Trends in Surface Water Quality at the University of Florida, Gainesville.

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Non-Thesis Masters Project
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Abstract

Phosphorus and Nitrogen are two nutrients that are very important when discussing water quality. Increases in either could cause harmful effects to surface waters through eutrophication and other chemical reactions. In 2003, the University of Florida began a clean water campaign on campus which initiated water quality monitoring at several streams and campus water bodies. The main water body on campus, Lake Alice, had been shown to have extremely high nitrogen and phosphorus levels for more than thirty years before 2003 (Wells, 2005). The data collected since the start of the campaign has been summarized in a yearly report, however long term analysis had not been conducted on any of the data. In order to determine if any of the campus policies or activities are effecting water quality on campus, the first step is to establish if the concentrations are increasing or decreasing. Due to the significant importance of phosphorus and nitrogen, these two metrics were analyzed using the statistical program, JMP. Bivariate analysis was conducted for each nutrient. Different comparisons included separating data by seasons, showing concentrations over the eight year study period and comparing with rainfall on campus. Rainfall and nutrient concentrations did not appear to be correlated and overall the results indicated a decreasing trend of total nitrogen over the eight year monitoring period while phosphorus data suggests an increasing trend over the same time period.

Introduction

The University of Florida's Clean Water Campaign was started in 2003 in response to the requirements of the National Pollutant Discharge Elimination System (NPDES) that came from the Federal Clean Water Act. The NPDES required that the University of Florida implement a stormwater management program (Lindhoss and Clark, 2009). The major receiving body on the University of Florida's campus is Lake Alice. One of the major reasons for beginning this campaign was that Lake Alice had been shown to be a eutrophic system containing high nitrogen and high phosphorus (Wells, 2005).

In support for the UF Clean water Campaign, the Campus Water Quality Monitoring Program (CWQ) was formalized in November 2003. Sampling efforts began in May 2003 with a total of fifteen sites. As of July 2011, the campaign included twenty sites. The sampling for this program was completed by several UF student organizations through volunteer efforts. However the endeavor was started by the UF Wetlands Club and the American Water Resources Association on campus. The physical characteristics and macro nutrients are currently the main focus of this program (Lindhoss and Clark, 2009).

Water quality can be influenced by many factors including land use, geology, soil drainage, depth to groundwater, rainfall and anthropogenic activities to name just a few. One quantitative aspect of water quality are nutrient levels (Lindhoss and Clark, 2009; Mylavarapu, 2011; Helland, 2004). There are many standards and procedures already in place for several water quality parameters such as dissolved oxygen, turbidity, phosphorus, nitrates, conductivity and more (EPA, 1997). Two of the most important nutrients are nitrogen and phosphorus (Mylavarapu, 2011).

Within the United States, nitrogen and phosphorus are some of the most frequently studied parameters in water quality research. Both of these nutrients may have undesirable effects on water quality. Phosphorus loading often increases due to events that occur in a watershed of a particular body of water. Such events may be land disturbance, soil erosion and change in proportion of impervious surfaces (Suranno et al., 1996). Phosphorus comes from sources that include municipal waste water treatment plants, industrial discharge, urban stormwater drains and water runoff from cropland, lawns, gardens, forests, and impervious surfaces (Helland, 2004; Mylavarapu, 2011; Smolen, 2007).

Phosphorus is an essential nutrient that naturally occurs nominally in surface waters and it is a major cause of impaired water quality (Mylavarapu, 2011; Andrew et al., 2000; Sharpley, 2000). Any increase in phosphorus can stimulate growth of nuisance algae and other plants called eutrophication (Bowman and Delfino, 1982; Smolen, 2007; Mylavarapu, 2011; NRCS, 1994; Sharpley, 2000). When these organisms die hypoxic conditions result from their decomposition which may then cause fish kills and other harmful effects (Smolen, 2007; Helland, 2004). Other impacts of the sudden algal increase are reduced water clarity, unpleasant odor and taste, and toxins from bluegreen algae (NRCS, 1994; Smolen, 2007). The excessive algal growth also decreases the amount of sunlight that penetrates to the water bottom that then decreases the ability of the bottom vegetation to survive (Smolen, 200; Mylavarapu, 2011). Thus providing more organic matter to be decomposed and thereby decreasing the oxygen levels further.

Nitrogen loading of freshwater systems could have direct and indirect negative effects. Direct effects include methyhemoglobinemia and ammonia toxicity. Indirect effects include eutrophication and alteration of food webs (Bernot and Dodds, 2005). As stated earlier, eutrophication can affect the entire ecosystem by creating hypoxic conditions unable to sustain life (Mylavarapu, 2011; NRCS, 1994; Sharpley et al., 2000). These occurrences not only affect the wildlife and organisms that inhabit the water ecosystems but could also affect human drinking water supply and food fisheries. Other anthropogenic activities such as fossil fuel burning, watershed disturbance, crop fertilization and wastewater disposal all work to increase the annual rates of nitrogen loading into the ecosystems (Bernot and Dodds 2005).

The watershed in which a water body is located can have major effects on the water quality of its surface waters. How large the watershed is, how much impermeable surface there is, how much human activity takes place, are all factors that can influence the water quality within a particular watershed (Lindhoss and Clark, 2009). Throughout the U.S. the transport of nutrients and sediment in watersheds are increasing due to agriculture, urban development, mining, forestry practices and distribution of land uses (Suranno et al., 1996; Cole et al., 2006). Due to these changes, nonpoint Phosphorus loading is a serious threat to water quality (Suranno et al., 1996). It has been shown that watersheds with a larger human population have higher nitrogen loading to their receiving waters (Cole et al., 2006). The University of Florida itself has undergone many changes over the years from being mainly agricultural in the 1800s to being heavily urbanized by the 1870s (Wells, 2005).

Although the data from the UF Clean Water Campaign is compiled on a yearly basis, there exists no long term trends from the continued efforts. The University of Florida continues to expand and tries to improve its campus. These changes however, could be affecting the watershed's water quality. The objective of this study was to determine if long term trends were appearing from the total nitrogen (TN) and total phosphorus (TP) results throughout the campus's surface waters. Because it has been shown in some areas that rainfall events could cause systems to become phosphorus limited and increases nitrogen concentrations for a brief time after the event (Greenaway and Gordon-Smith, 2006) a secondary objective of this study was to determine if rainfall was a contributing factor to any change in nutrient concentrations.

Methods

Sampling

Each site was sampled once a month. A YSI 556 Multi-Probe Sensor was used to measure temperature, dissolved oxygen, pH, total dissolved solids and reduction/oxidation potential. Trained student volunteers took measurements about 30 - 40 centimeters below the water surface. Measurements and samples were taken between noon and five pm.

A 500 mL water sample was taken from the mid-point of the water column when water was present. After transportation to the laboratory in a cooler filled with ice, samples were processed according to standard operating procedures certified by the National Environmental Laboratory Accreditation Conference (NELAC), which included filtration and sample preservation techniques per FL DEP SOP 001/01 Series FS2100. Analyzation of the samples included total suspended solids, nitrates, total kjeldahl nitrogen, ammonium, total phosphorus and soluble reactive phosphorus.

More detail on the sampling methods, preservation and analysis can be found in Appendix A of the 2009 Water Quality Report University of Florida Main Campus.

Total Nutrient Determination

Laboratory analysis was conducted at the Wetland Biogeochemistry Laboratory (WBL) within the University of Florida Soil and Water Science Department. This laboratory conducted all methods to adhere to the certification of the National Environmental Laboratory Accreditation Conference (NELAC). The total nitrogen concentration was obtained by combining the tested lab results for Nitrate (NO_3) and Nitrite (NO_2) along with the lab results for Total Kjeldahl Nitrogen (TKN) following the methods approved by NELAC. Total phosphorus was determined directly from the standard methods approved by NELAC. The samples were first digested by heating and acidifying. Following that procedure, the EPA-approved ascorbic acid method was used.

Statistical Analysis

Of the twenty sites that have been sampled since 2003, only the first twelve had more than fifty data points. Therefore statistical analysis was only completed for sites one through twelve.

For both Total Nitrogen and Total Phosphorus, multiple graphs were created using the JMP software. Multiple bivariate analyses were completed. The following list shows which comparisons were done. All time constitutes from the beginning of sampling in 2003 to December of 2010. The seasons were divided using three months per season. There were labeled season one through four. Season one included data from December, January, and February. Season two included March, April, and May. Season three was June, July, and August. Season four included September, October, and November.

All Sites Combined
- Nutrient vs All Time
- Nutrient vs Time by year

Each Site individually
- Nutrient vs All Time
- Nutrient vs Time by season
- Nutrient vs Rainfall (only 5, 6, 12)
- Nutrient vs Time by year

Rainfall data was obtained from the University of Florida's Physics Department (J. Mocko, Pers., Comm). The data was compiled on a daily basis in a text file and converted into a standard excel file. Monthly rainfall data was then determined by summing the daily totals for each month. The monthly rainfall tables were then used for analysis with sites, five, six and twelve.

The purpose of this particular analysis was to find a long term trend, therefore the data from the Nutrient vs Time by year graphs that were created, were not compiled into tables. All date range graphs were standardized with the same X axis formats. The Y axis was standardized for each site and nutrient, dependent on the range of values that existed. Linear trend lines were added to almost every graph created in order to determine relationship and strength of relationship. Slope and R^2 values were transferred to a table for easier visual analysis.

Results

Graphs representing Nitrate vs. All Time (2003-2010) all showed negative slopes and a downward trend except for sites 8 and 10, which had positive slopes (Figure 2). Site 8 was positive due to higher value outliers. The R^2 values ranged from 0.0039 to 0.2303. The F values ranged from <0.0001 to 0.6717 (Table 1). There is a definite decrease trend for nitrate over the study period (Figure 1). Sampling sites 5 and 6 had the most significant nitrogen decrease (Figure 2).

Table 1: Slope, R squared, and F Values for Nitrate vs. Entire Study Time (2003-2010)

Nitrate vs. All Time (2003-2010)			
Site ID	Slope	R Squared Value	F Value
All Sites	-3.117e-9	0.0051	0.0331
1	-2.192e-9	0.1165	0.036
2	-4.22e-9	0.0960	0.0085
3	-1.427e-9	0.0205	0.2330
4	-5.66e-10	0.0112	0.3805
5	-1.939e-8	0.2303	<0.0001
6	-1.04e-8	0.0916	0.0103
7	-6.954e-9	0.0395	0.0966
8	1.011e-8	0.1409	0.0013
9	-3.236e-9	0.0209	0.2793
10	2.328e-9	0.0168	0.3552
11	-5.5e-10	0.0039	0.6717
12	-8.265e-9	0.1414	0.0020

Figure 1. Nitrate vs. All Time for all sampling sites combined.

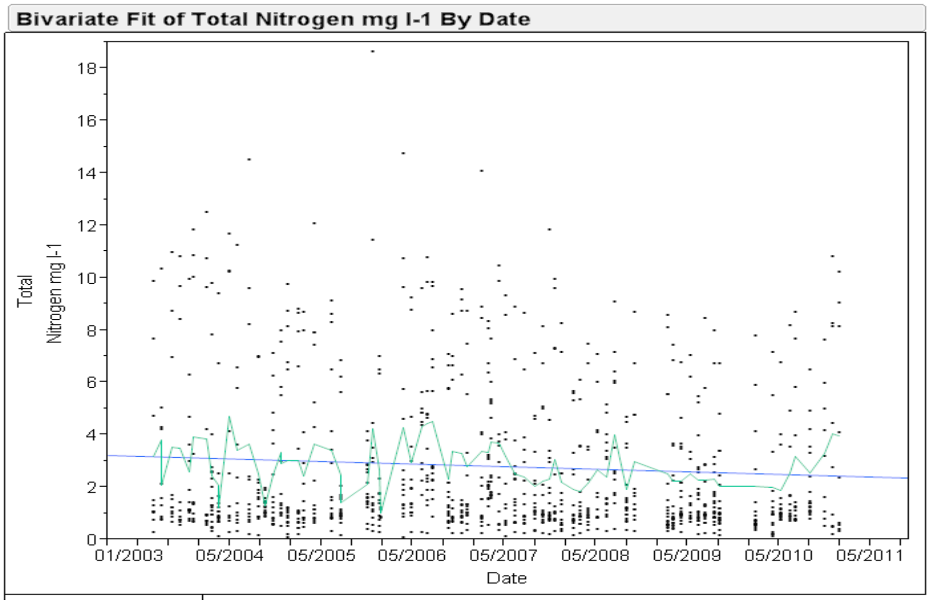
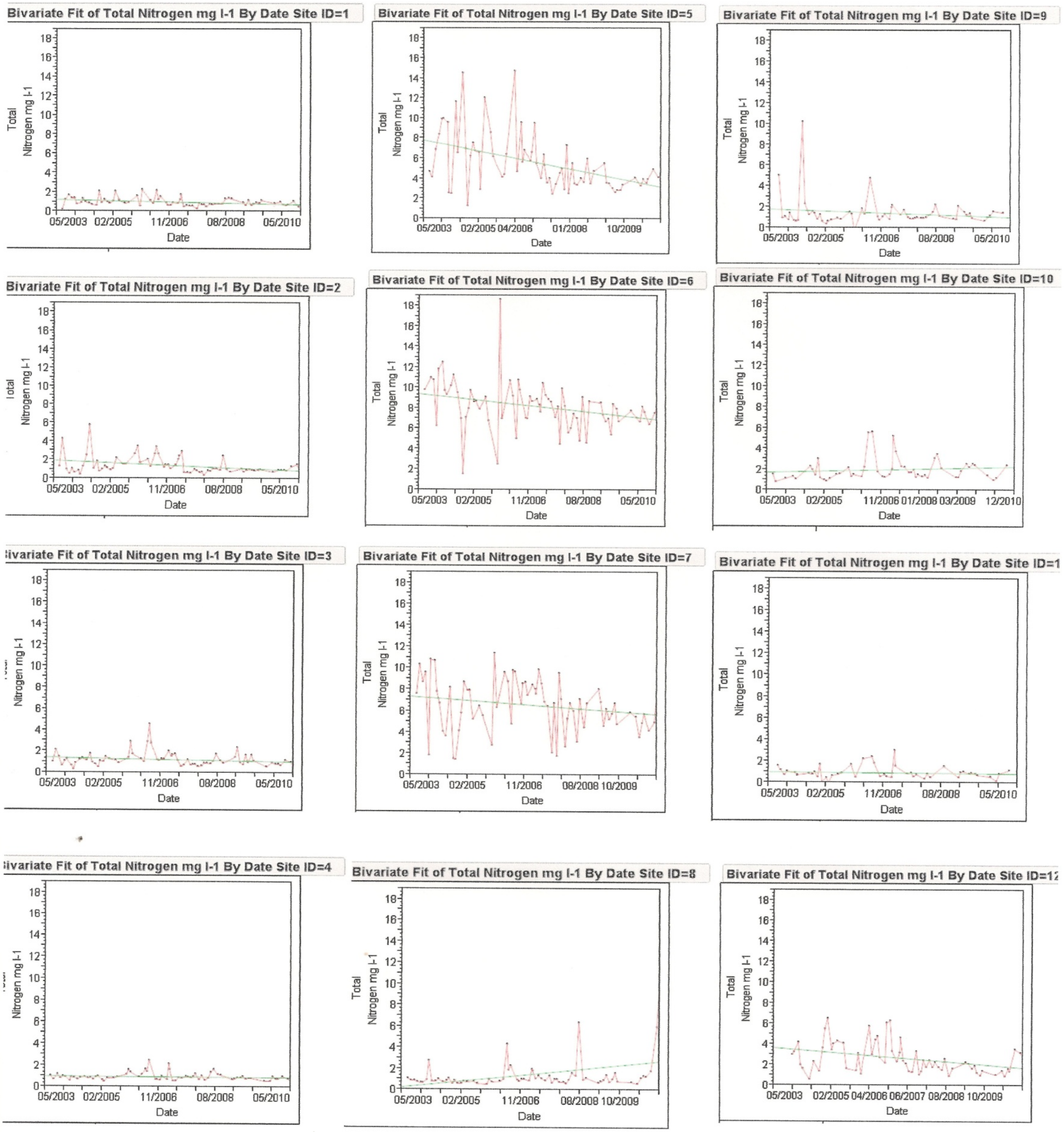


Figure 2. Nitrate vs. All Time (2003-2010). Separated by each sampling site



Graphs representing Phosphorus vs. All Time (2003-2010) all showed positive slopes and an upward trend except for Site 9, which had a negative slope (Figure 4). The R^2 values ranged from 0.00003 to 0.1925. The F values ranged from 0.0003 to 0.9717 (Table 2). All the data together for all sampling sites shows a definite increase in phosphorus (Figure 3). Site 10 had a significant increase in phosphorus (Figure 4).

Table 2: Slope, R squared, and F Values for Phosphorus vs. All Time

Phosphorus vs. All Time (2003-2010)			
Site ID	Slope	R Squared Value	F Value
All Sites	9.469e-10	0.0118	0.0011
1	4.613e-10	0.0270	0.1676
2	3.409e-10	0.0073	0.4740
3	1.380e-9	0.1744	0.0003
4	1.173e-9	0.0356	0.1124
5	4.103e-10	0.0283	0.1576
6	4.409e-10	0.0301	0.1446
7	1.67e-10	0.0045	0.5748
8	4.078e-10	0.0288	0.1514
9	-4.52e-10	0.0010	0.8102
10	5.036e-9	0.1925	0.0009
11	1.604e-11	0.00003	0.9717
12	1.348e-9	0.0142	0.3442

Figure 3. Nitrate vs. All Time for all sampling sites combined.

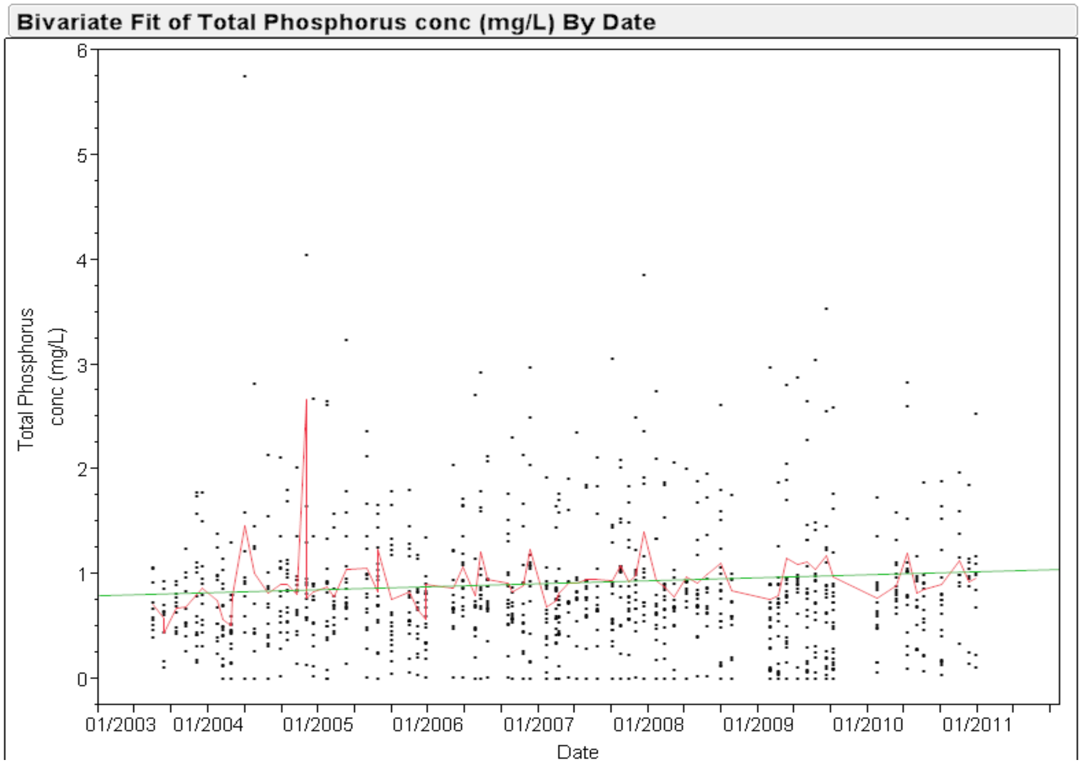
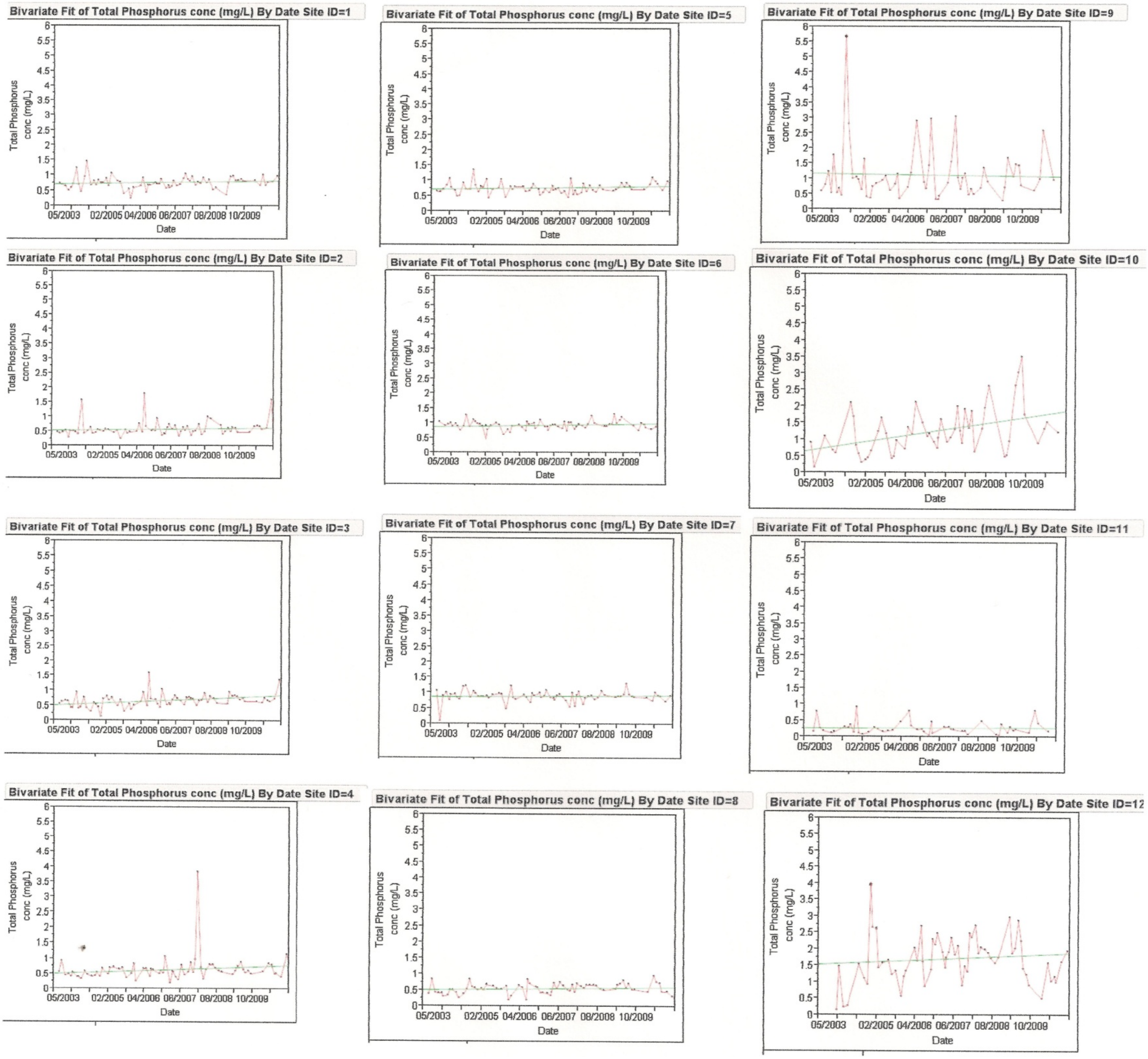


Figure 4. Phosphorus vs. All Time (2003-2010). Separated by each sampling site.



Season 1 graphs representing Nitrate vs Time (December - February) showed all but sites 9, 10, and 11 having negative slopes. The R^2 values ranged from 0.0044 to 0.3873. The F values ranged from 0.0100 to 0.8066 (Table 3). Season 2 graphs representing Nitrate vs Time (March - May) showed all but sites 4, 8, 10, and 12 having negative slopes. The R^2 values ranged from 0.0027 to 0.1725. The F values ranged from 0.0260 to 0.8169 (Table 3). Season 3 graphs representing Nitrate vs Time (June - August) showed all but site 8 having negative slopes. The R^2 values ranged from 0.0062 to 0.6115. The F values ranged from 0.0003 to 0.8454 (Table 3). Season 4 graphs representing Nitrate vs Time (September - November) showed all but sites 6, 7, 8 and 10 having negative slopes. The R^2 values ranged from 0.0093 to 0.5263. The F values ranged from 0.0007 to 0.7036 (Table 3). All but twelve of the forty-eight graphs shwed strong downward trends. Site 8 showed the most positive slopes.

Season 1 graphs representing Phosphorus vs. Time (December - February) showed all but sites 1, 3, 5, 7, and 9 having positive slopes. The R^2 values ranged from 0.00001 to 0.1814. The F values ranged from 0.100 to 0.9884 (Table 4). Season 2 graphs representing Phosphorus vs. Time (March - May) showed Sites 1, 2, 6, 7, and 9 having negative slopes and sites 3, 4, 5, 8, 10, 11, and 12 having positive slopes. The R^2 values ranged from 0.0159 to 0.5536. The F values ranged from 0.0006 to 0.6422 (Table 4). Season 3 graphs representing Phosphorus vs. Time (June - August) showed all but sites 4, 8, 11, and 12 having positive slopes. The R^2 values ranged from 0.0001 to 0.3163. The F values ranged from 0.0122 to 0.9688 (Table 4). Season 4 graphs representing Phosphorus vs. Time (September - November) showed all but sites 8, 9, and 11 having negative slopes. The R^2 values ranged from 0.0054 to 0.3972. The F values ranged from 0.0006 to 0.8037 (Table 4). All but seventeen of the forty-eight graphs showed strong upward trends.

Table 3: Slope, R squared, and F Values for Nitrate vs. All Time by Season. Season 1: December - February, season 2: March - May, season 3: June - August, season 4: September - November.

Nitrate vs. Time by Season				
Site ID	**Season**	**Slope**	**R Squared Value**	**F Value**
1	1	-0.0588	0.0572	0.3720
	2	-0.0199	0.0186	0.6139
	3	-0.0405	0.0355	0.4010
	4	-0.1259	0.5263	0.0007
2	1	-0.0292	0.0062	0.7726
	2	-0.3872	0.3931	0.0093
	3	-0.1701	0.1725	0.0546
	4	-0.0218	0.0116	0.6710
3	1	-0.0403	0.0149	0.6515
	2	-0.0164	0.0062	0.7723
	3	-0.0687	0.0299	0.4412
	4	-0.0419	0.0963	0.2101
4	1	-0.0151	0.0044	0.8066
	2	-0.0139	0.0109	0.7000
	3	0.0095	0.0027	0.8151
	4	-0.0406	0.2223	0.0482
5	1	-0.4859	0.1925	0.0891
	2	-0.9492	0.2784	0.0357
	3	-0.5629	0.2243	0.0260
	4	-0.4594	0.2369	0.0405
6	1	-0.7350	0.2398	0.0460
	2	-0.5879	0.6115	0.0003
	3	-0.2884	0.1166	0.1407
	4	0.0985	0.0093	0.7036
7	1	-0.6735	0.3873	0.0100
	2	-0.0513	0.0028	0.8454
	3	-0.3726	0.1429	0.0828
	4	0.1950	0.0302	0.4906
8	1	-0.0646	0.0517	0.3967
	2	0.0273	0.0304	0.5181
	3	0.0306	0.0027	0.8169
	4	0.9127	0.4769	0.0015
9	1	0.0292	0.0142	0.6606
	2	-0.4163	0.1383	0.2340
	3	-0.2121	0.1287	0.1725
	4	-0.0216	0.0304	0.5511
10	1	0.0523	0.1219	0.2210
	2	-0.0753	0.0122	0.7464
	3	0.1588	0.0755	0.2699
	4	0.0374	0.0144	0.7253
11	1	0.0685	0.0299	0.5907
	2	-0.0379	0.0230	0.6756
	3	-0.0190	0.0070	0.7665
	4	-0.0788	0.1384	0.2338
12	1	-0.3842	0.3264	0.0208
	2	-0.1937	0.0735	0.3285
	3	0.2703	0.1670	0.0922
	4	-0.1816	0.0601	0.3601

Table 4: Slope, R squared, and F Values for Phosphorus vs. All Time by Season. Season 1: December - February, season 2: March - May, season 3: June - August, season 4: September - November.

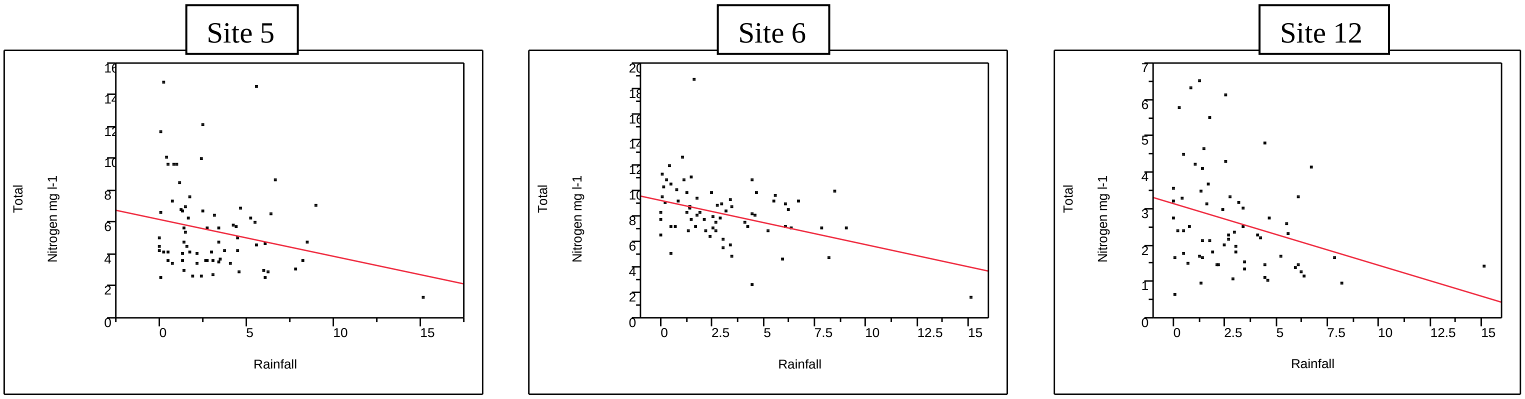
Phosphorus vs. Time by Season				
Site ID	Season	Slope	R Squared Value	F Value
1	1	-0.0169	0.0212	0.5909
	2	-0.0163	0.0203	0.5984
	3	0.0149	0.0757	0.2039
	4	0.0453	0.4889	0.0012
2	1	0.0033	0.0021	0.8658
	2	-0.0304	0.0500	0.4050
	3	0.0047	0.0014	0.8678
	4	0.0265	0.0419	0.4152
3	1	-0.0010	0.0001	0.9690
	2	0.0350	0.1911	0.0904
	3	0.0305	0.0848	0.1776
	4	0.0834	0.5339	0.0006
4	1	0.0531	0.0148	0.6532
	2	0.0514	0.3531	0.0152
	3	-0.0023	0.0014	0.8613
	4	0.0537	0.3972	0.0051
5	1	-0.0003	0.00001	0.9884
	2	0.0337	0.2561	0.0455
	3	0.0061	0.0053	0.7415
	4	0.0074	0.0126	0.6570
6	1	0.0137	0.0129	0.6633
	2	-0.0074	0.0159	0.6422
	3	0.0076	0.0099	0.6663
	4	0.0184	0.1285	0.1441
7	1	-0.0125	0.0612	0.3558
	2	-0.0259	0.1722	0.1100
	3	0.0219	0.0450	0.3311
	4	0.0068	0.0152	0.6257
8	1	0.0287	0.1814	0.1000
	2	0.0589	0.5536	0.0006
	3	-0.0044	0.0037	0.7829
	4	-0.0288	0.2169	0.0514
9	1	-0.0745	0.0456	0.4270
	2	-0.1909	0.0831	0.3635
	3	0.0487	0.0208	0.5807
	4	-0.0125	0.0054	0.8037
10	1	0.1159	0.1796	0.1310
	2	0.0727	0.1364	0.2637
	3	0.2129	0.3163	0.0122
	4	0.1316	0.2216	0.1439
11	1	0.0055	0.0093	0.7774
	2	0.0512	0.2439	0.1469
	3	-0.0008	0.0001	0.9688
	4	-0.0435	0.1151	0.2806
12	1	0.0455	0.0118	0.6888
	2	0.1215	0.1371	0.1925
	3	-0.0203	0.0066	0.7400
	4	0.0847	0.0442	0.4343

Graphs and tables showing Nitrate vs Rainfall for all time all showed negative slopes and low R^2 and extremely low F values (Table 5). The data points were scattered throughout the entire concentration range (Figure 5). The regression lines show significant downward slope. The extremely low F values demonstrate little to no correlation.

Table 5: Slope, R squared, and F Values for Nitrate vs. Rainfall for Sites 5, 6, and 12.

Nitrate vs. Rainfall (2003-2010)			
Site ID	Slope	R Squared Value	F Value
5	-0.2314	0.0511	0.0563
6	-0.3480	0.1622	0.0005
12	-0.1673	0.0938	0.0131

Figure 5. Nitrogen vs. Rainfall for Sampling Sites 5, 6, and 12.

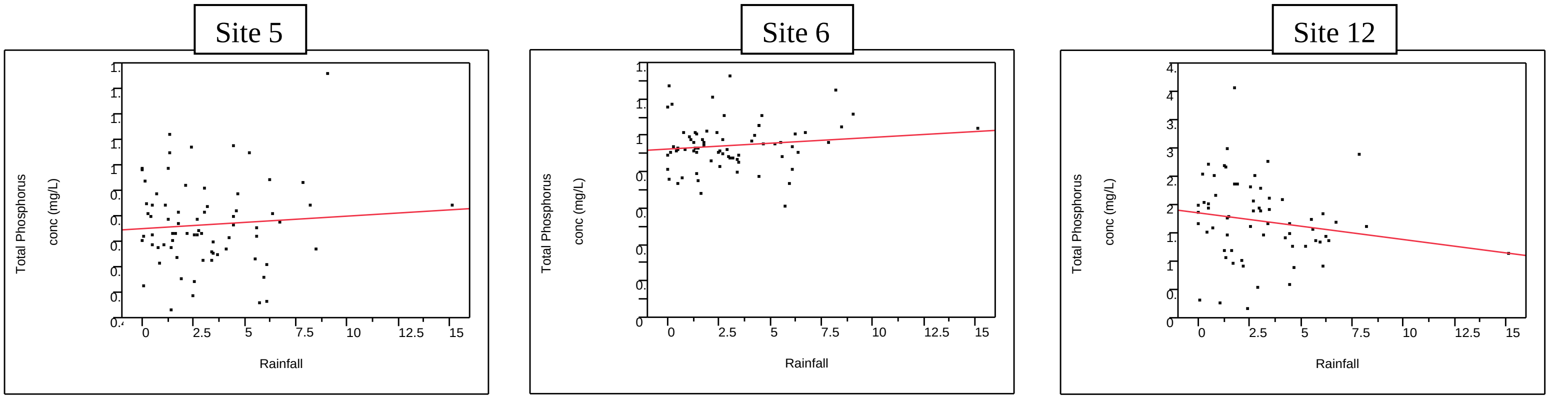


Graphs and tables showing Phosphorus vs Rainfall for all time showed positive slopes for sites 5 and 6 and negative slope for site 12 (Figure 6) showed low R^2 values and low to middle F values. (Table 6). The slopes are not significant. They are very flat lined as their slopes are extremely small.

Table 6: Slope, R squared, and F Values for Phosphorus vs. Rainfall for Sites 5, 6, and 12.

Phosphorus vs. Rainfall (2003-2010)			
Site ID	Slope	R Squared Value	F Value
5	0.0049	0.0064	0.5021
6	0.0064	0.0172	0.2754
12	-0.0467	0.0295	0.1748

Figure 6. Phosphorus vs. Rainfall for Sampling Sites 5, 6, and 12.



Graphs showing Nitrate vs. Rainfall divided by season showed all negative slopes except for site 5 and 6 season 3. The R^2 values ranged from 0.0033 to 0.3960. The F values ranged from 0.0090 to 0.8254 (Table 7). Graphs showing Phosphorus vs. Rainfall divided by season showed all positive slopes for site 5, positive slopes in season 2 and 3 for site 6 and only season 2 in site 12 was positive. The R^2 values ranged from 0.0001 to 0.2062. The F values ranged from 0.0891 to 0.9671 (Table 8). Site 5, 6, 12 nitrate concentration did not show significant correlation with rainfall (Figures 7, 8, 9). Site 6 season 2: phosphorus, showed the greatest cluster on the regression line (Figure 11). There was no other significant correlation between phosphorus concentration and rainfall for sites 5, 6, and 12 (Figures 10, 11, 12).

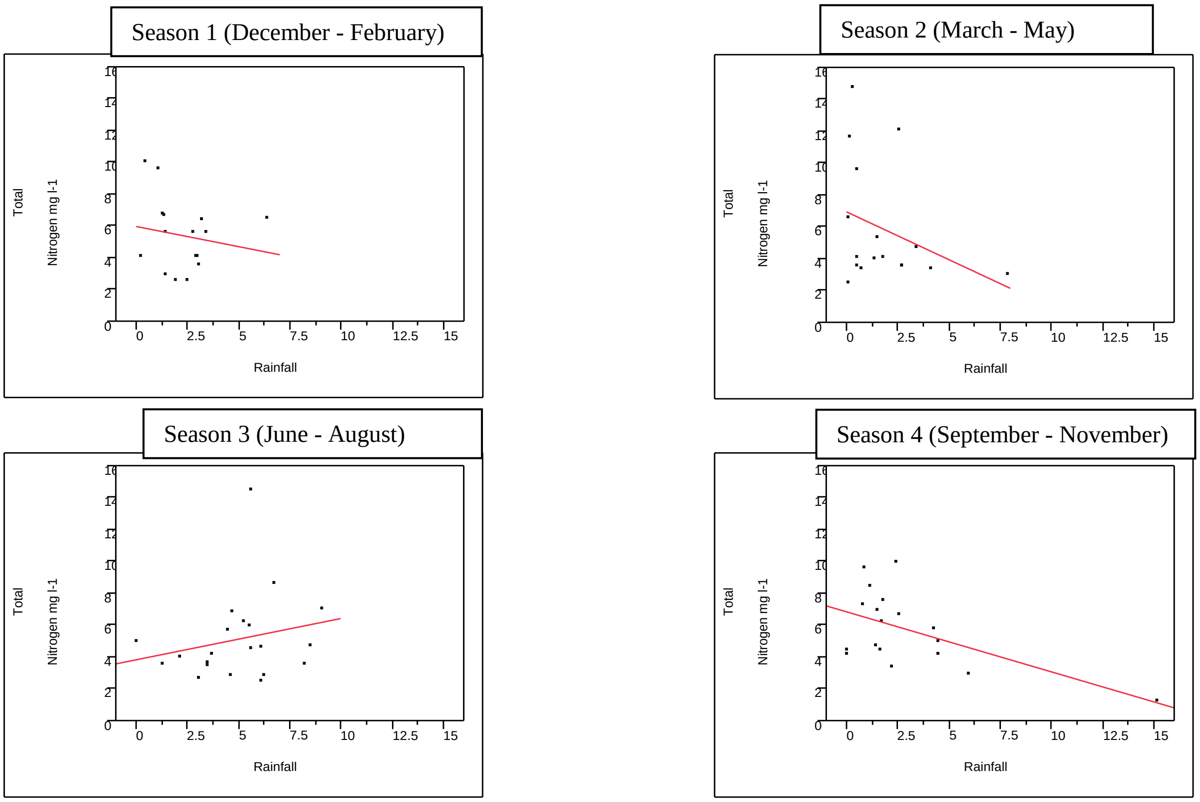
Table 7: Slope, R squared, and F Values for Nitrate vs Rainfall by Season. Season 1: December - February, season 2: March - May, season 3: June - August, season 4: September - November. For Sites 5, 6 , and 12 only.

Nitrate vs Rainfall by season				
Site ID	Season	Slope	R Squared Value	F Value
5	1	-0.2532	0.0283	0.5333
	2	-0.5986	0.1031	0.2090
	3	0.2613	0.0488	0.3359
	4	-0.3736	0.3146	0.0155
6	1	-0.7465	0.3960	0.0090
	2	-0.2945	0.1166	0.1797
	3	0.0939	0.0167	0.5980
	4	-0.6146	0.3420	0.0108
12	1	-0.4565	0.2509	0.0481
	2	-0.077	0.0116	0.6916
	3	-0.0315	0.0033	0.8254
	4	-0.1919	0.1682	0.1146

Table 8: Slope, R squared, and F Values for Phosphorus vs Rainfall by Season. Season 1: December - February, season 2: March - May, season 3: June - August, season 4: September - November. For Sites 5, 6 , and 12 only.

Phosphorus vs Rainfall by season				
Site ID	Season	Slope	R Squared Value	F Value
5	1	0.0015	0.0002	0.9586
	2	0.0078	0.0133	0.6597
	3	0.0107	0.0143	0.5959
	4	0.0005	0.0001	0.9671
6	1	-0.0214	0.1011	0.2300
	2	0.0051	0.0066	0.7564
	3	0.0196	0.0822	0.2205
	4	-0.0005	0.0001	0.9626
12	1	-0.0902	0.0285	0.5474
	2	0.1393	0.2062	0.0891
	3	-0.0097	0.0025	0.8428
	4	-0.0712	0.0814	0.2842

Figure 7. Site 5 Nitrogen Concentration vs. Rainfall separated by seasons.

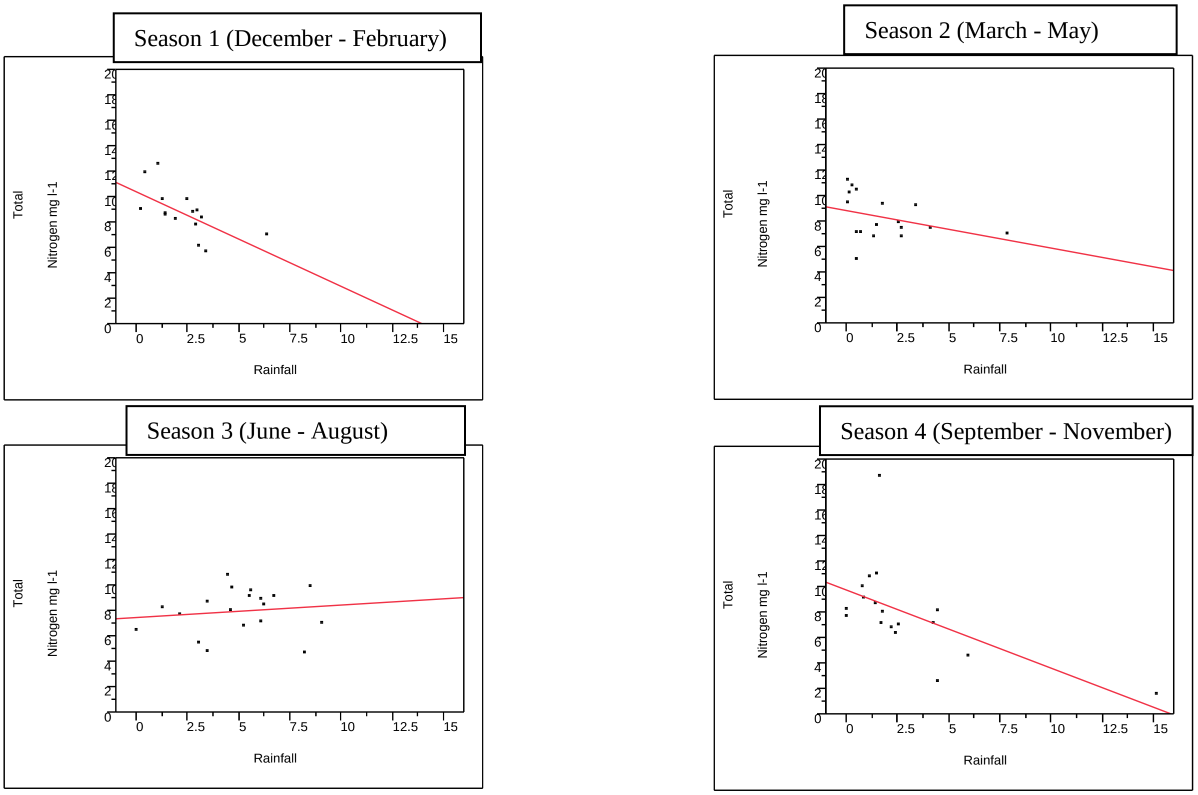

Season 1 (December - February)

Season 2 (March - May)

Season 3 (June - August)

Season 4 (September - November)

Figure 8. Site 6 Nitrogen Concentration vs. Rainfall separated by seasons.


Season 1 (December - February)

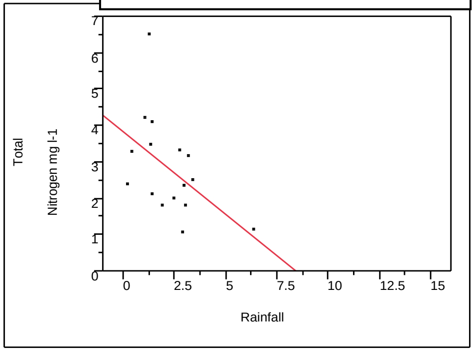
Season 2 (March - May)

Season 3 (June - August)

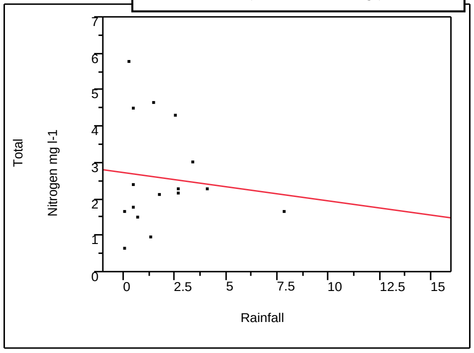
Season 4 (September - November)

Figure 9. Site 12 Nitrogen Concentration vs. Rainfall separated by seasons.

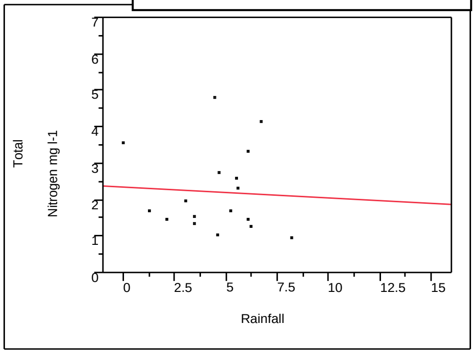
Season 1 (December - February)



Season 2 (March - May)



Season 3 (June - August)



Season 4 (September - November)

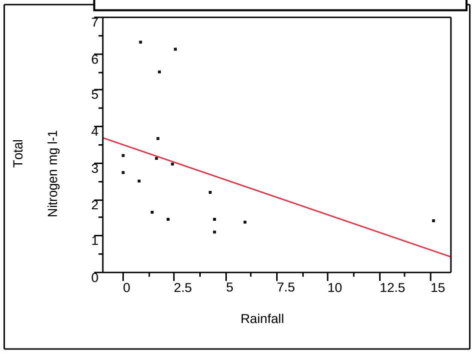
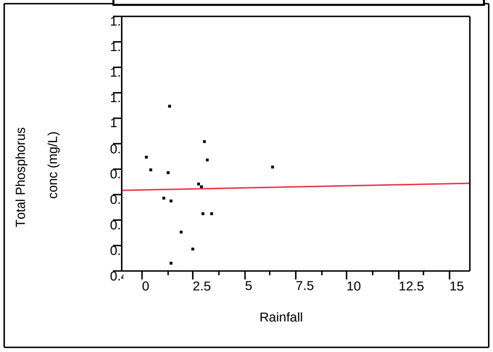
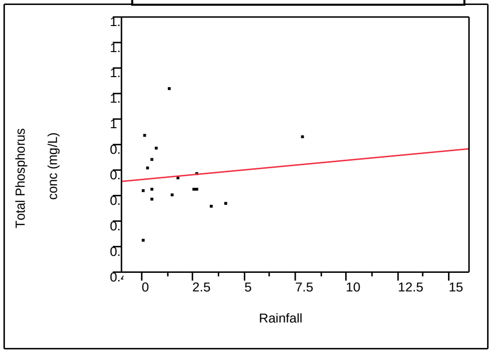


Figure 10. Site 5 Phosphorus Concentration vs. Rainfall separated by seasons.

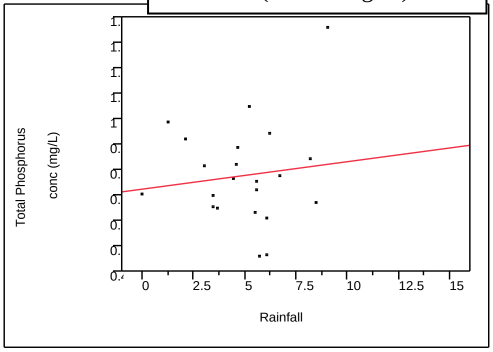
Season 1 (December - February)



Season 2 (March - May)



Season 3 (June - August)



Season 4 (September - November)

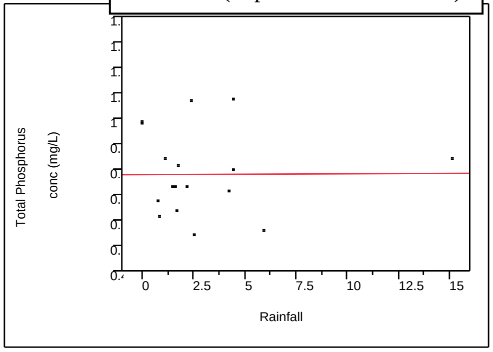


Figure 11. Site 6 Phosphorus Concentration vs. Rainfall separated by seasons.

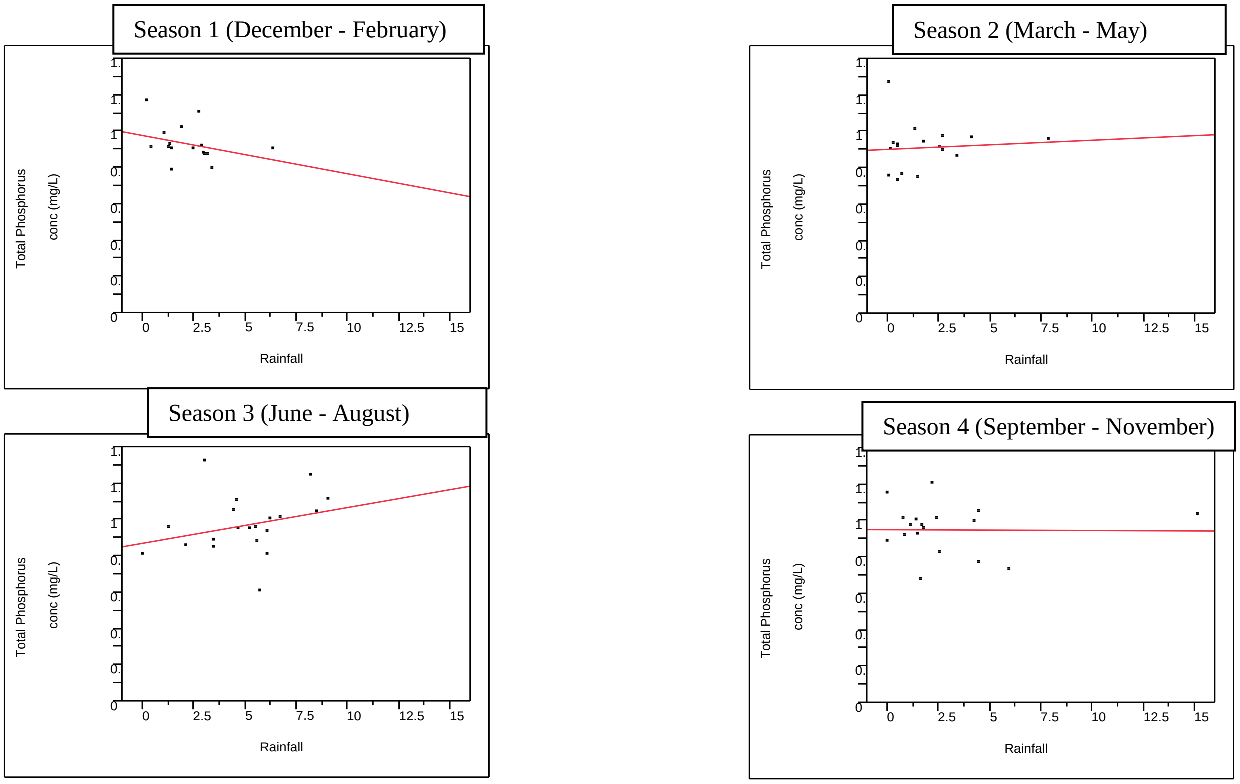
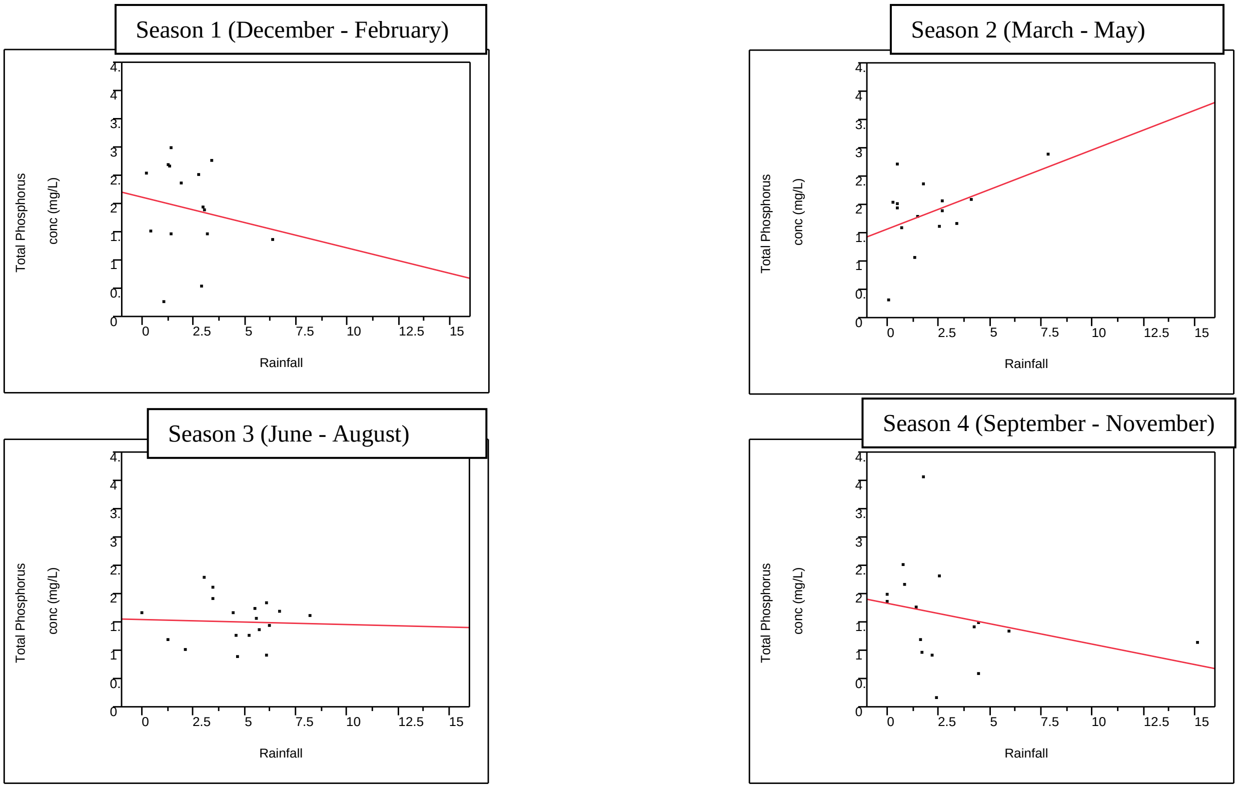


Figure 12. Site 12 Phosphorus Concentration vs. Rainfall separated by seasons.



Discussion

The study showed that Total Nitrogen is trending downward and has been decreasing over the past eight year study period. In the same study period we saw that Total Phosphorus trended upwards and has been increasing.

There were two nitrogen sites that showed a positive slope over the past eight years, Site eight, (the Baughman Center) and site ten (Near Animal Sciences Facility). Site eight had a few outliers that caused the slope of the line to increase rather than stay level as it would have without those outliers. The spikes in high concentration may have been due to high fertilizer additions to the golf course. Nutrients in fertilizer that is not taken up by plants can end up in runoff after rain events or with excess watering. The runoff then enters the surface waters increasing the concentrations. The sooner the fertilized area receives water the more nutrients that will likely end up in runoff. Site ten's slope was also positive, but that may have been attributed to some high spikes in 2006 and continuing in the following years. This site was located next to the animal sciences facility and the high spikes may have been due to possible excess manure additions to the soil in the area.

The graphs for nitrogen concentration over the entire study period showed large downward slopes indicating decreases in nitrogen. This is most likely due to the increase in standards for reclaimed water that is used for irrigation on the Universities campus. The physical plant does have strict standards for acceptable nitrogen levels in its effluent therefore it makes sense that as nitrogen is decreased from the source, it will decrease at the sampling point. When the data was split into four different seasons, the downward slopes became much more prevalent. There are many different environmental factors that may change season to season thereby accounting for the variability in nutrient concentrations. Even though there are a few instances of nitrogen increasing over the study period, those increases are either slight or most likely due to particular outlying events.

The sampling sites for phosphorus showed upward trending slopes except for site nine (Near IFAS Facilities Planning/Operations). However Site Nine's graph showed an almost level trend line and a high spike early on in the study, which may have caused the slight negative slope. The high spike occurred in 2004 and could have been caused by an extreme weather event, accidental fertilizer overdose or could also have been human error with regards to sampling and evaluation. If that value was removed, phosphorus would be increasing over the study period. When the data was divided by seasons, the upward trend lines became much more prevalent and had greater slope values than over the entire eight year study period. Environmental factors such as rainfall, temperature, pH, humidity, etc could all impact the nutrient concentrations through biological and chemical reactions. These factors vary from season to season. Therefore by separating the seasons, it gives more comparable data by removing some variability. Removing the variability shows significant support that phosphorus is increasing over the eight year study period.

One of the possible explanations for the fluxuation of nutrient concentrations was thought to be rainfall levels on campus. A correlation comparison between the monthly rainfall and nutrient concentrations for three of the twelve sites was completed; for Sampling Sites Five, Six and Twelve. Only three sites were chosen in order to get an idea if this comparison was even feasable. Although trend lines added to the graphs had fairly pronounced upward or downward slopes, the points appear to be random and more like a shotgun splatter. This makes us believe that there is no direct correlation between the amount of monthly rainfall and the monthly nutrient concentrations. However rainfall may still have had an impact on concentration. Another problem may be that there is not enough data to show a correlation. More data points may be needed in order to determine whether significance exists. Other studies may want to look at rainfall a few days before and after the date of sampling. Further comparisons and statistical analysis should be completed in order to rule out the possibility of any correlation.

The University of Florida's Physical Plant has been treating for nitrate since the Clean Water Campaign was started. If the physical plant wasn't treating before the campaign then after the campaign, it's logical that where the water was being used, nitrogen levels decreased. Reclaimed water is the major source for irrigation on the university's campus. The more the water is treated for nitrate, theoretically, the lower the nitrate levels in the reclaimed water. Thereby resulting in lower concentration levels in the surrounding sampling locations.

Phosphorus levels may be increasing for different reasons. Although the University of Florida's Physical Plant has the ability to treat for phosphorus there is no regulation to do so. This results in fluctuating amounts of phosphorus in the irrigation water that is supplied with the reclaimed water. Phosphorus is transported to surface waters predominantly in sediment-bound form (Soranno and others, 1996). Phosphorus may not be directly going from the irrigation water into the surface waters as it could be adsorbing to soil particles where the water is applied. However, the soil can only hold so much phosphorus before it starts to release the nutrient which then flows into the surrounding waters (Smolen, 2007; NRCS, 1994). If the amount of phosphorus continues to be unregulated, large amounts of phosphorus could be released from the soil in addition to any irrigation water entering surface waters directly.

Increasing nitrogen and phosphorus levels has been greatly studied and has shown to be quite detrimental to aquatic ecosystems and surrounding systems as well. The University of Florida's Clean Water Campaign has given us data to show that the University is doing an excellent job controlling the nitrogen levels on campus. However, phosphorus data suggests that levels are rising and if preventative measures are not taken to control the increase, devastating algal blooms or severe eutrophication could occur. It could take years after reducing or eliminating phosphorus sources before a decrease would be seen, thus action is needed in the present (Smolen, 2007).

Further study is needed to determine if the trends are statistically significant. At this time we can confidently say that there is at least an upward trend in phosphorus concentration and a downward trend in nitrate concentration in the tributaries of the Lake Alice Watershed on the University of Florida's Gainesville Campus.

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