

Leveraging  
**Citizen Science** and the **Internet of Things**  
to create  
a statewide community monitoring network.

Calvin Cupini, Clean Air Carolina, Charlotte, NC  
Brian Magi, Department of Geography and Earth Sciences, UNC Charlotte

ASIC  
Thursday September 16, 2018



## The Cloud and the Crowd

- Clean Air Carolina's **background**
- **AirKeepers** and the Citizen Science program
- Clean Air Carolina's participation with  
**EPA's colocation guide and macro analysis tool**
- **Success stories** through Citizen Science

## Our Mission

TO ENSURE  
**CLEANER AIR QUALITY**  
FOR **ALL**  
**NORTH CAROLINIANS**  
THROUGH **EDUCATION**  
AND **ADVOCACY**  
AND BY WORKING WITH OUR PARTNERS  
TO REDUCE SOURCES OF  
**POLLUTION**



*Your advocates for healthy air*

## Our Programs

### Medical Advocates for Healthy Air



### Clean Construction



### Clear the Air for the Kids!





Particle Falls

Communication Successes



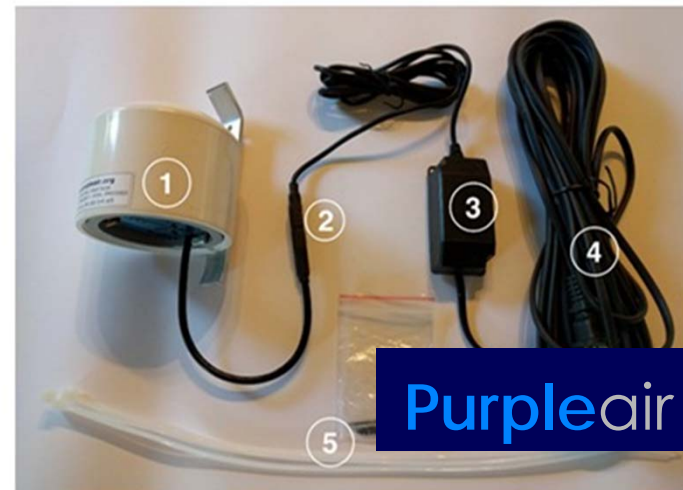
**AirKeepers**



## PM 2.5 Monitors

- Fraction of the **Cost**
- **Compact** size
- **Relative Humidity**,  
and **Temperature**
- **Geotagged** data-points
- Web-based **mapping**

**NOT a replacement** for professional tools



# Collocation Guide and Macro Analysis Tool

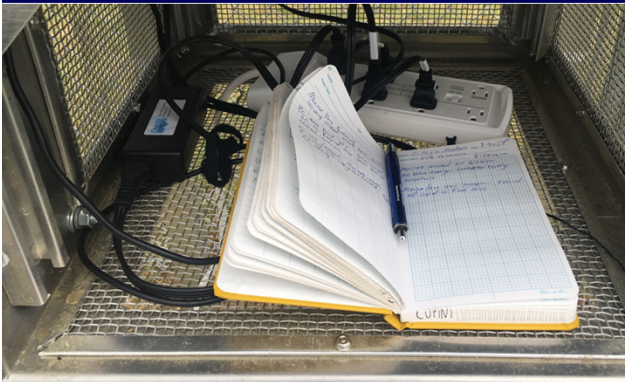


MECKLENBURG COUNTY  
*AIR QUALITY*





# Collocation Guide and Macro Analysis Tool

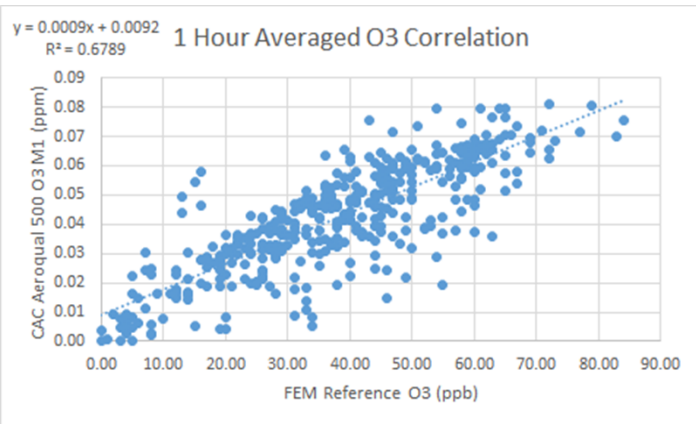
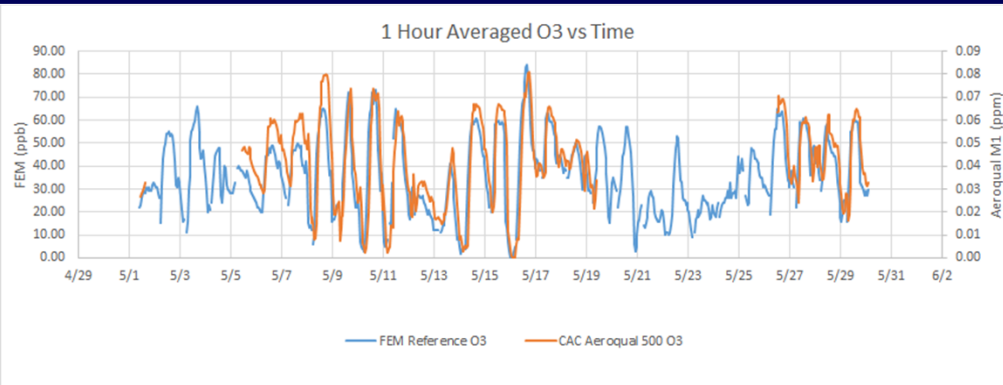


MECKLENBURG COUNTY  
*AIR QUALITY*

**Air  
Sensor**  
Measure · Learn · Share

A blue toolbox-shaped logo with the text "Citizen Science Toolbox" and a stylized cloud icon.

# Collocation Guide and Macro Analysis Tool



## How to Evaluate Low-Cost Sensors by Collocation with Federal Reference Method Monitors

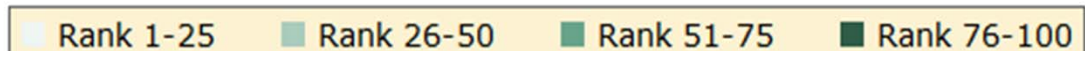
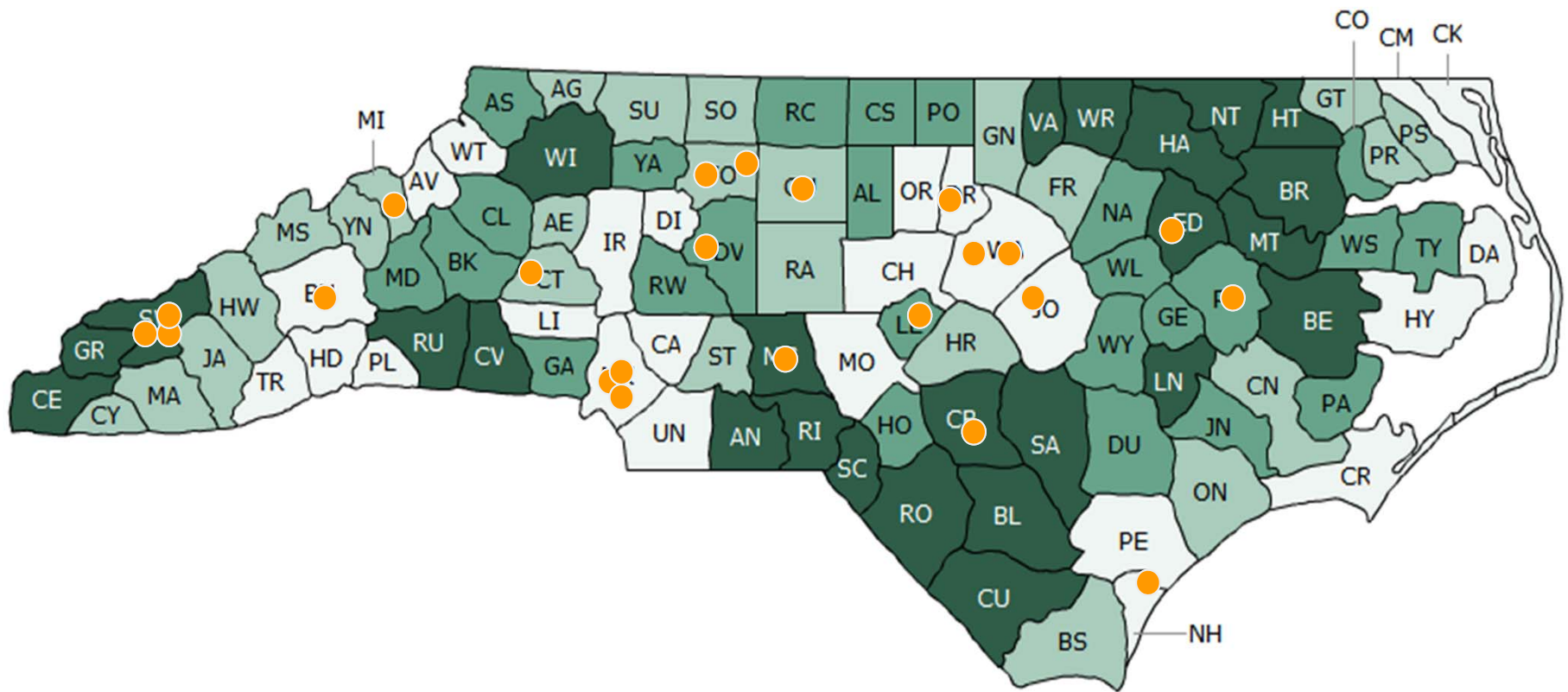
National Exposure Research Laboratory  
Office of Research and Development



MECKLENBURG COUNTY  
*AIR QUALITY*

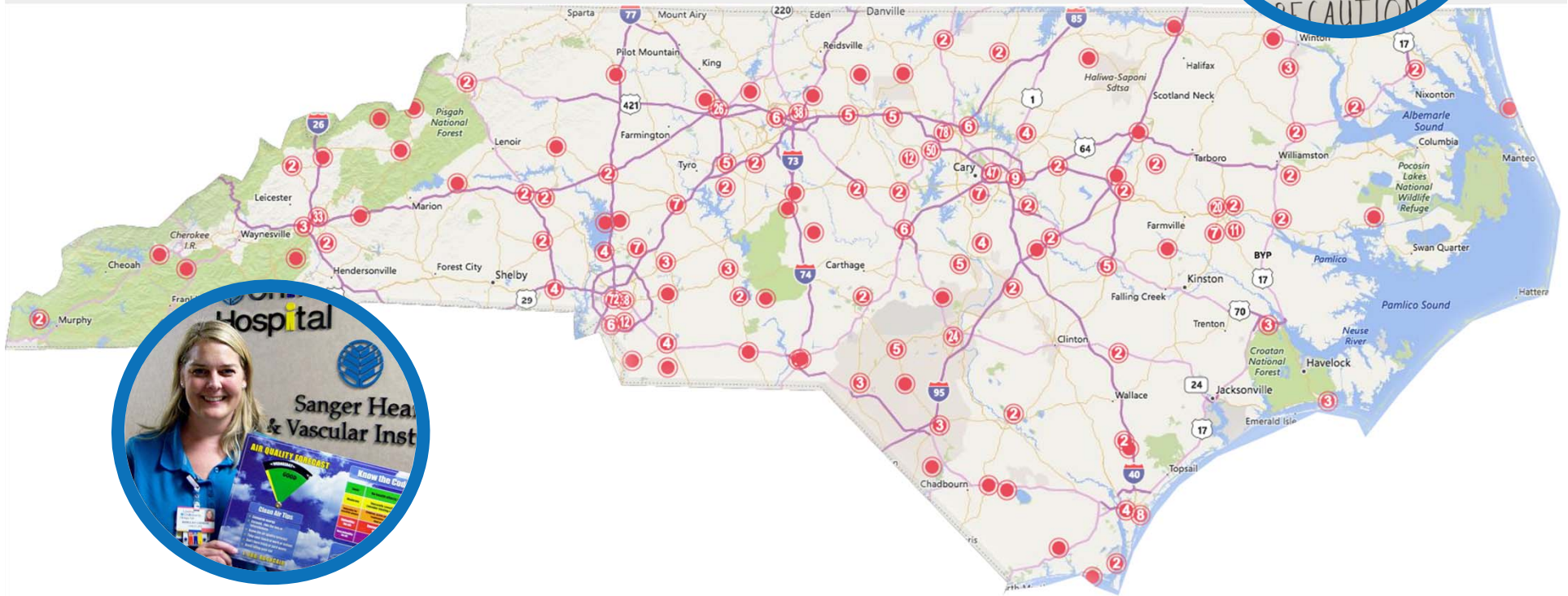


# Our Challenge



# Action Network

More than 900 members across NC



This report provides an overview of air quality issues in Richmond County, North Carolina. The report identifies vulnerable populations, examines the impact of air pollution on public health, and proposes possible solutions to achieve cleaner air.

- 23 toxic air emissions permits, including three Title V permits
- Traffic proximity higher than 67% of North Carolina counties
- 50% of Richmond County residents are economically disadvantaged
- High rates of respiratory-related illness and death

**Air Quality Report**

Due to the lack of air monitors in Richmond County, air pollution levels are currently unknown. However, large quantities of air pollution are emitted from industrial facilities and high-traffic roads, particularly in Rockingham and Hamlet.

**Pollution sources**

**A. Industrial facilities**

- Proximity to facilities using extremely hazardous substances for residents of Richmond County ranks higher than 80% of NC counties.
- 23 facilities have toxic air emissions permits (black squares in Figure 1) — 115% the state average.
- Three facilities have Title V permits, meaning they emit more than 100 tons of air pollutants annually (black stars in Figure 1). In 2017, a biomass company called Enviva acquired a Title V permit to build a large wood pellet production facility in Hamlet. This will push Richmond County past the state average for Title V permits.

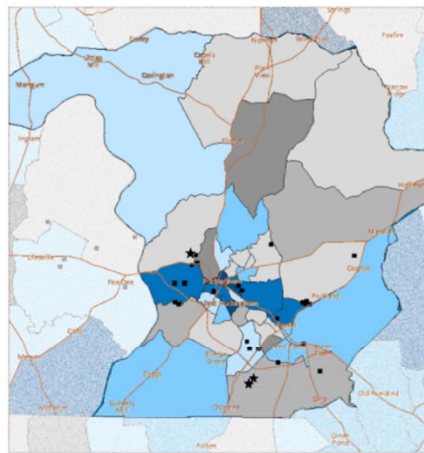
**B. Traffic emissions**

- Traffic proximity is higher than 67% of North Carolina counties. In Rockingham, individuals are exposed to traffic-related air pollution levels higher than 80-90% of North Carolinians.
- Traffic-related air pollutants include diesel particles, NOx, and ozone.

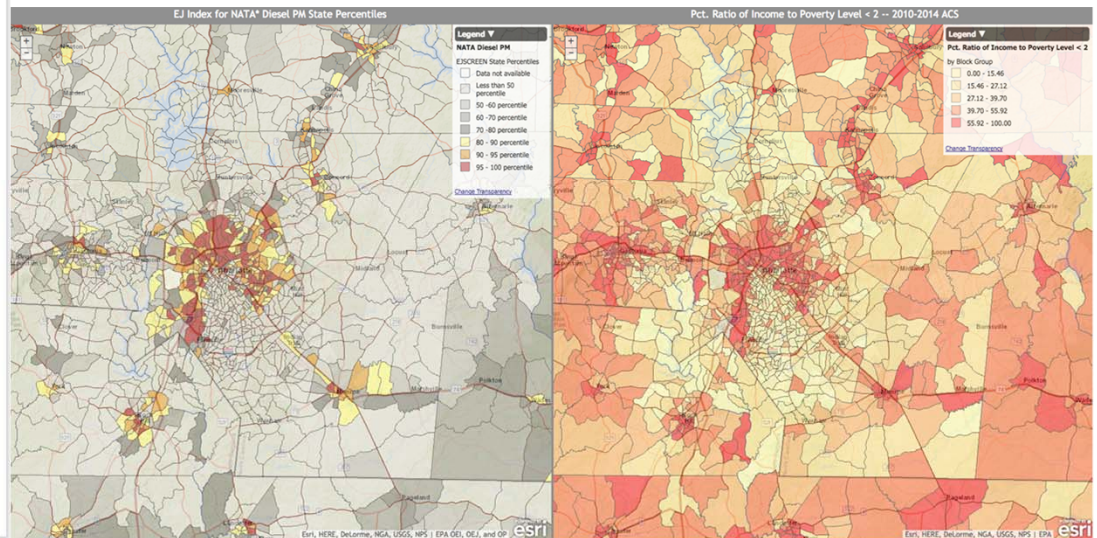
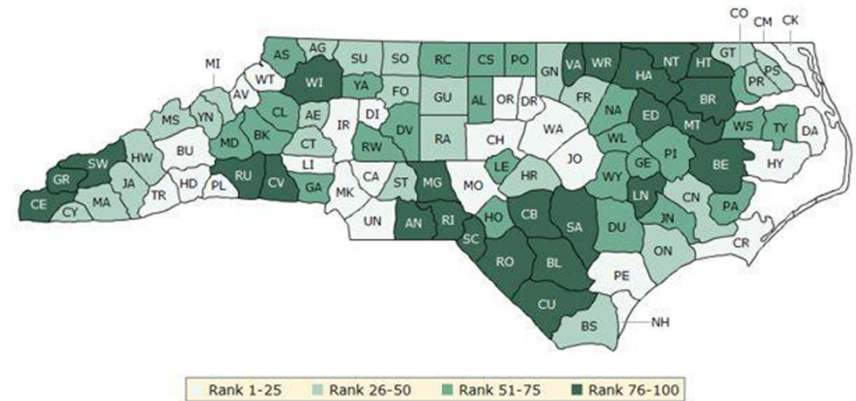
**Demographics**

- Low-income communities, children, the elderly, and individuals with respiratory illness are more susceptible to the negative health effects of air pollution.
- 50% of Richmond County is economically disadvantaged, and 20% of the population is elderly.
- Particularly in Hamlet and Rockingham, children living or going to school near industrial facilities and busy traffic routes are more likely to be exposed to unhealthy levels of air pollution.

Fig.1 Distribution of Low Income Population (State Percentile)

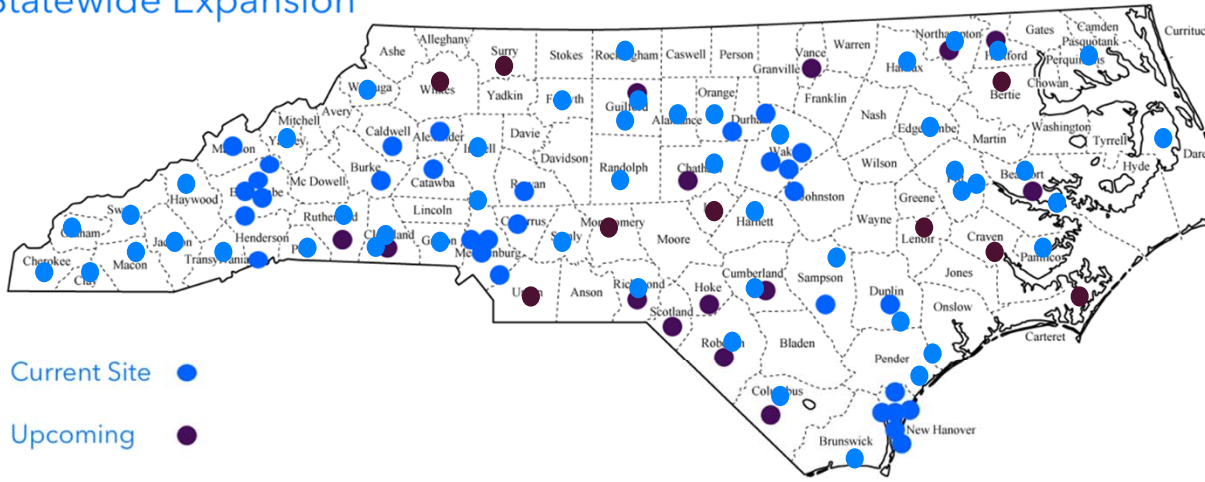


# County Level Reports



# Statewide Platform

## Statewide Expansion



Current Site ●  
Upcoming ●

Catawba County Report | AirKeepers Citizen Science | Clean Air Carolina

Secure | https://cleanaircarolina.org/purpleair/

Clean Air Carolina

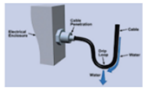

ACTION & EVENTS LEARN PROGRAMS NEWS & PRESS ABOUT DONATE

### PURPLEAIR™ SET-UP PROTOCOL


Instructions on how to install your PurpleAir™ sensor, configure your WiFi, and register your sensor so the data will be added to PurpleAir™ maps.

#### INSTALLATION TIPS

1. The PurpleAir™ enclosure is designed to let air flow freely while protecting the electronics from the elements.
2. Although the power supply is waterproof, it should be mounted so that it will not be submerged in water or covered by snow.
3. Use a drip loop with wires to prevent water from running directly down wires into the device, power supply, or power outlet.

4. It is best to mount the sensor in a shady spot under the eave of the roof (usually the north-facing part of the house).
5. To produce better data, it is best to mount it away from vents or anything that might affect the readings, such as a charcoal grill.
6. The power cord is only 23 feet long, so you will need a power outlet within 33 feet of the sensor. (make sure you're in WiFi range as well)



#### INSTALLATION GUIDE

\*Note: all screenshots are meant to provide a general guideline as screens for other devices may look different.

**INSTALL YOUR PURPLEAIR™ SENSOR**


Step 1  
Step 2  
Step 3  
Step 4  
Step 5

Go to <https://map.purpleair.org/install> where you will click through screens as you follow these instructions in order to reach the page where you can register your sensor. You will register your sensor after installing it and configuring your WiFi.

**CONFIGURE WIFI**

Step 1  
Step 2  
Step 3  
Step 4  
Step 5  
Step 6  
Step 7  
Step 8


Connect your phone, tablet, or computer to a WiFi network called "AirMonitor\_XXXX". The "XXXX" is specific to your sensor.



**REGISTER YOUR PURPLEAIR™ SENSOR**

Step 1  
Step 2  
Step 3  
Step 4  
Step 5  
Step 6  
Step 7  
Step 8  
Step 9


Locate your sensor's MAC address.



**CONGRATULATIONS!**

You have installed and registered your PurpleAir™ sensor. It may take a couple of days for the data from your sensor to appear on the PurpleAir™ Map.

# Modular Protocols




### THE POWER OF MONITORING

Clean Air Carolina is reaching out to individuals and organizations across that state who want to participate in the next revolution in understanding our environment through citizen science. We need your help to build a network that addresses environmentally impacted communities across the state, particularly those located near sources of pollution. We are interested in locating monitors in communities whose health is disproportionately affected by air pollution (communities of color, low-income, children, and seniors).

---


## HOW TO GET A MONITOR

Clean Air Carolina has set a goal to deploy monitoring sites in every single county in North Carolina in 2018. Monitors will be provided **free of charge** for eligible sites in uncovered counties.




#### WHAT IS POSSIBLE?

- Real-time high-resolution mapping of air quality at a far greater density than regulatory monitors
- fenceline monitoring to detect emissions events
- community monitoring to assess hot spots
- personal monitoring
- applications to collect data in remote places, and access it from anywhere.



#### WHAT IS THE DEVICE?


The PurpleAir™ sensor is a device that uses two laser particle counters to capture and record data about microscopic particulate matter (PM<sub>2.5</sub>) suspended in the air. It then calculates the mass of the particles in micrograms per cubic meter (µg/m<sup>3</sup>). The sensor uses Wi-Fi connectivity to report real-time air quality readings to the web, where data can be shared with scientists and the public.



#### WHAT IS REQUIRED?

The sensor needs 3 things:

- Access to an outdoor power source, that is not too close to a source of emissions like a grill, or exhaust pipe.
- A location in range of a Wi-Fi network that is reliable, and on 24/7.
- A position about 6-15ft off the ground, with as much fresh air as possible.



#### WHERE IS THE DATA GOING?

The data collected by the sensors is going directly to our AirKeepers page where it can be viewed anytime (CleanAirCarolina.org/AirKeepers). The data is also being shared with researchers, public health experts, and other stakeholders to advance our understanding of air quality concerns around the state.

\* Q. Qian, Wang Y, Zanobetti, A, Wang, Y, Koutrakis, P., et al. "Air Pollution and Mortality in the Medicare Population". *New England Journal of Medicine*, June 30, 2017.

www.CleanAirCarolina.org/AirKeepers

Page 2 / 2

## Clean Air

Carolina

Your advocates for healthy air

### Citizen Science Worksheet

1. List your Group Members:

---



---

2. Create a Session Name:

School	Team Name	Date	Session Title
Example: NWSA	Eagles	9/8/16	NWSA Eagles 9/8/16

3. Collect Environmental Conditions (Wait and complete this outside to observe conditions.)

Using the data below, complete the following chart to get your AirCasting "Session Notes"

#### Landscape:

- "U" Dense urban areas surrounded by taller buildings, with roughly 1,000 people or more per square mile.
- "S" Sparse suburban city areas, surrounding a city. Primarily houses and mixed use.
- "R" Areas of mostly natural surroundings, including forests, farmland, and large undeveloped area.

#### Cloud Cover:

- "100%" If no sky is visible through clouds. Completely overcast.
- "75%" If there is less blue sky visible than clouds. Mostly Cloudy.
- "50%" If there is equal amounts of cloud and sky. Lightly Cloudy.
- "25%" If only few clouds are visible, or most clouds are very small.
- "0%" If the sky is clear.

#### Wind:

- "H" Heavy gusts of wind.
- "M" Moderate levels of wind.
- "L" Light wind, steady breeze.
- "C" Calm conditions. Little to no noticeable wind.

#### Most Recent Rain:

- Count the number of days since rainfall at the testing location. "1" if rain fell the previous day, "2" if two days ago, "3" if three days ago, "3+" if longer than three days since last rainfall. Do not record during the rain.

Landscape	Cloud Cover	Wind	Most Recent Rain	Session Notes
Example: U	75%	L	2	U75%L2

4. Preliminary questions before AirCasting. Discuss as a group and answer.

1) What is the air like where you live and go to school?

---

2) Can you see air pollution, like exhaust, smog, or smoke?

---

3) Are there busy roads, trains, or airports nearby?

---

# NC BREATHE Conference



Late March 2019



Thank You

Calvin A. Cupini  
Calvin@CleanAirCarolina.org



FIRST WARD PART

# Carolinas HealthCare System



# Cannon School



# Low Cost Sensor Validation



## Collocation

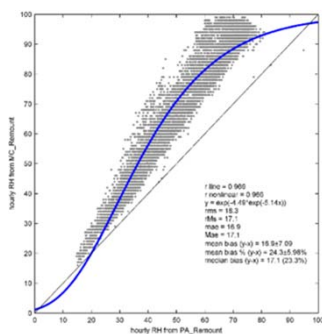
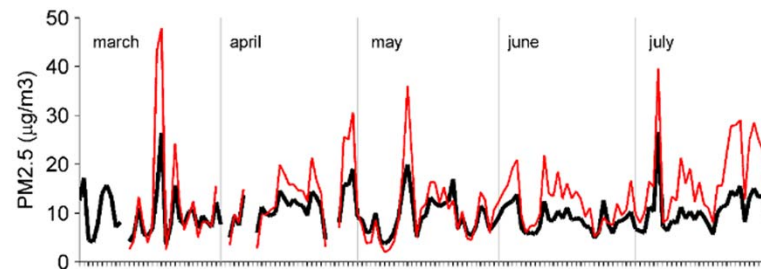


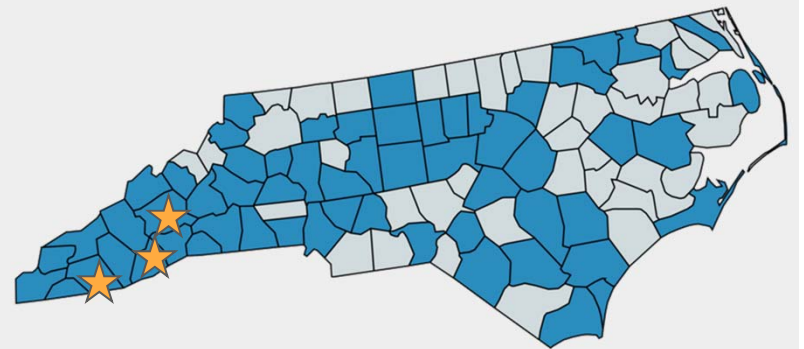
Figure 3: Daily comparison of PA-II with BAM



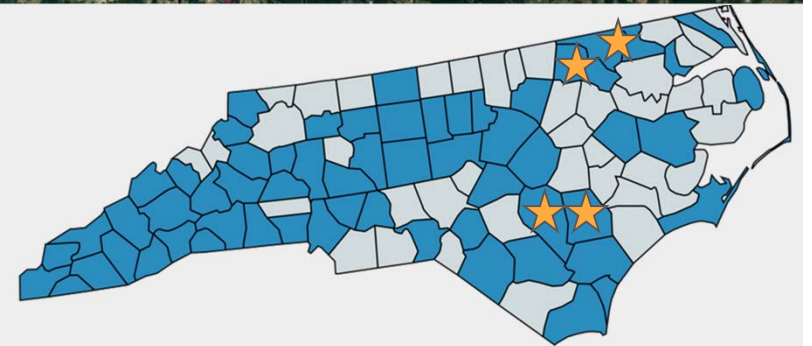
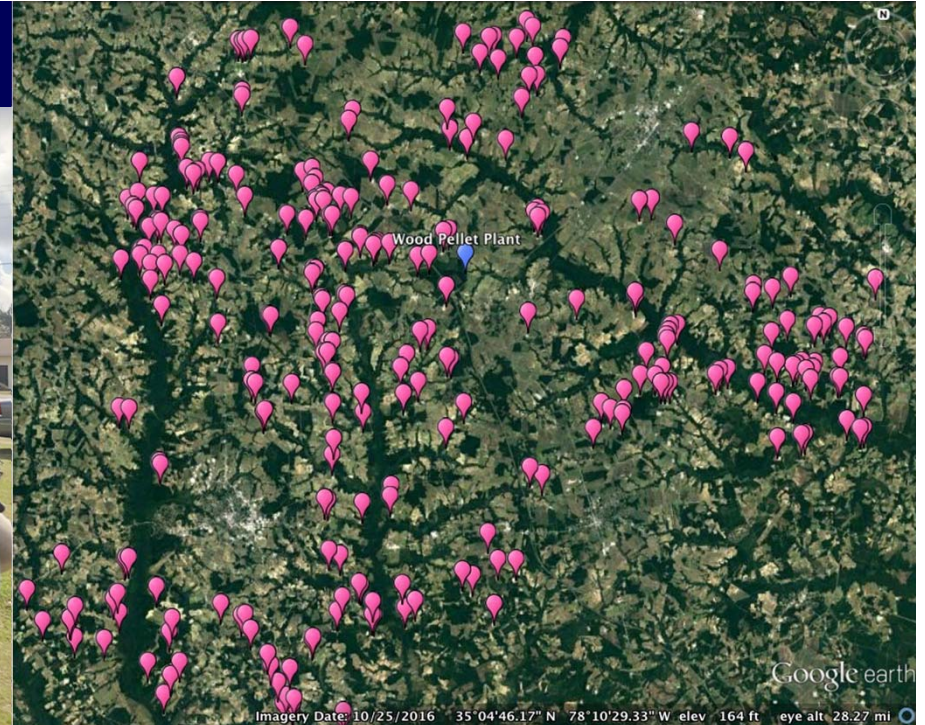
## The Message

No one cares  
how much you know  
until they know  
**How much you care**

# STEM Outreach in the West



# EJ issues in the east



# Monitoring on Campus



**Fast Food vs. Forest Air: Fair or Foul?**

Peighton Quin and Christina Sawyer  
University of North Carolina at Charlotte

**Abstract:** Fast food restaurants are a popular convenience for many students on campus. We wanted to know if the air around these fast food restaurants could potentially have a negative effect on our health due to PM2.5 levels.

**Method:** We used a method of collecting data a few times a week between the afternoon hours of three and four o'clock in the same two locations: between two major fast food restaurants in the Student Union and a deep point in the forest on campus. At each location we used the air monitor and tablet provided by Clean Air Carolina to record the amount of air particulate matter present at the time of recording.

**Results:** Our results established that there is a significant difference in the amount of air particulate matter present in the forest as compared to the number of a typical building of the University. The forest had a significantly less amount of air particulate matter than the fast food environment did. When on one day specifically the fast food environment in the Student Union had about 75 measured air particulate matters present, the forest had about 4 or 5 at most.

**Diagram of Fast Food Location:** A floor plan diagram showing the layout of a fast food restaurant with monitoring points indicated.

**References:** "Indoor Air Quality, Ventilation and Health Symptons in Schools: An Analysis of Existing Literature" by Doney, Anjali, and Apte published 2005.

**Acknowledgements:** Thank you to Clean Air Carolina for lending us the equipment necessary for this project. We appreciate the Air Monitor, tablet, and all the kindness and help from you guys!



UNIVERSITY of NORTH CAROLINA  
PEMBROKE



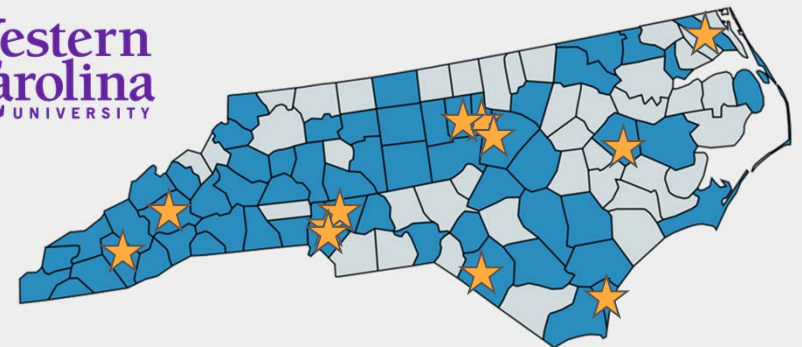
THE UNIVERSITY  
of NORTH CAROLINA  
at CHAPEL HILL



Johnson C. Smith University  
Become yourself. Change our world.

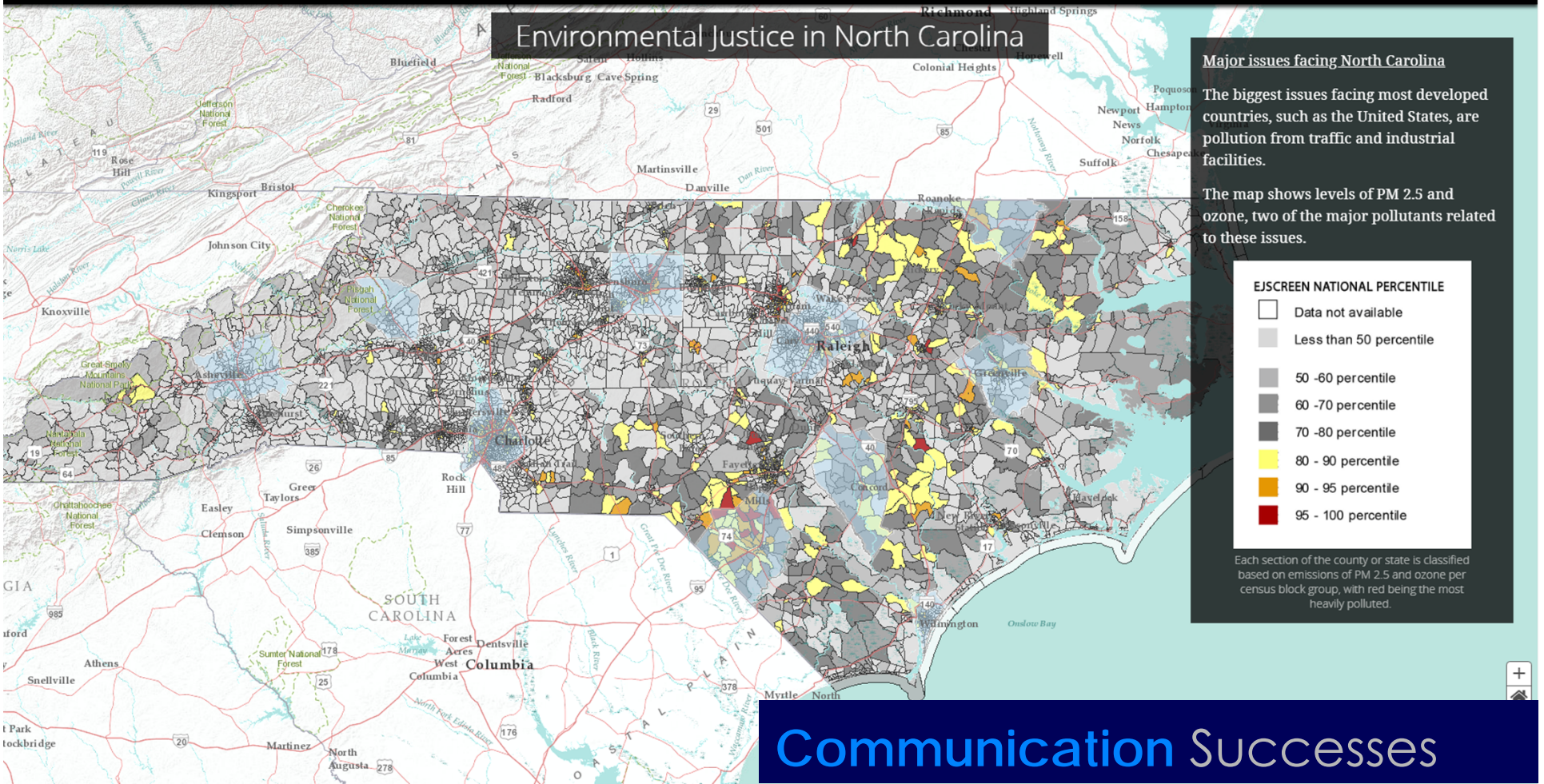


CENTRAL PIEDMONT  
COMMUNITY COLLEGE





# Environmental Justice in North Carolina



**Major issues facing North Carolina**

The biggest issues facing most developed countries, such as the United States, are pollution from traffic and industrial facilities.

The map shows levels of PM 2.5 and ozone, two of the major pollutants related to these issues.

**EJSREEN NATIONAL PERCENTILE**

- Data not available
- Less than 50 percentile
- 50 -60 percentile
- 60 -70 percentile
- 70 -80 percentile
- 80 - 90 percentile
- 90 - 95 percentile
- 95 - 100 percentile

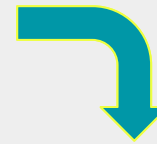
Each section of the county or state is classified based on emissions of PM 2.5 and ozone per census block group, with red being the most heavily polluted.

## Communication Successes

## Philosophy



Opportunity



Capacity

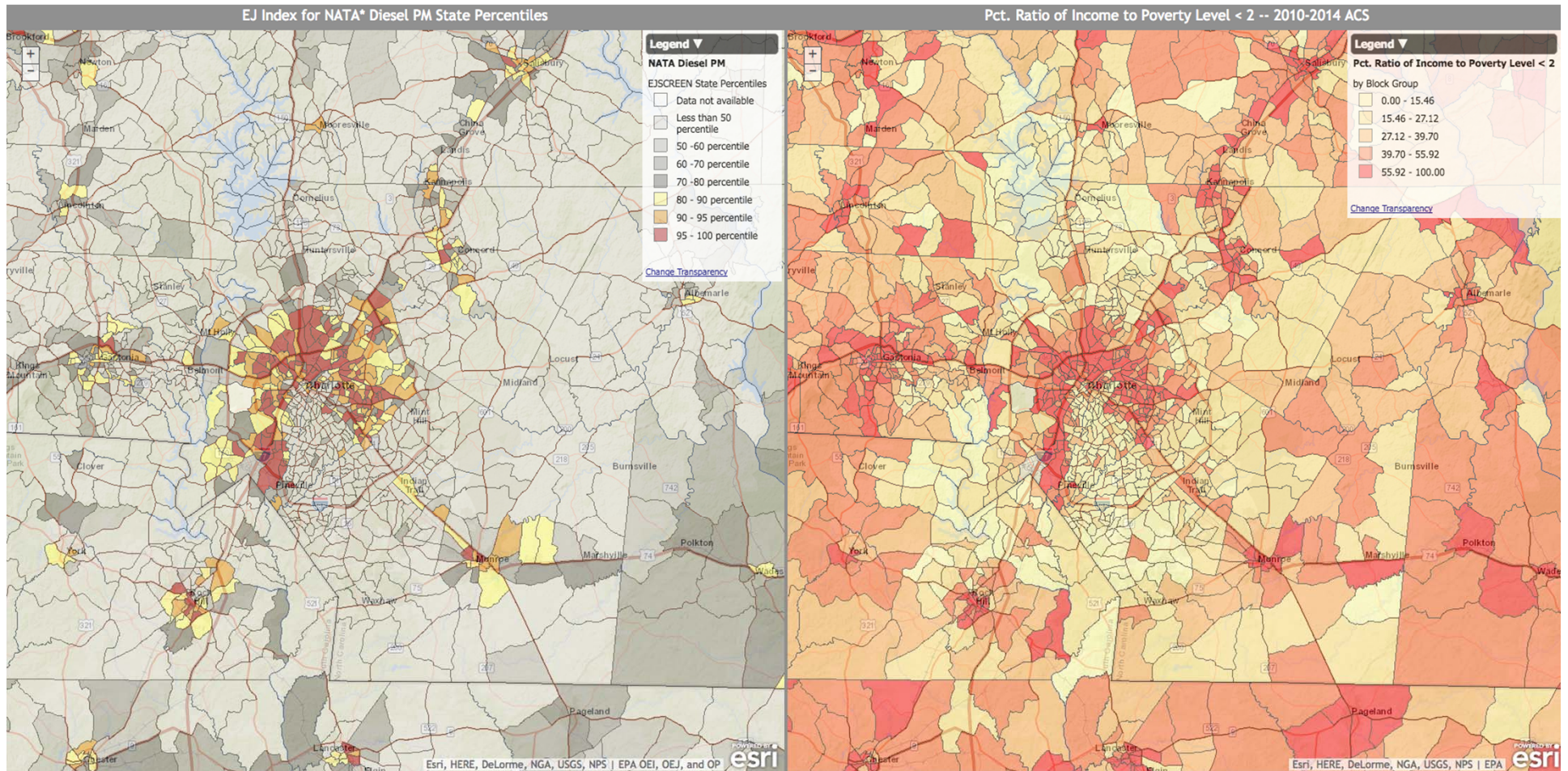
Recognition



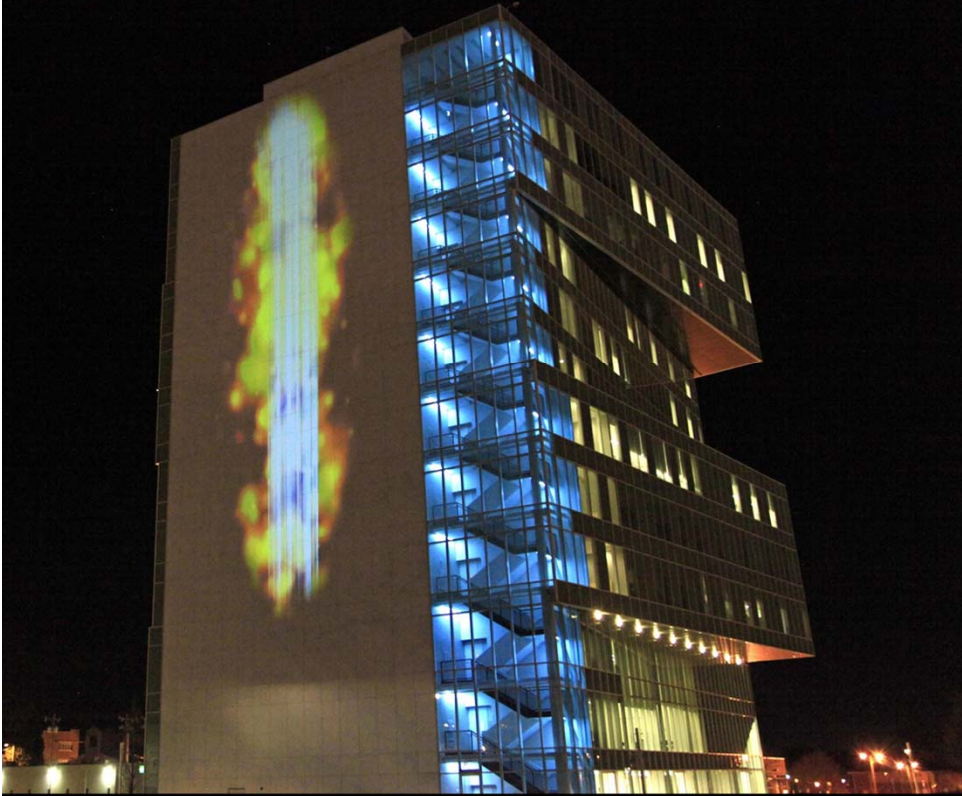
Partnerships



# Environmental Disparities

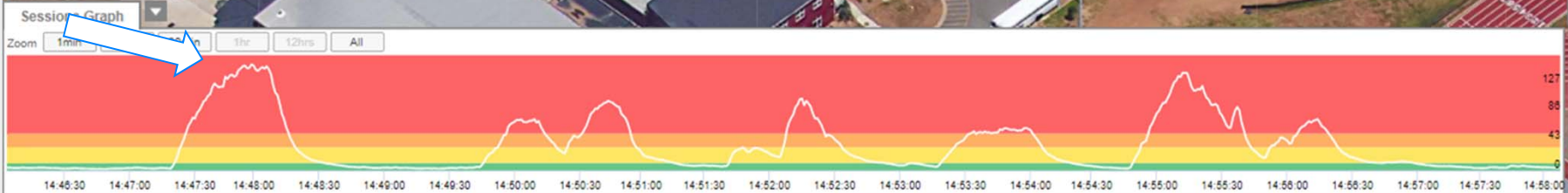
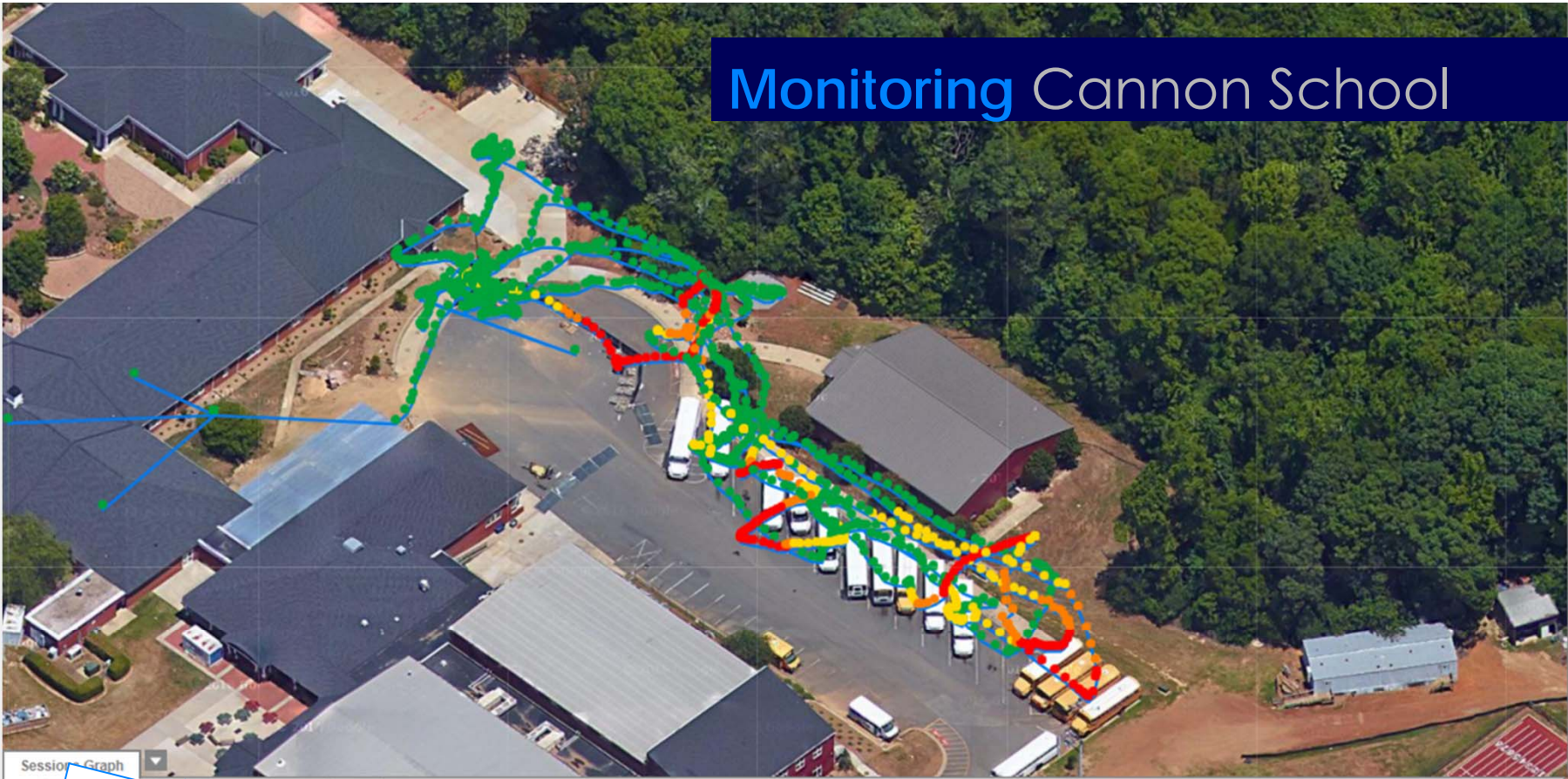


## Particle Falls Charlotte



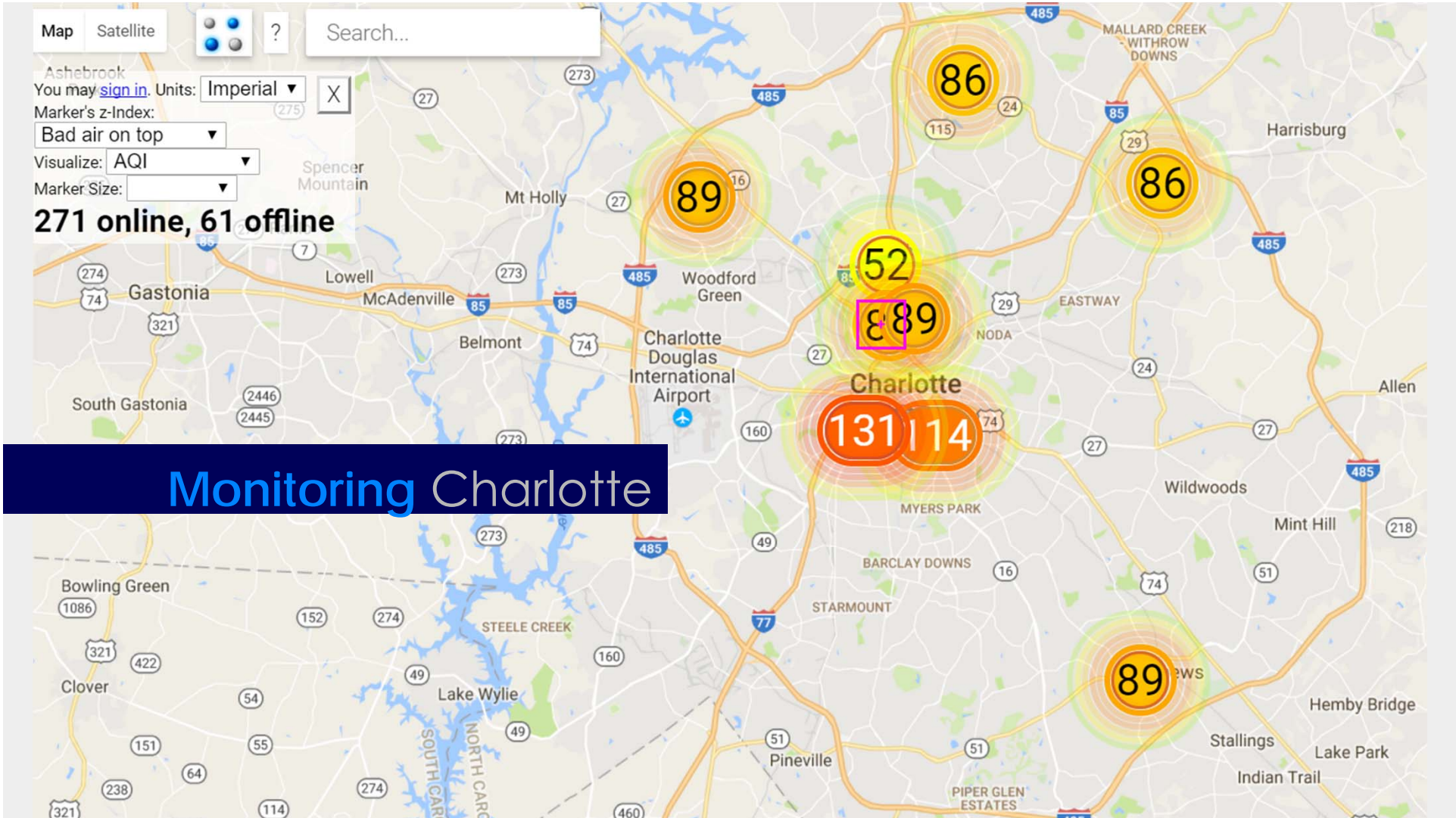
## Particle Falls Raleigh

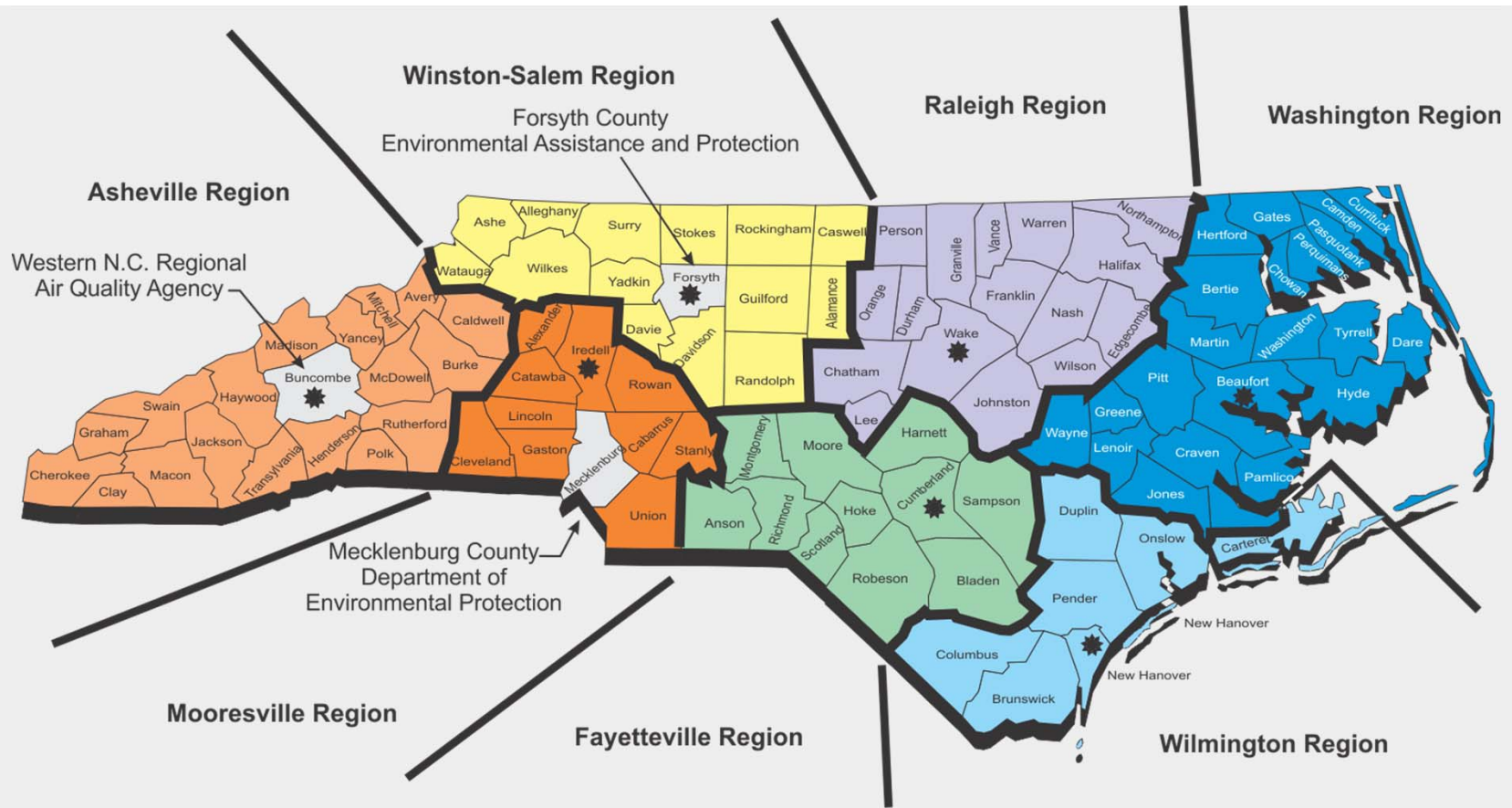
# Monitoring Cannon School



## Citizen Science

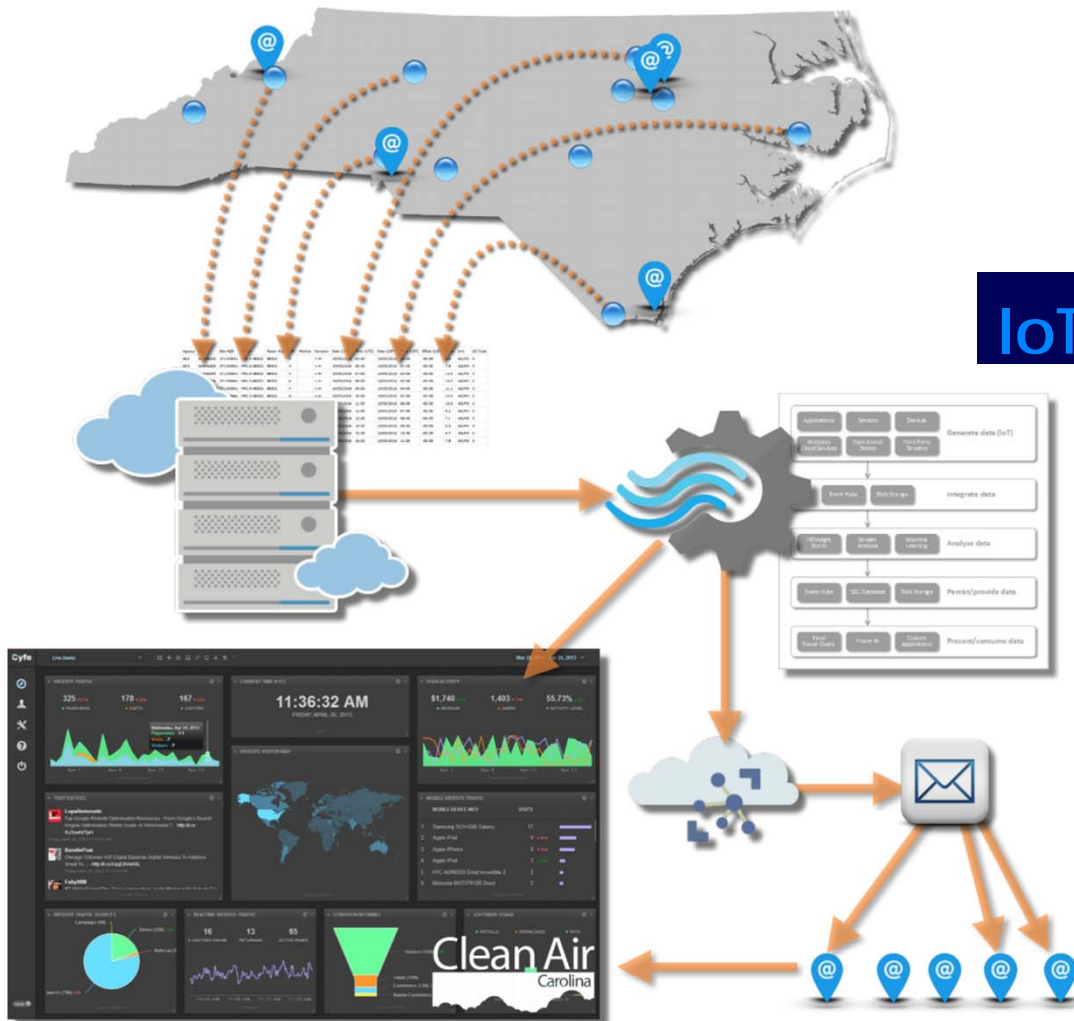
- Interested members of the general public **contributing** to the collection or analysis of data
- Participating **actively or passively**.
- Citizen Science can provide **expanded capacity and scope** to projects with limited resources.
- The projects offer **STEM learning** opportunities
- **Direct public outreach** through hands on learning, and communication





# Monitoring NC





# IoT Platform

# Citizen Science Presentations



## Our Mission

**What factors predict success?**



## Our Mission

**Success Stories of  
communication?**



## Our Mission

**How can they be  
sustained after money  
is spent?**



## Our Mission

**How can the diverse partners work together to meet community needs? (MeBr)**



# MAHA Initiative Clean Construction Partnership



**Atrium Health**

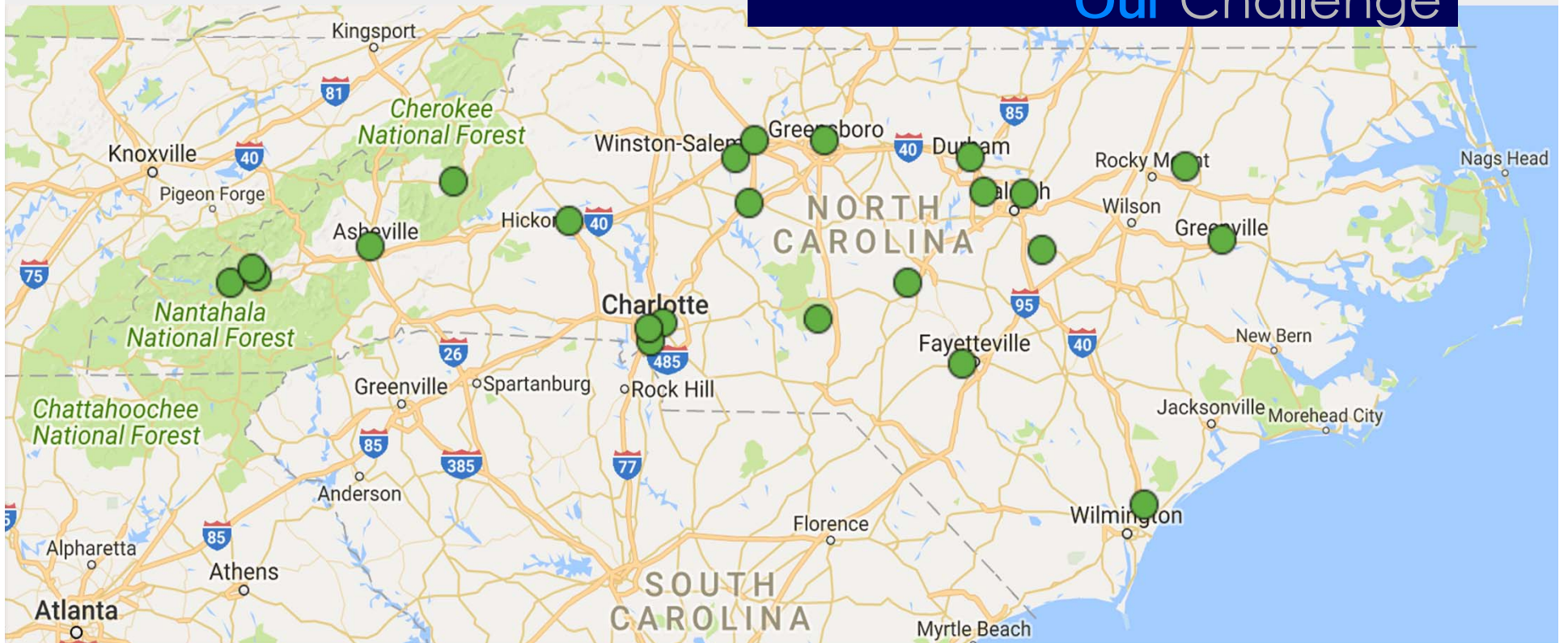
**N** ■ **NOVANT**  
■ **HEALTH**

## The Message

The most important part  
of Crowdsourcing  
**is the Crowd**



## Our Challenge



## PM Reference Monitors