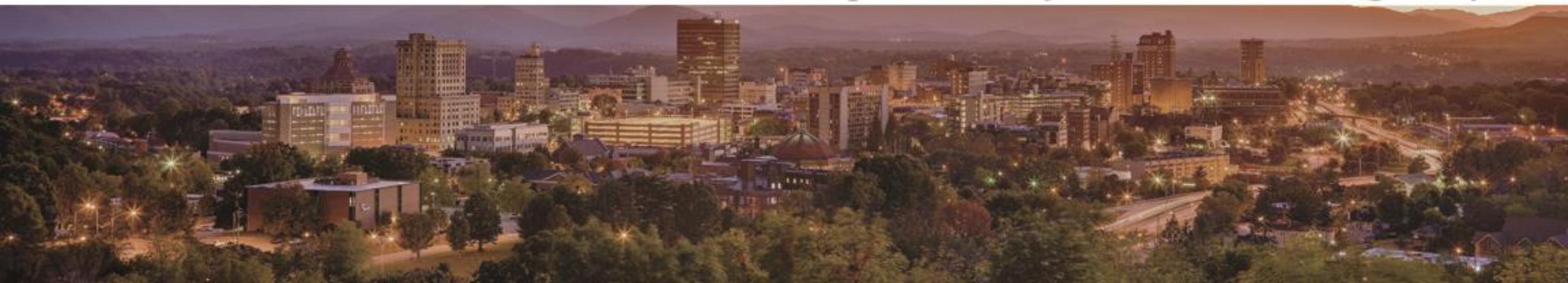




How Prescribed Burning and Wildfires Can Impact Daily Air Quality Forecasting

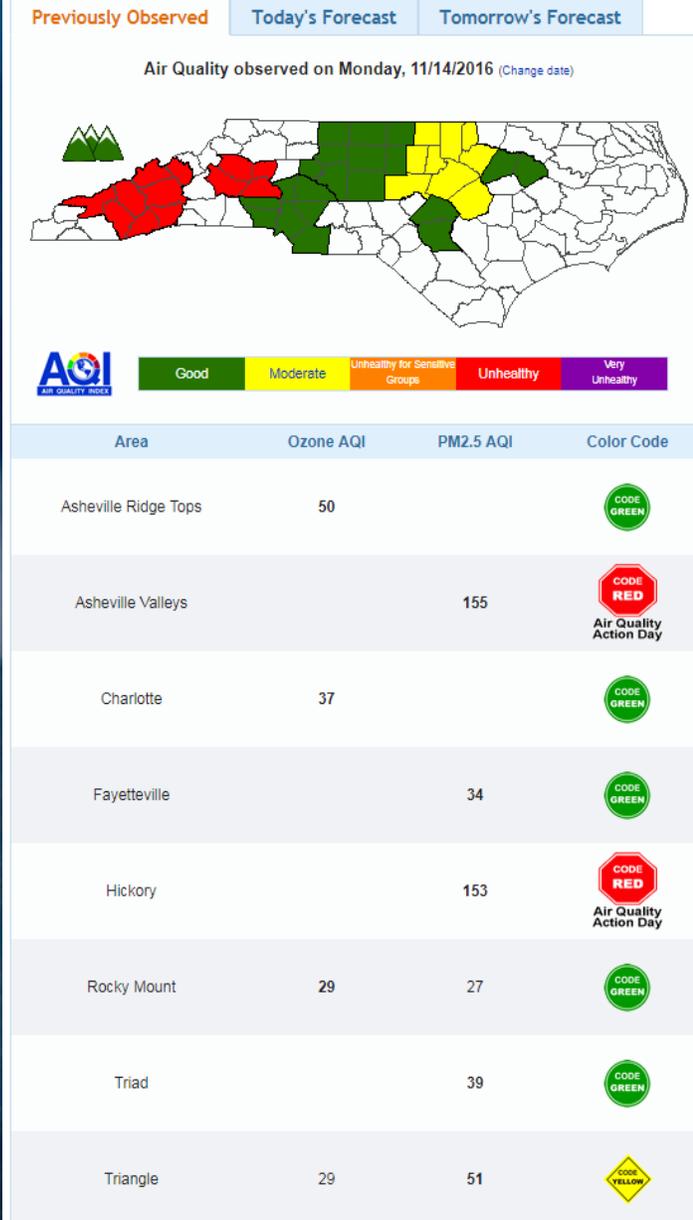
September 6, 2017

Department of Environmental Quality



Outline

- Air Quality Forecasting Overview
- Prescribed Fire Impacts Case Study
- 2016 Wildfires Lessons
- Conclusions



Air Quality Forecasting Overview

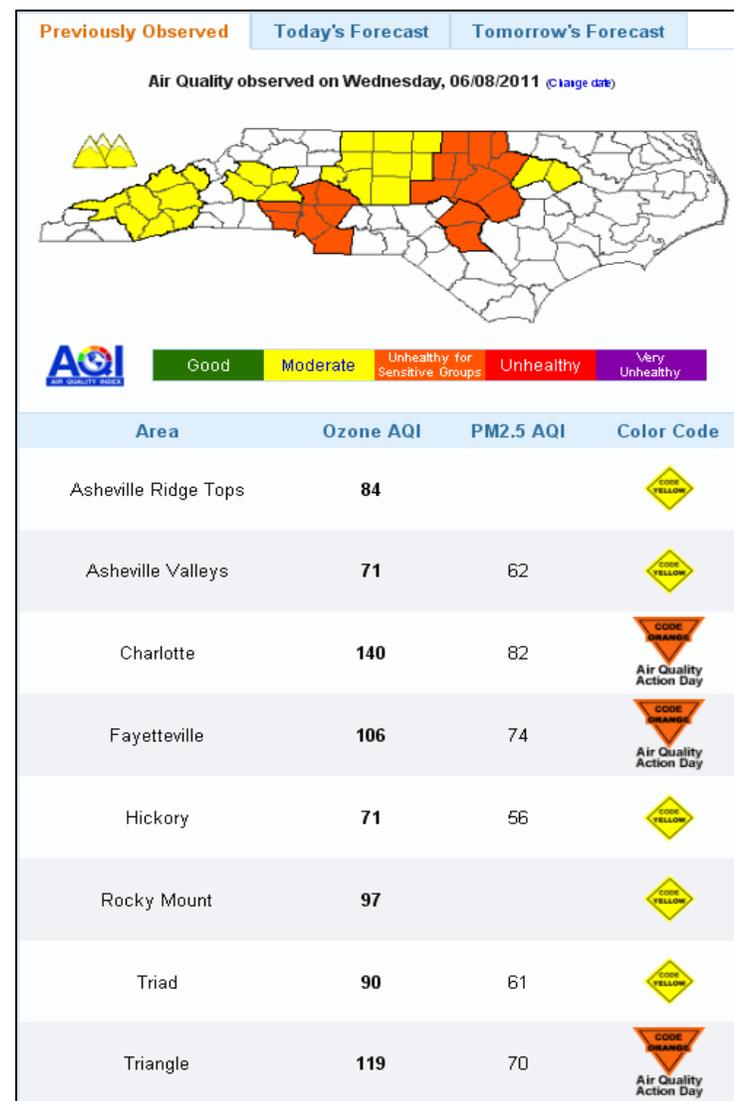


Air Quality Forecasting Overview

What We Do

Forecast air quality for six regions within North Carolina:

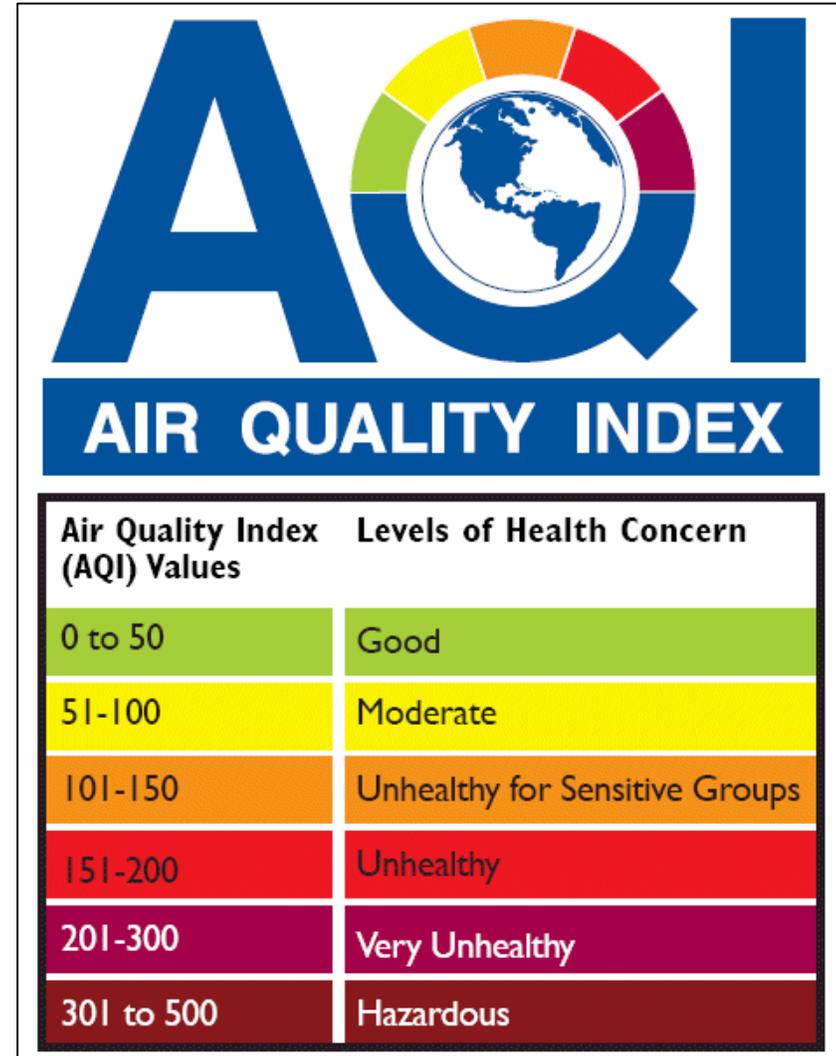
- **Asheville** Valleys and Ridge Tops
- **Hickory**
- **Charlotte**
- **The Triangle**
 - Including: Raleigh/Durham/Chapel Hill
- **Rocky Mount**
- **Fayetteville**
- The Triad area is handled by the Forsyth County Office of Environmental Assistance and Protection



Air Quality Forecasting Overview

The Air Quality Index (AQI)

- We **classify air quality** using a number-based, color-coded system called the Air Quality Index (AQI)
- The AQI is a simple way of relaying to the public what the air quality currently is, or is forecast to be
- Forecast is issued 7 days per week
- Initially issued by 3:00 pm for next day; then revised, as needed, until next forecast is issued.



Air Quality Forecasting Overview

A Big Puzzle

Forecasting the air quality is like solving a gigantic puzzle: many different atmospheric and human activity elements to consider:

- Current **state of the atmosphere** and **air mass**
 - Ambient monitoring data
 - Satellites
 - Radar
 - Media reports
- **Meteorological forecast** of atmospheric changes
 - Pattern changes such as cold or warm frontal passages, precipitation events, wind speed and directional changes
- New or ongoing **sources** of **polluted air mass** both locally and further away
 - Mobile emissions (work week commute, holiday travel, etc.)
 - Smoke from wildfires, prescribed burns, agricultural burns
 - Pollution transport from other locations (as far away as Canadian wildfires or African dust!)



Air Quality Forecasting Overview

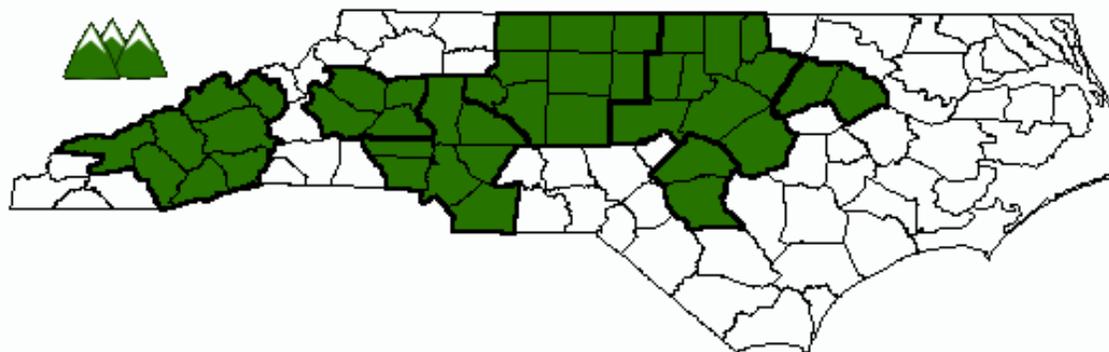
Complications from Anthropogenic Burning

Air quality forecasting is further complicated by prescribed & agricultural burns

- Not well-announced or known
- Emissions not considered in Air Quality Models
- Leads to under-prediction of PM_{2.5} and PM₁₀ concentrations in forecast



Air Quality Forecast for Monday, 04/03/2017



Last Updated: 04/02/2017 09:23 AM EDT



Prescribed Fire Impacts on Air Quality Forecast

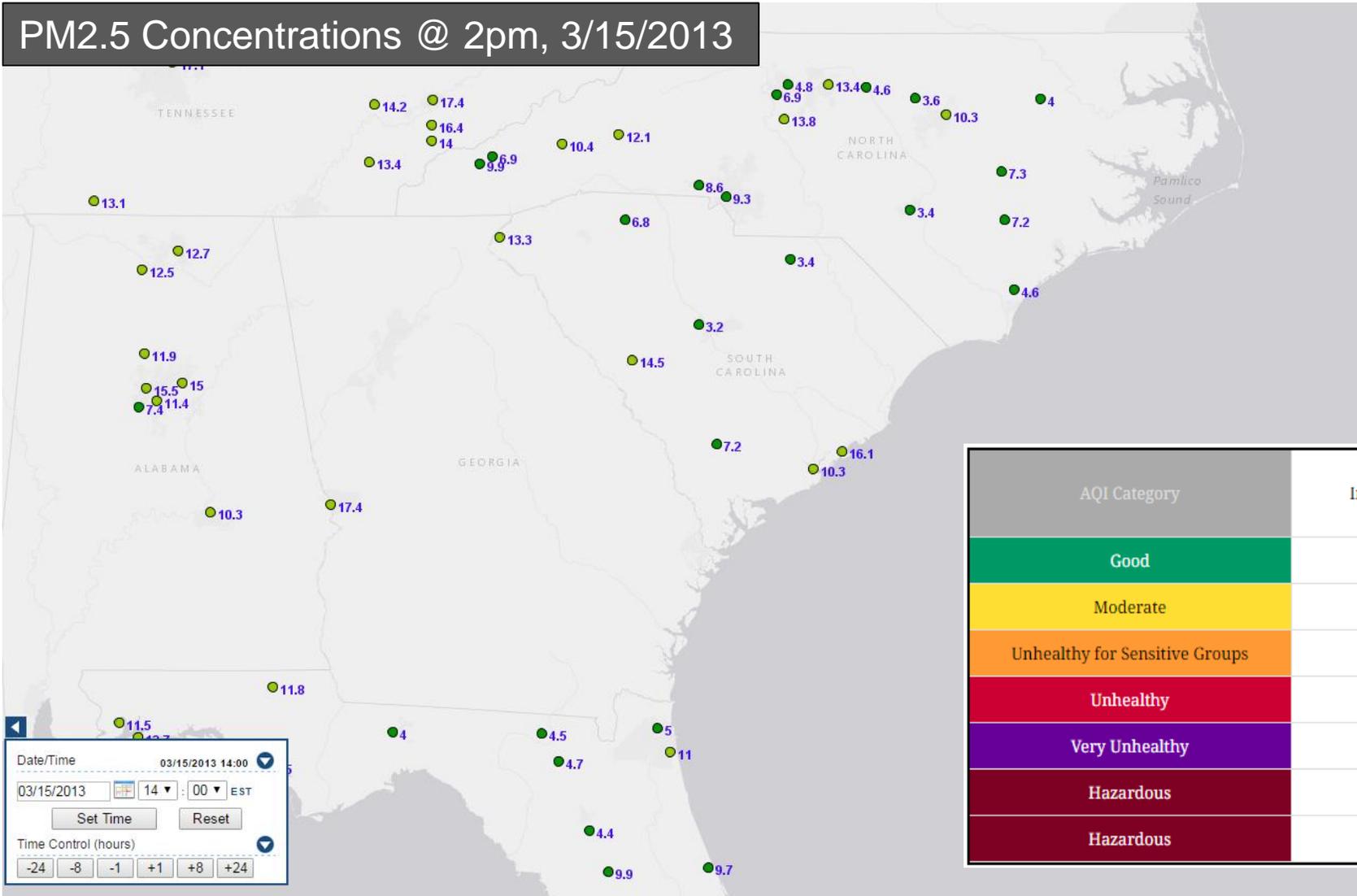
Case Study: Region-wide Prescribed Burn Event



Prescribed Fire Impacts on Air Quality Forecast

March 16, 2013 Regional Event – The Forecast

PM2.5 Concentrations @ 2pm, 3/15/2013



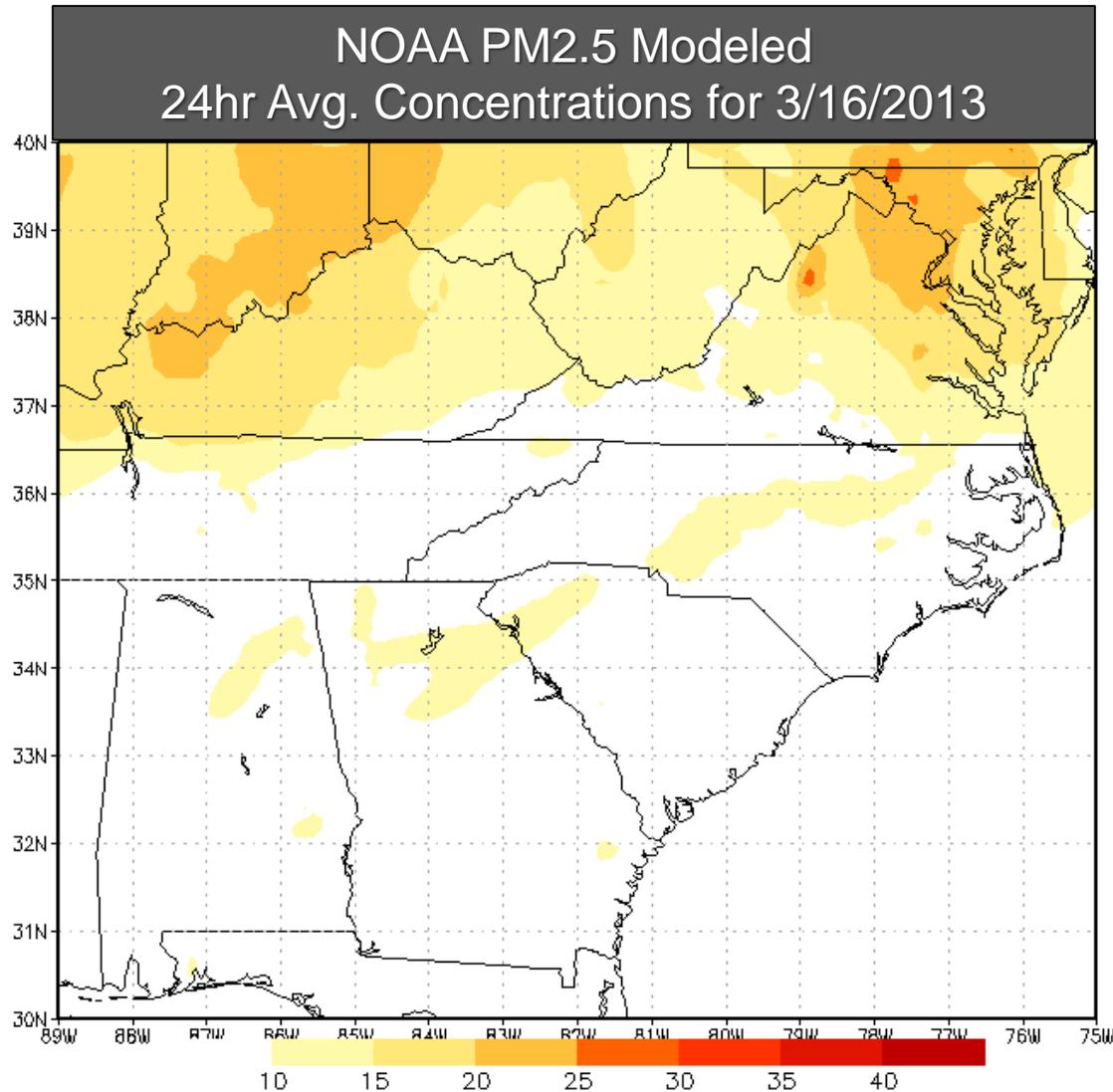
Used Friday, 3/15/2013 hourly PM2.5 concentrations for Saturday, 3/16/2013 forecast (primarily **Code Green** across the southeastern U.S.)

AQI Category	Index Values	Revised Breakpoints ($\mu\text{g}/\text{m}^3$, 24-hour average)
Good	0 - 50	0.0 - 12.0
Moderate	51 - 100	12.1 - 35.4
Unhealthy for Sensitive Groups	101 - 150	35.5 - 55.4
Unhealthy	151 - 200	55.5 - 150.4
Very Unhealthy	201 - 300	150.5 - 250.4
Hazardous	301 - 400	250.5 - 350.4
Hazardous	401 - 500	350.5 - 500



Prescribed Fire Impacts on Air Quality Forecast

March 16, 2013 Regional Event – The Forecast



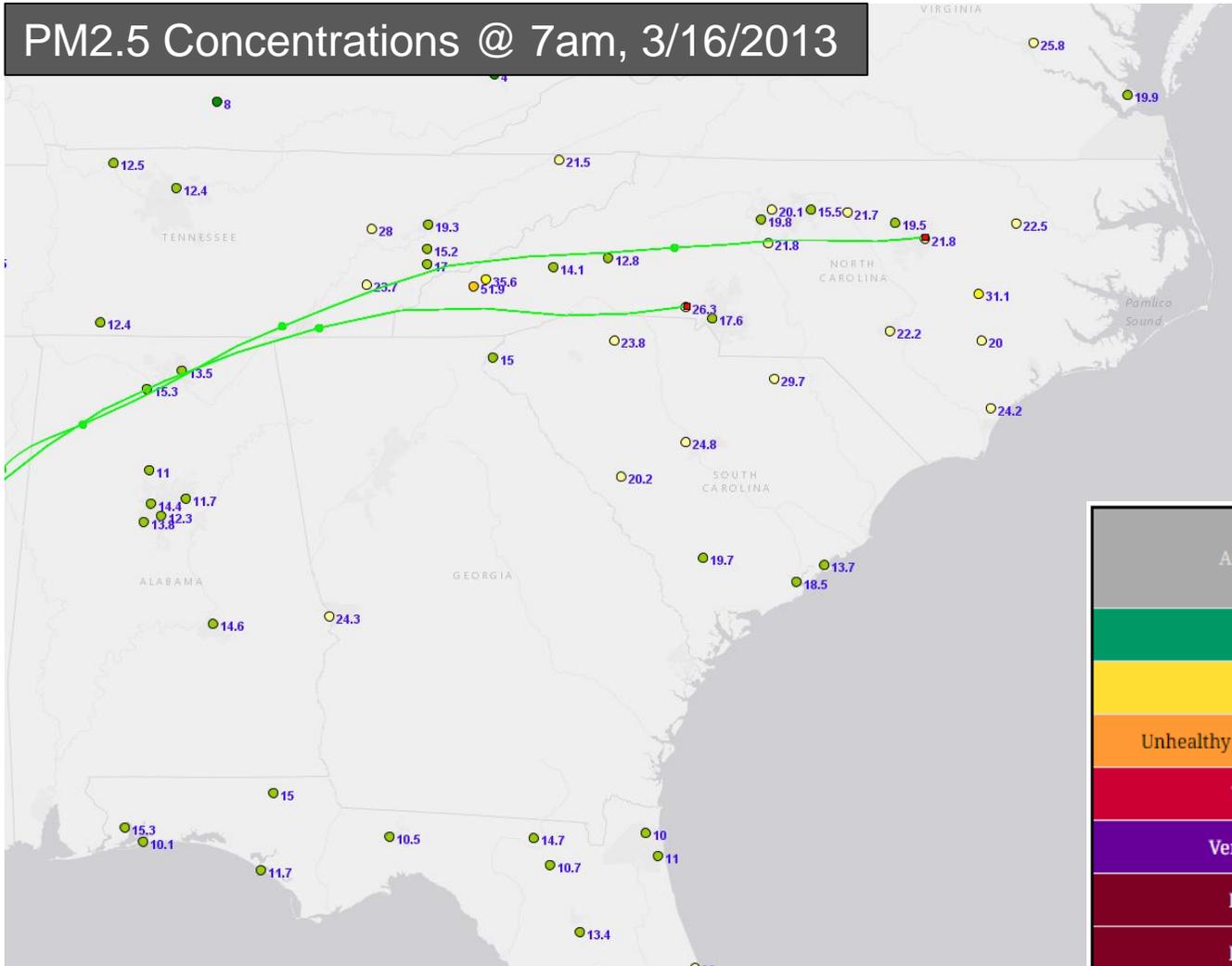
Meteorological analysis and model projections supported a continuation of **Code Green** conditions on Saturday, 3/16/2013



Prescribed Fire Impacts on Air Quality Forecast

March 16, 2013 Regional Event – Forecast Gone Bad

PM2.5 Concentrations @ 7am, 3/16/2013



- Hourly PM2.5 concentrations early on 3/16 were elevated well within the **Code Yellow** range across the state
- 24 hour backward air parcel trajectory analysis shows air parcels over NC early on 3/16 were originating from central and northern MS/AL 24 hours prior

AQI Category	Index Values	Revised Breakpoints ($\mu\text{g}/\text{m}^3$, 24-hour average)
Good	0 - 50	0.0 – 12.0
Moderate	51 - 100	12.1 – 35.4
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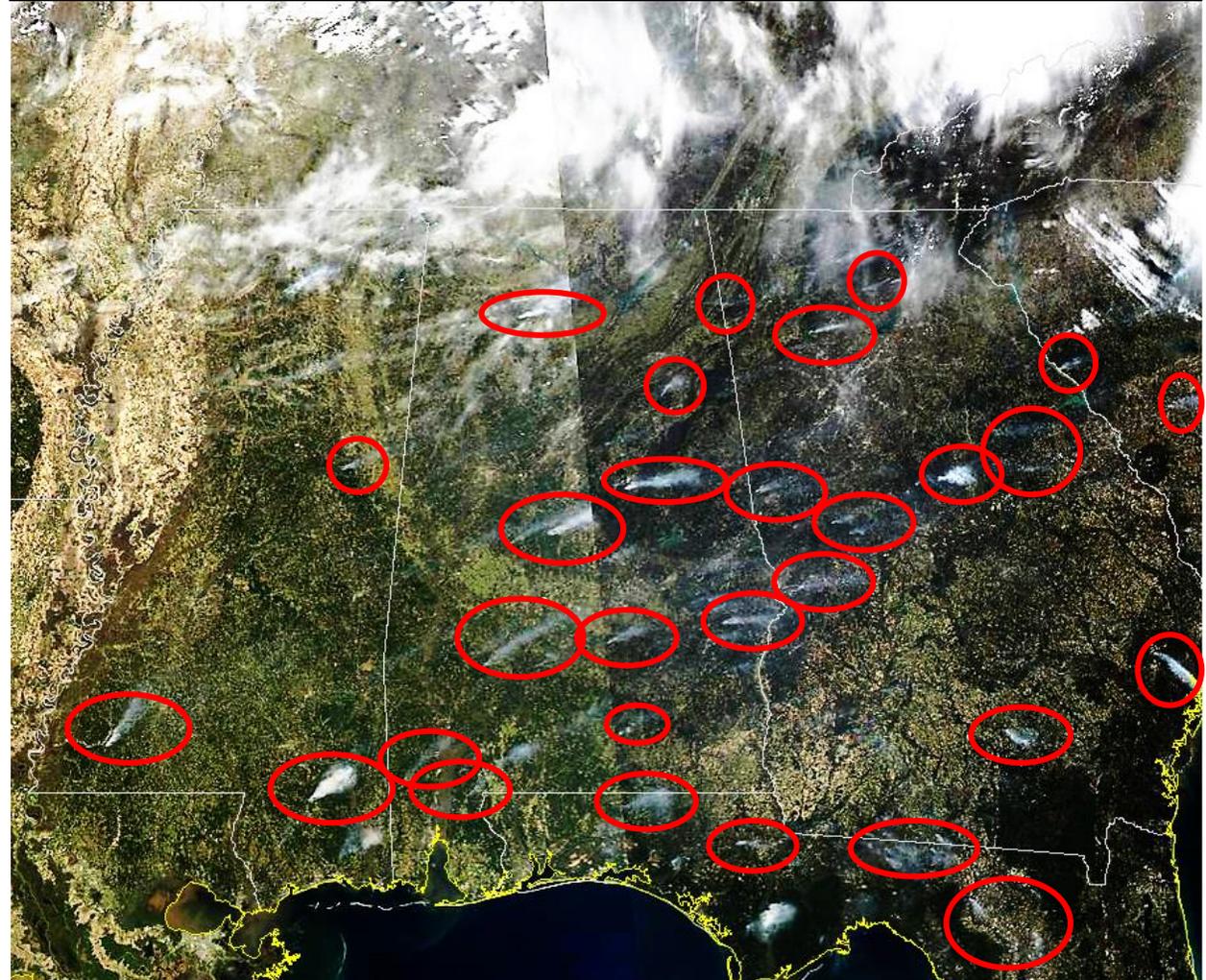


Prescribed Fire Impacts on Air Quality Forecast

March 16, 2013 Regional Event – What Happened

- A review of high resolution satellite imagery reveals numerous small fires burning across the Deep South on Friday afternoon (3/15)
 - Including central and northern MS and AL, where 24 hour back trajectories from NC on 3/16 originated
 - Some clouds over northern MS/AL/TN/GA makes it difficult to discern all of the fire activity there

Visible Satellite Imagery – Afternoon of 3/15/2013



Prescribed Fire Impacts on Air Quality Forecast

March 16, 2013 Regional Event – Summary

- Background particle pollution levels on Friday, 3/15/2013 were in the **Code Green** range across the southeastern U.S.
- Numerous small, prescribed burns during the afternoon almost doubled the background PM_{2.5} concentrations across the region
- Air quality models have no inherent way to “see” fires unless the data is programmatically ingested into them, so they run as if the fires do not exist:
 - In this case, model simulations essentially showed what concentrations would have been without the prescribed burns (**Code Green**)



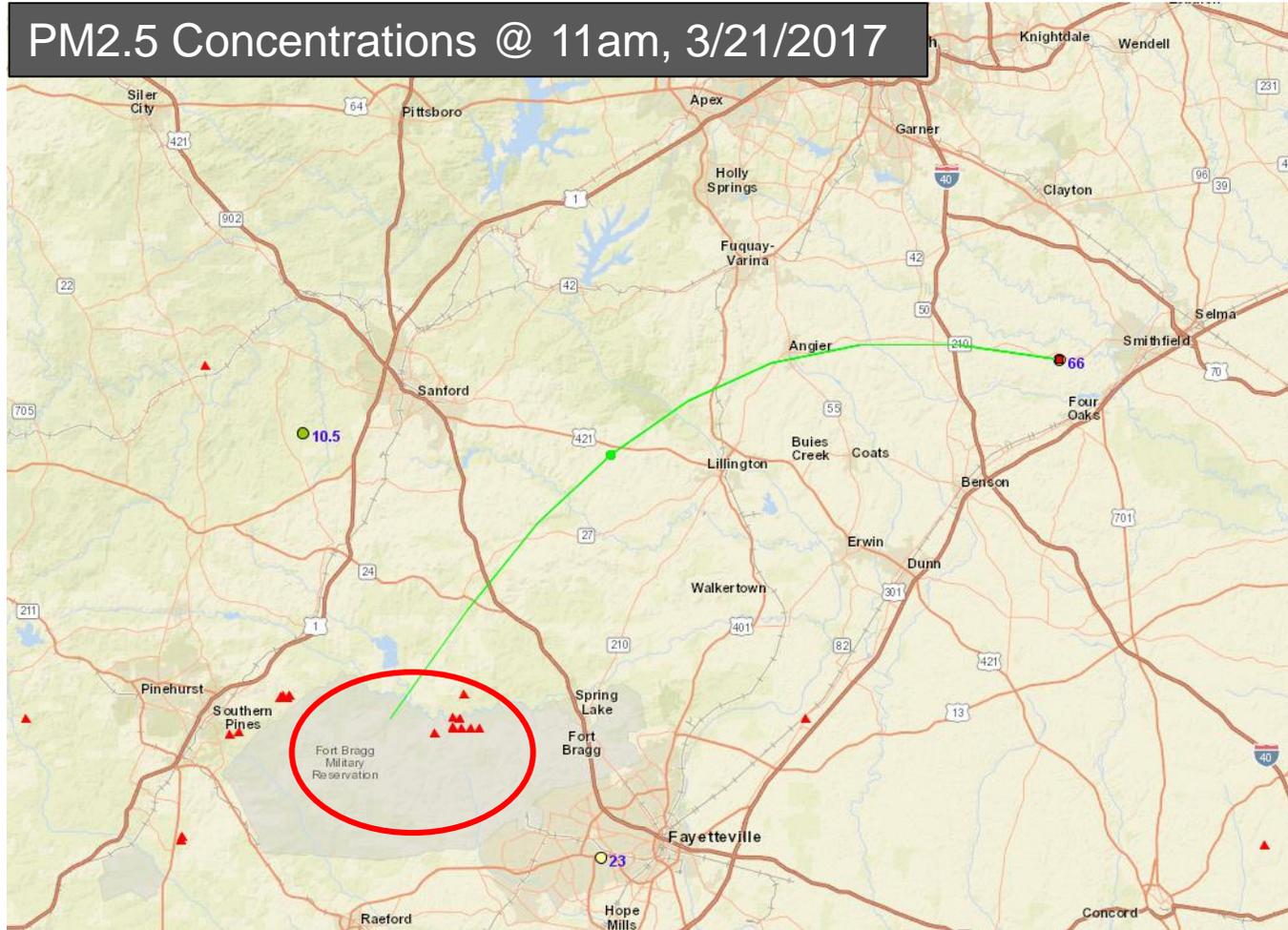
Prescribed Fire Impacts on Air Quality Forecast

Case Study: Localized Prescribed Burn Event



Prescribed Fire Impacts on Air Quality Forecast

March 21, 2017 Local Prescribed Burn Event



- Prescribed burn conducted at Fort Bragg AFB, NC on 3/21/17
 - Smoke trapped near the surface due to collapse of the planetary boundary layer
 - Effect similar to putting a lid on a steaming pot trapping steam inside
- Early the next morning smoke drifted northeast
 - PM2.5 monitor readings spiked at $66 \mu\text{g}/\text{m}^3$
 - Areas along the **back trajectory** corridor were experiencing **Code Orange** to **Code Red** PM2.5 concentrations for several hours until smoke could mix out as the boundary layer rose due to surface heating



Prescribed Fire Impacts on Air Quality Forecast

March 21, 2017 Regional Event – Summary

- Prescribed burn occurred on 3/21/17 and resulted in smoke being trapped near the ground
- Particle pollution concentrations – though slightly elevated into the low **Code Yellow** range elsewhere across NC – were doubled in the corridor where smoke was trapped
- Air quality forecasters had no prior knowledge of this burn, so the forecast was for only low **Code Yellow** PM2.5 concentrations



Wildfire Impacts on Air Quality Forecast
Lessons from the Western NC wildfires of 2016





~30 Wildfires
>80,000 Acres
October 23 ~ November 28

NCFS



**>\$50 million (NC Fires)
State of Emergency in 47 NC Counties
2300 firefighters (USFS-NC led fires)**

MODIS Image / NASA



Wildfire Impacts on Air Quality Forecast

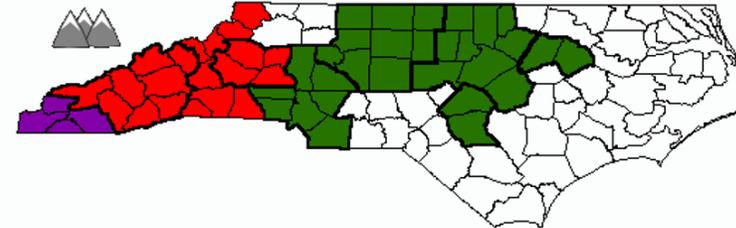
Lessons from the Western NC wildfires of 2016

Multiple large, dynamic fires burned across the Appalachians, fall 2016.
Several important lessons learned.

- Improving communication among official channels.
 - County Emergency Management officials
 - Joint Information Center (JIC)
 - U.S. Forest Service
- Forecast regions too broad spatially; county-based forecasting needed statewide.



Monday morning (11/14/16) Air Quality Forecast Update



Valid through 12AM Tuesday, 11/15/16



Mobile Monitoring - $PM_{2.5}$



WNC Permanent monitors:

- Bryson City
- Cherokee (Tribal monitor)
- Asheville (WNCRAQA)
- Spruce Pine
- Hickory

NCDAQ Mobile Monitor Sites:

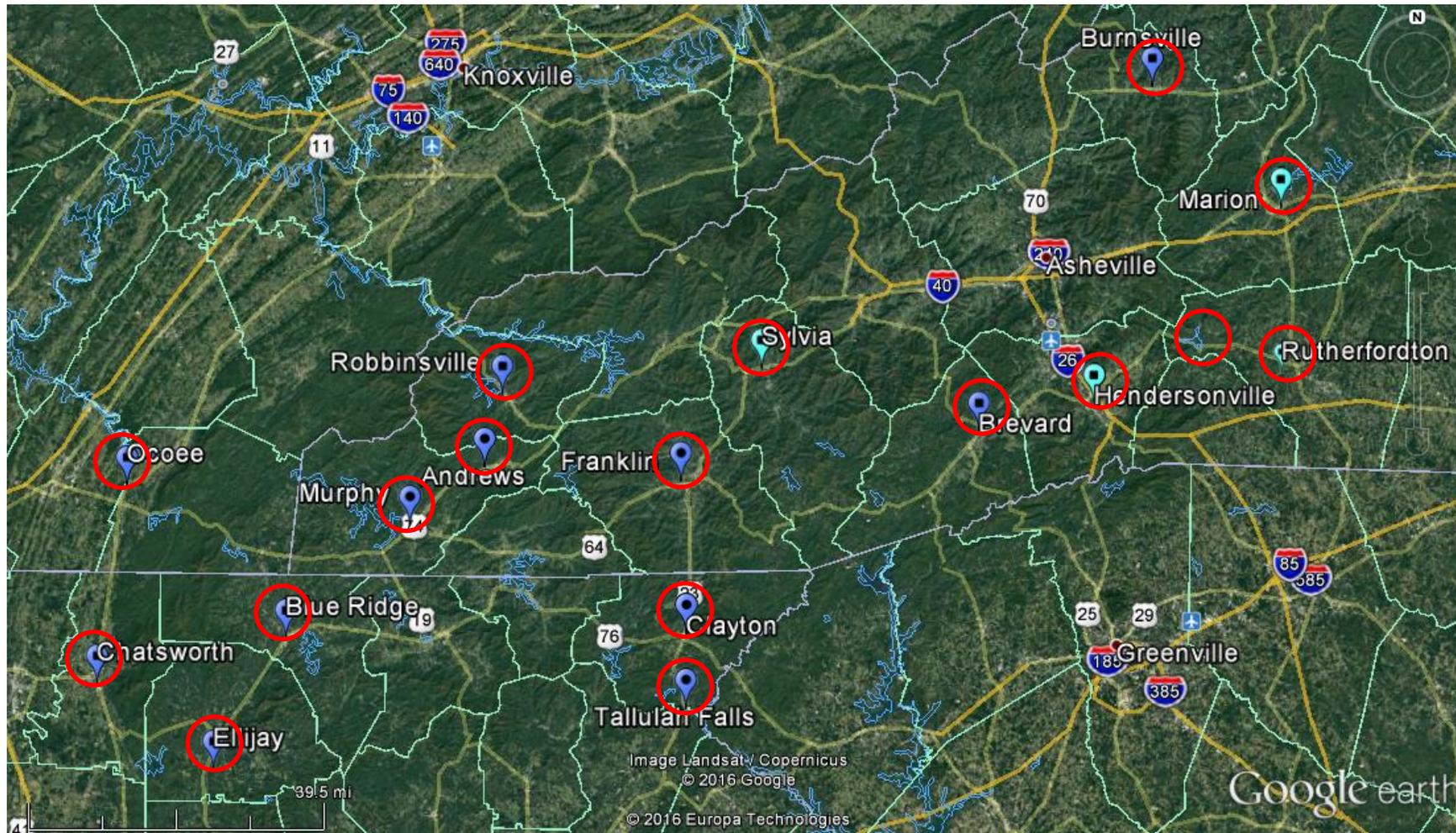
- Sylva
- Lake Lure
- Rutherfordton
- Marion
- Hendersonville

USFS Mobile Monitors

- Robbinsville
- Andrews
- Franklin
- Brevard
- Burnsville
- Murphy



Portable $PM_{2.5}$ Monitors

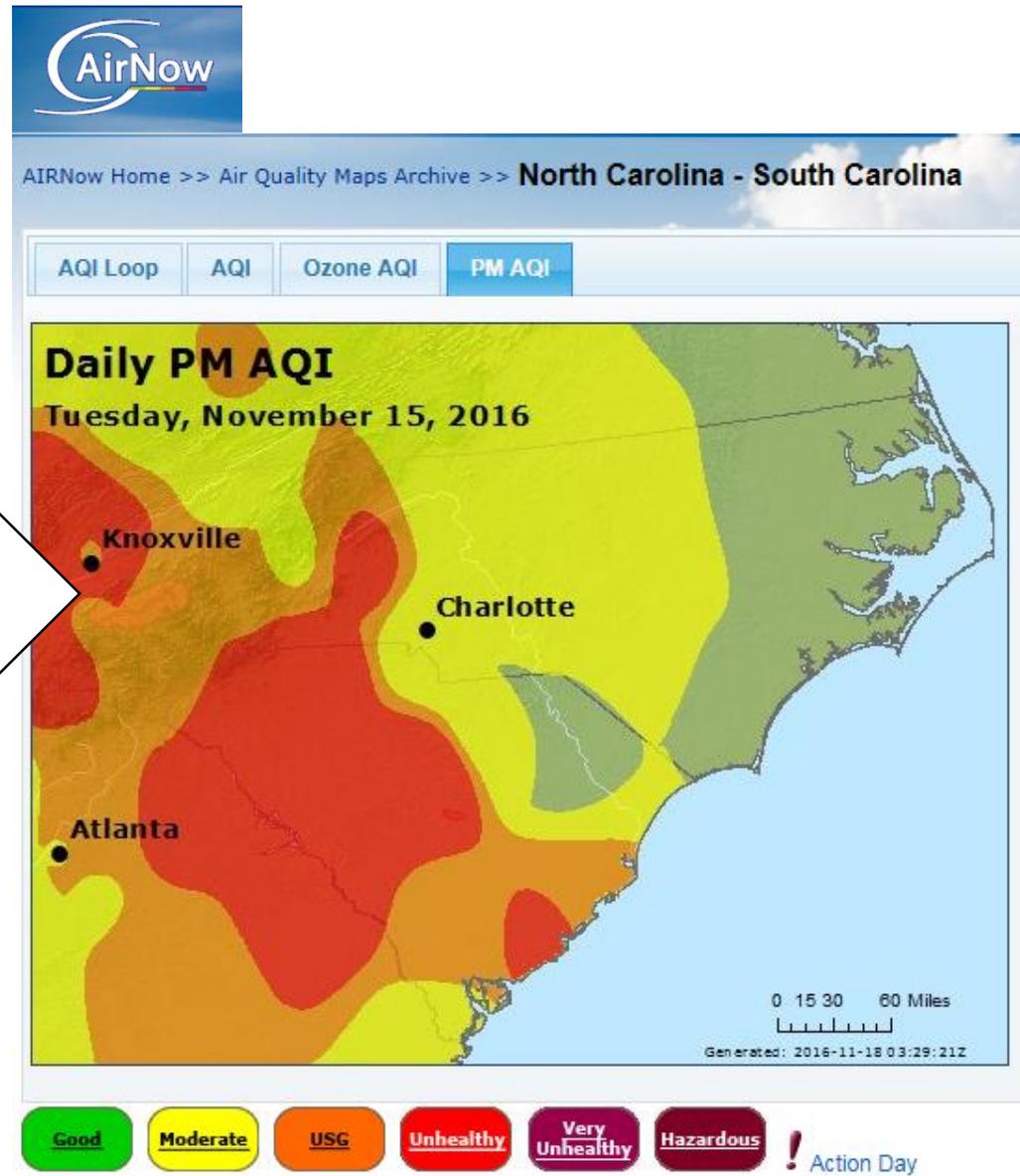


Monitors obtained from National cache, Regional/Forests, NC DAQ and NC Forest Service.

USFS - Air Resource Management



Department of Environmental Quality



Conclusions

- Prescribed Burning:
 - Can have a profound impact on air quality at the local and regional levels.
 - Air quality forecasts can be improved if the forecast team has information on prescribed burning the day before it occurs:
 - For example, when, where, how many, and how large is the prescribed burning activity?
 - Timely access to NCFS Smoke Management Database will be most helpful
 - Satellite imagery (Terra and Aqua) has limitations for identifying fire activity:
 - Cloudy days can obscure imagery
 - Delays in receiving imagery (2-3 hours)



Conclusions

- Wildfires:
 - Communication with sister agencies critical
 - NCFS, USFS, JIC, local programs
 - Use of mobile PM_{2.5} monitors important to forecast accuracy for local areas
 - Ground truth
- Current DAQ Priorities:
 - Updating AQ forecast page to enable county-level forecasting
 - Developing wildfire information page to point user to key information
 - NCDAQ Air Quality Forecast Page
 - Keeping contact lists for local authorities updated (e.g., EMS staff)



Acknowledgements

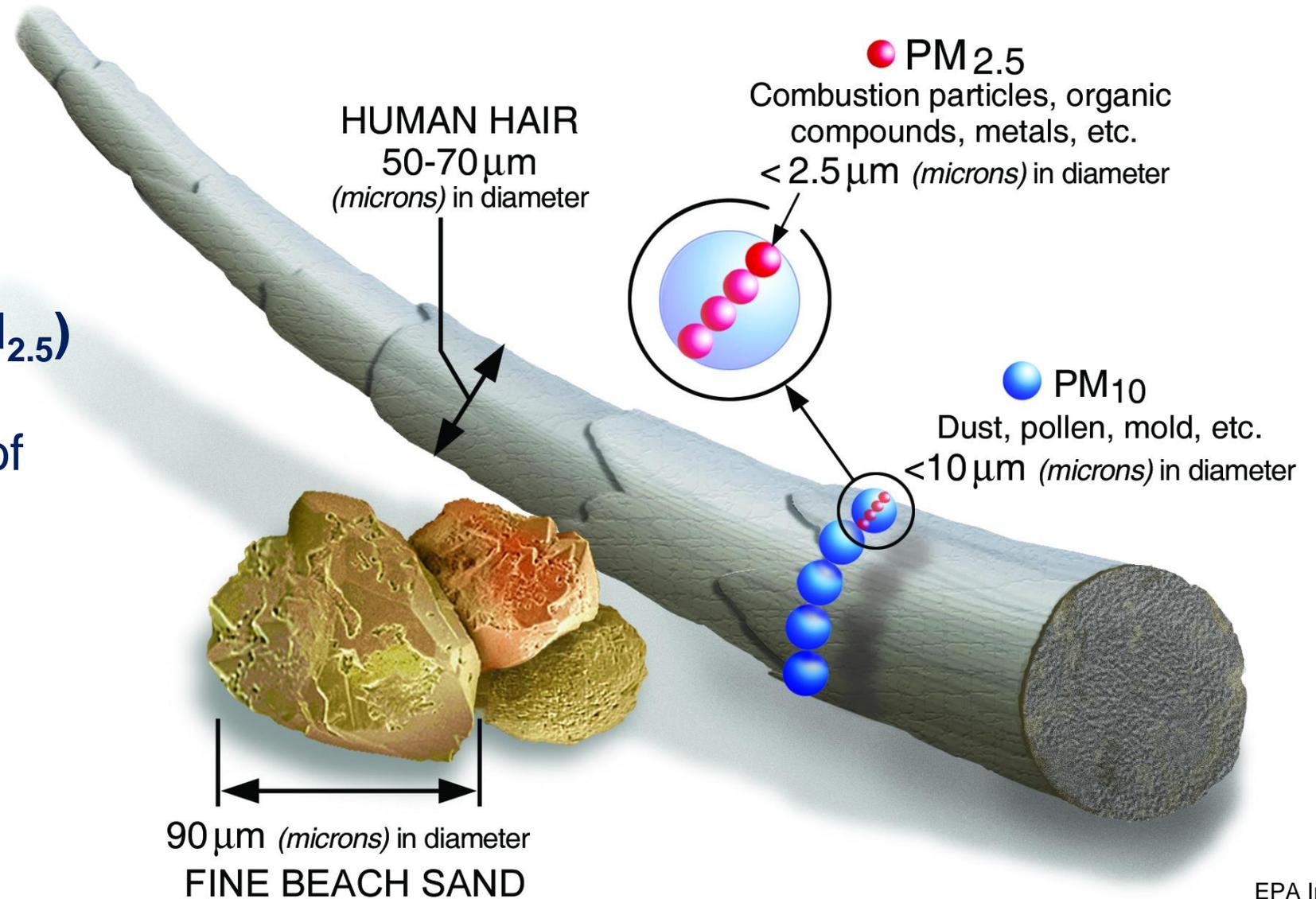
- North Carolina's Air Quality Forecast Team:
 - Bradley McLamb, Meteorologist I
 - Elliot Tardif, Meteorologist II
 - Nick Witcraft, Meteorologist II



Health Concerns

Particulate matter (PM_{2.5})

The principal pollutant of concern from wildfire smoke



Health effects:

- eye and respiratory tract irritation
- persistent cough, phlegm, wheezing
- difficulty breathing
- reduced lung function
- bronchitis
- exacerbation of asthma
- premature death

Health Concerns

Cardiac Arrest

JAHA: PM_{2.5} exposure was associated with increased risk of out-of-hospital cardiac arrests and IHD during the 2006–2007 wildfires in Victoria.

Source: Anjal et al; *Impact of Fine Particulate Matter (PM_{2.5}) Exposure During Wildfires on Cardiovascular Health Outcomes*; Journal of the American Heart Association. 2015

EPA Peat Bog Fire Study NC (2008): The study found a 37 percent increase in emergency room visits for people with symptoms of heart failure ...

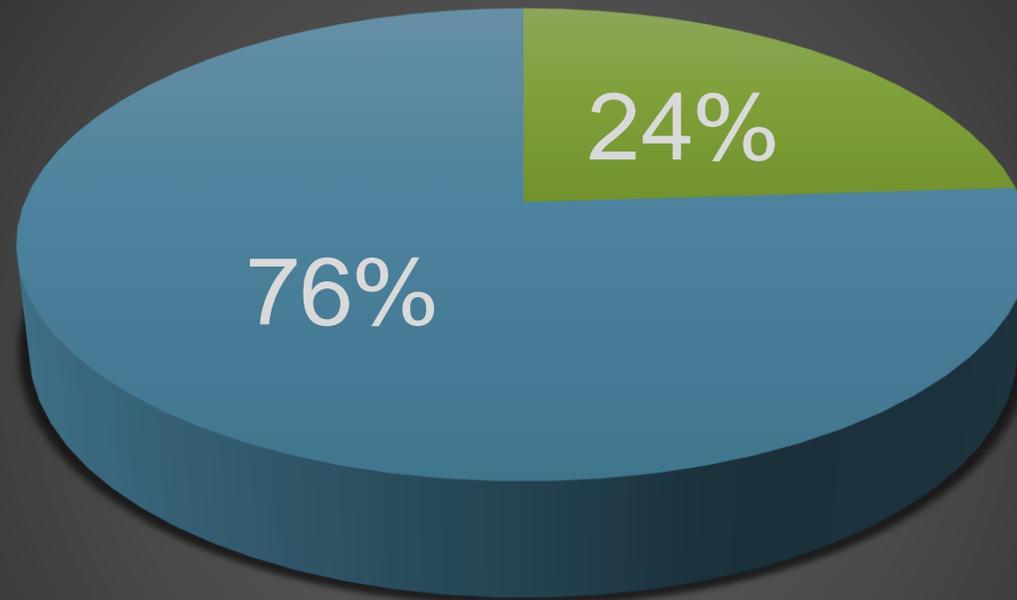
Source: <https://www.epa.gov/sites/production/files/2014-09/documents/nc-wildfire-study-fact-sheet-final.pdf>



The Context...

- One in three households has someone with respiratory issues: child with asthma, COPD, emphysema, etc. 26 million have asthma in US.
 - Conditions: asthma (7.3% prevalence), COPD (6.3% prevalence), chronic rhinitis (20% prevalence), pneumonia, lung cancer & other (CDC).
 - Sensitive groups at risk: people with asthma, older adults and those of low income. Science indicates: pregnant women, diabetics.
-
- **And now wildland and agricultural fires contributing to more than 40% of PM2.5 based on the EPA's 2011 National Emission Inventory**

Acres by Percent



■ Forestry - 8,946,900 Acres

■ Agriculture - 2,795,099 Acres

Department of Environmental Quality

