Long-term Nutrient Increases in the Lower Cape Fear River Basin Driven by livestock CAFOs and small wastewater discharges, 2000-2019

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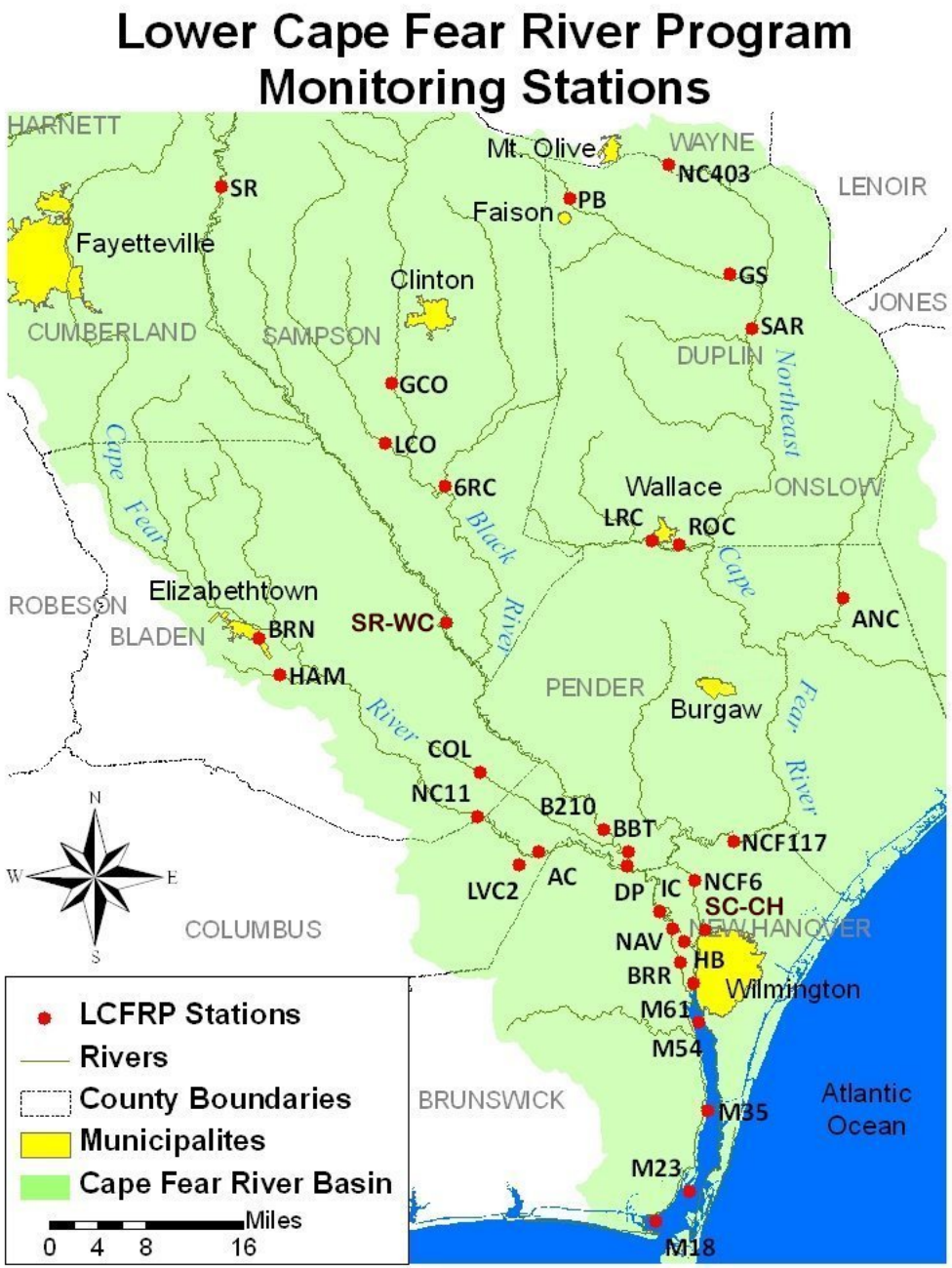


All data shown within were collected by the Lower Cape Fear River program at UNC Wilmington.

The program began in 1995 and is ongoing. Data are state-certified and available from 32 sites on our UNCW laboratory website https://uncw.edu/cms/aelab/lcfrp/ where our annual reports are on-line; the data in the reports are in Excel format.

Or email Dr. Mallin at mallinm@uncw.edu.

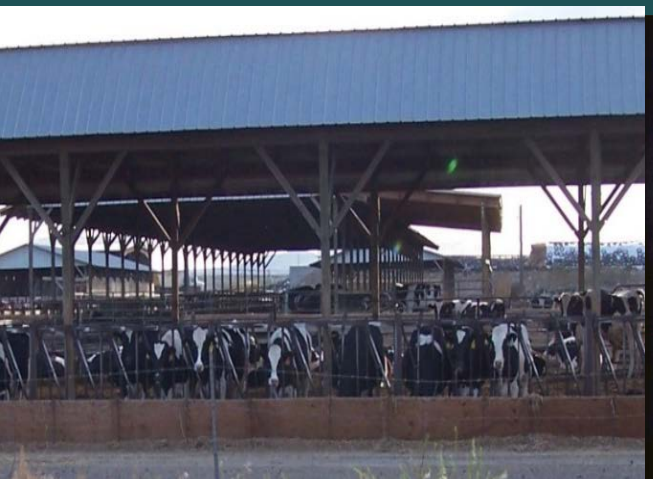
CAFOS – Concentrated (also called confined) animal feeding operations

The U.S. EPA (2014) defines large CAFOs as containing ≥ 1,000 head of beef cattle, 2,500 swine > 25 kg or 10,000 swine < 25 kg, 125,000 chickens or 82,000 laying hens or 55,000 turkeys.

(left) cattle CAFO Washington state

(middle) swine CAFO interior, Duplin Co., NC

(right) turkey CAFO interior, Duplin Co. NC



Swine fecal waste is pumped from the hog houses outside to a waste lagoon. From there it is sprayed out on surrounding fields

hog houses

waste lagoon

sprayfield


Swine CAFO waste disposal is by spraying onto nearby fields; note saturated fields

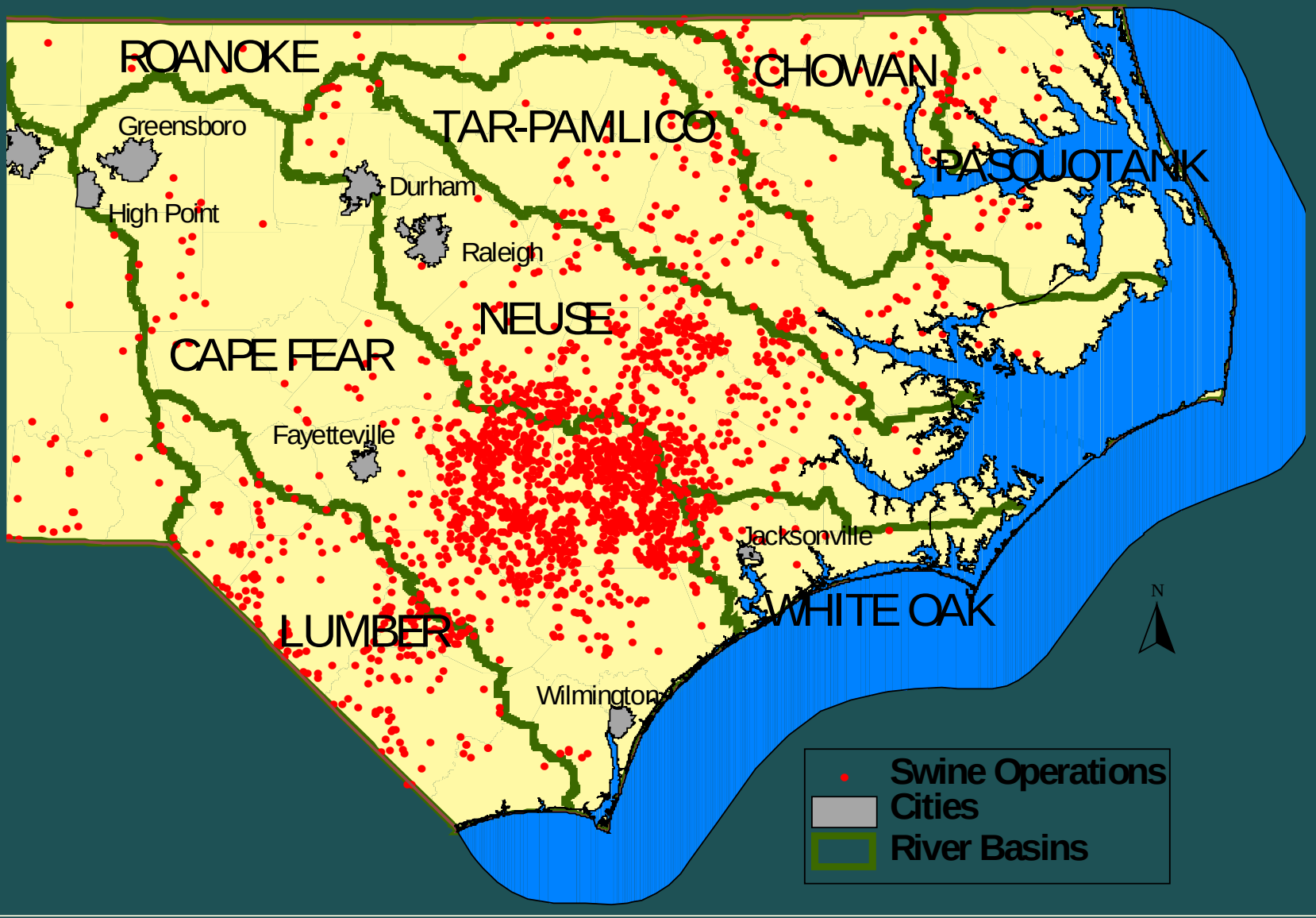

Swine waste lagoon


Swine CAFOs eastern NC


Swine CAFO in Minnesota


Poultry CAFOs near
Charlotte, NC

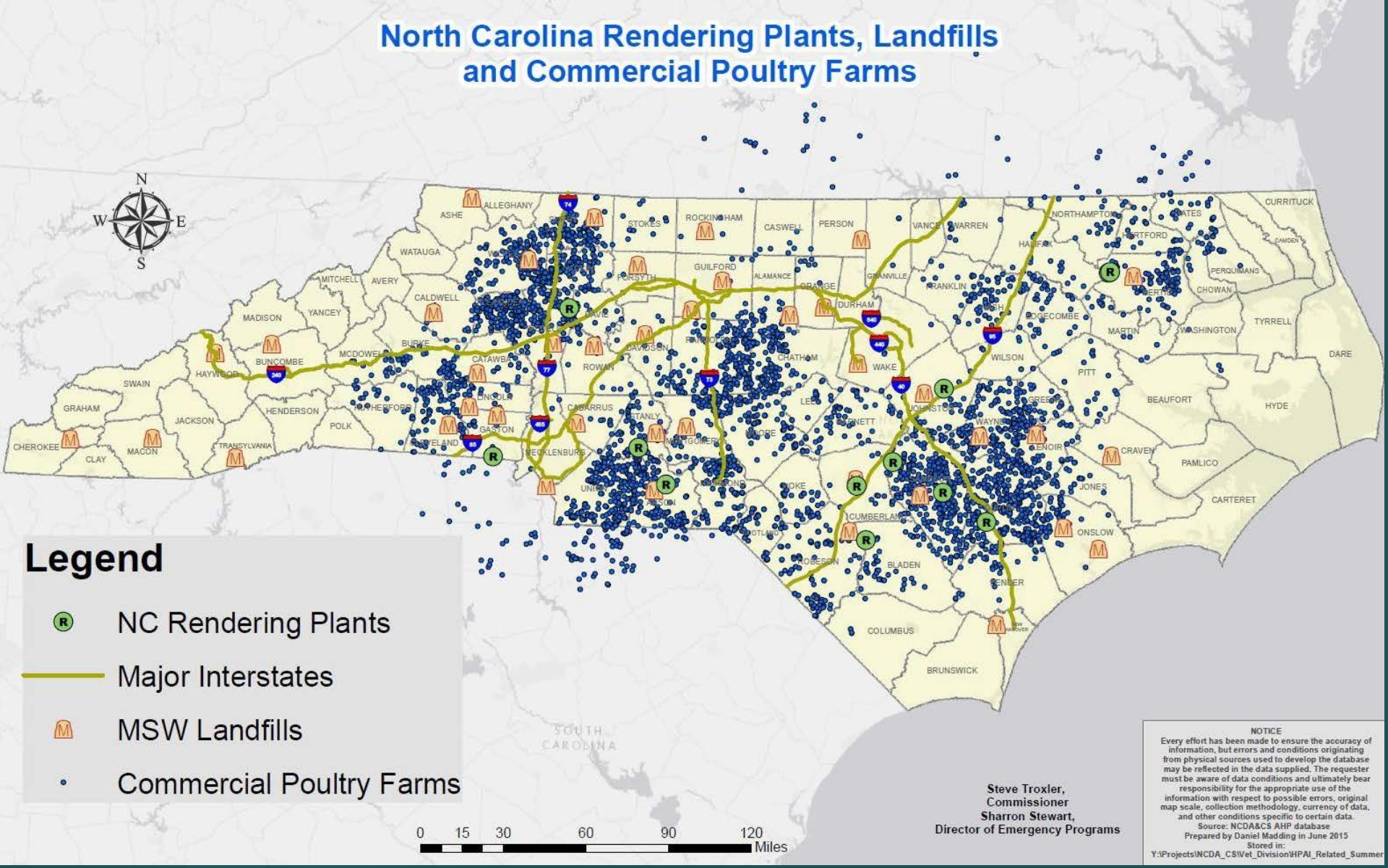
Swine CAFOs in eastern North Carolina River Basins: 2017 NC swine inventory 8,9000,000



Confined turkeys Duplin Co., NC

Poultry waste is spread as dry litter onto surrounding fields and subject to stormwater runoff

Poultry CAFO dry waste in pile

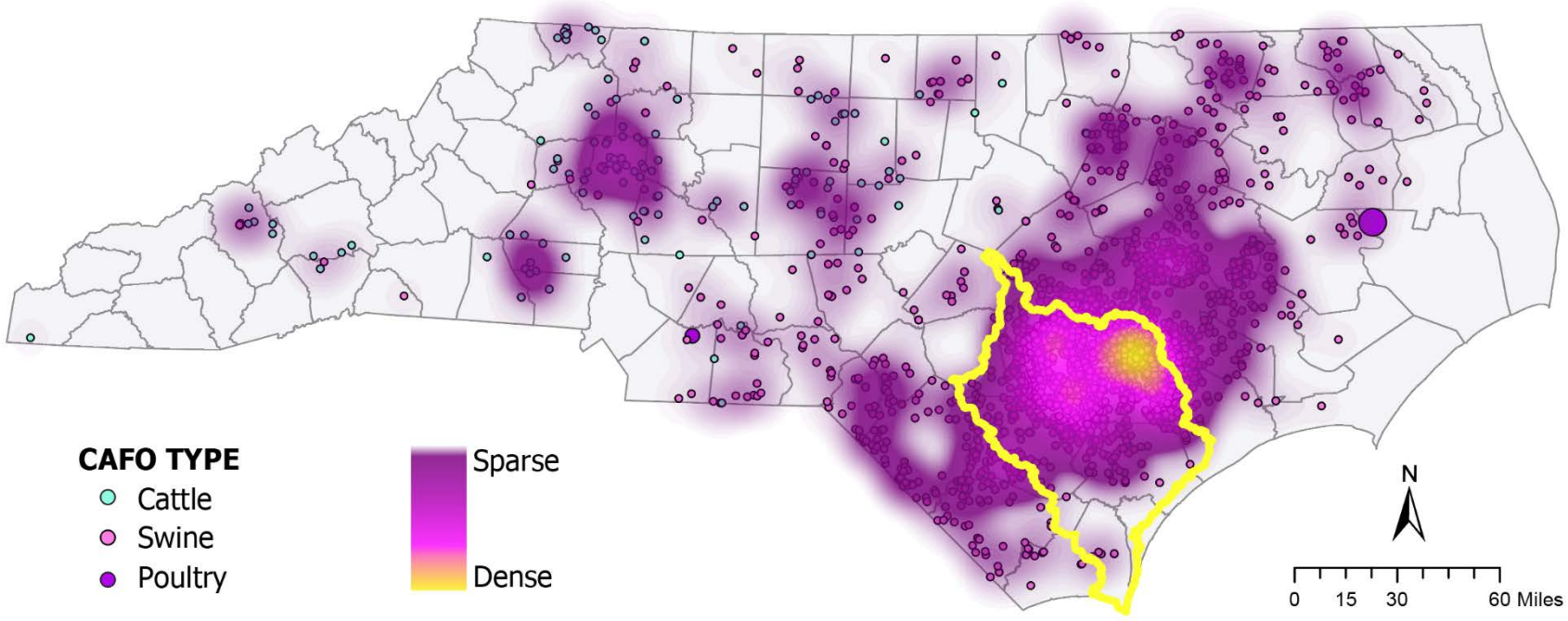


Data from NC DEQ (Patt 2017) for five coastal watersheds (Cape Fear, Lumber, Neuse, Tar-Pamlico and White Oak Rivers) total numbers of birds increased from approximately 762,224,000 in 1992 to 886, 280,400 in 2014, an increase of > 124,000,000 birds. This increase is ongoing!

Industrial Agriculture

Highest concentration of CAFOs in the world

~25% of land use is agriculture & livestock



Data source: Division of Water Resources (DWR) Animal Operation Permits

Map credit: Colleen Brown

Pathways of CAFO waste inputs to off-site receiving surface- and groundwaters (trans-boundary pollution)

- Acute spills and breaches
- Storm-related incidents
- Spray-field surface and subsurface stormwater runoff
- Lagoon leakage
- Illegal pumping activity
- Atmospheric NH_4^+ transport
- Animal “losses” (NC – 10% swine death; burial, incineration, dumping)

NO_3 (nitrate + nitrite) – 20-Year increases, 13 sites (as µg N/L)

- **Black River basin nitrate <u>increases</u>**

- 6RC (R= 0.803, *df*=18, *n*=20,
- *p*= 2.3 E-05) 4th order

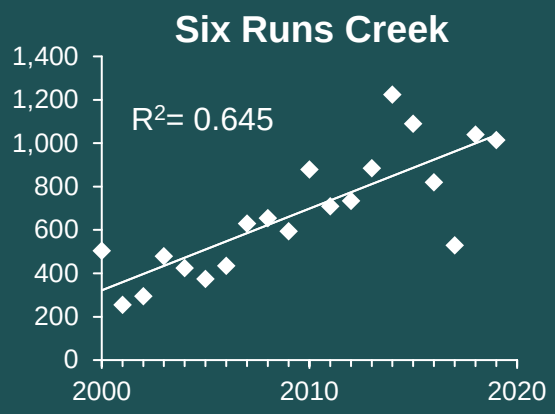
- LCO (R= 0.733, *df*=18, *n*=20,
- *p*= 0.0003) 3rd order

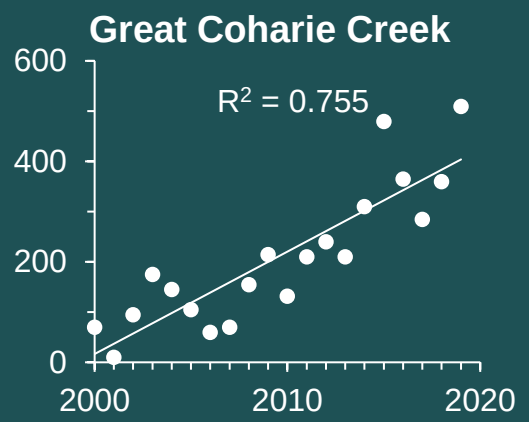
- GCO (R= 0.869, *df*=18, *n*=20,
- *p*= 7.0 E-07) 4th order

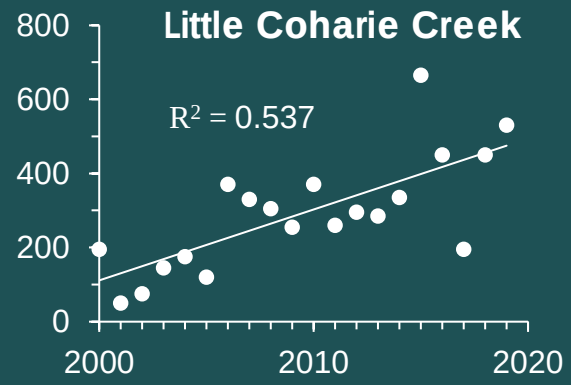
- SR (R= 0.682, *df*=18, *n*=20,
- *p*= 0.001)

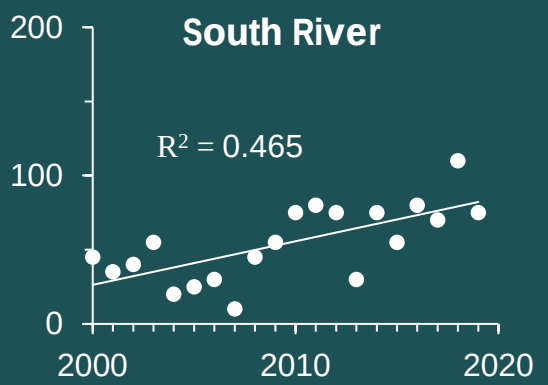
- COL (R= 0.310, *df*=18, *n*=20, *p*= 0.197 (non-significant) 2nd order

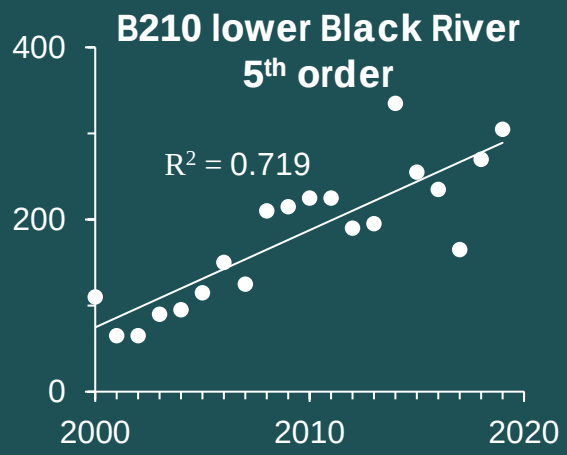
- B210 (R= 0.848, *df*=18, *n*=20,
- *p*= 2.6 E-07) 5th order
- **NO POINT SOURCE DISCHARGES** IN THE BLACK RIVER BASIN

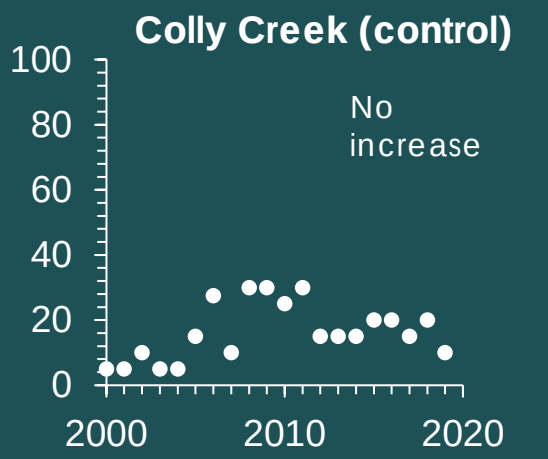








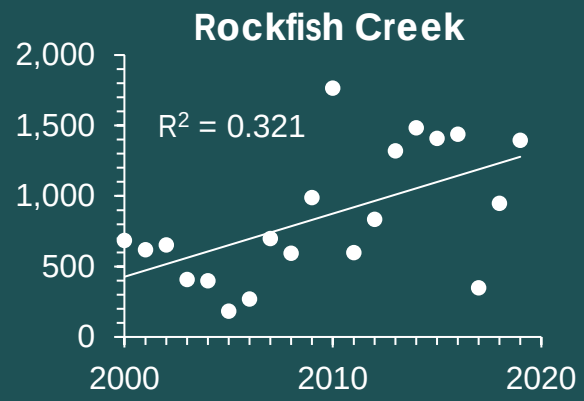


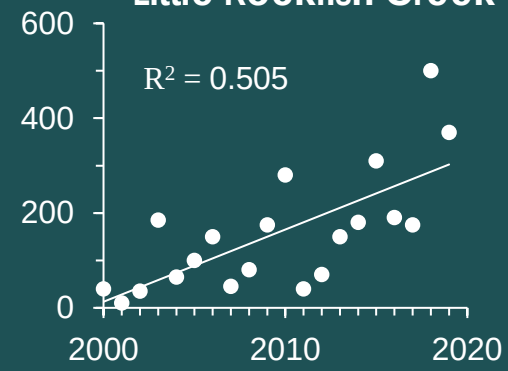


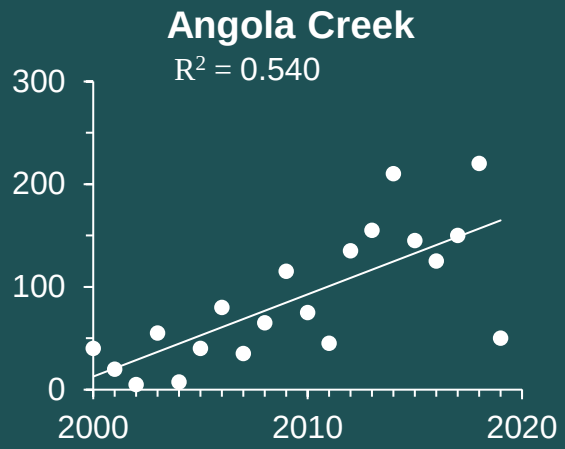
NO_3 (nitrate + nitrite) – 20-Year Summary (as mg/-N/L)

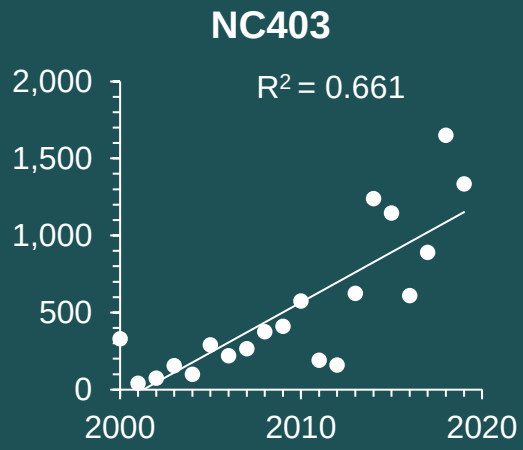
- **Northeast Cape Fear River basin nitrate increases**

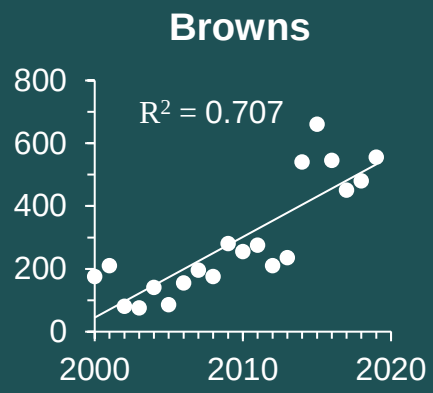
- ANC (R= 0.735, *df*=18, *n*=20,
- *p*= 0.0002) 2nd order
- ROC (R= 0.567, *df*=18, *n*=20,
- *p*= 0.01) 4th order
- LRC (R= 0.711, *df*=18, *n*=20,
- *p*= 0.0005)
- NCF117 (R= 0.592, *df*=18, *n*=20, *p*= 0.007) 5th order
- **Main CF River tributaries**
- BRN (R= 0.841, *df*=18, *n*=20,
- *p*= 3.8 E-06) 2nd order
- HAM (R= 0.764, *df*=18, *n*=20,
- *p*= 9.6 E-05) 3rd order

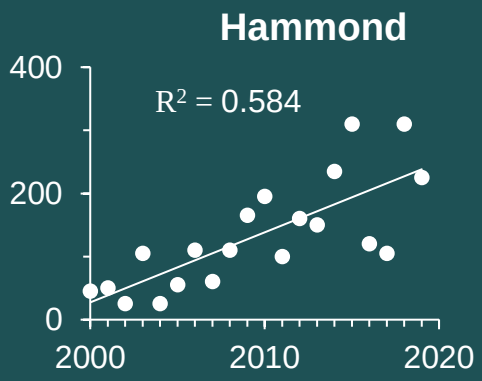


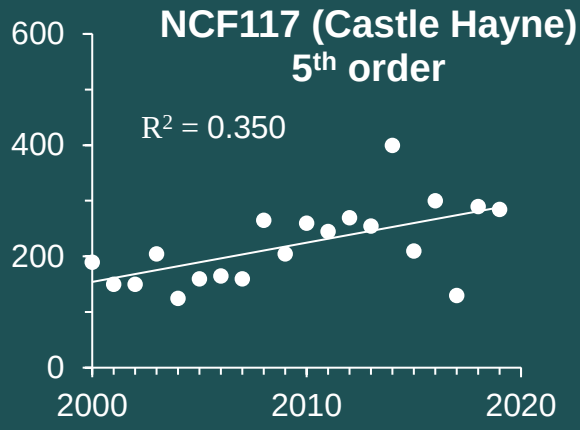








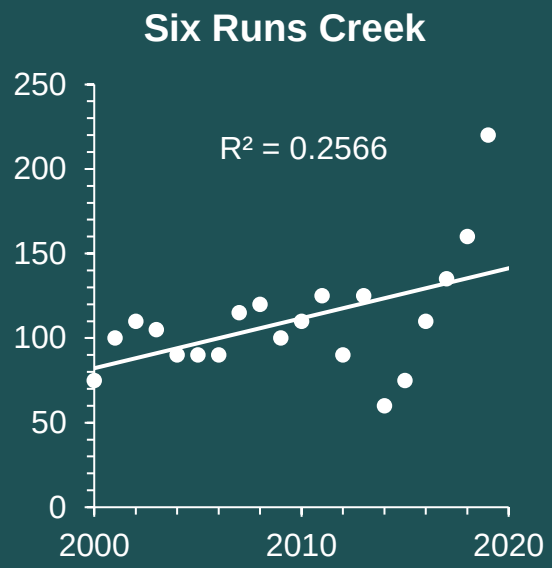


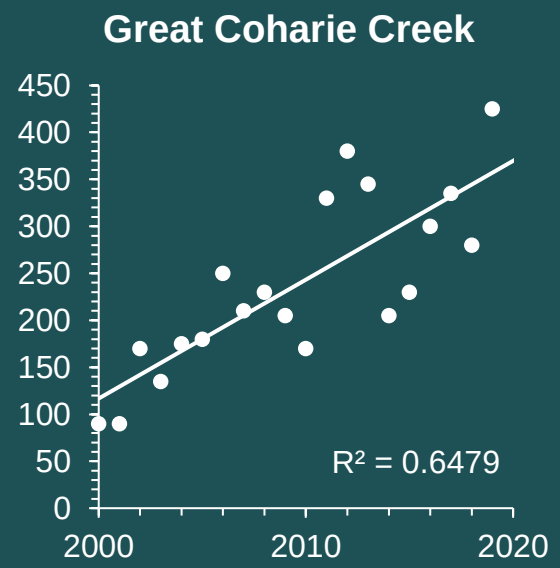


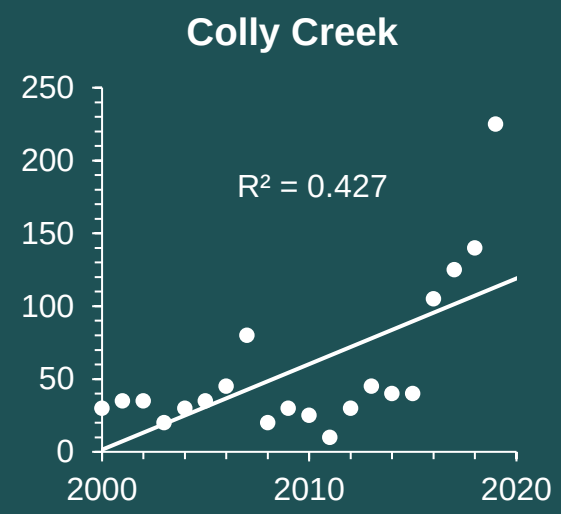
Total Phosphorus (TP) – 20-Year Summary (as µg-P/L)

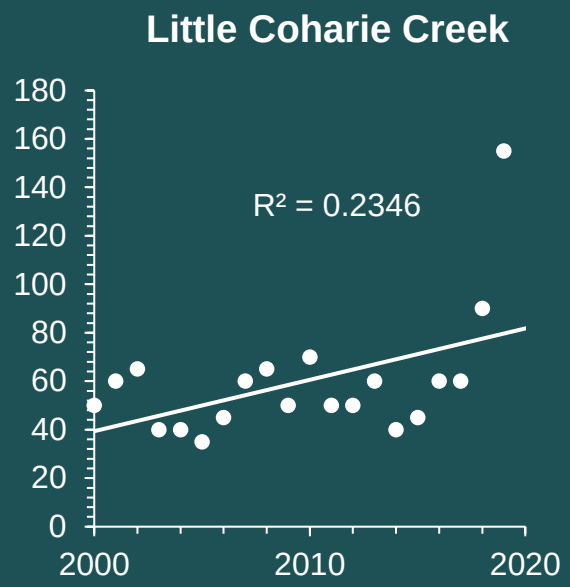
- **Black River** basin TP trends (2000-2019):

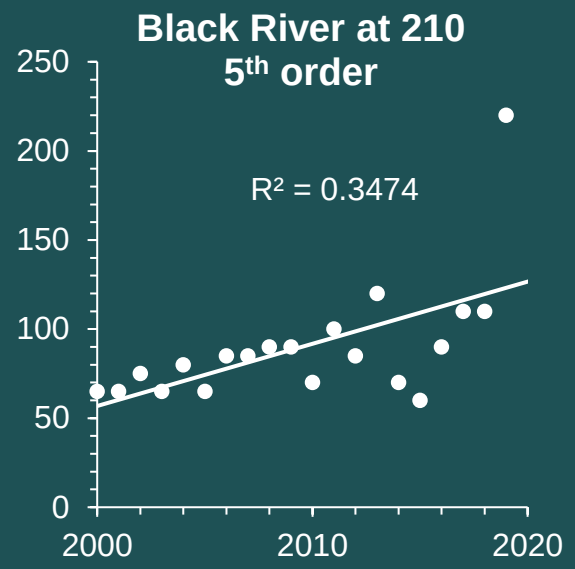
- 6RC (R= 0.507, *df*=18,
- *p*= 0.025)
- GCO (R = 0.805, *df*=18,
- *p*= 2.1E-05)
- LCO (R= 0.484, *df*=18,
- *p*= 0.033)
- COL (R= 0.653, *df*=18,
- *p*= 0.002)
- B210 (R= 0.589, *df*=18,
- *p*= 0.007)





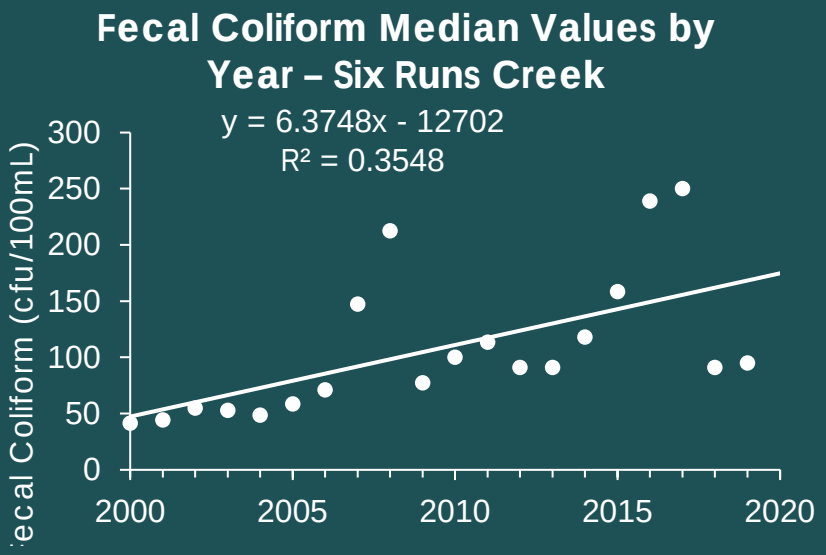


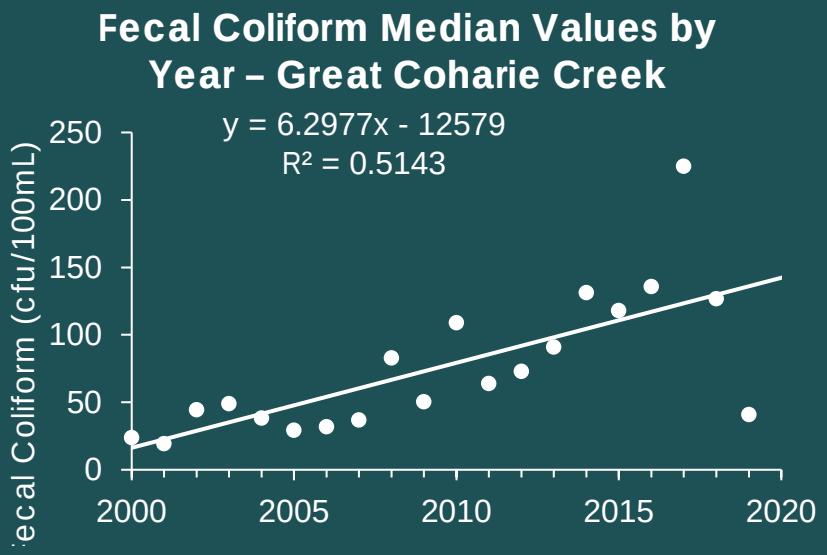


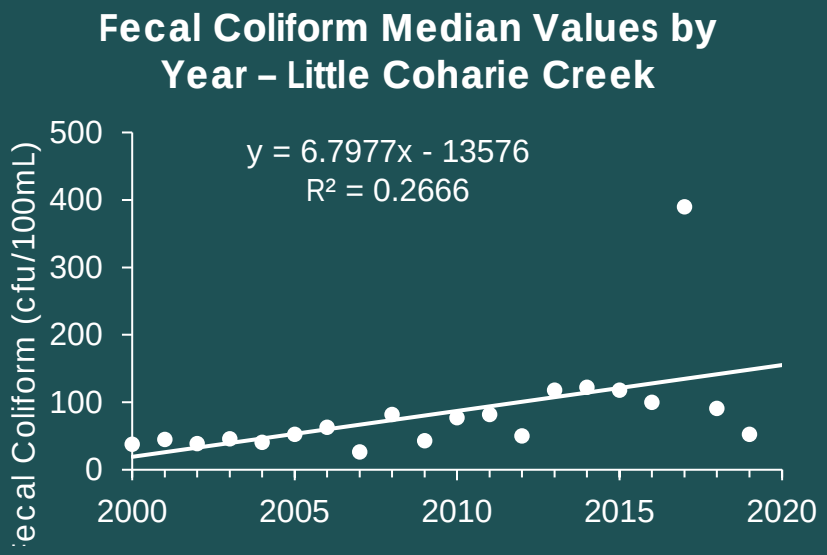


FECAL COLIFORM BACTERIA – TREND SUMMARY BLACK RIVER

- Significant increases in fecal coliform (cfu/100 mL), 20 year period 2000-2019 (all non-point stations except NC403 and possibly Colly Creek)
- Black River Watershed
- 6RC (R= 0.596, *df=18*, *p*= 0.006)
- LCO (R= 0.516, *df=18*, *p*= 0.020)
- GCO (R= 0.717, *df=18*, *p*= 0.0004)
- COL (R= 0.517, *df=18*, *p*= 0.020)



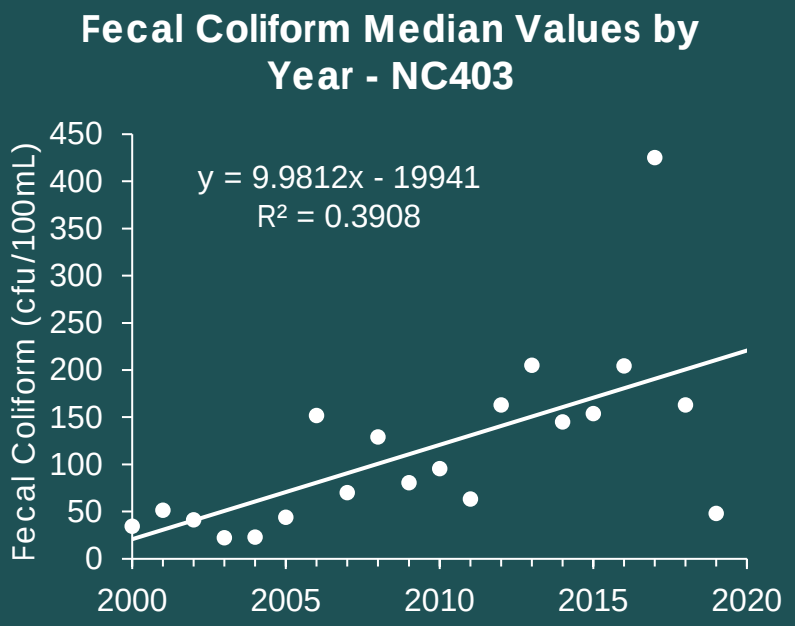


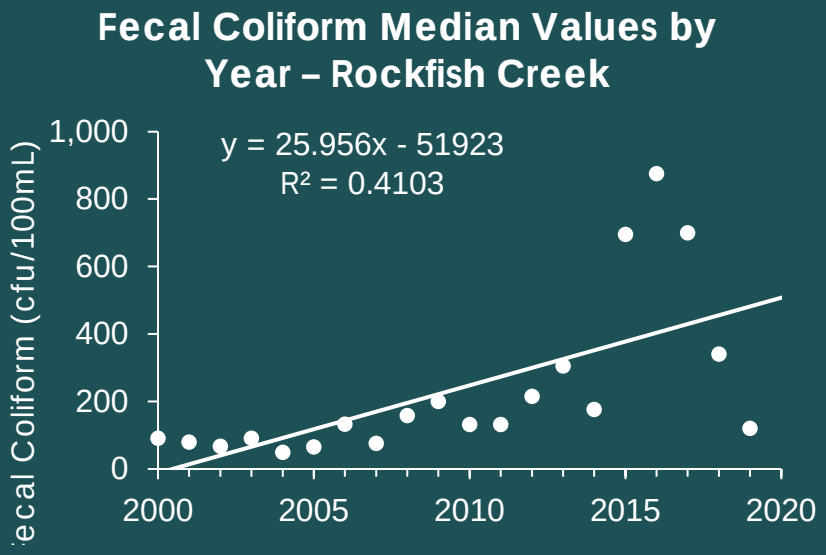


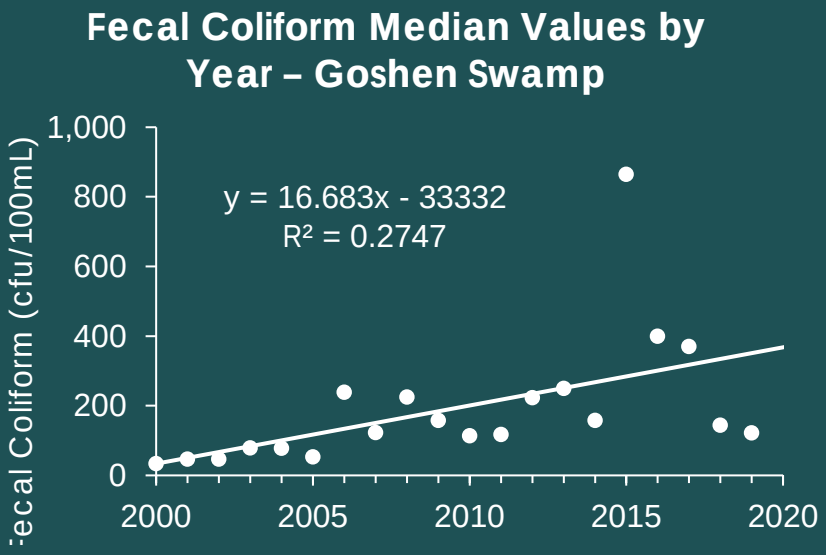
FECAL COLIFORM – TREND SUMMARY NECFR BASIN

- Significant increases in fecal coliform (cfu/100 mL) over the 20-year period from 2000-2019
- **Northeast Cape Fear Watershed**
- GS (R= 0.760, *df=18*, *p*= 0.028)
- ROC (R= 0.641, *df=18*, *p*= 0.002)
- NC403 (R= 0.625, *df=18*, *p*= 0.003)

- **Cape Fear Watershed**
- BRN (R= 0.598, *df=18*, *p*= 0.006)
- HAM (R= 0.523, *df=18*, *p*= 0.018)



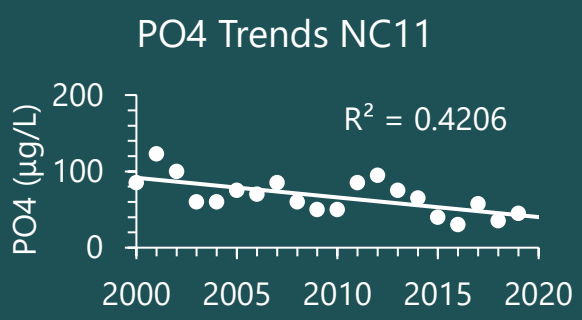


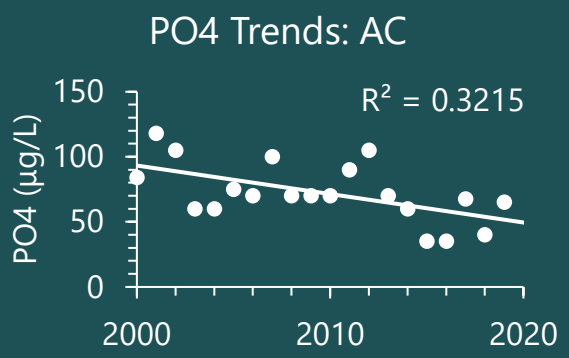


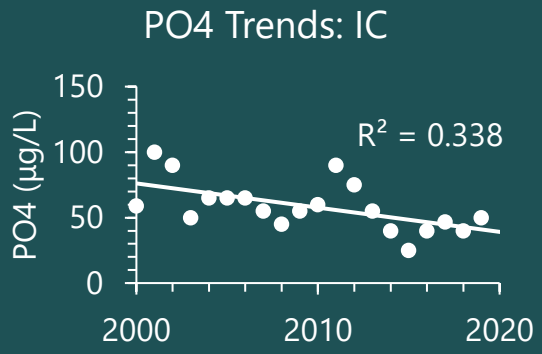
Orthophosphate (PO_4) Cape Fear River

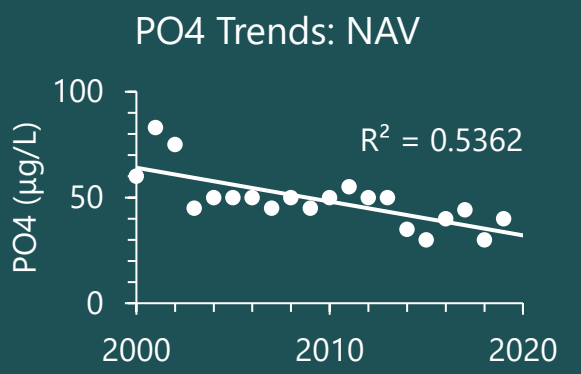
Main CF River 6th order stream Significant PO_4 decreases (2000-2019):

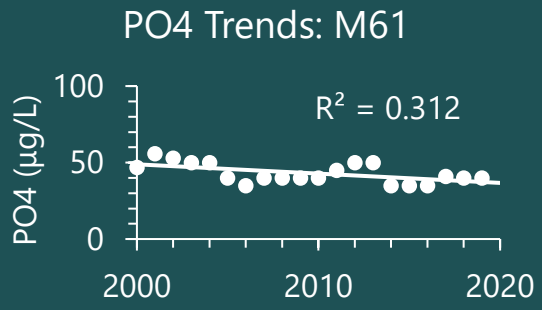
- NC11 (R= -0.649,
- *p*= 0.002)
- AC (R= -0.567,
- *p*= 0.008)
- DP (R= -0.505,
- *p*= 0.021)
- BBT (R= -0.460,
- *p*= 0.038)
- IC (R= -0.581,
- *p*= 0.006)
- NAV (R= -0.732,
- *p*= 0.0002)
- HB (R= -0.795,
- *p*= 2.3E-05)
- BRR (R= -0.578,
- *p*= 0.006)
- M61 (R= -0.559,
- *p*= 0.008)
- M54 (R= -0.723,
- *p*= 0.0002)

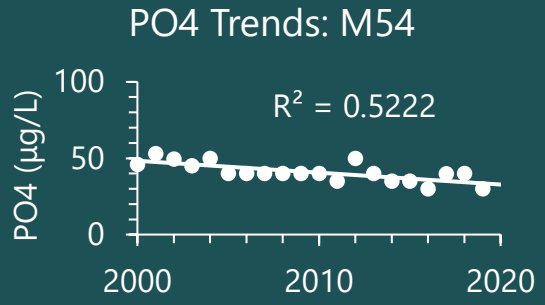






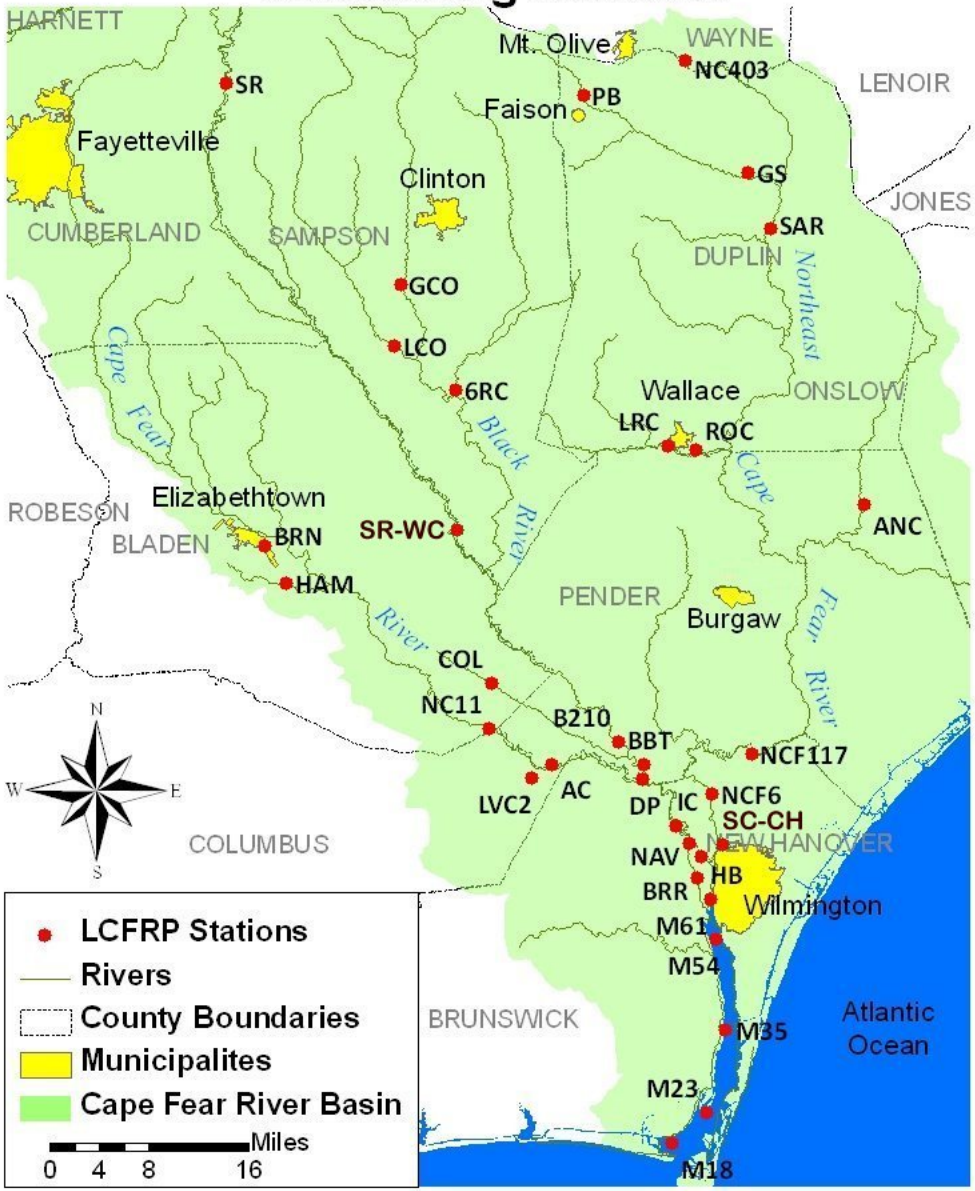






Significant decreases in orthophosphate were found from Lock and Dam 1 downstream to the middle of the Cape Fear Estuary. This is a major NPDES point source discharge reach.

Lower Cape Fear River Program Monitoring Stations



Summary Long-Term Information

- 13 Black and Northeast Cape Fear basin stations showed significant nitrate increases (mainly non-point source areas)
- TN significantly increased at 7 sites, including the Black River
- 10 Black and Northeast Cape Fear basin stations showed significant TP increases, as did 2 lower CFR estuary stations
- Fecal coliforms significantly increased at numerous sites
- In contrast, most stations along the mainstem Cape Fear River (dominated by large NPDES dischargers) showed no significant changes in nitrate, ammonium, TN or TP.
- However, 10 of these mainstem sites showed significant decreases in orthophosphate over the 20-year period.

Published UNCW research (Brown, Mallin, Loh 2020, Env Mon Assessment 192:515) demonstrated that nitrate concentrations were significantly correlated with high 15N signatures (animal manure signal), proving the high N was not related to fertilizer or N fixation.

Thus, non-point nutrient discharge from CAFOs, as well as small WWT plants are major sources of the nutrient increases to the LCFR basin.

For funding we thank the Lower Cape Fear River Program and the NC Water Resources Research Institute.

For field, laboratory and GIS help over many years we thank Lauren Bohrer, Dr. Scott Ensign, Amy Grogan, Nick Iraola, Jenny Johnson, Dr. Amanda Kahn, Kerry Mapes, Doug Parsons, Nick Picha, Dr. Anna Robuck, Dr. Chris Shank, Byron Toothman, Rena Turner and Heather Wells.

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