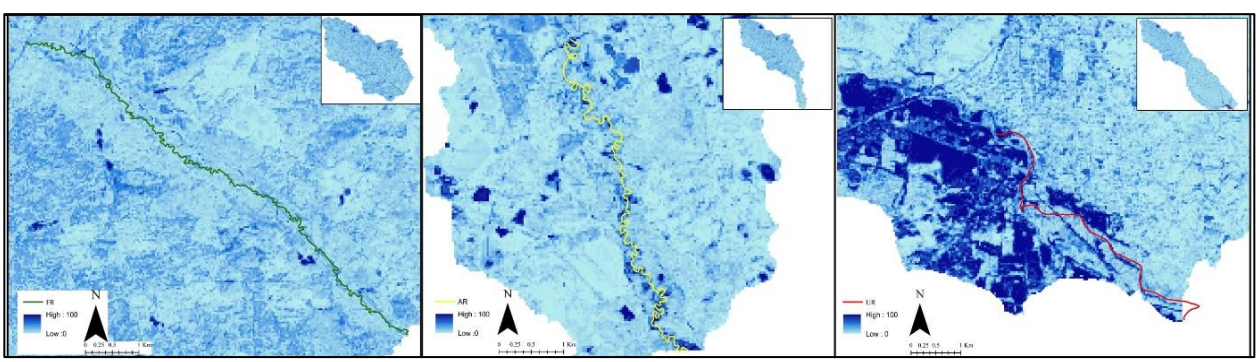

Figure 2: Estimates of flood extent following Hurricane Matthew using satellite imagery analyzed by Dr. Joshua Gray (NCSU).

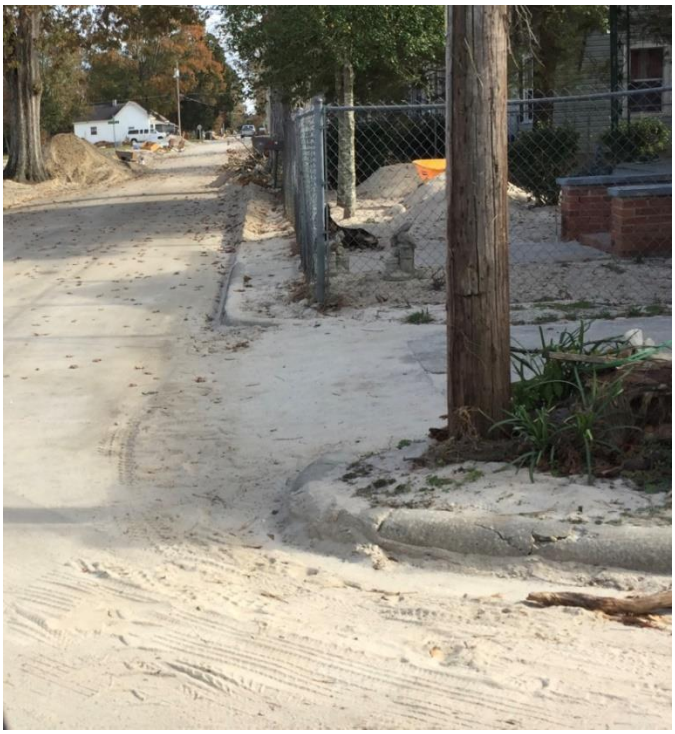

Figure 3: Sediment deposited by Hurricane Matthew flooding in a neighborhood southwest of downtown Lumberton, NC.

The timing of Hurricane Matthew coincided with a year-long study of the spatial variability of dissolved nitrate (NO_3^-) in three reaches of the Lumbee River characterized by their proximal land use: forested, agricultural, and urban. Flooding caused by Hurricane Matthew provided a unique opportunity to study in-stream nitrogen processing before and after the flood. Potential sediment transport, addition of woody debris, temporary connectivity of nutrient sources, and other phenomena associated with the flood may have altered the river's capacity to either retain NO_3^- or to deliver this nutrient to downstream waters.

This work focused on three reaches that are part of an ongoing study of water quality in the Lumbee River basin (Figure 4). Synoptic NO_3^- samples collected along each reach were combined with estimates of streambed area and used to compute NO_3^- retention values for each reach and sampling date. Each reach was sampled 4-5 times before and after Hurricane Matthew, resulting in a distribution of NO_3^- retention values for each reach and date. The resulting dataset included a total of 28 distributions of NO_3^- retention from all three reaches, 14 in the months before Hurricane Matthew, and 14 in the months after the storm. We used these distributions in Wilcoxon Rank-Sum and 2-Sample Kolmogorov Smirnov tests to determine whether or not NO_3^- retention differed significantly for each reach before and after Hurricane Matthew.

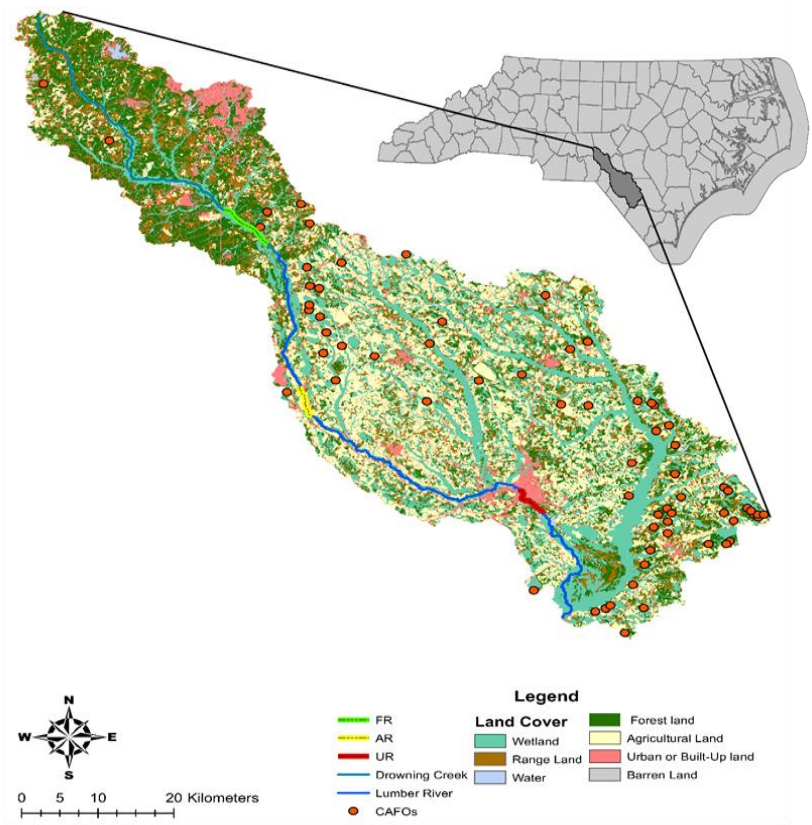

Figure 4: Land cover and study reaches within the Lumbee River basin. Inset shows location of river basin within North Carolina.

Results

All of the stream reaches acted as both sources and sinks for NO_3^- on any given sampling date; however, all three reaches retained more stream NO_3^- prior to Hurricane Matthew than before the storm (Table 1). On sampling dates after Hurricane Matthew, all reaches became less efficient at retaining NO_3^-, but the rate of NO_3^- removal was greater. Moreover, the spatial variability in NO_3^- retention increased significantly following Hurricane Matthew (Figure 5). Whereas NO_3^- retention was fairly homogeneous prior to the hurricane, the range of sources and sinks along reaches increased substantially afterward.

Table 1: Nitrate (NO3-) retention statistics for study reaches

	Pre HM				***Post HM***			
	Mean Percent Retention	**Interquartile Range**	**Mean Areal Uptake**	**Interquartile Range**	**Mean Percent Retention**	**Interquartile Range**	**Mean Areal Uptake**	**Interquartile Range**
Forested	0.2	2.99	-45.86	202.44	-2.84	6.70	-2.84	106.06
Agricultural	0.32	4.43	-169.91	442.08	-3.14	8.22	26.38	162.26
Urban	-0.24	4.89	-13.01	720.19	-0.65	7.80	12.00	134.63

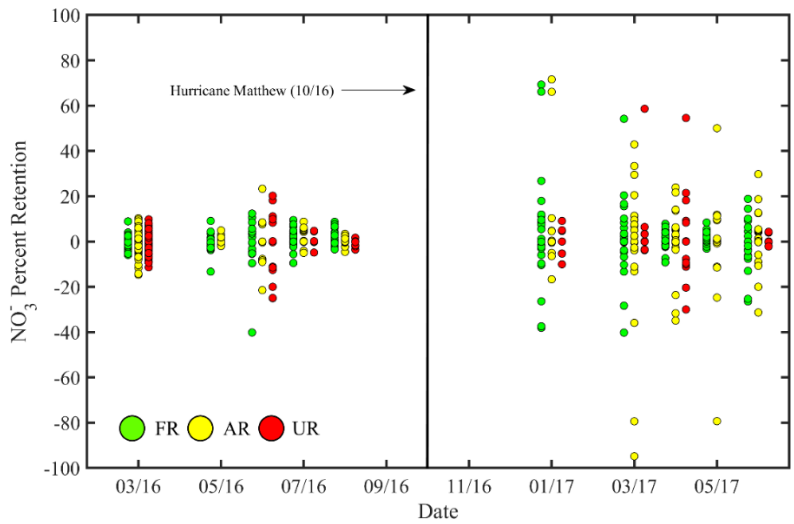

Figure 5: Percent NO3- retention for forested (FR), agricultural (AR) and urban (UR) reaches before and after Hurricane Matthew.

We are continuing to interpret these results in an effort to understand implications for local environments and downstream waters, including estuaries that receive massive nutrient fluxes following storms such as Hurricane Matthew. The high spatial resolution of our dataset gives us a unique opportunity to study the variability of nitrogen processing within a reach, which has the potential to reveal new insight about how biogeochemical functions of streams are altered during major floods.

Products

To date, the project has allowed one NCSU Master's student (Justine Neville) to successfully complete and defend her thesis. The project provided direct funding to Neville and allowed her to travel to the 2017 American Geophysical Union Fall Meeting to present her work. It has also provided lab training for one undergraduate research assistant (Jalen Rose). Products to date include two poster presentations, led by Neville, at the AGU Fall Meeting and the 2018 NC Water Resources Research Institute Conference. The project has supported two scholarly manuscripts, which are currently in preparation.