# Characteristics of Nutrient Transport from Tate's Hell State Forest into East Bay Estuary in Northwest Florida

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# Introduction

- From 1988 to 1998 an average of 3,639 miles of rivers and streams in the southern U.S. were impacted by silvicultural activities.

- Impacts from silvicuture can be considerable if best management practices (BMPs) are not applied.

- Non-point source impacts on water quality include:
  - increase in nutrient concentrations, primarily nitrogen and phosphorus.
  - High levels of nutrients may also leach from soils that might have been disturbed or exposed.
  - Sedimentation of rivers, streams and marine ecosystems
  - hydrological alterations
  - Water quality physio-chemical parameters such as low pH, DO, increased temperature, turbid and tanned water.

# Environmental Monitoring

Monitoring can be conducted for many purposes. Four major purposes are to:

- Characterize waters and identify changes or trends in water quality over time
- Identify specific existing or emerging water quality problems.
- Gather information to design specific pollution prevention or remediation programs
- Determine whether program goals -- such as compliance with pollution regulations or implementation of effective pollution control actions -- are being met.

# Site and Background History

- Tate's Hell State Forest (THSF) is located in Franklin County, Florida and borders the Apalachicola National Forest Near the Apalachicola National Estuarine Research Reserve (ANERR)

- Silvicultural ditching, diking and rapid drainage transported fresh water from the once swamped area to allow for pine forest production

- These activities resulted in alteration of the natural drainage and led to channelized rainfall runoff into receiving water bodies such as East Bay which flows directly into the Apalachicola Bay

# Site and Background History

- A six-year study conducted in the Apalachicola estuary indicated that the alterations along with extensive clear cutting in THSF, resulted in flash flooding during heavy rainfalls

- Runoff from THSF is assumed to be primarily responsible for periodic increases in higher nutrient levels, tanned water color and decreases in dissolved oxygen and pH in the upper portions of the East-Apalachicola Bay.

# Goals and Objectives

General

To monitor water quality from an impacted (High Bluff Creek) and non-impacted (Hog’s Branch Creek) watersheds in THSF that may have a negative impact on East-Apalachicola Bay system

Specific

- Characterize and compare the Physio-chemical parameters of the water column at both sites
- Compare the concentration of nitrogen (N) and phosphorous (P) in run-off water at the two sites
- Compare N and P concentrations in sediment samples from both sites

# Rationale

- The East-Apalachicola Bay system is considered to be fairly clean. It is renowned for its economic resources (provides nursing ground for marine life – supports the largest oyster, shrimp, crab and fish industry in Florida)

- Water quality and nutrient loading data are lacking for streams and basins within the THSF Watersheds.

- Monitoring of water quality run-off from THSF could provide information on sources of impact on the water quality of the East-Apalachicola Bay.

# Rationale

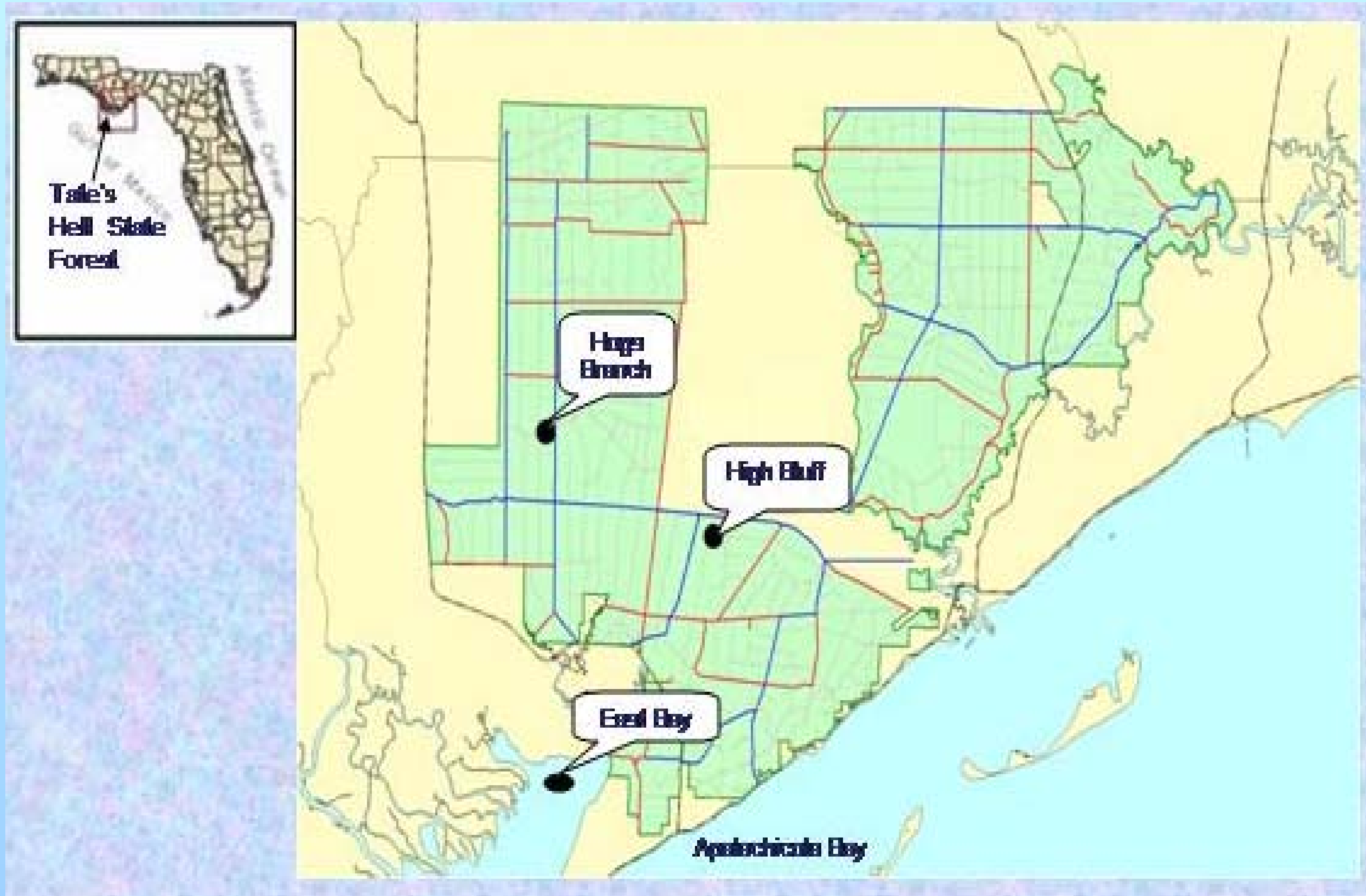
- This type of information (env. monitoring) is essential for understanding relationships between land use and management on water quality, for thoroughly characterizing the quality of the overall system, and for evaluating existing and potential pollution control measures.

# Study Sites

- Hogs branch watershed is government owned, (managed by the Division of Forestry - Carabelle, FL)
  - It is currently under natural vegetation of slash pine (*pinus elfiotti*) pond cypress (*Taxodium ascendens*)  and titi (*Cyrilla racemiflora*)
  - Soil Type - #34 – Surrency fine sand and # 28 Plummer fine sand

- High Bluff watershed at the time of the study was privately  owned and planted with pine trees for commercial use.
  - Soil type - #16 Bonsai mucky fine sand (frequently flooded) and #33 – Scranton fine sand

# Study Sites


Tate's Hell State Forest
Hogs Branch
High Bluff
East Bay
Apalachicola Bay

# Materials and Methods

## Water Quality Sampling and Monitoring:

- Grab samples were collected monthly from each site for N and P analysis.
- YSI 6920 Sonde continuous-stage water quality loggers were installed at both sites, that measured; temperature, pH, dissolved oxygen, conductivity, salinity and turbidity. Measurements were recorded at 30 minute intervals. Data download and calibration were done every 3-4 weeks.
- Orphimedes bubbler level loggers and tipping bucket rain gauges with data loggers were installed to collect and record water levels and rainfall at 30 minute intervals, respectively.

# Materials and Methods

**Sediment Sampling:**

- Cores of sediment samples were taken during the summer and winter seasons. Samples were taken to a depth of 30.5 cm (12 inches) by use of a gravimetric corer.

Analysis

- Water and sediment samples were colorimetrically analyzed by use of a Bran & Luebbe Auto-analyzer III, for $NO_3$-N, $NH_4$-N, ortho-phosphate.
- Sediment samples to be analyzed for $NO_3$-N, $NH_4$-N were extracted using 2M KCl solution and for the analysis of ortho-P, sediment samples were extracted with 0.01 M $CaCl_2$.

# Results and Discussion

| 2003 | 2003 Non-Impacted Site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Month | Water Depth (cm) | Dissolved Oxygen (mgL-1) | pH | Salinity (ppt) | Water Temperature (◦C) | Turbidity (NTU) | Total Rainfall (mm) |
| | January | 3.05 ± 0.003 | 7.72 ± 0.07 | 5.780 ± 0.004 | 0.0200 ± 0.0001 | 11.5 ± 0.06 | 4.56 ± 0.09 | 9.91 ± 0.18 |
| | February | 4.36 ± 0.12 | 7.07 ± 0.07 | 5.670 ± 0.030 | 0.0200 ± 0.0001 | 11.82 ± 0.08 | 4.18 ± 0.37 | 174.50 ±2.54 |
| | March | 46.83± 0.27 | 3.69 ± 0.04 | 4.100 ± 0.002 | 0.0200 ± 0.0001 | 18.87 ± 0.05 | 1.18 ± 0.04 | 320.55 ± 4.57 |
| | April | 16.46± 0.15 | 2.48 ± 0.05 | 3.870± 0.020 | 0.0200 ± 0.0001 | 20.05 ± 0.08 | 3.98 ± 0.08 | 43.18 ± 0.76 |
| | May | 6.61 ± 0.03 | 2.82 ± 0.55 | 3.630 ± 0.060 | 0.0200 ± 0.0001 | 24.47 ± 0.24 | 61.08 ± 9.56 | 55.37 ± 1.27 |
| | June | 18.90 ± 0.27 | 2.99 ± 0.11 | 4.080± 0.010 | 0.0200 ± 0.0001 | 24.88 ± 0.06 | 58.00 ± 8.56 | 481.84 ± 6.10 |
| | July | 19.20 ± 0.12 | 1.94 ± 0.06 | 4.100± 0.020 | 0.0200 ± 0.0001 | 24.93 ± 0.06 | 3.51 ± 0.14 | 278.13 ± 2.29 |
| | August | 18.29 ± 0.06 | 1.84 ± 0.02 | 4.070 ± 0.001 | 0.0200 ± 0.0001 | 25.07 ± 0.03 | 15.62 ± 0.81 | 324.10 ± 2.54 |
| | September | 15.54 ± 0.27 | 1.98 ± 0.03 | 5.010 ± 0.030 | 0.0300 ±0.0002 | 24.23 ± 0.02 | 14.23 ± 0.04 | 112.52 ± 1.78 |
| | October | 7.01± 0.09 | 2.89 ± 0.02 | 5.990 ± 0.030 | 0.0300 ±0.0002 | 20.87 ± 0.02 | 17.65 ± 0.03 | 187.45 ± 3.30 |
| | November | 5.18 ± 0.12 | 3.67 ± 0.13 | 6.05 0± 0.040 | 0.0300 ±0.0002 | 19.76 ± 0.03 | . | 179.58 ± 3.30 |
| | December | 3.35 ± 0.06 | 4.25 ± 0.07 | 6.24 0± 0.030 | 0.0300 ±0.0002 | 17.83 ± 0.02 | . | 83.31 ± 1.27 |
| 2003 | Impacted Site | | | | | | | |
| | January | 6.10 ± 0.91 | 7.51 ± 0.07 | 6.040 ± 0.003 | 0.0300 ±0.0002 | 10.42 ± 0.16 | 6.14 ± 0.18 | 9.91 ± 0.18 |
| | February | 11.58 ± 0.31 | 6.39 ± 0.07 | 5.610 ± 0.020 | 0.0300 ±0.0002 | 13.14 ± 0.06 | 7.60 ± 0.16 | 174.50 ±2.54 |
| | March | 16.15 ± 0.12 | 3.19 ± 0.03 | 4.900 ± 0.010 | 0.0200 ± 0.0001 | 19.18 ± 0.10 | 7.95 ± 0.10 | 320.55 ± 4.57 |
| | April | 14.33 ± 0.09 | 2.27 ± 0.05 | 5.600 ± 0.010 | 0.0200 ± 0.0001 | 20.38 ± 0.08 | 10.48 ± 0.11 | 43.18 ± 0.76 |
| | May | 11.58 ± 0.03 | 2.03 ± 0.04 | 6.130 ± 0.010 | 0.0300 ±0.0002 | 25.03 ± 0.07 | 4.67 ± 0.10 | 55.37 ± 1.27 |
| | June | 22.86 ± 0.31 | 1.98 ± 0.06 | 5.050± 0.020 | 0.0300 ±0.0002 | 26.21 ± 0.04 | 0.45 ± 0.07 | 481.84 ± 6.10 |
| | July | 37.80 ± 0.09 | 0.80 ± 0.04 | 4.360± 0.010 | 0.0200 ± 0.0001 | 26.31 ± 0.04 | 5.41 ± 0.75 | 278.13 ± 2.29 |
| | August | 29.36 ± 0.12 | 1.36 ± 0.01 | 4.330 ± 0.010 | 0.0200 ± 0.0001 | 26.52 ± 0.04 | 8.71 ± 0.07 | 324.10 ± 2.54 |
| | September | 19.81 ± 0.18 | 1.56 ± 0.02 | 5.310 ± 0.020 | 0.0300 ±0.0002 | 25.03 ± 0.04 | 16.14 ± 0.06 | 112.52 ± 1.78 |
| | October | 19.81 ± 0.19 | 2.65 ± 0.02 | 6.110 ± 0.004 | 0.0300 ±0.0002 | 21.70 ± 0.11 | 19.08 ± 0.06 | 187.45 ± 3.30 |
| | November | 19.81 ± 0.20 | 3.46 ± 0.03 | 6.120 ± 0.020 | 0.0300 ±0.0002 | 19.85 ± 0.05 | . | 179.58 ± 3.30 |
| | December | 19.81 ± 0.21 | 3.74 ± 0.05 | 6.430 ± 0.010 | 0.0300 ±0.0002 | 17.91 ± 0.04 | . | 83.31 ± 1.27 |

# Results and Discussion

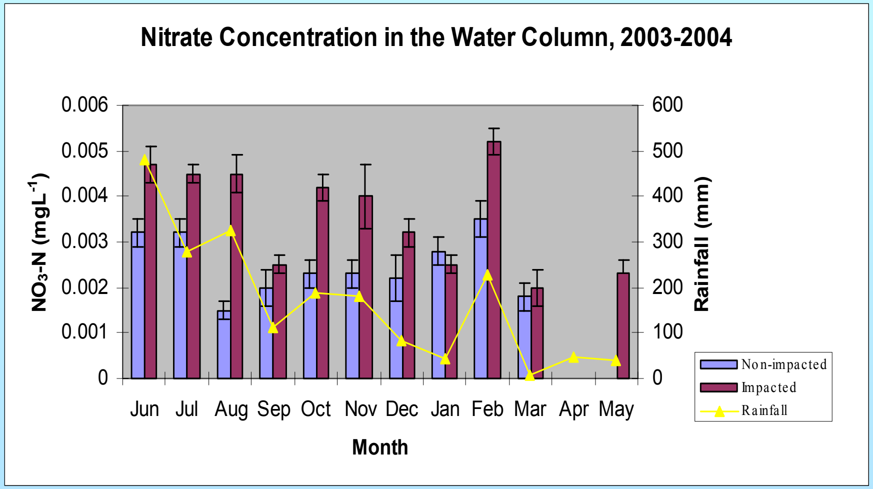
| 2004 | Non-Impacted Site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Month | Water Depth (cm) | Dissolved Oxygen (mgL-1) | pH | Salinity (ppt) | Water Temperature (◦C) | Turbidity (NTU) | Total Rainfall (cm) |
| | January | 23.470 ± 0.12 | 5.03 ± 0.05 | 6.08 ± 0.01 | 0.0300 ±0.0002 | 13.38 ± 0.18 | 6.45 ± 0.61 | 44.96 ± 0.51 |
| | February | 30.78 ± 0.31 | 4.76 ± 0.03 | 5.46 ± 0.03 | 0.0300 ±0.0002 | 13.55 ± 0.07 | 7.23 ± 0.86 | 226.31 ± 2.79 |
| | March | 14.63 ± 0.09 | 4.02 ± 0.04 | 5.21 ± 0.03 | 0.0300 ±0.0002 | 16.75 ± 0.06 | 8.57 ± 0.39 | 7.11 ± 0.18 |
| | April | 6.71 ± 0.09 | 4.79 ± 0.03 | 6.34 ± 0.02 | 0.0300 ±0.0002 | 16.23 ± 0.08 | 7.65 ± 0.06 | 48.26 ± 0.76 |
| | May | 7.32 ± 0.61 | 3.45 ± 0.03 | 5.87 ± 0.03 | 0.0200 ± 0.0001 | 19.05 ± 0.05 | 5.56 ± 0.06 | 38.86 ± 0.76 |
| | June | 7.92 ± 0.61 | 3.22 ± 0.02 | 4.78 ± 0.02 | 0.0200 ± 0.0001 | 22.17 ± 0.03 | 4.76 ± 0.05 | 178.05 ± 1.78 |
| | July | 13.11 ± 0.61 | 3.26 ± 0.01 | 3.950 ± 0.002 | 0.0200 ± 0.0001 | 26.02 ± 0.04 | 4.58 ± 0.08 | 234.70 ± 1.78 |
| | August | 15.54 ± 0.12 | 2.54 ± 0.02 | 3.980 ± 0.002 | 0.0200 ± 0.0001 | 26.00 ± 0.05 | 4.47 ± 0.10 | 129.54 ± 1.78 |
| | September | 17.59 ± 0.12 | 1.81 ± 0.04 | 3.790 ± 0.002 | 0.0300 ±0.0002 | 23.46 ± 0.04 | 44.59 ± 8.56 | 237.24 ± 3.30 |
| | October | 15.54 ± 0.06 | 2.47 ± 0.02 | 3.910 ± 0.002 | 0.0200 ± 0.0001 | 21.84 ± 0.04 | 42.69 ± 8.43 | 103.63 ± 1.52 |
| | November | 13.11 ± 0.09 | 4.05 ± 0.03 | 5.52 ± 0.05 | 0.0200 ± 0.0001 | 17.11 ± 0.10 | 41.7 ± 7.56 | 73.41 ± 1.27 |
| | December | 15.54 ± 0.06 | 5.00 ± 0.03 | 7.33 ± 0.03 | 0.0200 ± 0.0001 | 14.86 ± 0.10 | 2.99 ± 0.07 | 131.06± 2.03 |
| **2004** | **Impacted Site** | | | | | | | |
| | January | 25.91 ± 0.18 | 4.02 ± 0.05 | 6.01 ± 0.02 | 0.0400 ± 0.0002 | 14.23 ± 0.09 | 7.89 ± 0.73 | 44.96 ± 0.51 |
| | February | 37.49 ± 0.06 | 3.98 ± 0.03 | 5.37 ± 0.02 | 0.0400 ± 0.0002 | 14.57 ± 0.08 | 8.65 ± 0.95 | 226.31 ± 2.79 |
| | March | 18.59 ± 0.15 | 3.53 ± 0.03 | 5.68 ± 0.02 | 0.0300 ±0.0002 | 17.96 ± 0.07 | 10.66 ± 0.48 | 7.11 ± 0.18 |
| | April | 11.28 ± 0.06 | 4.59 ± 0.06 | 6.39 ± 0.03 | 0.0400 ± 0.0003 | 17.08 ± 0.13 | 8.74 ± 0.08 | 48.26 ± 0.76 |
| | May | 12.5 ± 0.12 | 3.19 ± 0.04 | 5.85 ± 0.02 | 0.0300 ±0.0002 | 19.39 ± 0.09 | 7.49 ± 0.07 | 38.86 ± 0.76 |
| | June | 19.2 ± 0.15 | 3.01 ± 0.03 | 5.45 ± 0.03 | 0.0300 ±0.0002 | 23.74 ± 0.06 | 6.85 ± 0.07 | 178.05 ± 1.78 |
| | July | 23.47 ± 0.15 | 1.6 ± 0.02 | 5.00 ± 0.01 | 0.0300 ±0.0002 | 28.08 ± 0.03 | 5.45 ± 0.19 | 234.70 ± 1.78 |
| | August | 28.96 ± 0.24 | 1.3 ± 0.02 | 4.22 ± 0.02 | 0.0200 ± 0.0001 | 27.3 ± 0.05 | 3.11 ± 0.07 | 129.54 ± 1.78 |
| | September | 32.61 ± 0.15 | 1.54 ± 0.03 | 4.05 ± 0.01 | 0.0200 ± 0.0002 | 24.41 ± 0.03 | 2.08 ± 0.06 | 237.24 ± 3.30 |
| | October | 26.21 ± 0.15 | 2.22 ± 0.02 | 4.5 ± 0.01 | 0.0220 ± 0.0001 | 23.03 ± 0.05 | 3.84 ± 0.06 | 103.63 ± 1.52 |
| | November | 17.07 ± 0.06 | 3.67 ± 0.04 | 5.47 ± 0.01 | 0.03 00± 0.0002 | 19.55 ± 0.14 | 7.27 ± 0.06 | 73.41 ± 1.27 |
| | December | 19.51 ± 0.09 | 3.89 ± 0.03 | 7.21 ± 0.03 | 0.0300 ± 0.0002 | 15.75 ± 0.09 | 6.89 ± 0.05 | 131.06± 2.03 |

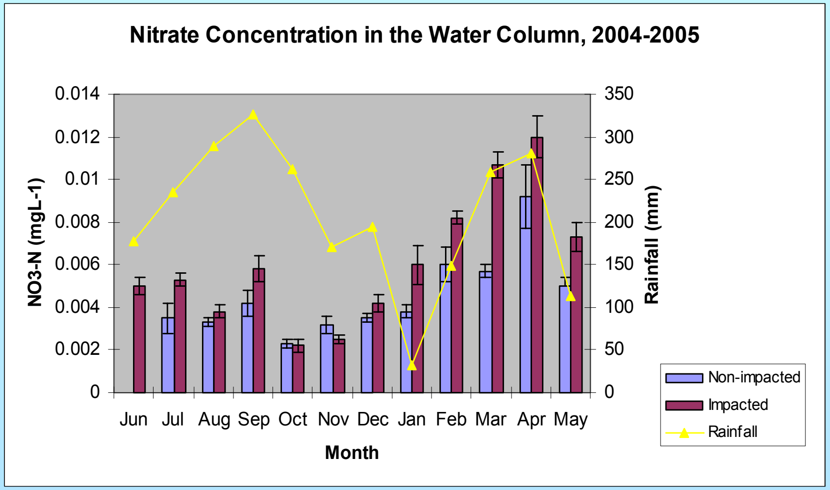
# Results and Discussion

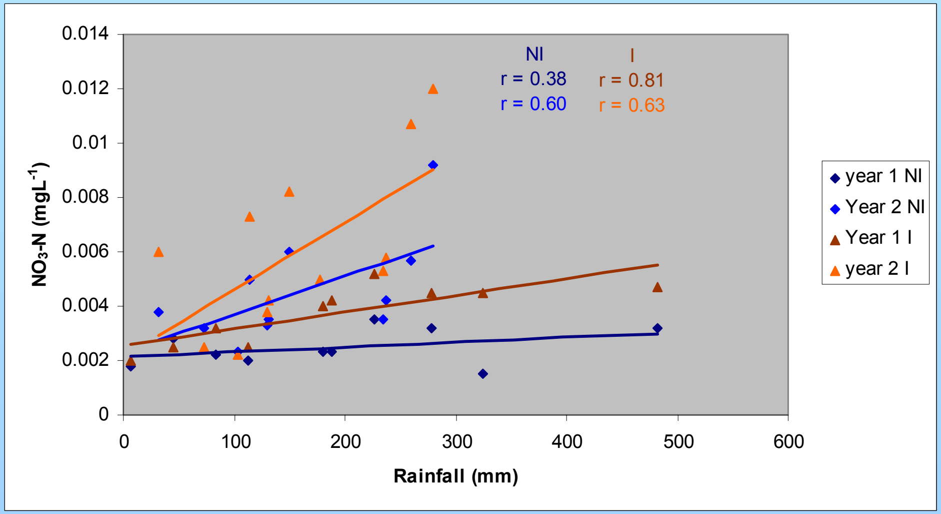
| **2005** | **Non-Impacted Site** | | | | | | |
|---|---|---|---|---|---|---|---|
| Month | Water Depth (cm) | Dissolved Oxygen (mgL-1) | pH | Salinity (ppt) | Water Temperature (◦C) | Turbidity (NTU) | Total Rainfall (cm) |
| January | 15.24 ± 0.09 | 6.42 ± 0.16 | 6.410 ± 0.004 | 0.0200 ± 0.0001 | 11.08 ± 0.08 | 2.27 ± 0.02 | 32.00 ± 0.76 |
| February | 13.41 ± 0.09 | 6.94 ± 0.28 | 5.980 ± 0.020 | 0.0200 ± 0.0001 | 12.95 ± 0.10 | 2.64 ± 0.10 | 149.35 ± 3.05 |
| March | 15.54 ± 0.31 | 5.52 ± 0.57 | 7.930 ± 0.020 | 0.0200 ± 0.0001 | 17.6 ± 0.12 | 2.56 ± 0.04 | 259.33 ± 4.40 |
| April | 17.68 ± 0.31 | 3.97 ± 0.67 | 6.770 ± 0.010 | 0.0200 ± 0.0001 | 19.13 ± 0.06 | 5.05 ± 0.15 | 279.91 ± 4.57 |
| May | 18.90 ± 0.31 | 3.8 ± 0.47 | 6.610 ± 0.004 | 0.0200 ± 0.0001 | 21.71 ± 0.07 | 4.15 ± 0.06 | 113.54 ± 1.52 |

| **2005** | | | | **Impacted Site** | | | |
|---|---|---|---|---|---|---|---|
| Month | Water Depth (cm) | Dissolved Oxygen (mgL-1) | pH | Salinity (ppt) | Water Temperature (◦C) | Turbidity (NTU) | Total Rainfall (cm) |
| January | 22.86 ± 0.18 | 6.70 ± 0.42 | 5.33 ± 0.01 | 0.0200 ± 0.0001 | 12.42 ± 0.08 | . | 3.2 ± |
| February | 18.59 ± 0.12 | 7.05 ± 0.35 | 6.03 ± 0.01 | 0.0300 ± 0.0002 | 14.75 ± 0.10 | . | 14.94 ± |
| March | 22.25 ± 0.31 | 5.03 ± 0.04 | 5.97 ± 0.01 | 0.0200 ± 0.0002 | 18.21 ± 0.10 | . | 25.91 ± |
| April | 28.04 ± 0.31 | 2.67 ± 0.26 | 4.87 ± 0.01 | 0.0200 ± 0.0001 | 19.77 ± 0.05 | 6.12 ± 0.07 | 27.99 ± |
| May | 21.95 ± 0.31 | 2.86 ± 0.54 | 4.91 ± 0.01 | 0.0160 ± 0.0001 | 23.31 ± 0.08 | 4.76 ± 0.06 | 11.35 ± |

# Results and Discussion

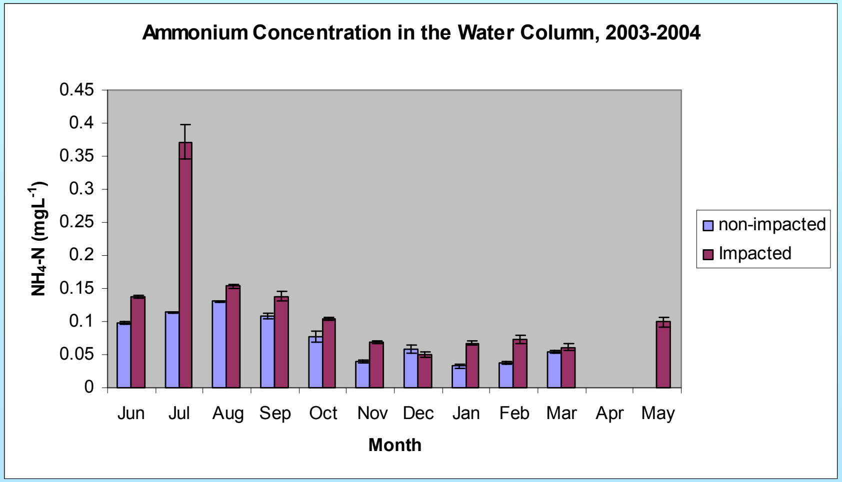


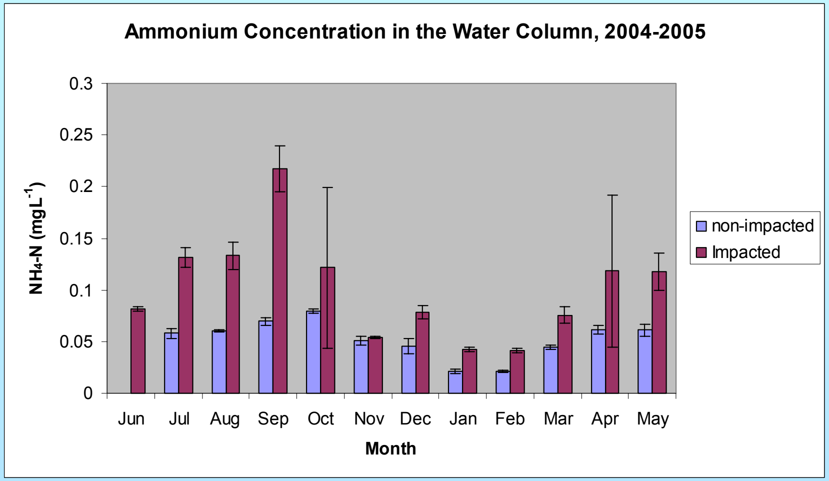



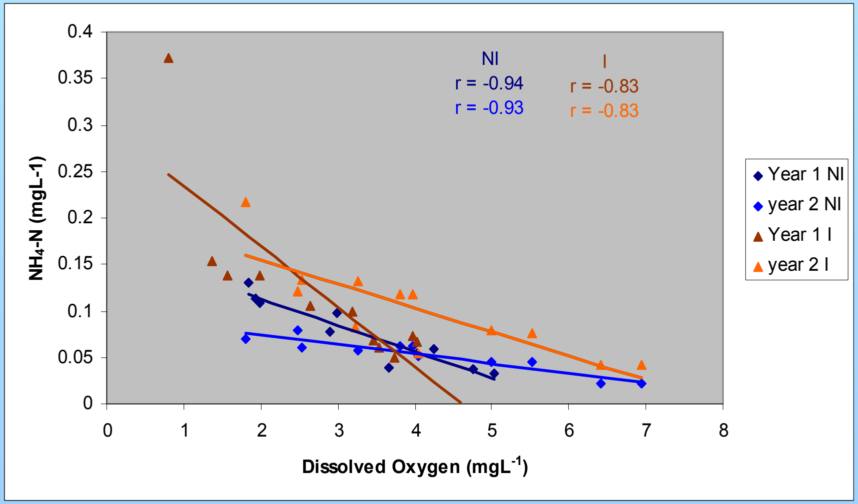




The relationship between Nitrate concentration and Rainfall

# Results and Discussion

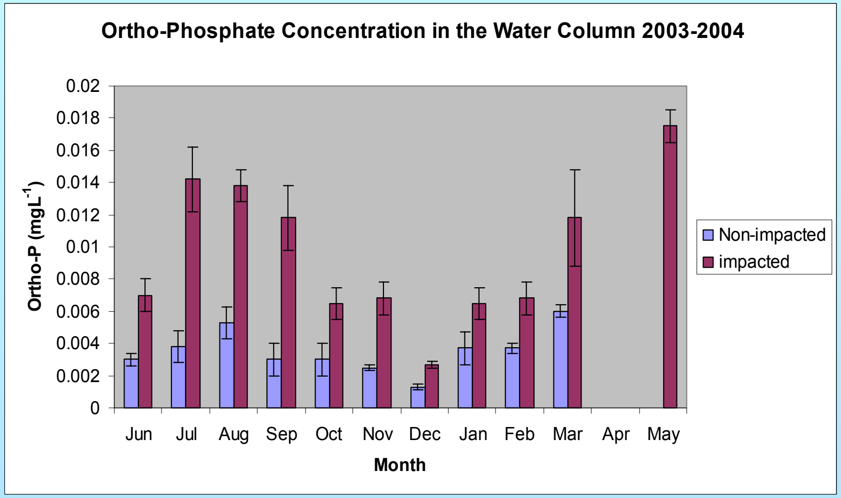


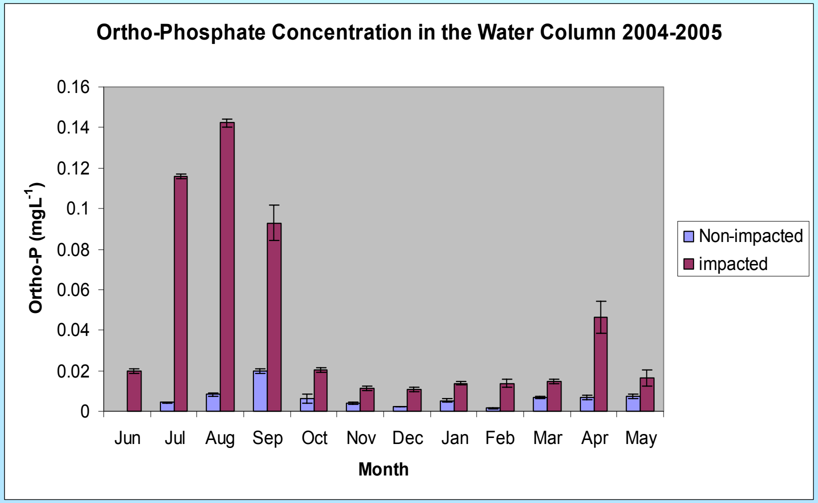



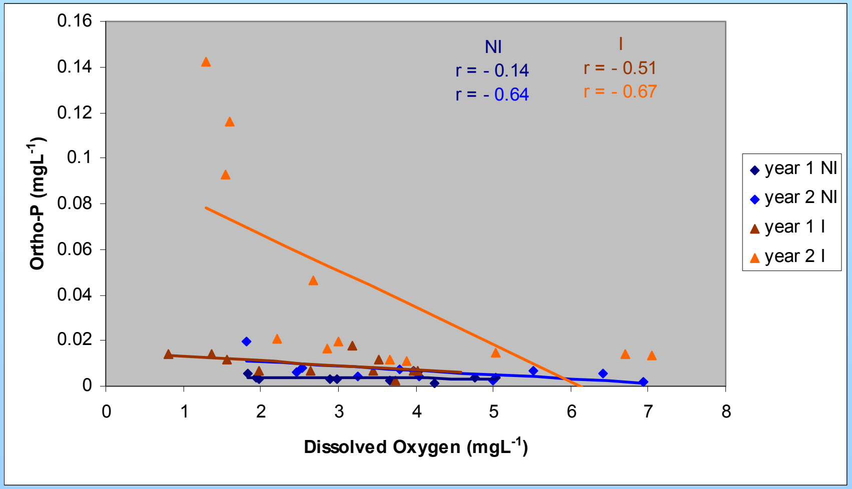




The relationship between ammonium concentration and Dissolved Oxygen

# Results and Discussion

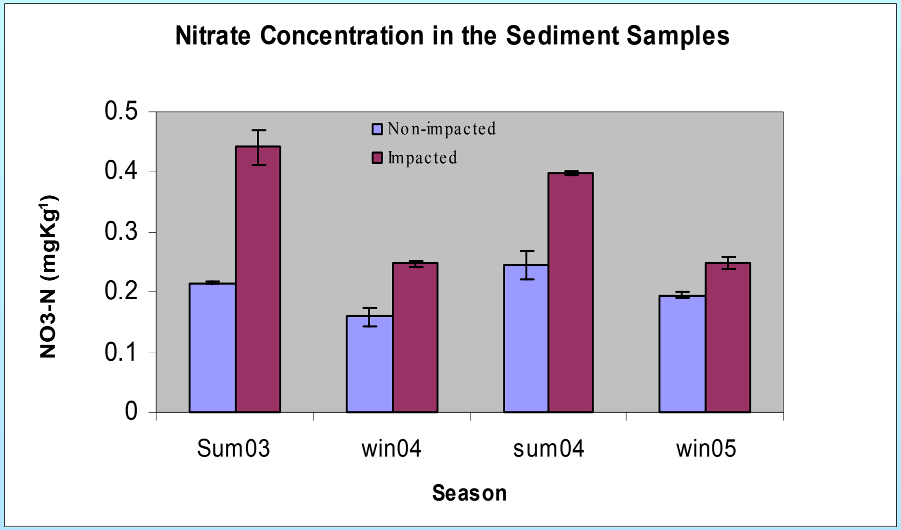


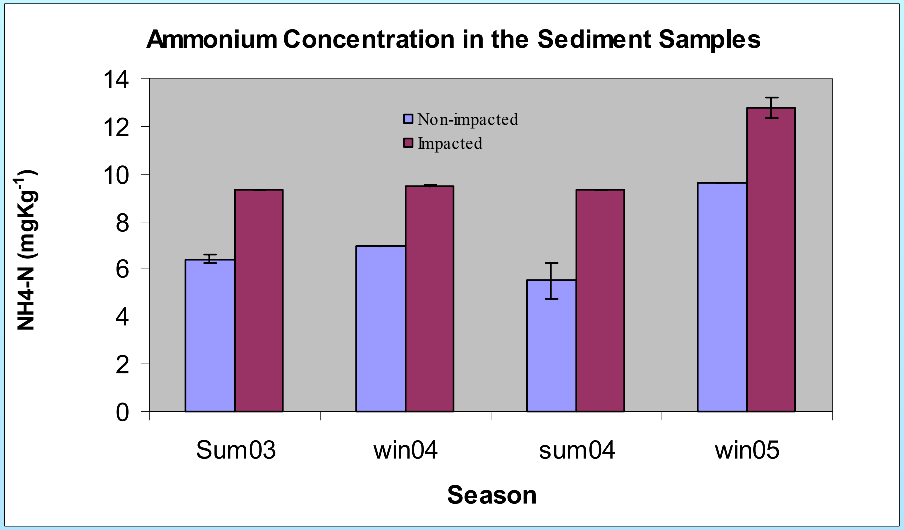



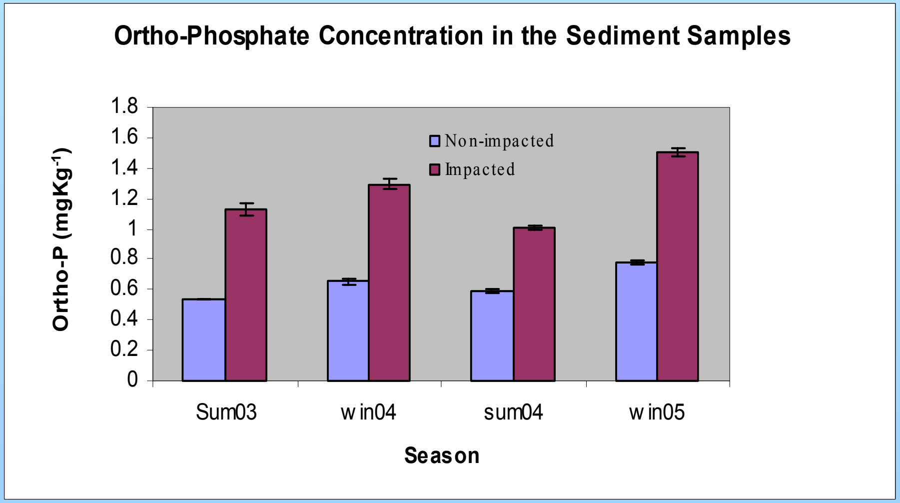




The relationship between Ortho-phosphate concentration and Dissolved Oxygen

# Results and Discussion



# Conclusion

- A comparison of the water column data from both sites showed that the concentration of nitrate, ammonium, and ortho-phosphate were higher at the impacted site.
  - nitrate concentrations were 31 and 26 % higher
  - Ammonium concentrations were 38 and 39 % higher
  - And ortho-phosphate concentrations were 63 and 85 % higher in years 1 and 2 respectively
- Nitrate concentrations correlated positively with rainfall
- Ammonium and ortho-phosphate concentrations had a negative correlation with dissolved oxygen

# Conclusion

- In the sediment samples:
  - Nitrate concentrations were greater at the impacted site, and higher during the summer season
  - Ammonium and Ortho-phosphate concentrations were greater at the impacted sites. These concentrations were higher in the winter seasons when the dissolved oxygen concentrations were highest
- The data indicate that if not managed properly post silvicultural activities may negatively impact surface water ecosystems.

## Acknowledgement

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  - The Environmental Sciences Institute (Florida A&M University, FAMU)
  - Title III (FAMU) and
  - NOAA

# Questions