

Examining the Relationship between Flow and Nutrient Levels at Upstream and Downstream Locations along Ellerbe Creek, North Carolina

https://github.com/rml41/EDA_2020_Project.git

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1 Rationale and Research Questions

Ellerbe Creek runs into the Falls Lake Reservoir, through the city of Durham, North Carolina. Falls Lake serves as the source of drinking water for the City of Raleigh and does not meet North Carolina standards for *chlorophyll a*, which is found in algae (SOURCE: <https://durhamnc.gov/716/Falls-Lake>). Algal blooms generally come from excess nutrients such as phosphorus and nitrogen. Ellerbe Creek is one of the sources of excess nutrients and contaminants in Falls Lake. The Ellerbe Creek Watershed has the highest population density of Durham's watersheds, with an estimated 22% impervious surface (SOURCE: <https://files.nc.gov/ncdeq/Water%20Quality/Planning/BPU/BPU/Neuse/Neuse%20Plans/2009%20Plan/Chapter%201.pdf>). It is impacted by both point and nonpoint sources and was found to deliver the highest nutrient loads to Falls Lake (SOURCE: <https://files.nc.gov/ncdeq/Water%20Quality/Planning/BPU/BPU/Neuse/Neuse%20Plans/2009%20Plan/Chapter%201.pdf>). Ellerbe Creek and Falls Lake are both on the state's impaired water bodies list (303(d) list) (SOURCE: <https://durhamnc.gov/711/Ellerbe-Creek-Watershed>, https://www.usgs.gov/centers/sa-water/science/groundwatersurface-water-interaction-near-ellerbe-creek-durham-nc?qt-science_center_objects=0#qt-science_center_objects). Ellerbe Creek was first listed on the 303(d) list in 1998 (SOURCE: <https://files.nc.gov/ncdeq/Water%20Quality/Planning/BPU/BPU/Neuse/Neuse%20Plans/2009%20Plan/Chapter%201.pdf>)

This analysis and report will aim to answer the following questions: 1. Are Nitrogen and Phosphorus levels in Ellerbe Creek above recommended levels? 2. Is there a relationship between flow and Nitrogen or Phosphorus levels? 3. How does location, upstream vs. downstream, impact nutrient levels?

2 Dataset Information

Nutrient data for this project were downloaded from the the Water Quality Portal, a cooperative service sponsored by the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), and the National Water Quality Monitoring Council (NWQMC) on February 27, 2020. Discharge data were downloaded for two stream gages along Ellerbe Creek, HUC code 030202010403, from USGS using the data dataRetrieval package in R. The dataset analyzed contains 21 monitoring locations with measurements for nitrogen and phosphorus levels from 1982 to 2018 and daily discharge data from 2008 to 2020. Not all locations had data for each nutrient. Nitrogen and Phosphorus concentrations are recorded as mg/L of Nitrogen or Phosphorus in various compounds including, nitrate, nitrite, ammonia, ammonium, organic nitrogen, phosphate, and organic phosphorus. The USGS gage locations are Club Blvd (0208675010), upstream, and Gorman (02086849), downstream.

Variable	Units	Range	Mean	Median	Source
Nitrogen	mg/L N	0.37 - 33.00	7.18	2.82	NC DENR and USGS
Phosphorus	mg/L P	0.039 - 17.00	1.091	0.157	NC DENR and USGS
Discharge Club	ft ³ /s	0.20 - 781.00	9.39	1.28	USGS
Discharge Gorman	ft ³ /s	7.52 - 1750.00	48.84	20.50	USGS

3 Exploratory Analysis

3.1 Initial Exploration

Explored raw data from the water quality portal to determine potential variables for analysis and time period of data. Examined a summary of all the characteristics in the dataset to determine the count for each variable. Selected Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3) and Phosphorus as the two variables to analyze. Explored discharge data to determine date range of data.

Table 2. Sample of summary results from raw data

Variable	Count
Dissolved Oxygen	636
Nitrate	128
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3)	209
Phosphorus	286
RBP Stream Width	14
Temperature, water	1146
Total Dissolved Solids	278

3.2 Location of Monitoring Sites

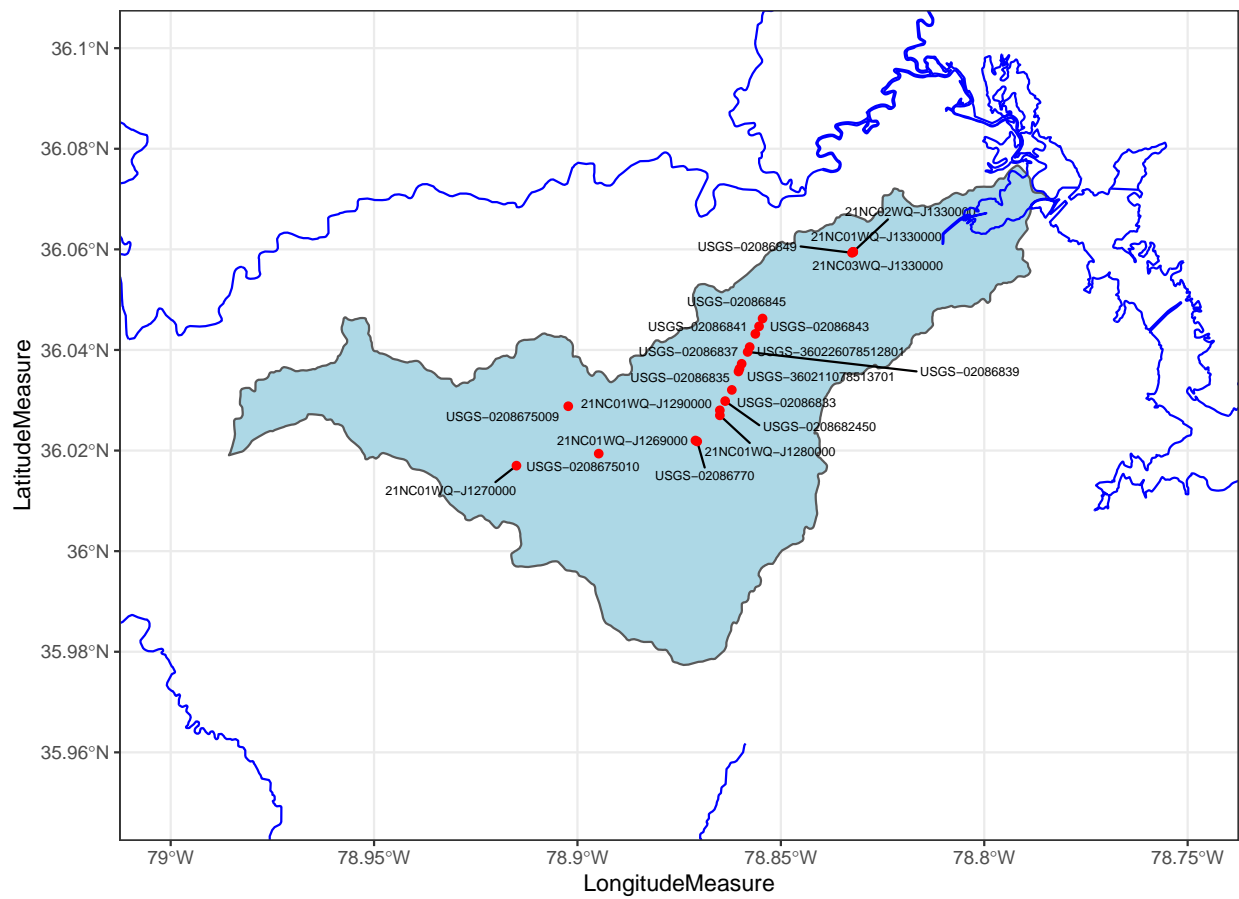


Figure 1: Map of the Ellerbe Creek Watershed and Monitoring Locations along Ellerbe Creek

3.3 Discharge Data Wrangling

Flow data from the two USGS stream gages were combined in two data sets, one as a long format with all discharge in one column and one in wide format, with two separate columns for discharge based on location.

3.4 Discharge Data Exploration

A boxplot was made to visualize the range of discharge at each site

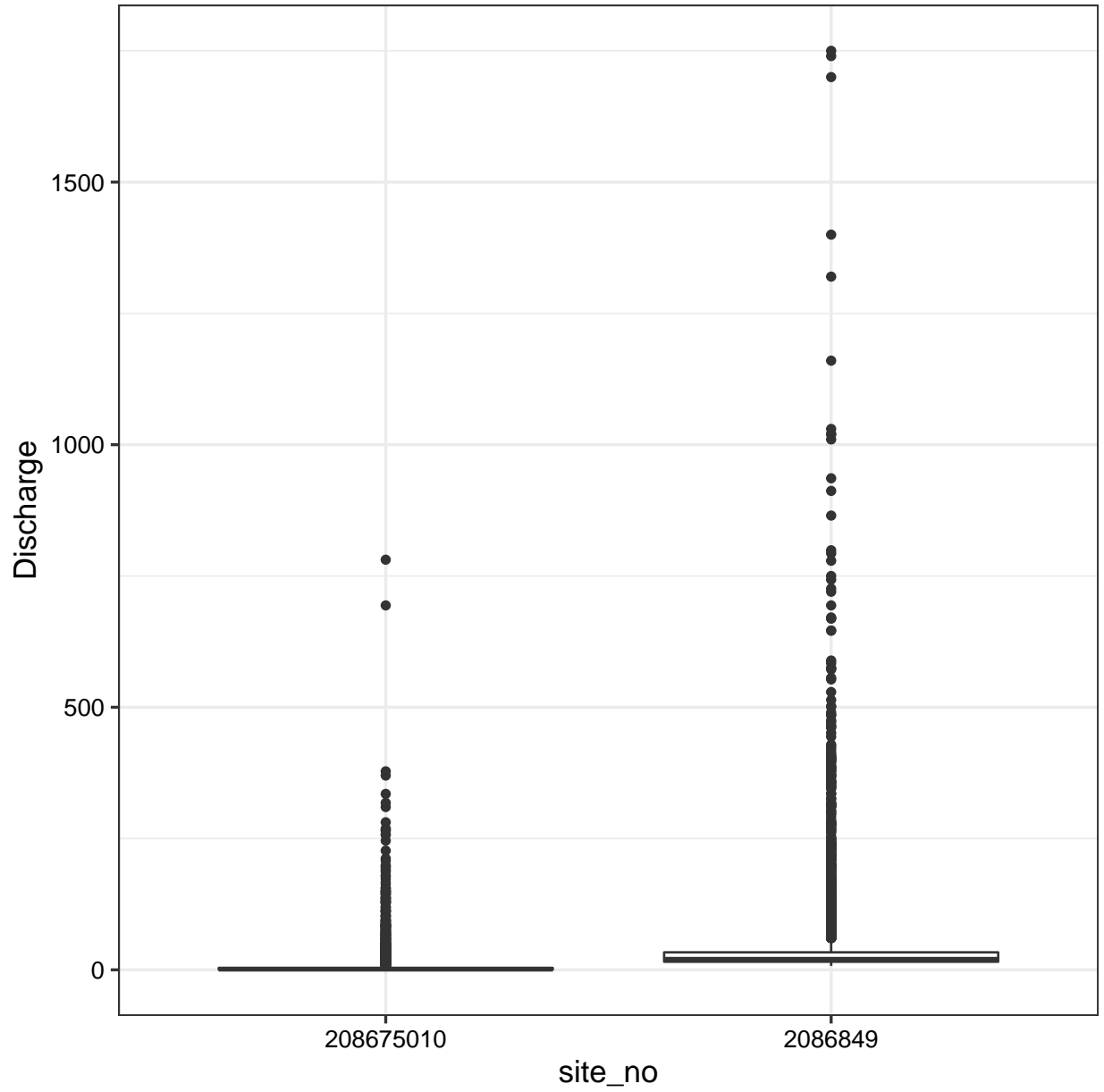


Figure 2: Distribution of discharge at two sites, upstream (208675010) and downstream (2086849) along Ellerbe Creek from January 1, 2008 to April 17, 2020

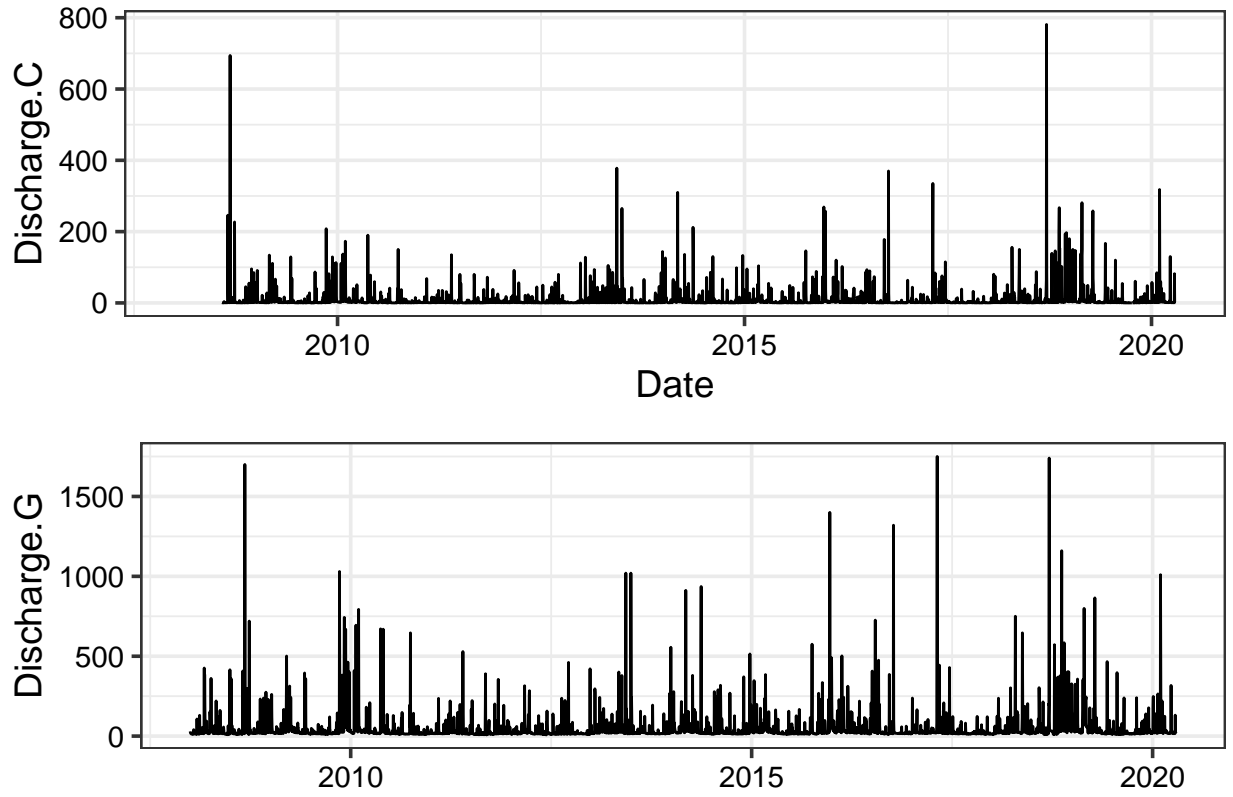


Figure 3: Daily discharge at along Ellerbe Creek from January 1, 2008 to April 17, 2020

The discharge over time at each location does not show any obvious seasonal or annual trends.

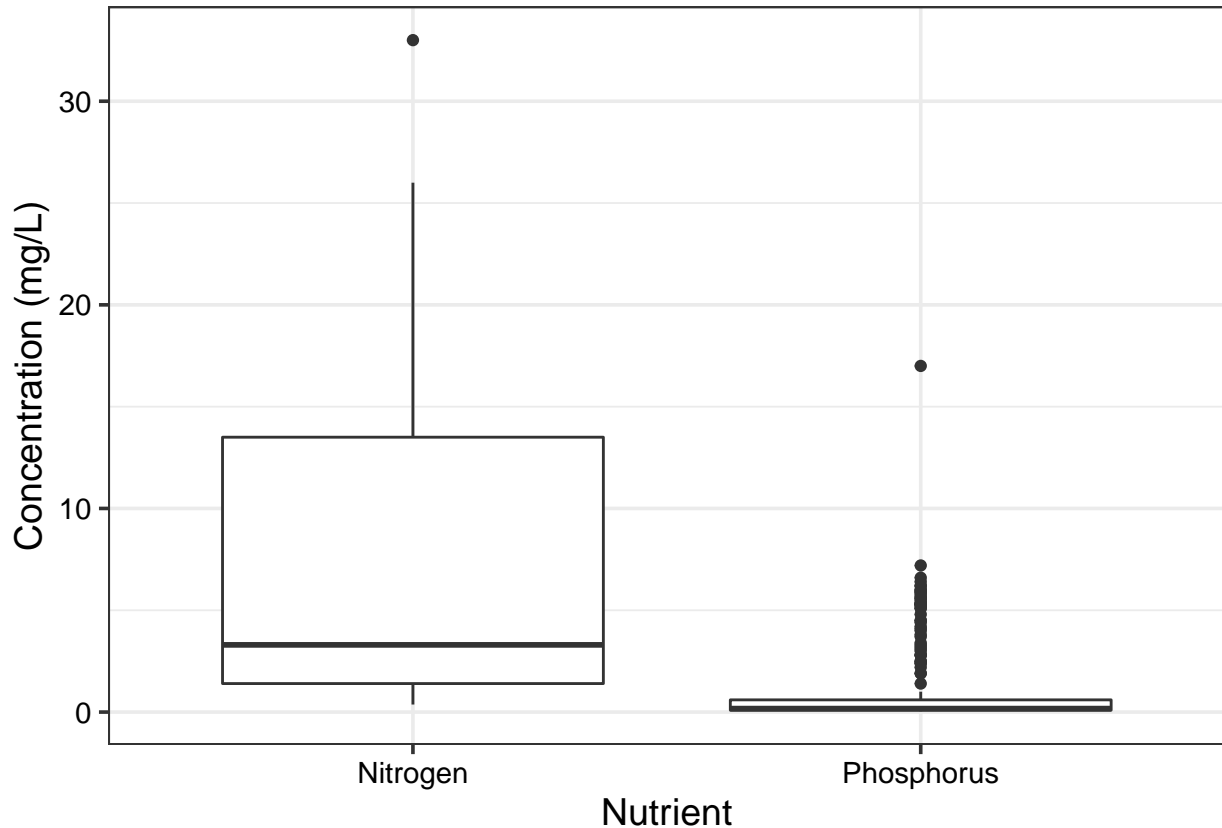


Figure 4: Distribution of Nitrogen and Phosphorus Concentrations in Ellerbe Creek from November 17, 1982 to December 17, 2018

3.5 Nutrient Data Wrangling

The nutrient data set from the water quality portal was cleans to remove all irrelevant information and retain just characteristics of interest, Nitrogen and Phosphorus. Nitrogen and Phosphorus values for many samples were recorded as both mg/L of N and P, and of NO₃ and PO₄ respectively. Data were downloaded in long format and were converted to wide format in order to convert Nitrogen and Phosphorus values to mg/L of N or P. Relevant columns such as data, location, hydrologic event, variable name, measured value, and units were selected and processed data were saved as both long and wide format.

3.6 Nutrient Data Exploration

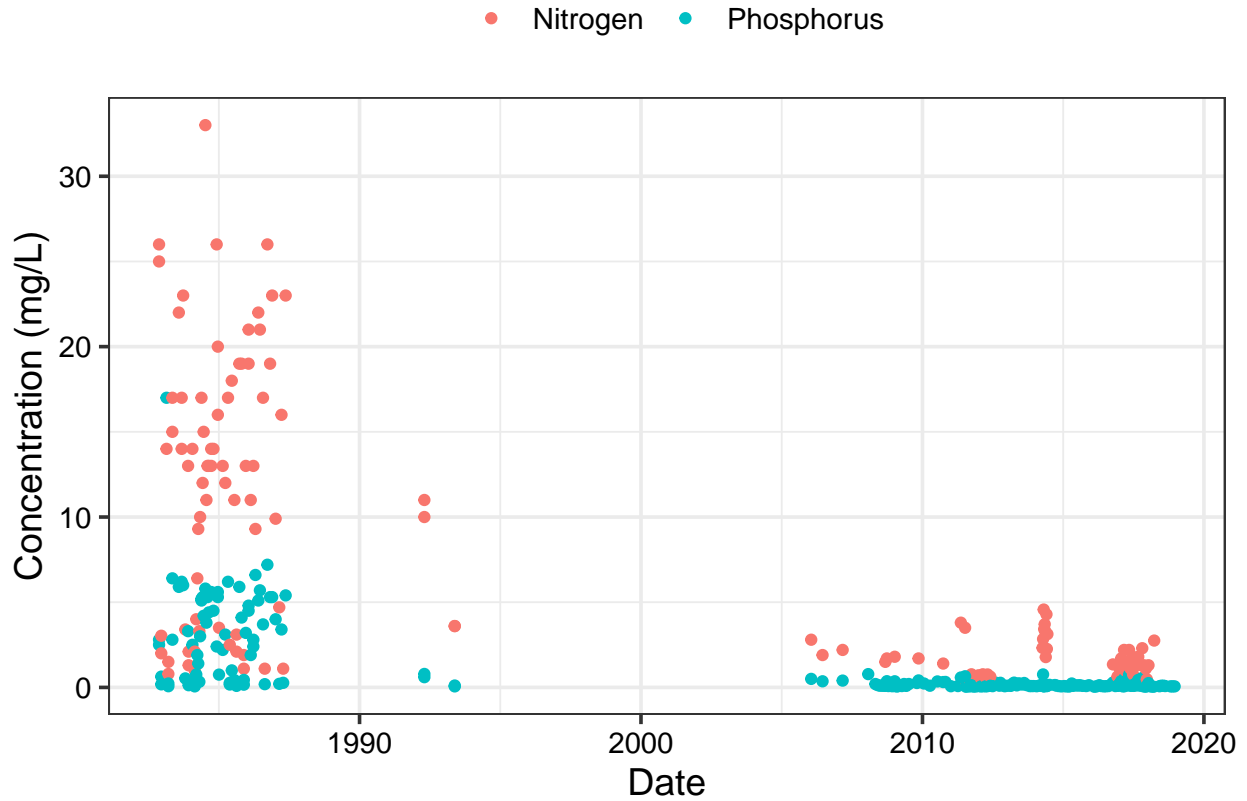


Figure 5: Concentrations of Nitrogen and Phosphorus over Time in Ellerbe Creek from November 17, 1982 to December 17, 2018

4 Analysis

4.1 Question 1: Are Nitrogen and Phosphorus levels in Ellerbe Creek above recommended levels?

Table 3: Total Nitrogen and Phosphorus Conentrations

mean.N	min.N	max.N	Standard.dev.N	mean.P	min.P	max.P	Standard.dev.P
7.183095	0.37	33	7.773407	1.091398	0.039	17	2.082384

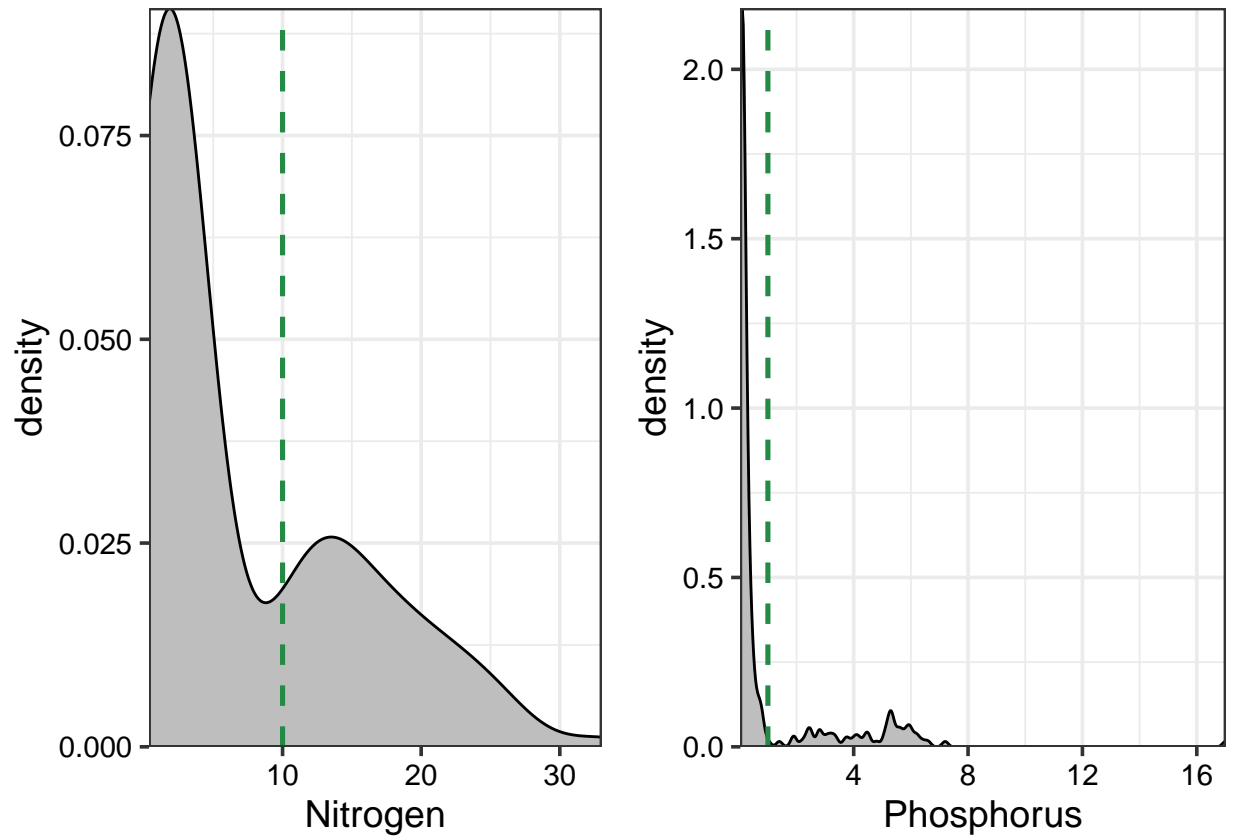


Figure 6: Density plots of Nitrogen and Phosphorus Concentrations

4.2 Question 2: Is there a relationship between flow and Nitrogen or Phosphorus levels?

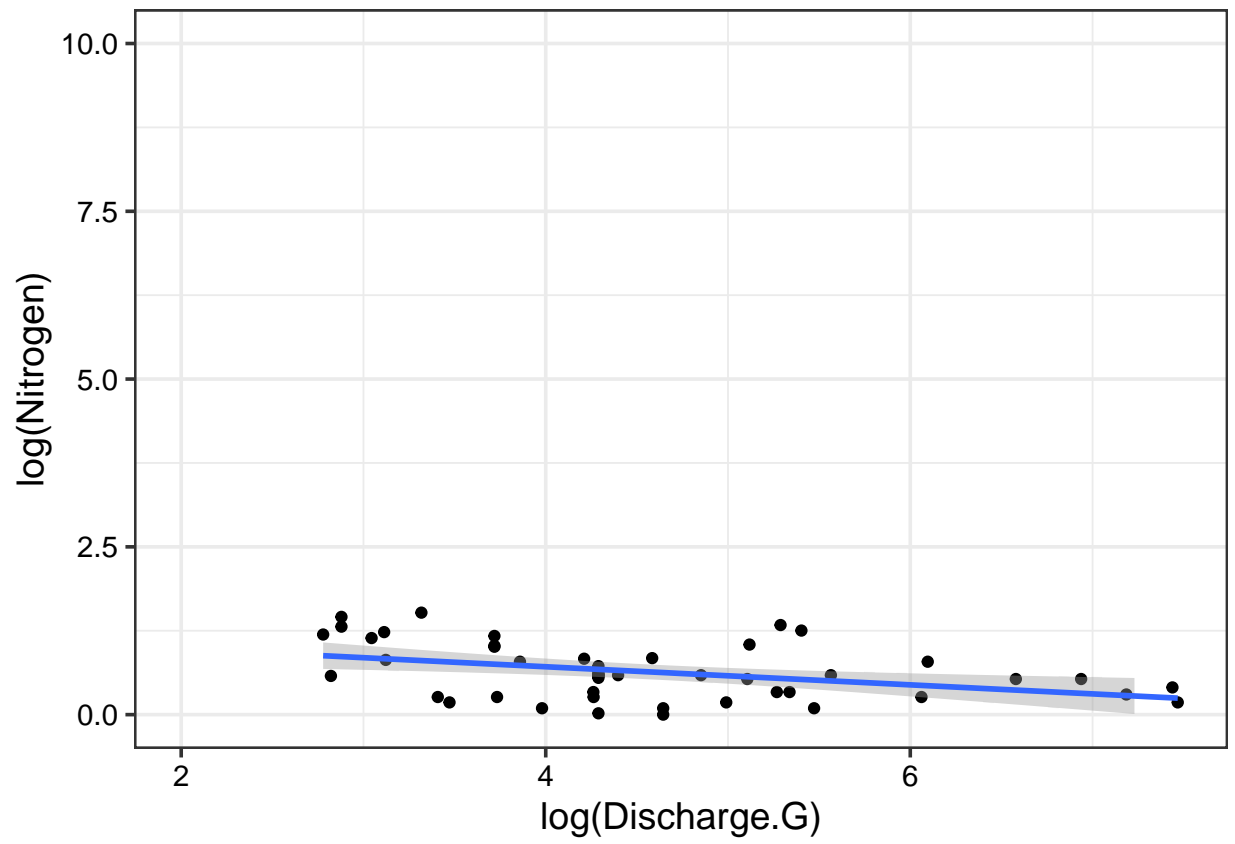


Figure 7: Linear regression of the log of Nitrogen Concentration vs. the log of Discharge

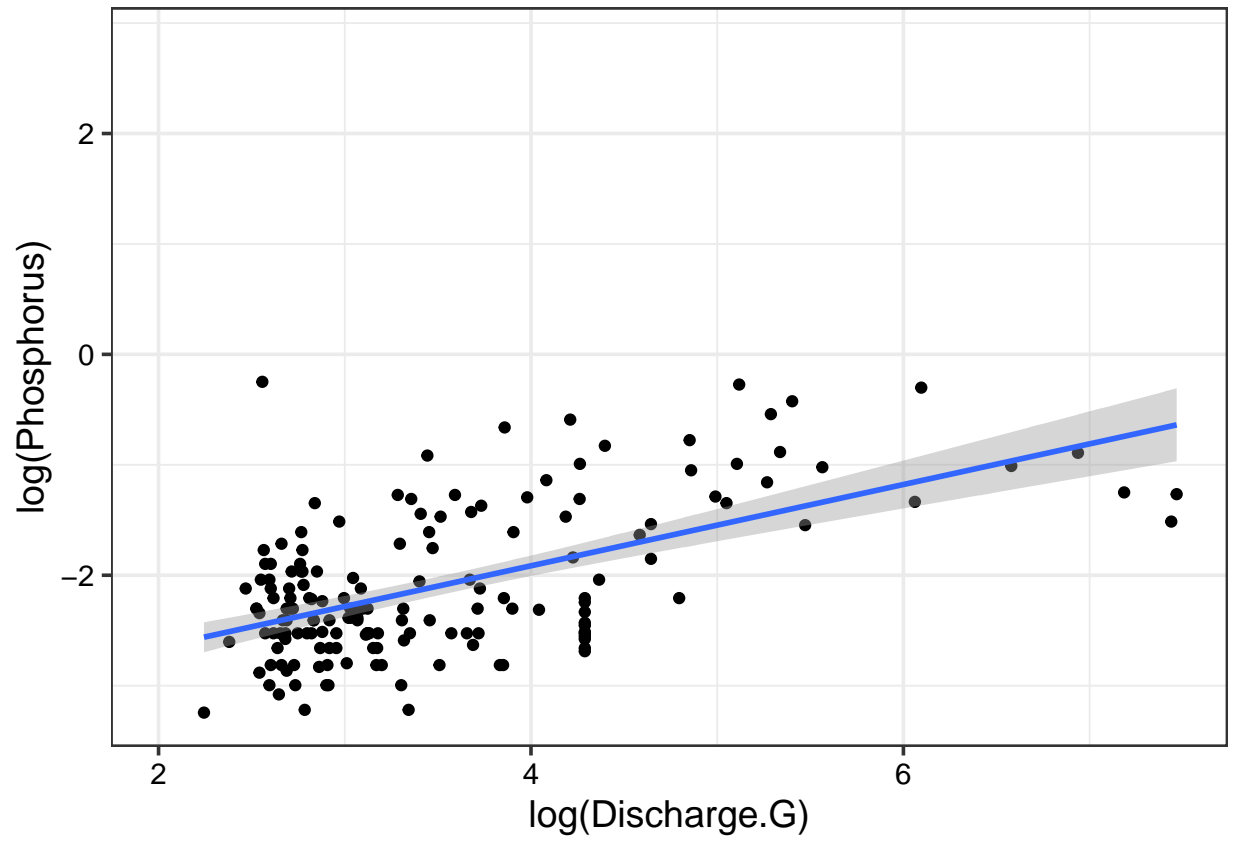


Figure 8: Linear regression of the log of Phosphorus Concentration vs. the log of Discharge

4.3 Question 3: How does location, upstream vs. downstream, impact nutrient levels?

Table 4: Nitrogen and Phosphorus concentrations by Location

mean.N	min.N	max.N	Standard.dev.N	mean.P	min.P	max.P	Standard.dev.P
7.740577	0.37	33	7.952157	1.134506	0.039	17	2.116099

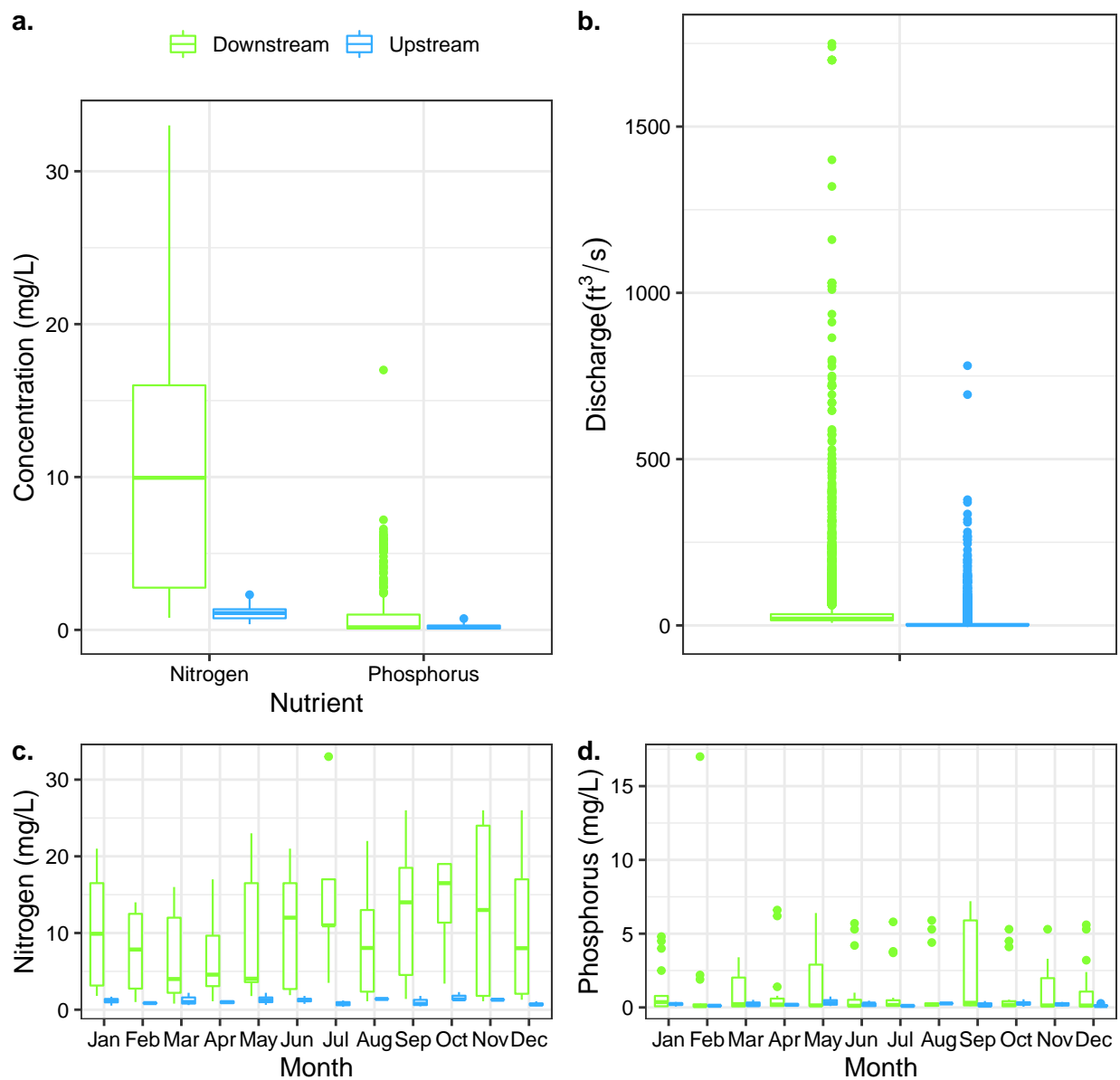


Figure 9: Distributions of nutrient concentrations and flow at upstream and downstream monitoring sites along Ellerbe Creek in North Carolina. a) Nitrogen and phosphorus concentrations at upstream and downstream monitoring sites. b) Flow at upstream and downstream monitoring sites. c) and d) Monthly distributions of nitrogen and phosphorus concentrations at upstream and downstream monitoring sites.

5 Summary and Conclusions

6 References

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