# *Analysis of Ozone Trends in the East in Relation to Interstate Transport*

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## *Background and Context*

- Recent analyses of measured data by some states suggest that the current ozone problems in parts of the Eastern US may have become more of local problem within the nonattainment area and nearby states, as opposed to broad regional problem with a large geographic reach far upwind of the downwind state.

- In this analysis we examine ozone trends and spatial patterns based on measured data in urban and rural/regional locations to further understand the extent to which high ozone concentrations remain a regional problem in the East or if high ozone concentrations in have become more of a local problem.

# *Analytic Approach*

- This analysis focuses on comparing ozone in 2010/2011/2012 to ozone in 2015/2016/2017.
  - 2010/2011/2012 were each very conducive for ozone formation in parts of the East.
  - 2015/2016/2017 are the most current three years of data. Of these three years, 2016 was the most conducive for ozone formation in the East.
  - 2013 and 2014 were not included in this analysis because those years, particularly 2014, were not conducive for ozone formation in large portions of the East.
  - Note that the ozone reductions seen in measured data between the time period 2010-2012 and 2015-2017 are due to a combination of reductions in emissions and also inter-annual variability in meteorology conducive to ozone formation and transport.
- Part 1. Analysis of the spatial patterns in the number of summer days with measured MDA8 ozone exceedances of the 2008 and 2015 NAAQS.
- Part 2. Analysis of ozone trends at rural sites (mainly high elevation sites) upwind of the Northeast Corridor in comparison to trends at near-urban high ozone sites within the Corridor; similar analysis for rural sites in portions of Midwest and South compared to high ozone at key sites along the shoreline of Lake Michigan.

# *Preliminary Results*

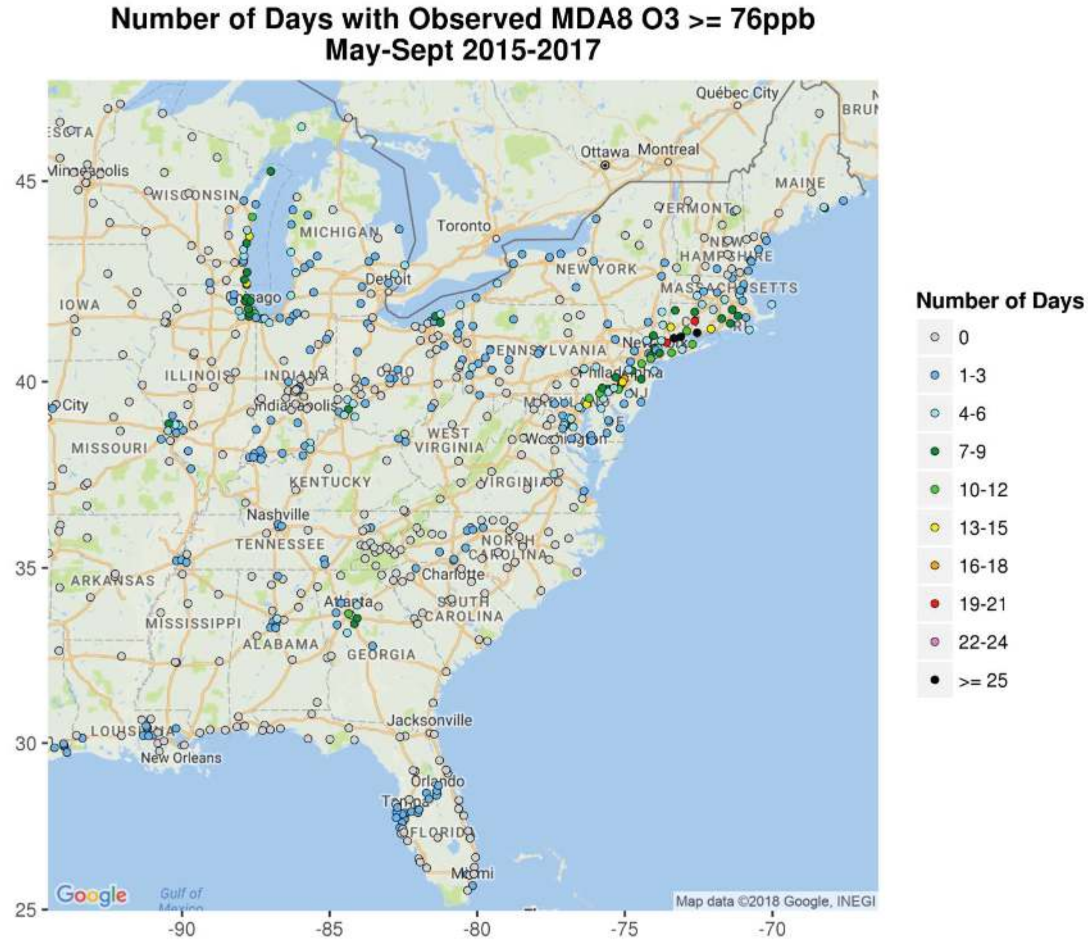
- From an Eastern US perspective, the current ozone levels appear to be more of a “local” problem (i.e., home state and adjacent neighboring states) compared to the larger regional ozone problem for that was evident back in 2010-2012.
- The magnitude of net ozone available for transport into the NE Corridor and the Lake Michigan area from more distant upwind states appears to have declined by 5 to 10 ppb based on 2010-2012 vs 2015-2017 avg ranked ozone values.
- Ozone levels have also declined substantially at the traditionally high ozone sites in the southern and central portions of the NE Corridor and at the traditionally high ozone sites along Lake Michigan
- Despite the ozone reductions at regional sites upwind of the NE Corridor and at sites in the central and southern Corridor, there is relatively little reduction between the 2010-2012 and the 2015-2017 avg ranked ozone at most of the sites in Coastal Connecticut.

*Regional Extent of Ozone Problem*
*2010-2012 vs 2015-2016*

*Metric: Number of total ozone season days that exceed 2008 and 2015 NAAQS*

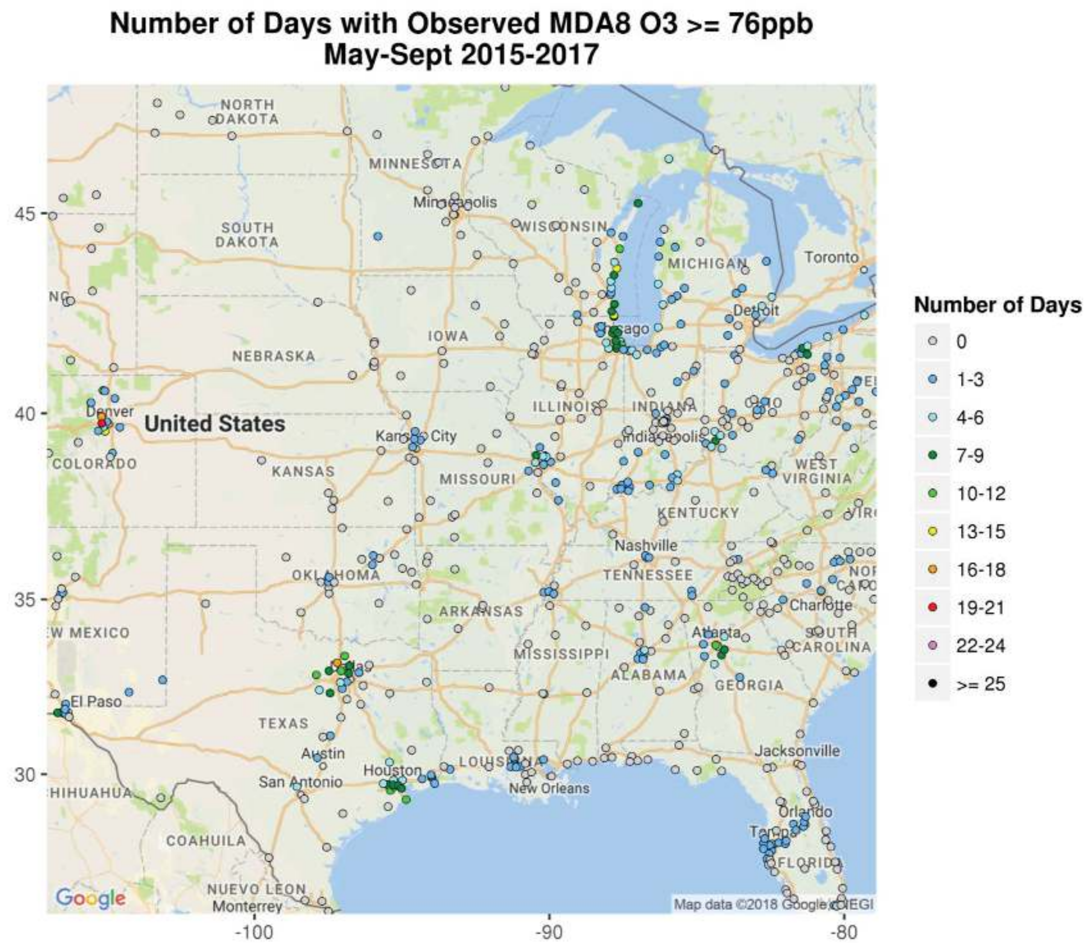
## 2010-2012 – 2008 NAAQS


## 2015-2017 – 2008 NAAQS



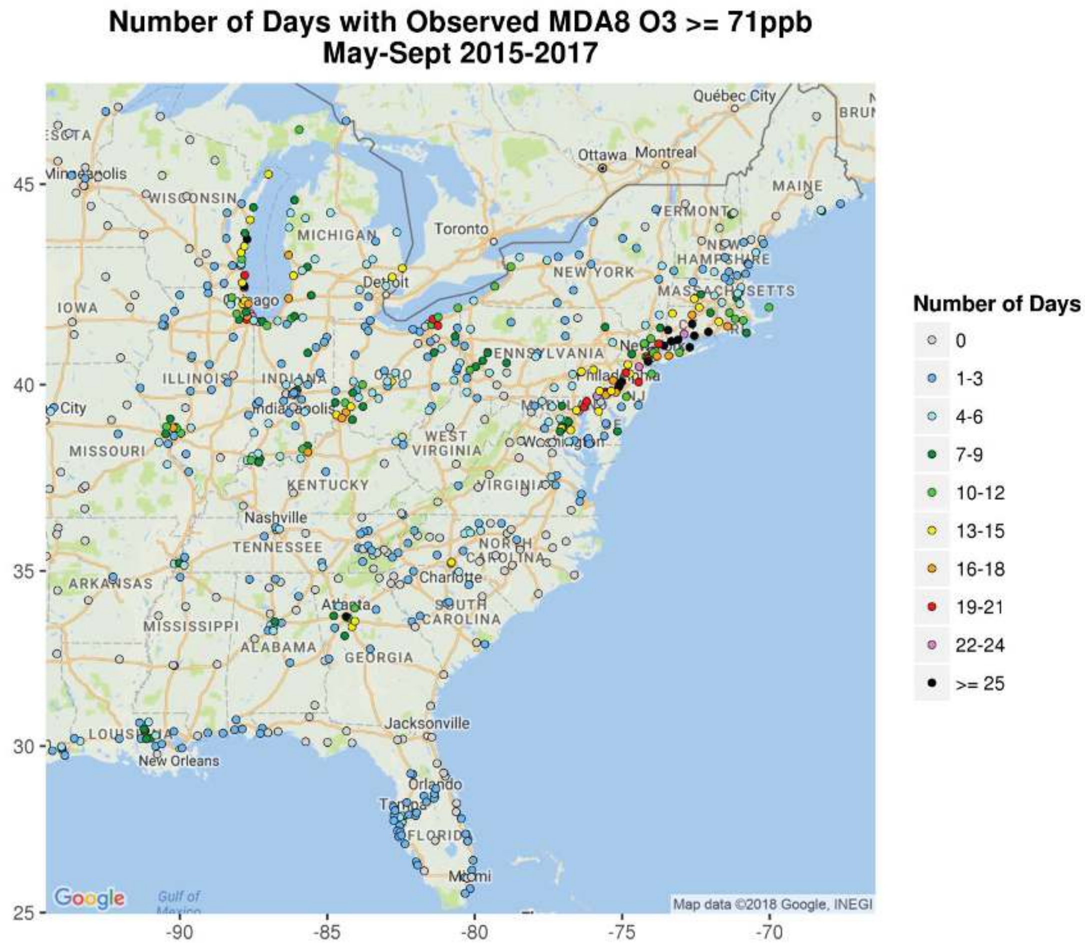
## 2010-2012 – 2008 NAAQS


## 2015-2017 – 2008 NAAQS



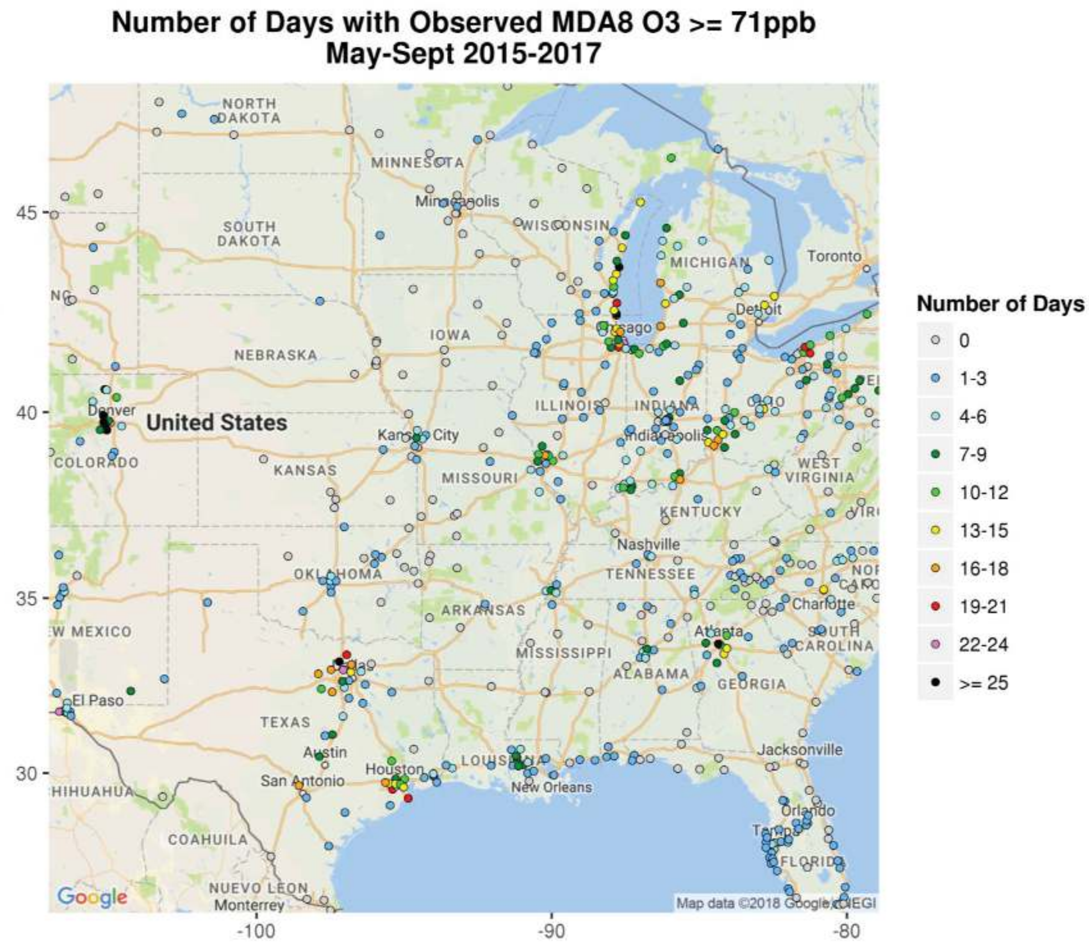
## 2010-2012 – 2015 NAAQS


## 2015-2017 – 2015 NAAQS



## 2010-2012 – 2015 NAAQS


## 2015-2017 – 2015 NAAQS



## *Analysis of Trends in Ranked MDA8 Ozone Concentrations in the Northeast*

Rural "Upwind" Sites

Kane Forest, PA 618 m (2,028ft)

Penn State U, PA 364 m (1,194 ft)

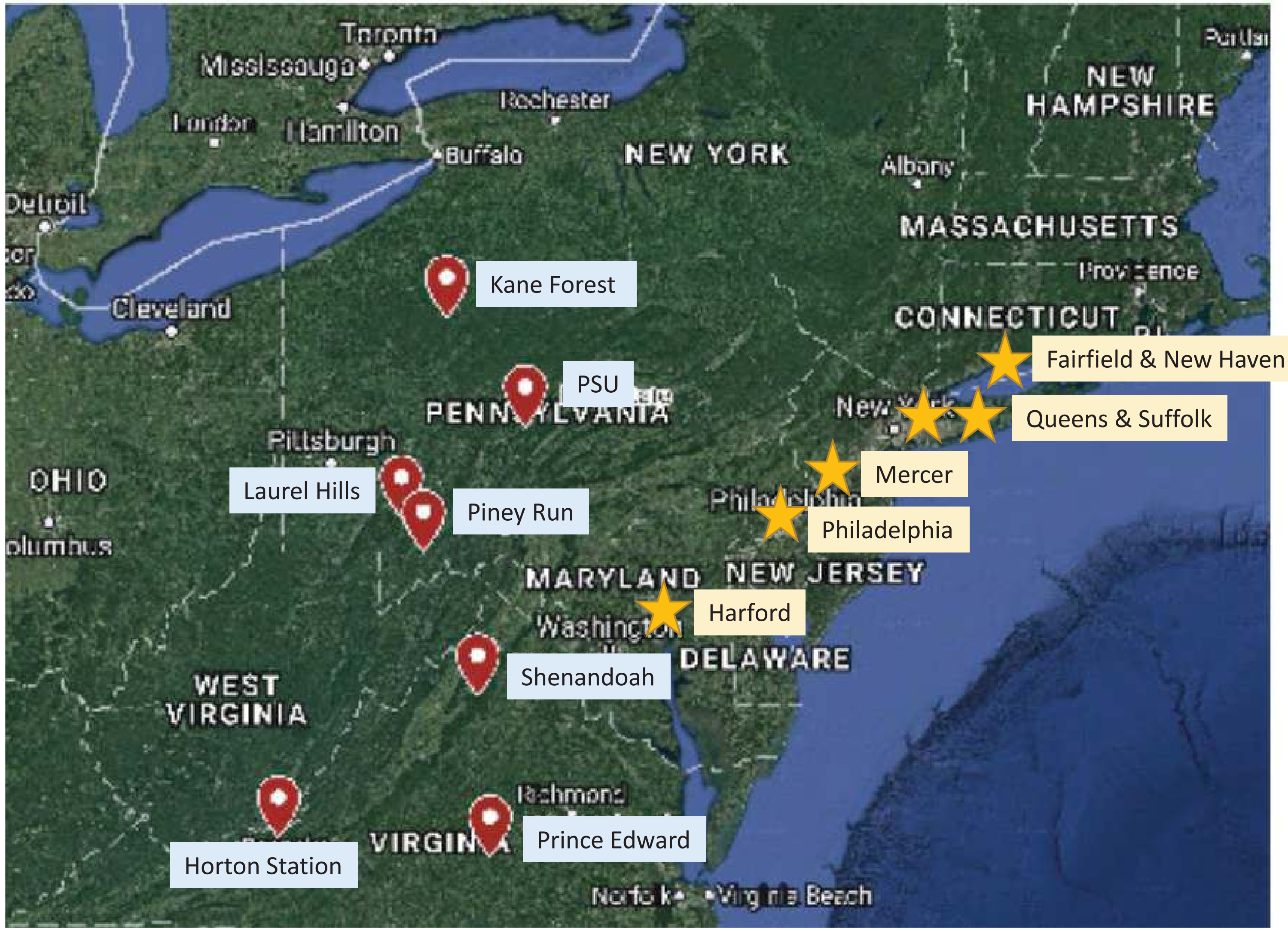
Laurel Hills, PA 615 m (2,018 ft)

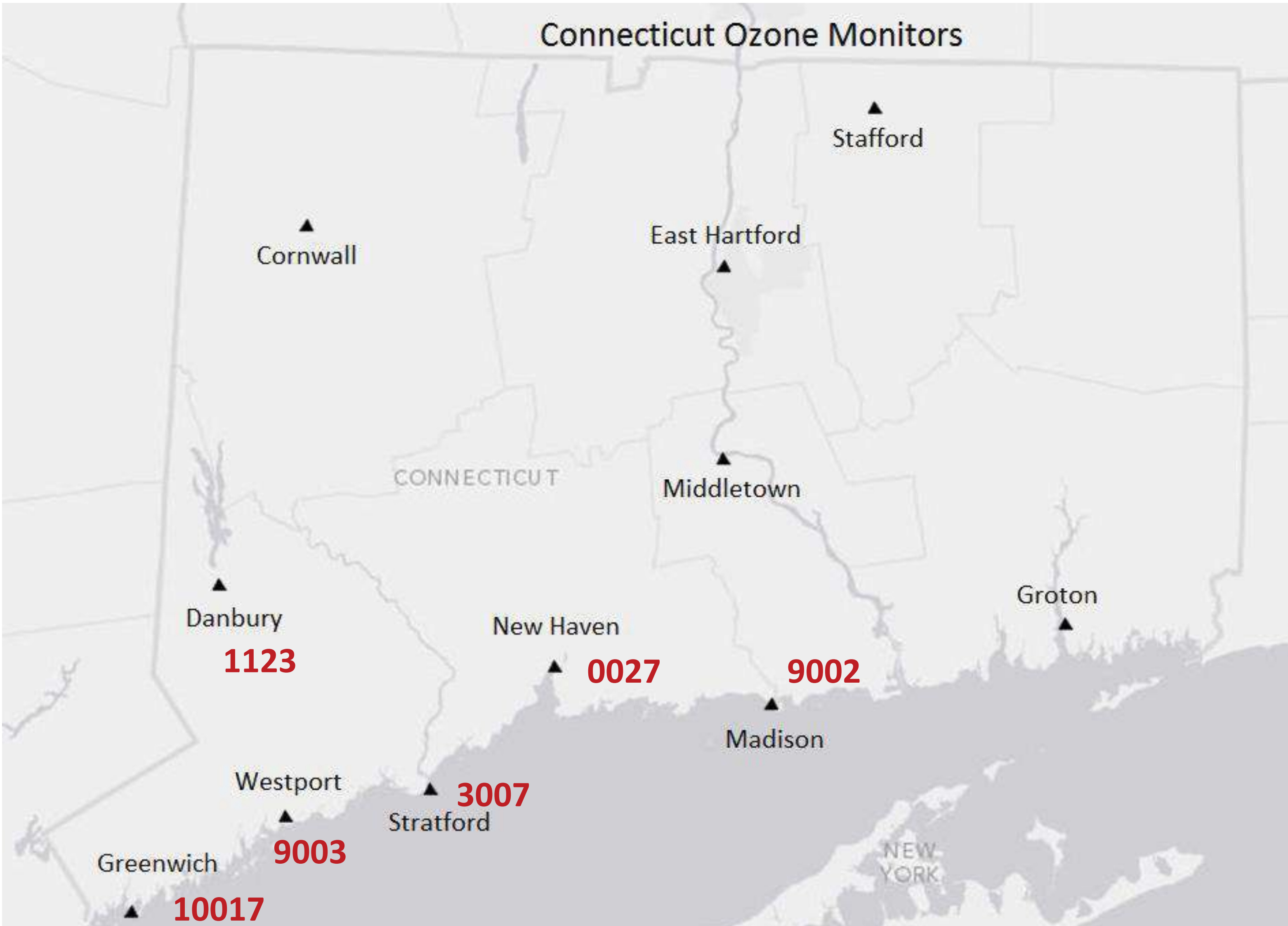
Piney Run, MD 777 m (2,549 ft)

Shenandoah, VA 1068 m (3,504 ft)

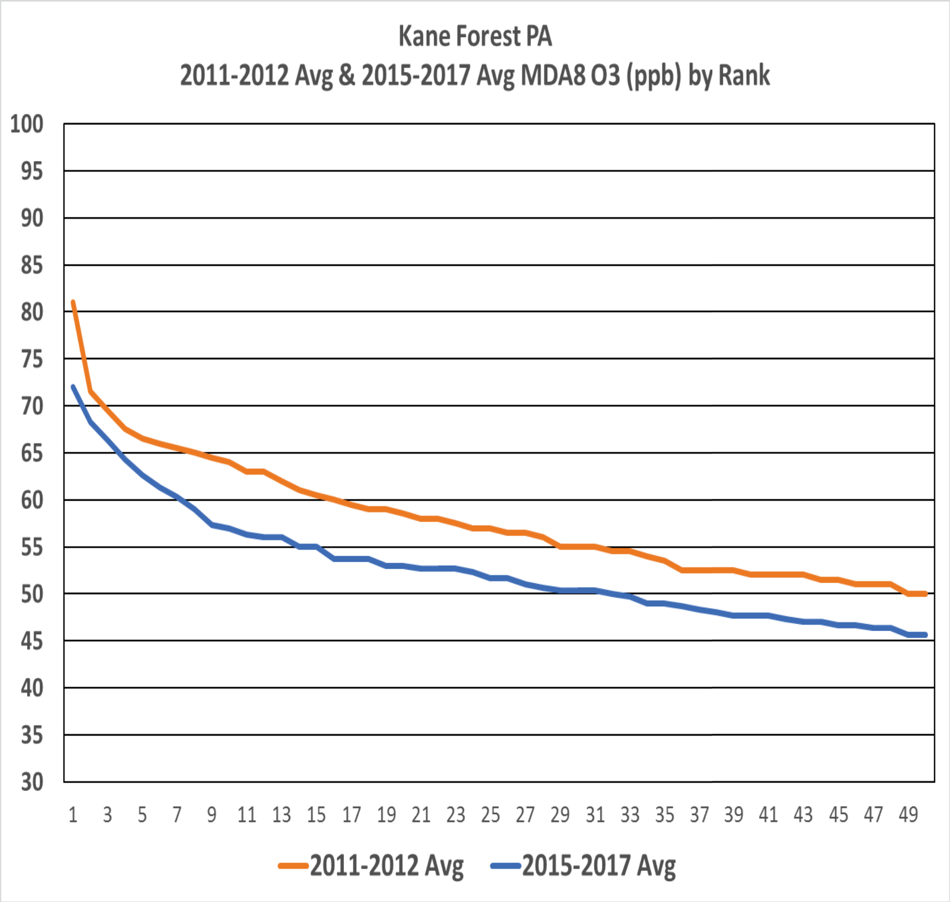
Horton Station, VA 920 m (3,018 ft)

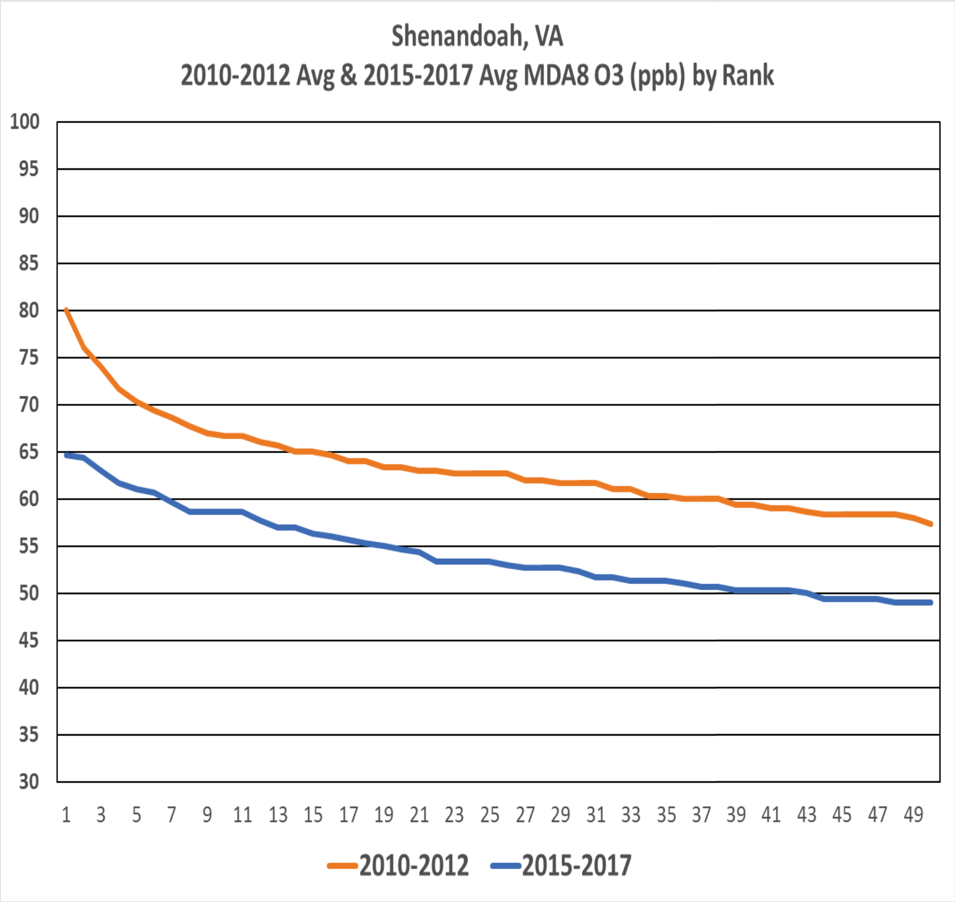
Prince Edward, VA 149 m (489 ft)



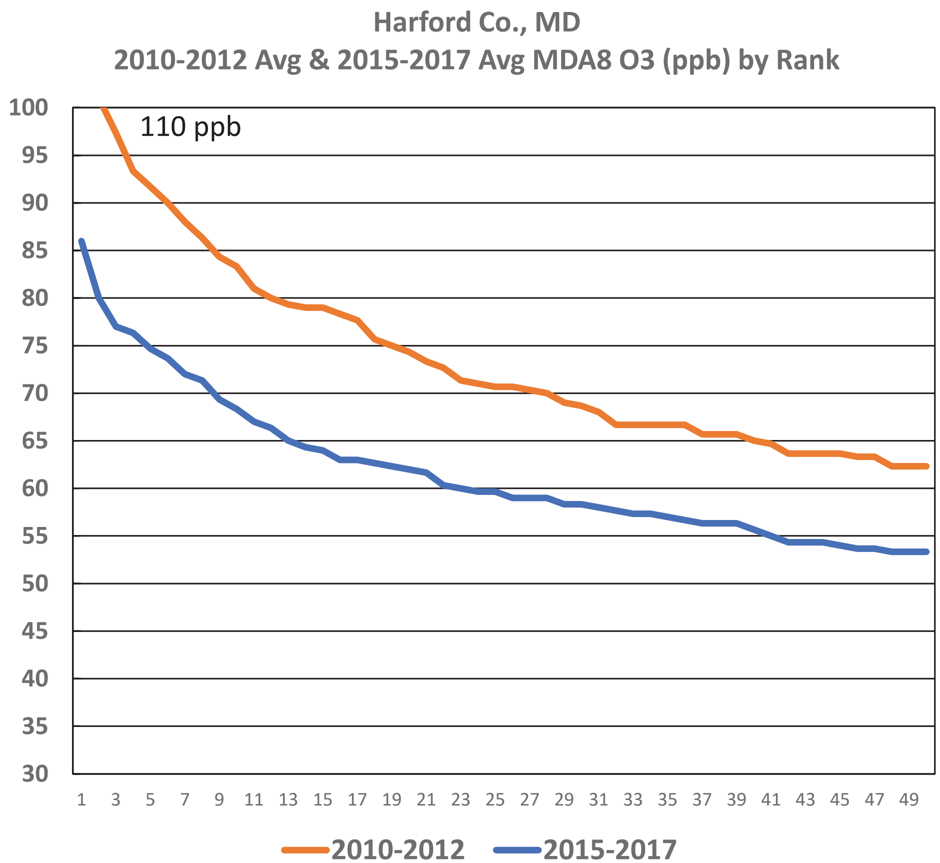

Connecticut Ozone Monitors
Stafford
Cornwall
East Hartford
CONNECTICUT
Middletown
Danbury
1123
New Haven
0027
9002
Groton
Madison
Westport
3007
Stratford
9003
Greenwich
10017
NEW YORK

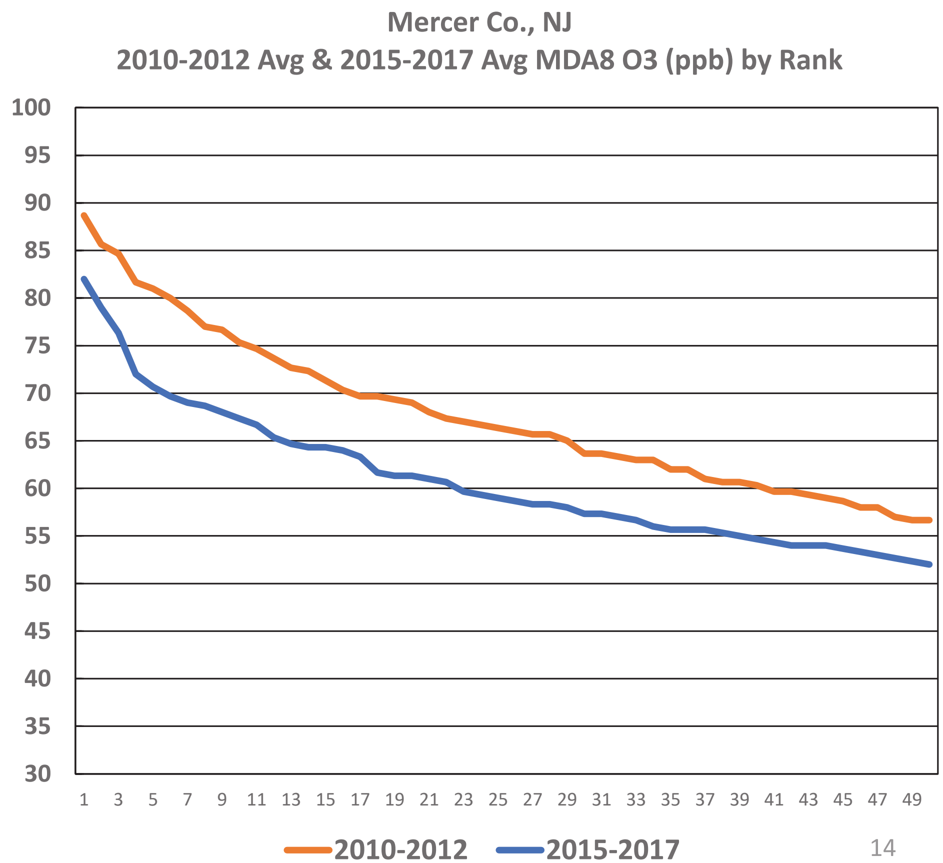
# *3-Year Avg Ranked MDA8 Ozone at Example Sites*
# *"Upwind of the NE Corridor"*



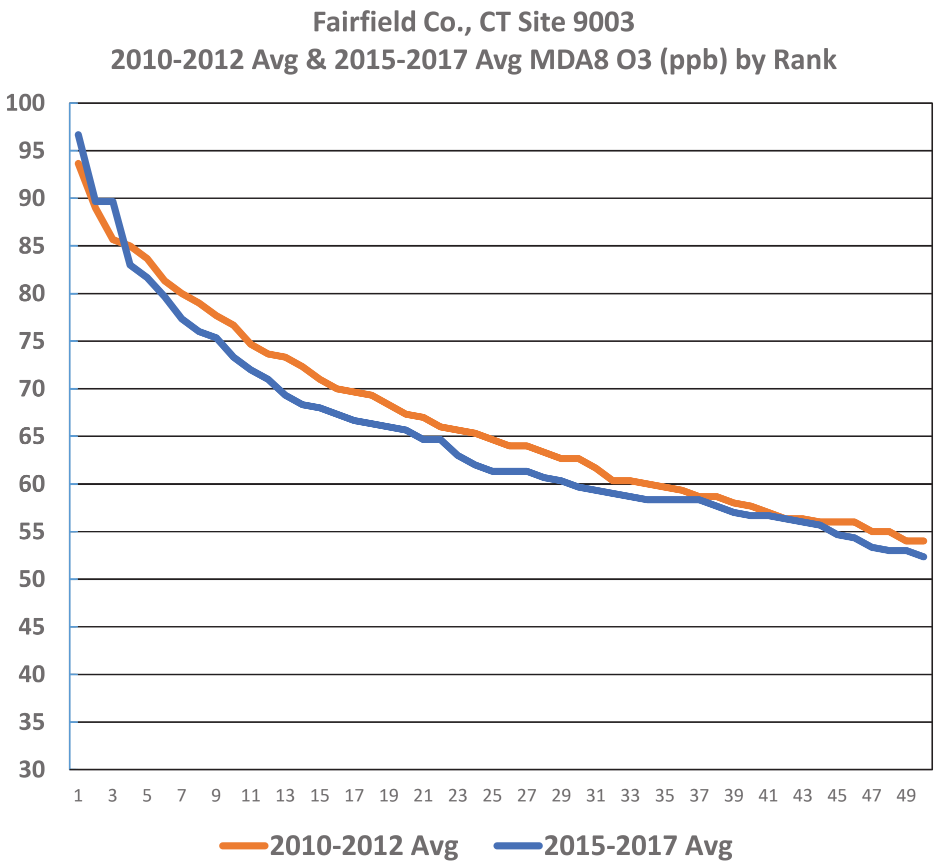



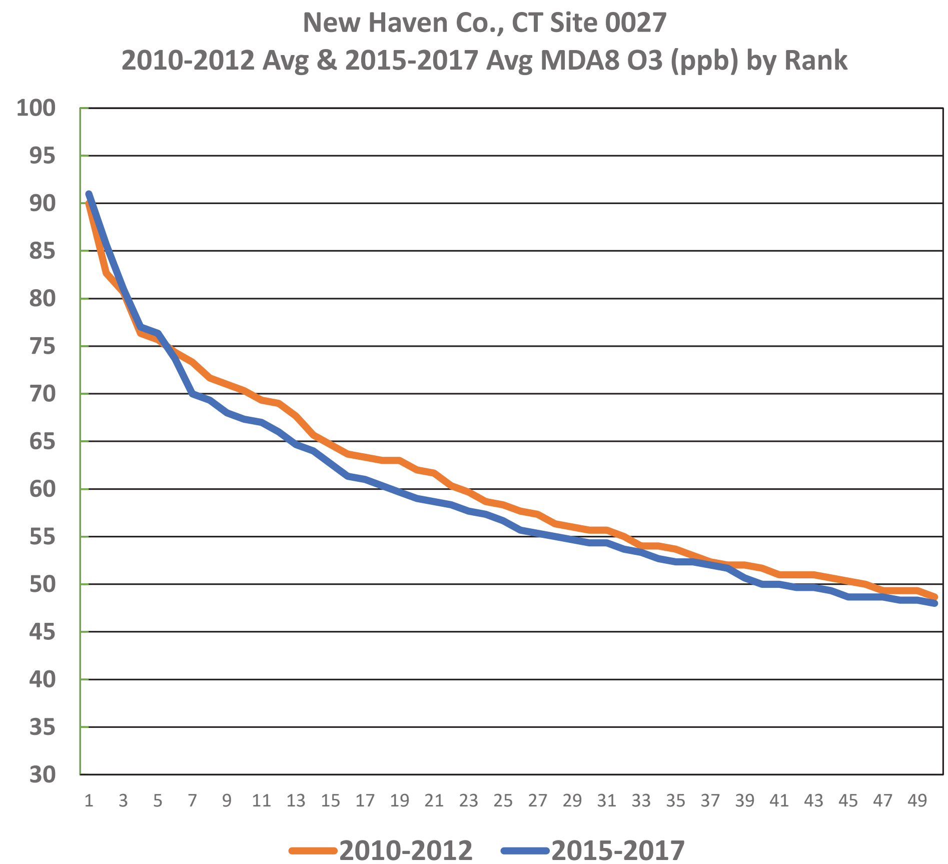
# *3-Year Avg Ranked MDA8 Ozone at Example High Ozone Sites in the Southern and Central Part of the NE Corridor*



# 3-Year Avg Ranked MDA8 Ozone at Example High Ozone Sites in Coastal Connecticut



*Reductions in O3 of ~5 to 10 ppb at sites upwind of the NE Corridor and along the Corridor up to NYC*

**Comparison of 2010-2012 Avg vs 2015-2017 Avg Ranked O3 (ppb)**

| | Avg Change: Top 5 Days | Avg Change: Days 6-15 | Avg Change: Days 16-30 |
|---|---|---|---|
| **Rural Upwind Sites** | | | |
| Kane Forest, PA | -4.4 | -6.1 | -5.3 |
| Penn State, PA | -8.5 | -8.5 | -6.5 |
| Laurel Hills, PA | -5.8 | -6.6 | -5.6 |
| Piney Run, MD | -11.7 | -10.6 | -10.0 |
| Shenandoah, VA | -11.4 | -8.4 | -9.0 |
| Horton Station, VA | -4.8 | -5.2 | -5.8 |
| Prince Edward, VA | -8.1 | -6.6 | -6.8 |
| **NE Corridor Sites** | | | |
| Harford, MD | *-19.8* | *-14.9* | *-12.0* |
| Philadelphia, PA | *-6.6* | *-8.7* | *-7.9* |
| Mercer, NJ | *-8.3* | *-8.4* | *-7.1* |
| Queens, NY | *-7.5* | *-6.4* | -3.5 |
| Suffolk, NY | *-12.8* | *-8.3* | *-5.1* |
| Danbury, CT 1123 | *-6.8* | -1.8 | -1.4 |
| *Greenwich, CT 1017* | -2.1 | -2.8 | -3.9 |
| *Westport, CT 9003* | 0.7 | -2.9 | -2.6 |
| *Stratford, CT 3007* | -0.2 | -3.5 | -2.0 |
| *New Haven, CT 0027* | 1.1 | -2.4 | -2.1 |
| *Madison, CT 9002* | -4.0 | -0.9 | -1.4 |

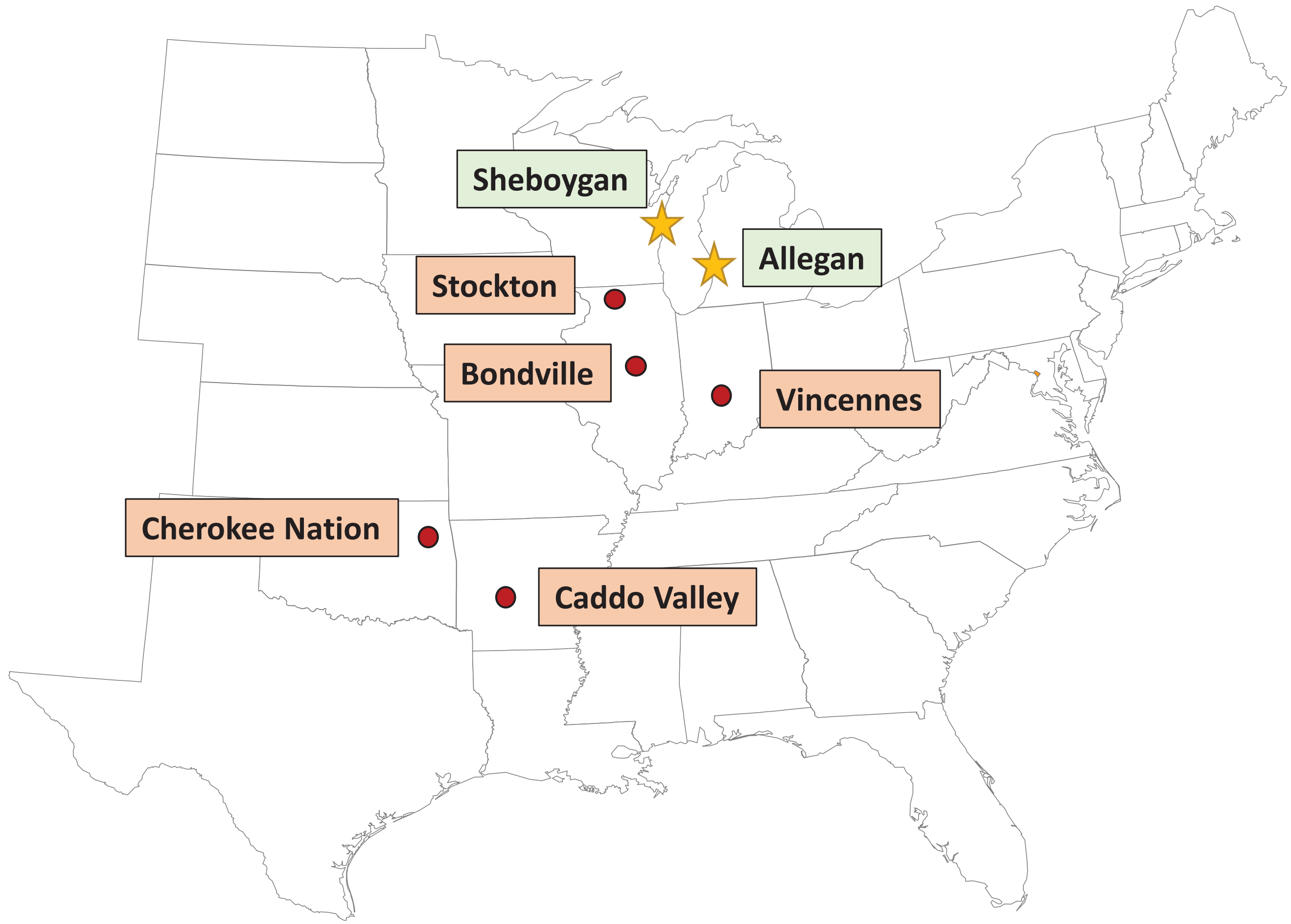
CT Coastal Sites

*Reductions in O3 of less than 1 ppb to an increase of 1 ppb at sites in Coastal CT*

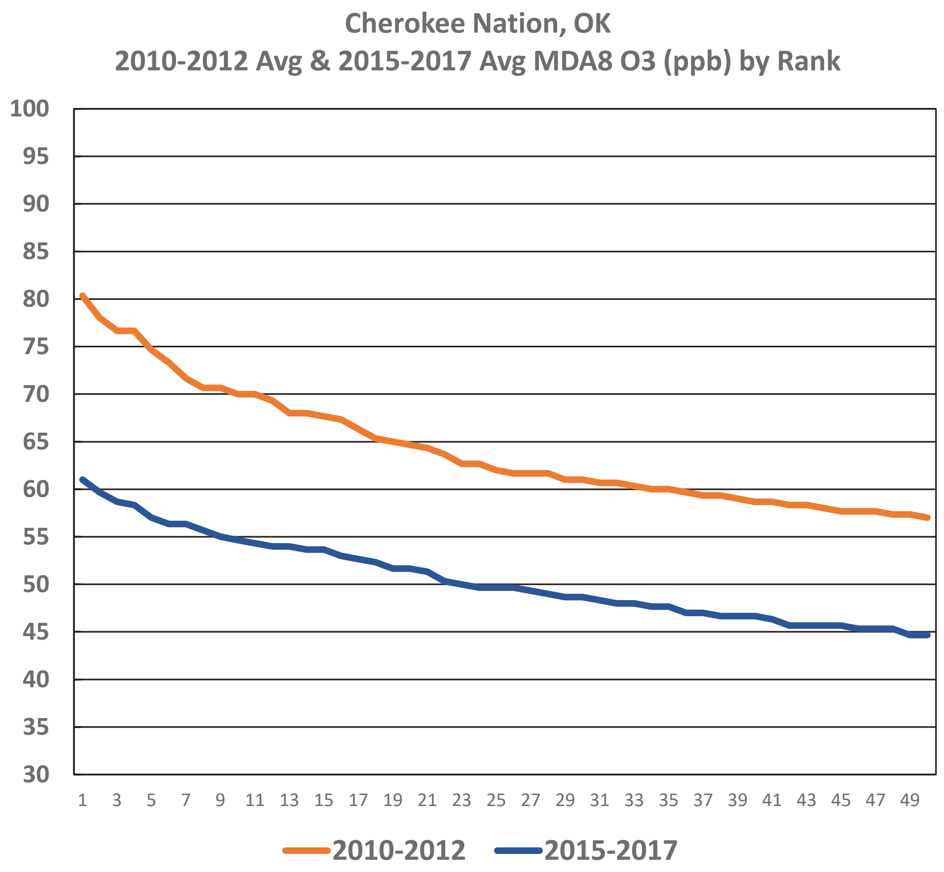
# *Why Does High Ozone Persist at Sites in Coastal CT?*

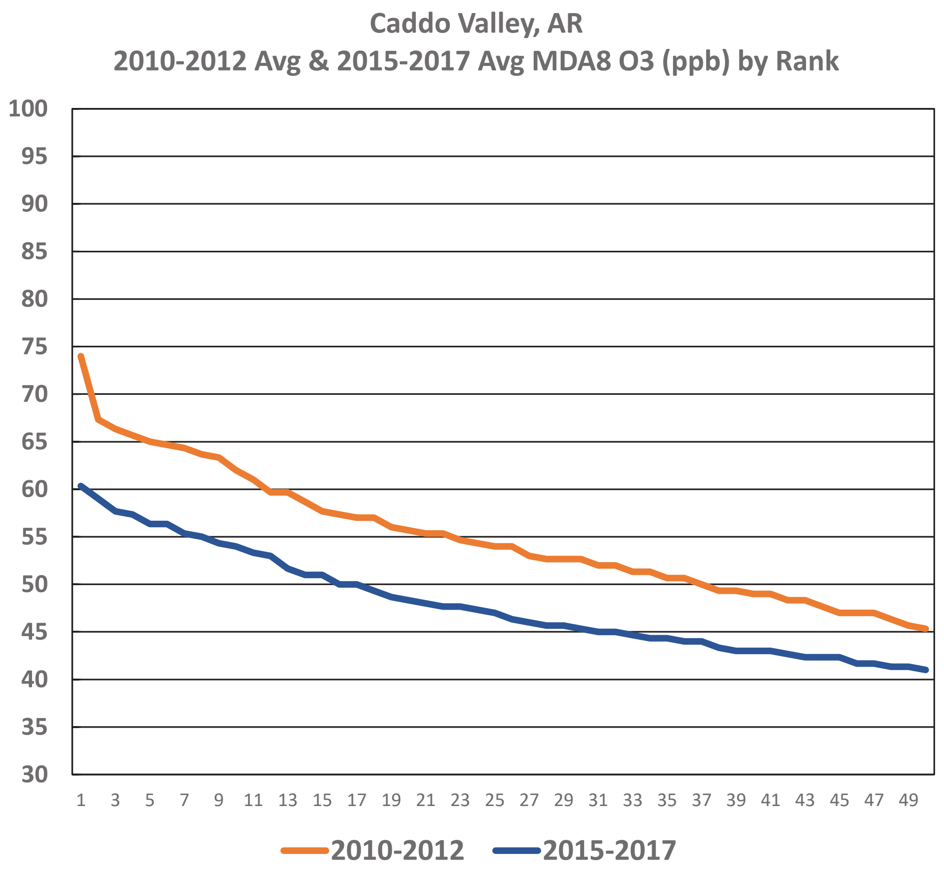
- Possible hypotheses include:
  - The core of the NYC urban area may still be “oxidant-limited” such that the substantial NOx reductions have yet to become fully beneficial
    - Downwind benefits of NOx reductions will become greater as the oxidant-limited area continues to shrink
  - Complex on-shore wind flows and limited vertical mixing associated with coastal meteorology contribute to the formation of high ozone levels in this area
  - The NYC area has higher mobile source emissions than other parts of the OTR, (on-road and non-road sources)
  - A unique mix of local (Tri-State area) contributions from other sources such as EGU, non-EGU point, nonpoint, and commercial marine.
  - “Behind the meter” generation (diesel generators that are not controlled and not in the emissions inventory that operate on hot summer days)
  - Peaking units (HEDD) within the OTR that may operate on mostly on high ozone days.
- Further exploration of the relative contribution from various source sectors within the NE Corridor and in nearby upwind states might also be informative.

## *Analysis of Trends in Ranked MDA8 Ozone Concentrations in Portions of the Midwest and South*

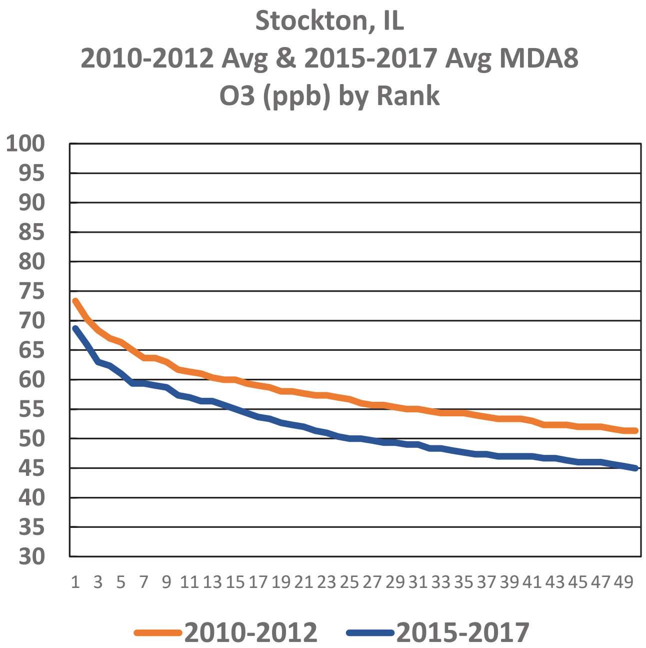

Sheboygan
Allegan
Stockton
Bondville
Vincennes
Cherokee Nation
Caddo Valley

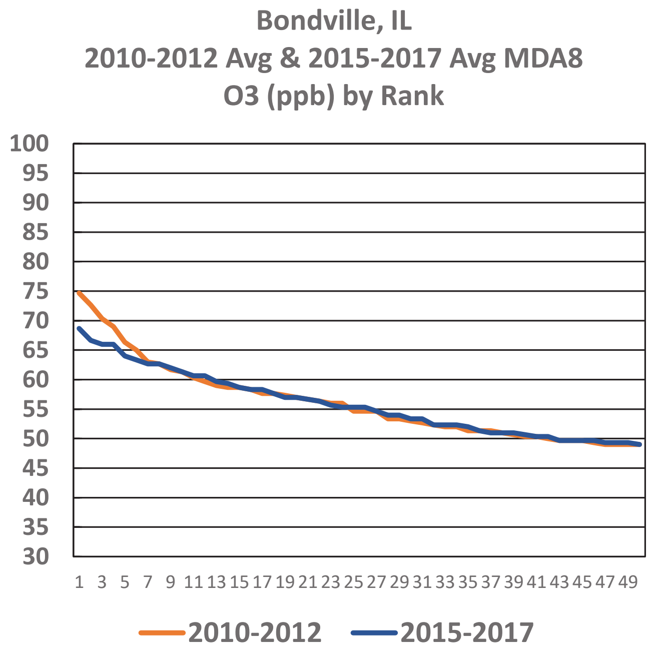
# 3-Year Avg Ranked MDA8 Ozone at Rural Sites Example Rural Sites in the South

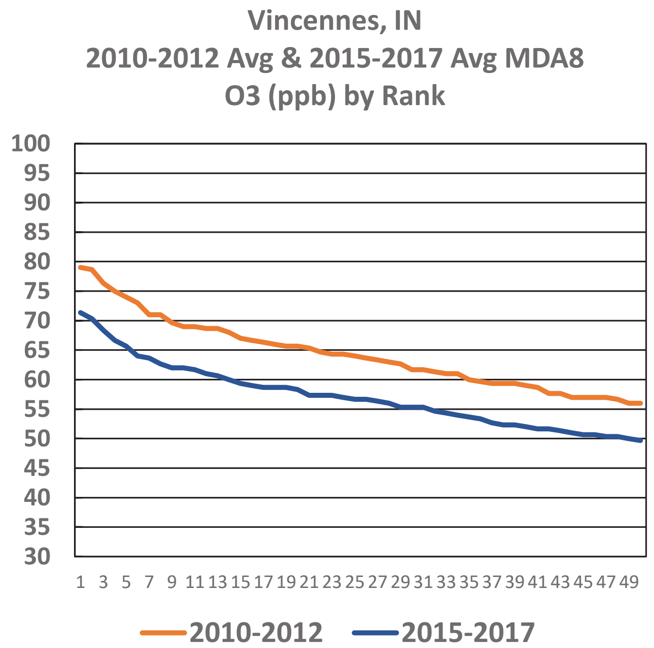


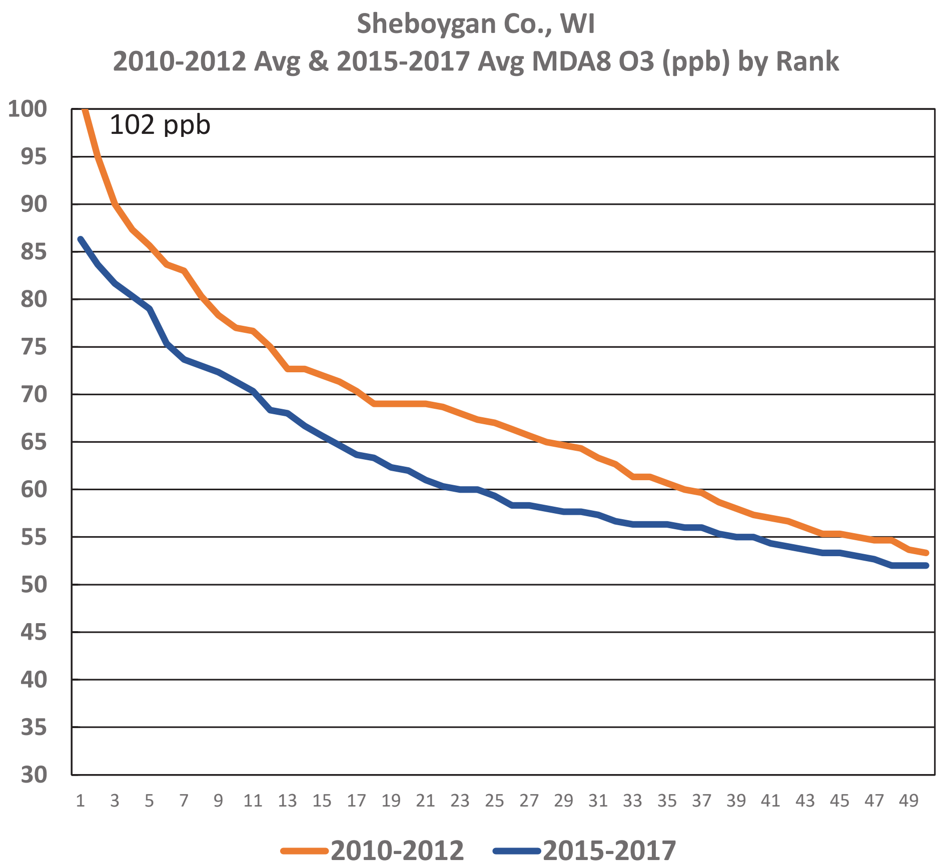



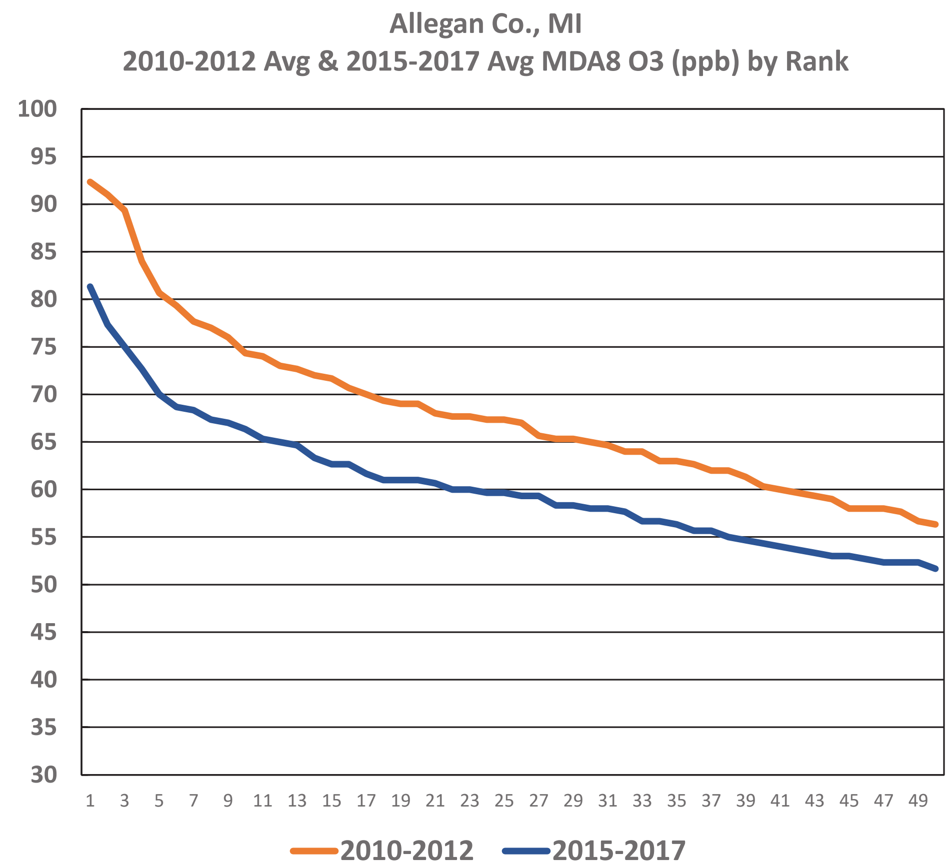
# *3-Year Avg Ranked MDA8 Ozone at Rural Sites*
# *Example Rural Sites in the Midwest*




Sheboygan Co., WI
2010-2012 Avg & 2015-2017 Avg MDA8 O3 (ppb) by Rank
102 ppb
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
2010-2012
2015-2017


Allegan Co., MI
2010-2012 Avg & 2015-2017 Avg MDA8 O3 (ppb) by Rank
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
2010-2012
2015-2017

## *Next Steps*

- Additional analyses of measured and modeled ozone data are planned to more fully understand the role of ozone transport and the relative importance of various source sectors to local ozone formation and transport.

- Collaborate with MJOs/states to help analyze issues which may be contributing to persistent nonattainment problems