# Updated CART Analysis for Ozone through 2008 (PRELIMINARY DRAFT)


## Summary

CART analysis was performed for 11 geographic areas in the LADCO region. Each of the major metropolitan areas is represented, as well as several regions where ozone formation is dominated by transport. Only monitors with continuous records for the 1995 - 2008 period were included. For each geographic area, regression trees were developed that classify each summer day (May-September) by its meteorological conditions. An example regression tree (for Cleveland) is presented in Figure 1. (Regression trees for other cities are provided in Attachment 1.) The splitting criteria for each node are given in the blue boxes. If the condition is true, then follow the left branch; if not, then follow the right branch. Terminal nodes (red boxes) give an average concentration and standard deviation of all the ozone concentrations that fall into that node.

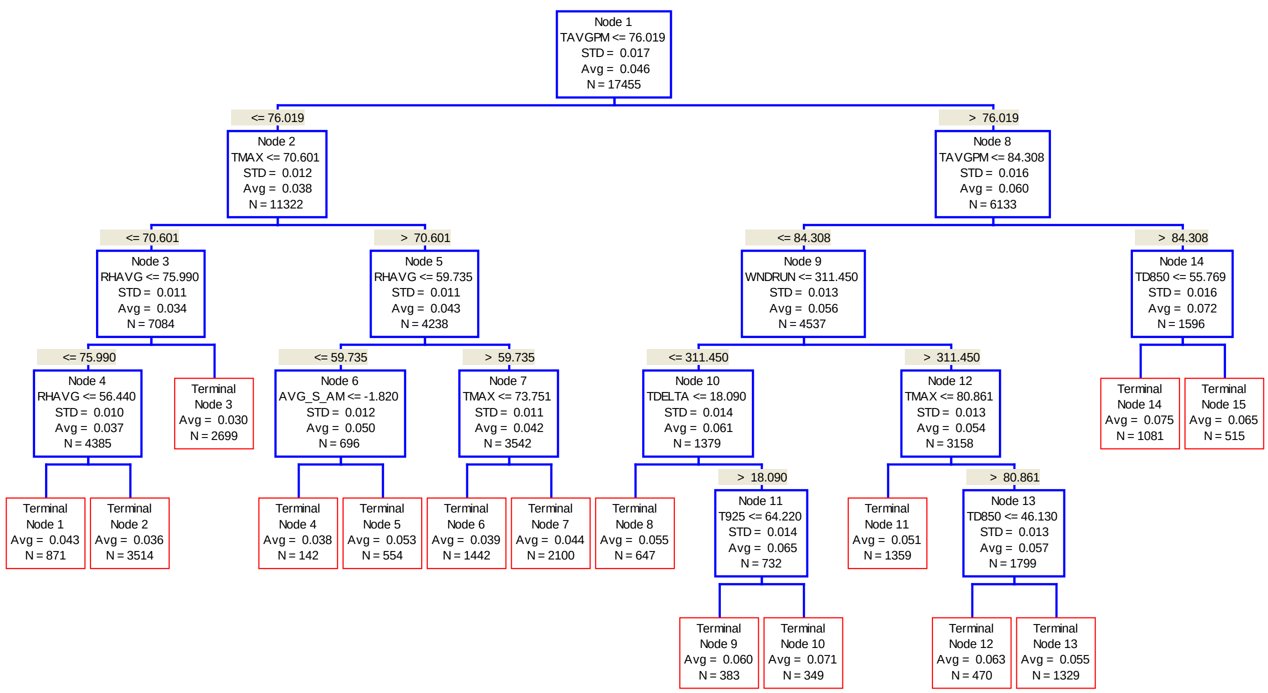




**Figure 1. Regression tree for Cleveland**

No *a priori* selection of important meteorological variables is used to develop the trees; instead, the CART model searches exhaustively through the 60 meteorological variables supplied to determine which are most efficient in predicting ozone. Although the exact selection of predictive variables changes from site to site, the universally common predictors are temperature, wind direction, and relative humidity. These are included in the dataset as daily averages and maximums as well as averages at specific times throughout the day (morning 7-10 am, afternoon 1-4 pm, etc.). Only occasionally did upper air variables, transport time or distance, lake breeze, or other variables become significant. Notably, the Door County site in Wisconsin is one where transport variables are more important than temperature.

Meteorological data are from National Weather Service stations, usually airports. Upper air data are included as well. Because the upper air sites are far fewer in number than surface observation sites, data from the nearest upper air site is matched to each surface site. USEPA provided the meteorological dataset, which was compared to a similar dataset compiled at LADCO and found to be largely identical. The USEPA dataset offered the advantage of some additional variables based on trajectory calculations for each surface station.

Individual nodes represent days with similar meteorological conditions. Ozone trends in these nodes were plotted (see example trend plot for Cleveland in Figure 2 – trend plots for other cities are provided in Attachment 2). By grouping days with similar meteorology, the influence of meteorological variability on the underlying trend in ozone concentrations is partially removed; the remaining trend is presumed to be due to trends in precursor emissions or other non-meteorological influences. Trends in almost all cases were declining or flat.

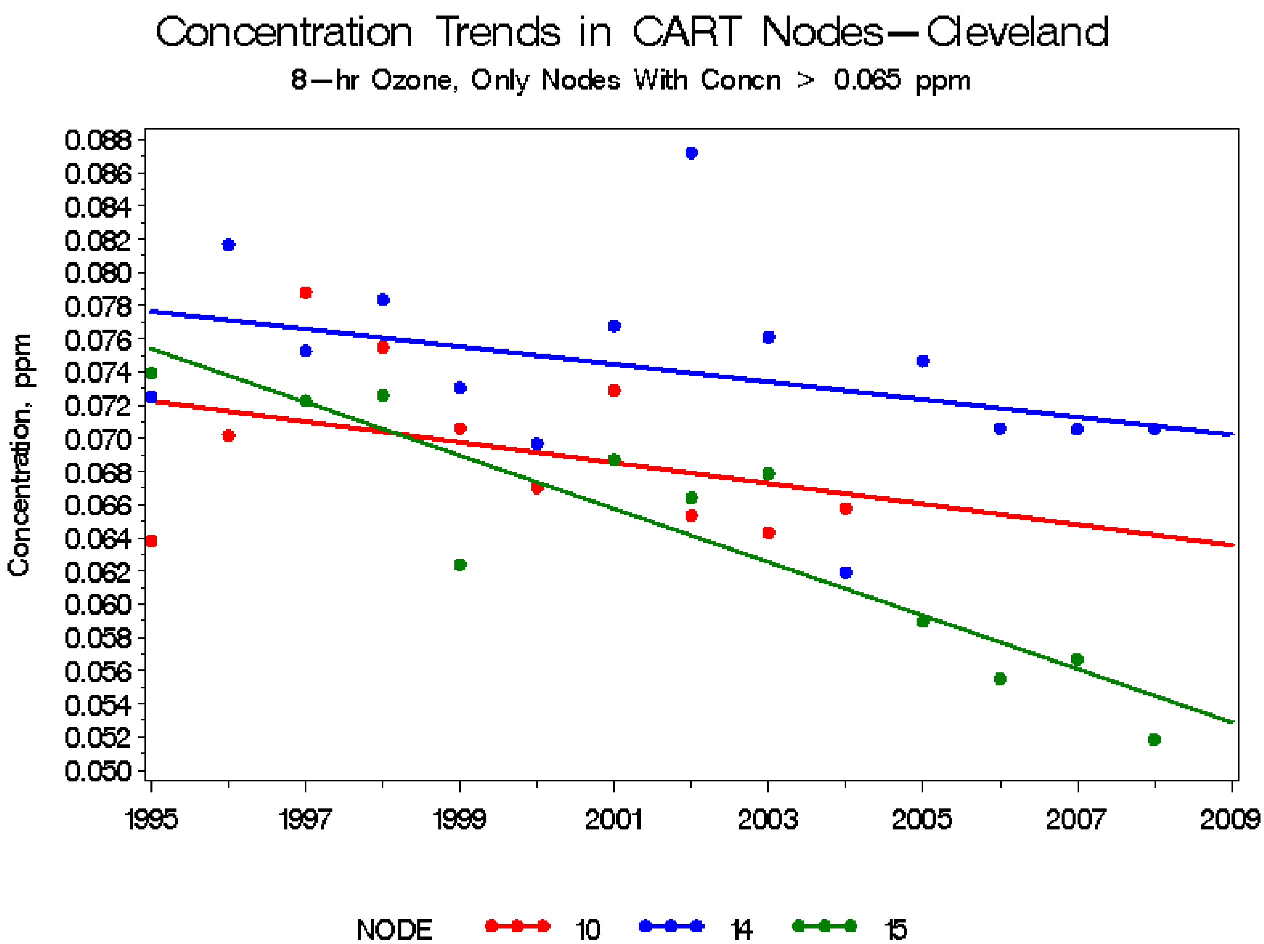



**Figure 2. Trend in higher concentration CART nodes for Cleveland**

The CART results were further examined by developing an index of ozone-conduciveness as a means to compare the propensity of particular years to form ozone. Years with many days characterized by meteorological conditions like high temperatures and low humidity are expected to produce higher ozone concentrations than years with less conducive conditions. An index based on the number of days assigned to high-concentration nodes in each year compared to the average days in those nodes over the 14-year study period should reflect this varying ozone conduciveness. For each geographic region, the index is shown (see example plot for Cleveland in Figure 3 – plots for other cities are provided in Attachment 2). For most sites examined, ozone concentrations in the most recent years are lower than previous years, even when the ozone index indicates the meteorological conditions were similar to those in previous years. This is a possible indication that regional NOx controls implemented under the NOx SIP call, which were largely completed by 2004, have been effective in reducing ozone.

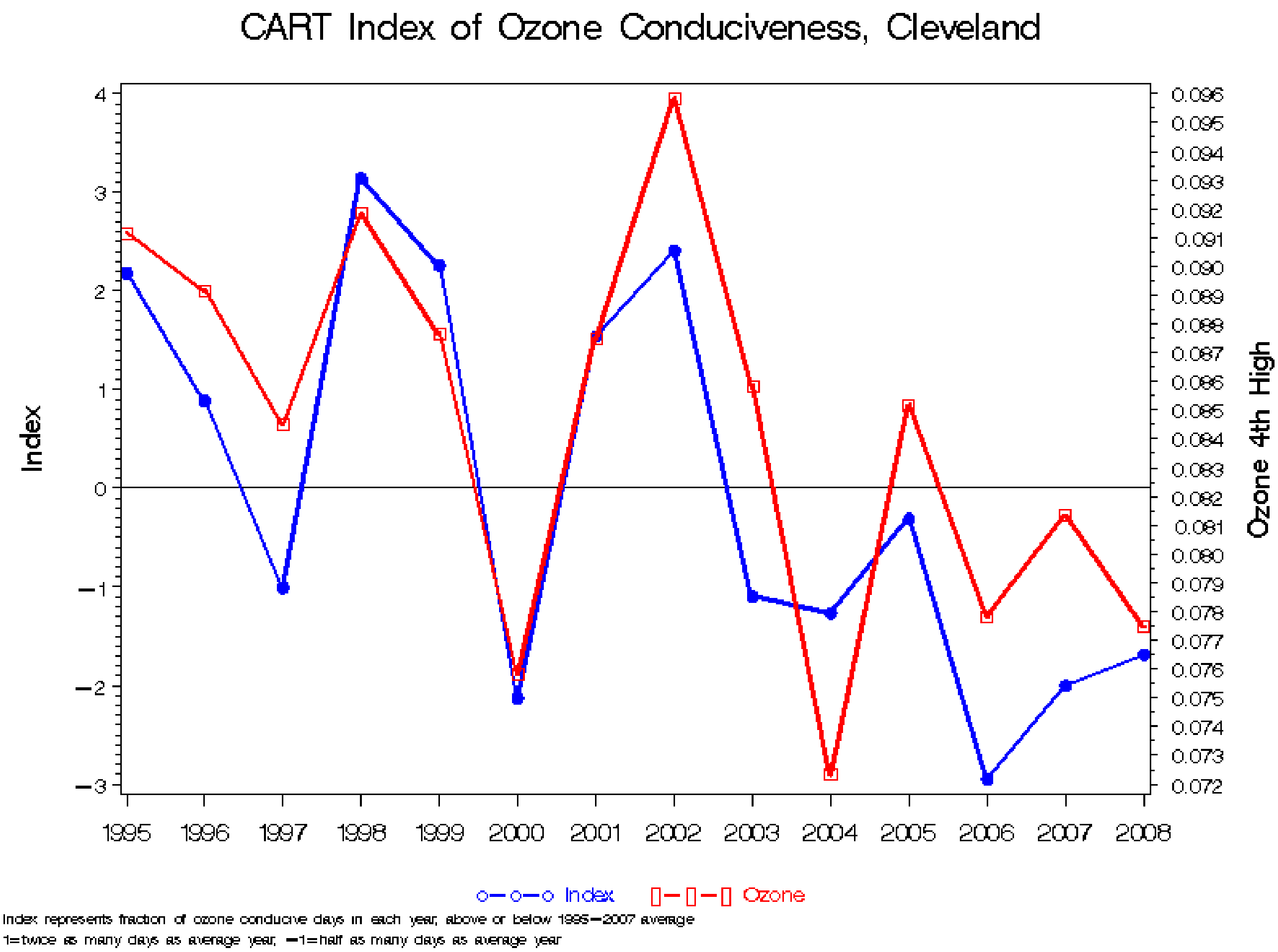
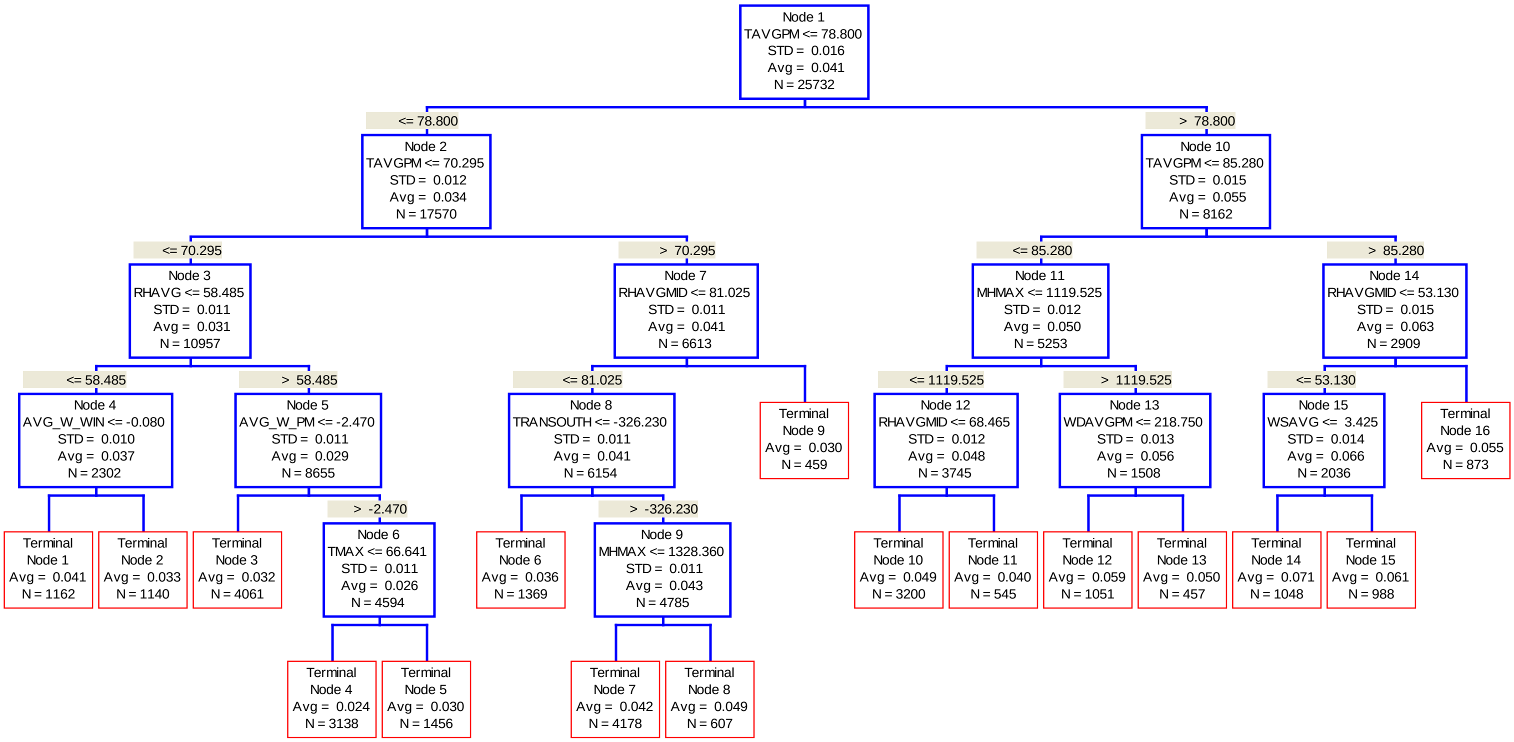


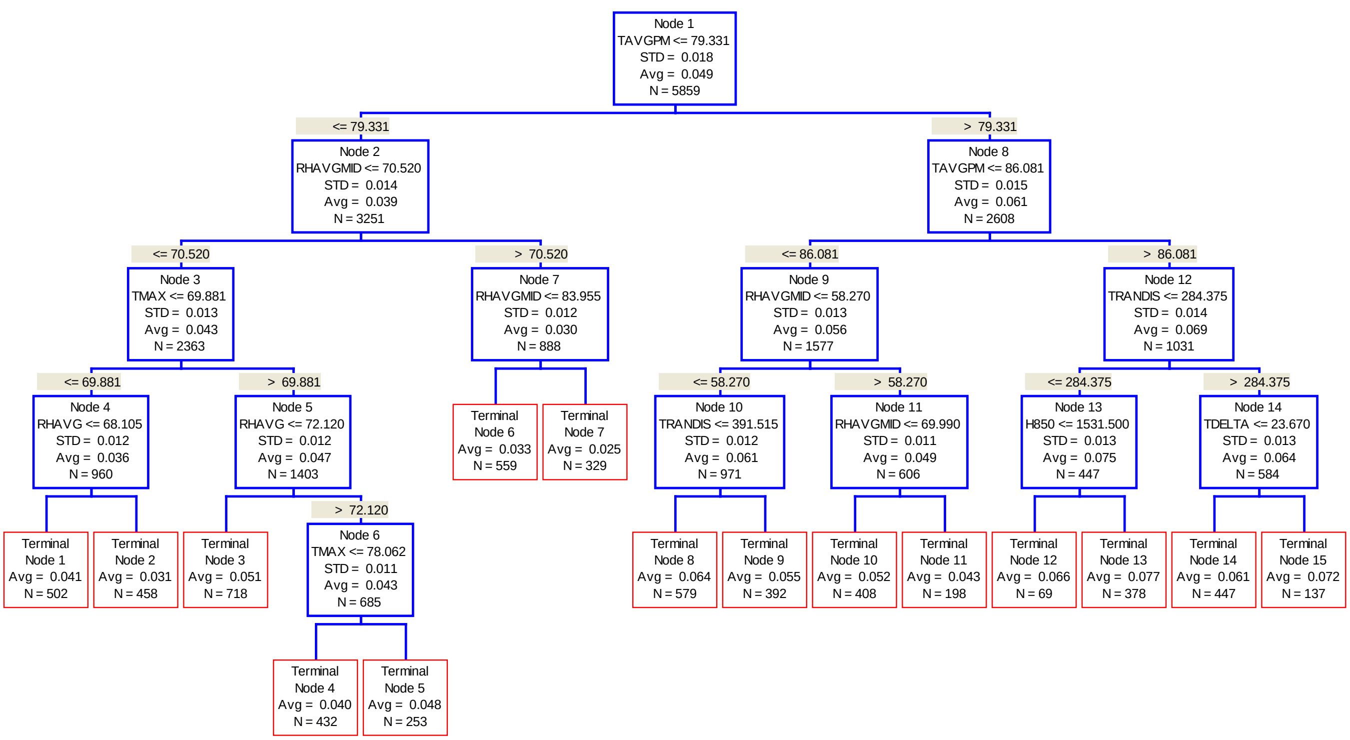

**Figure 3. Trend in ozone conduciveness index for Cleveland**

# Attachment 1
# Regression Trees

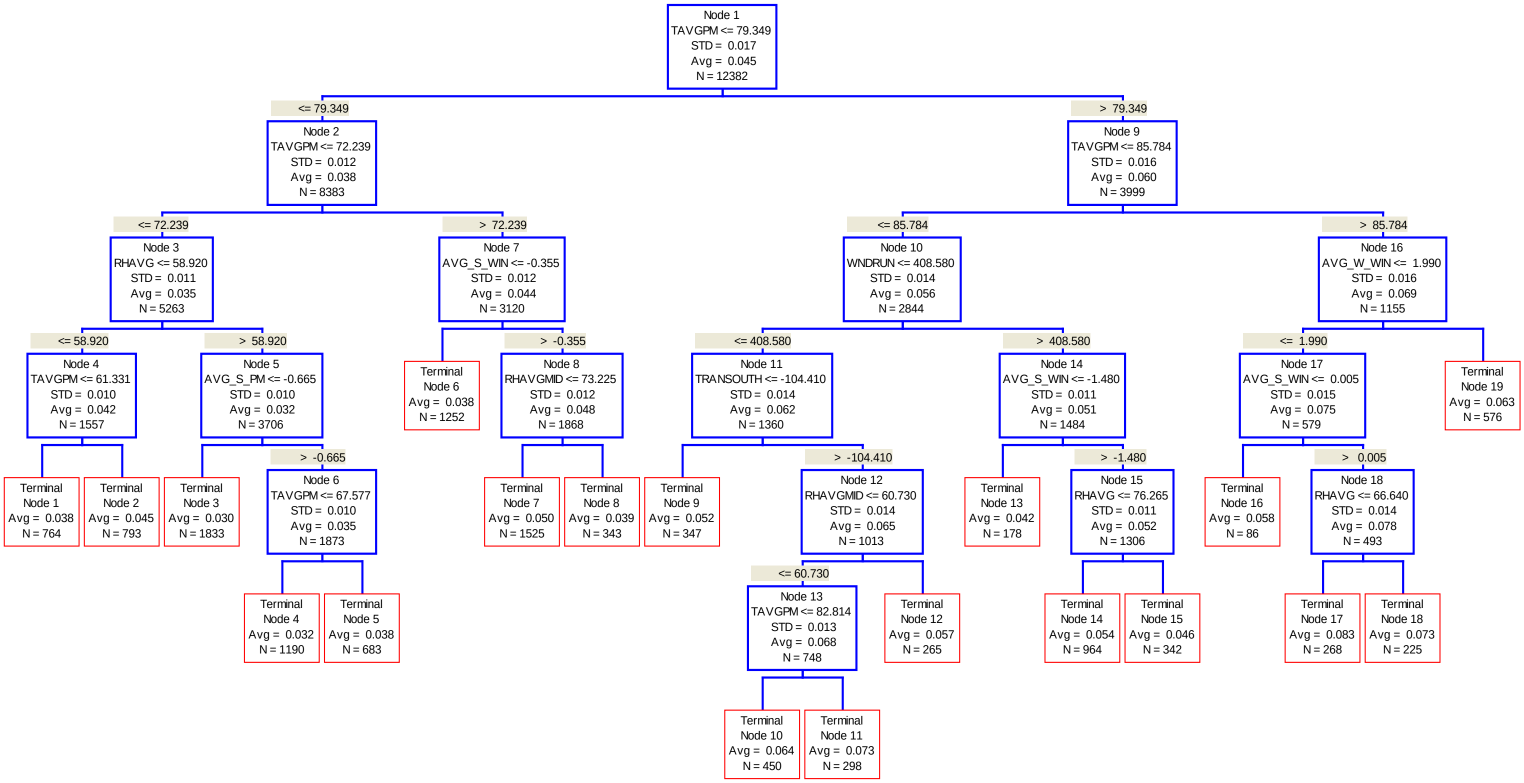
## Chicago



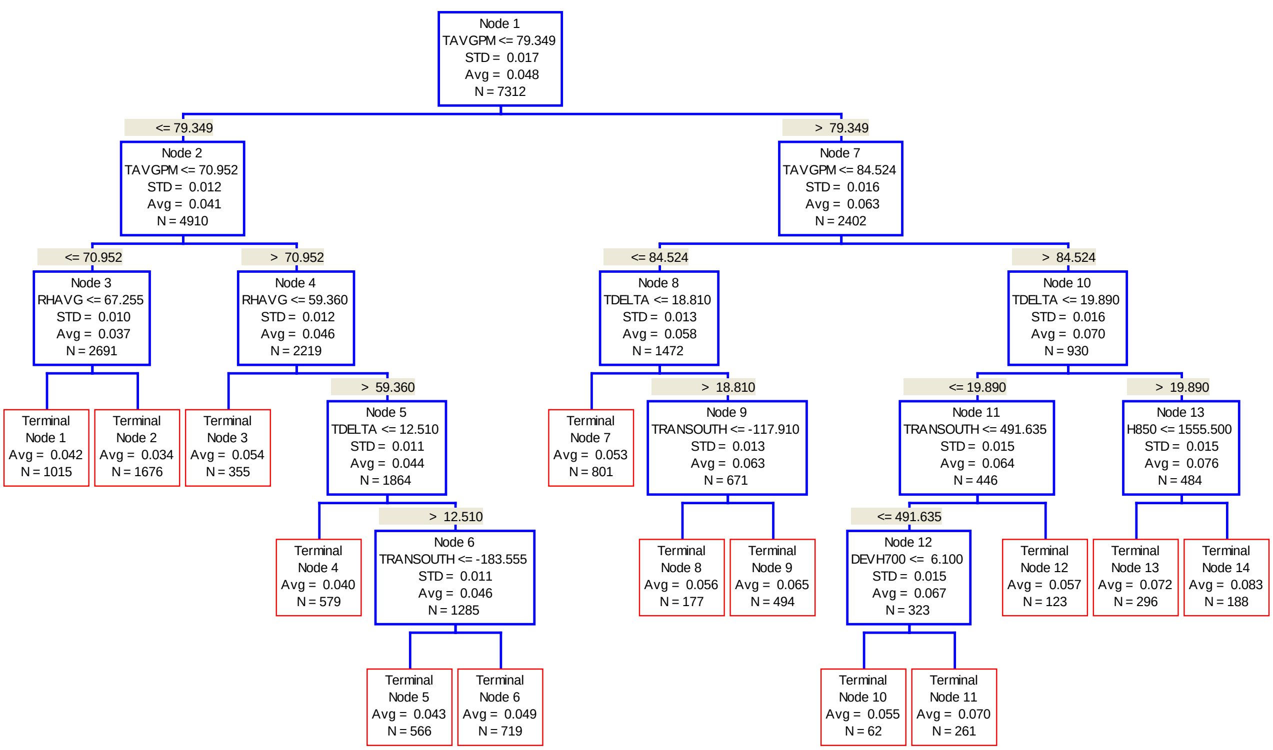

## Cincinnati



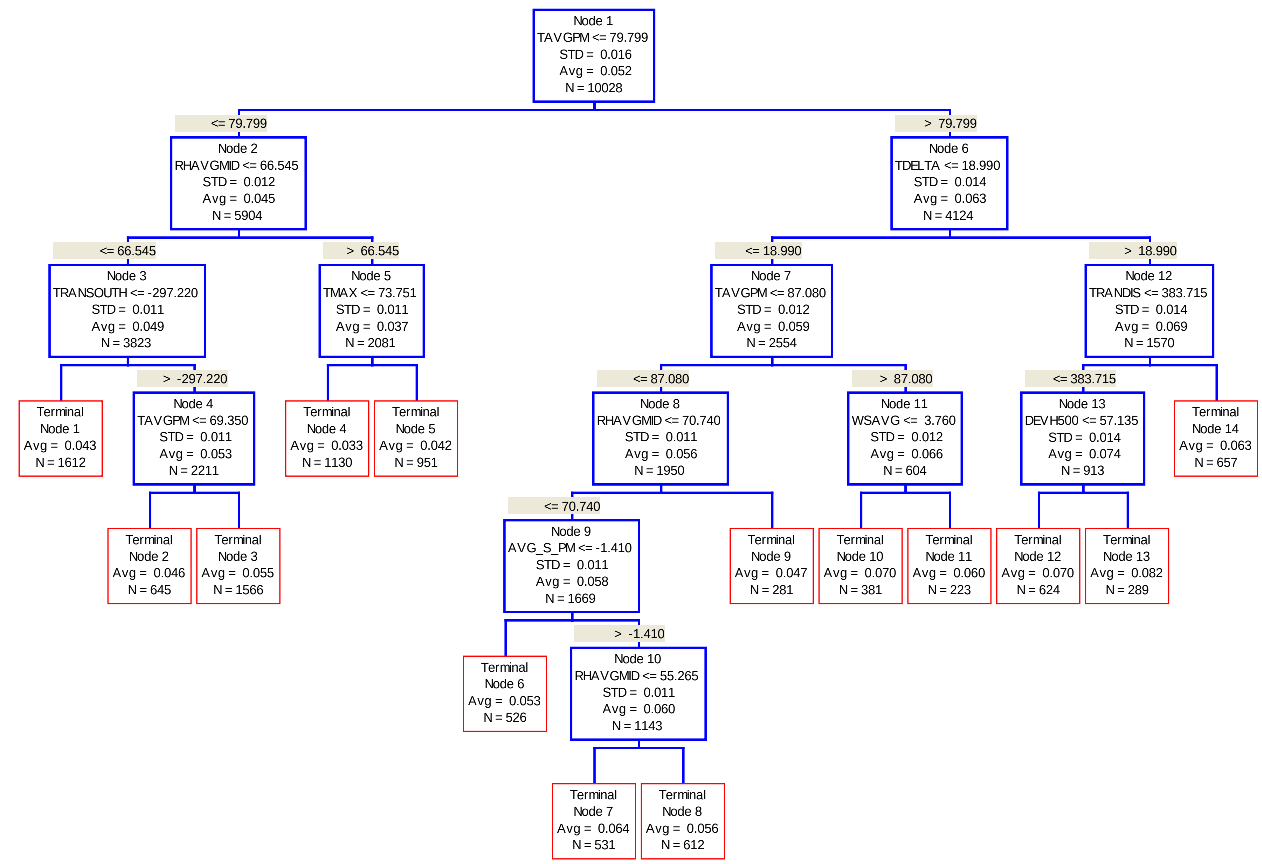
## Detroit



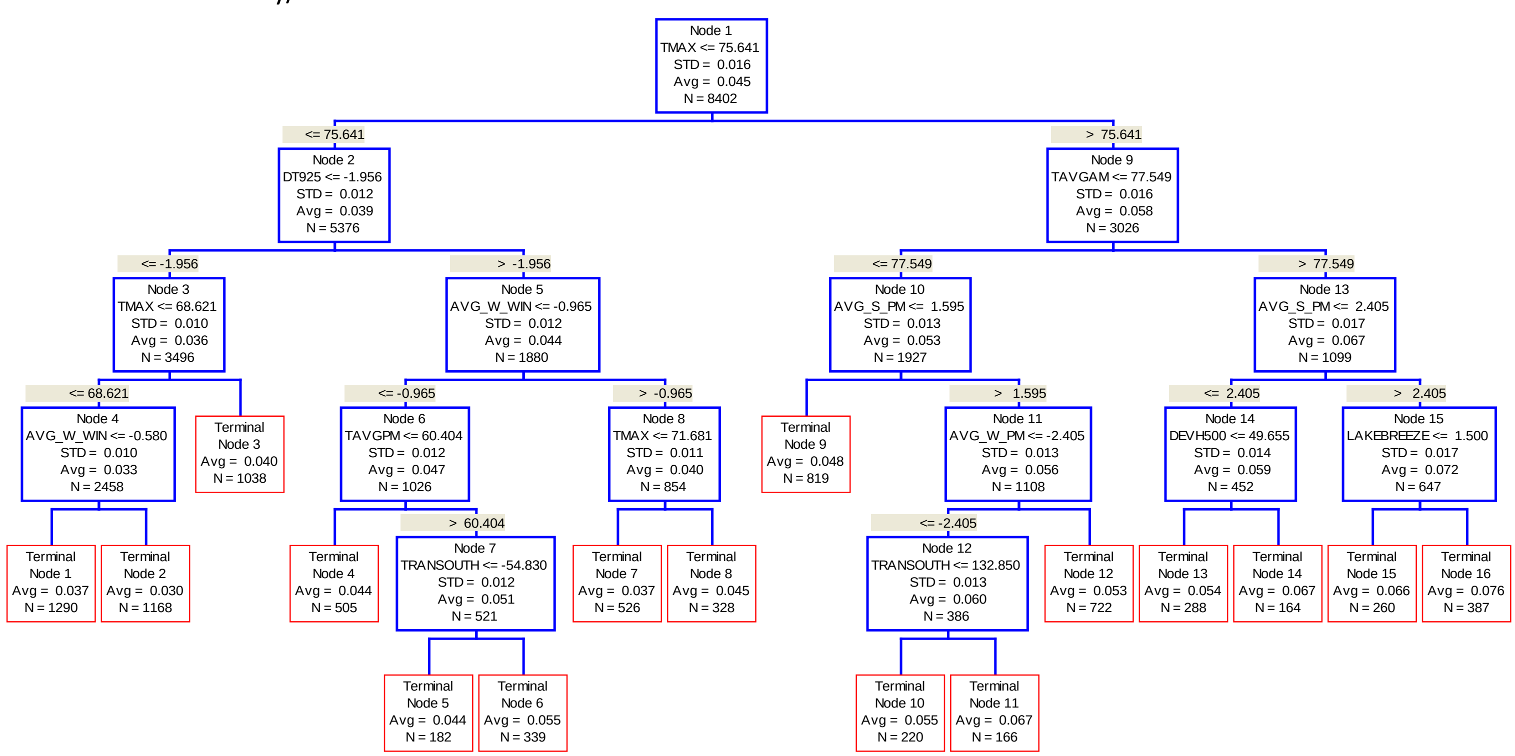

## Indiana - Lakeshore



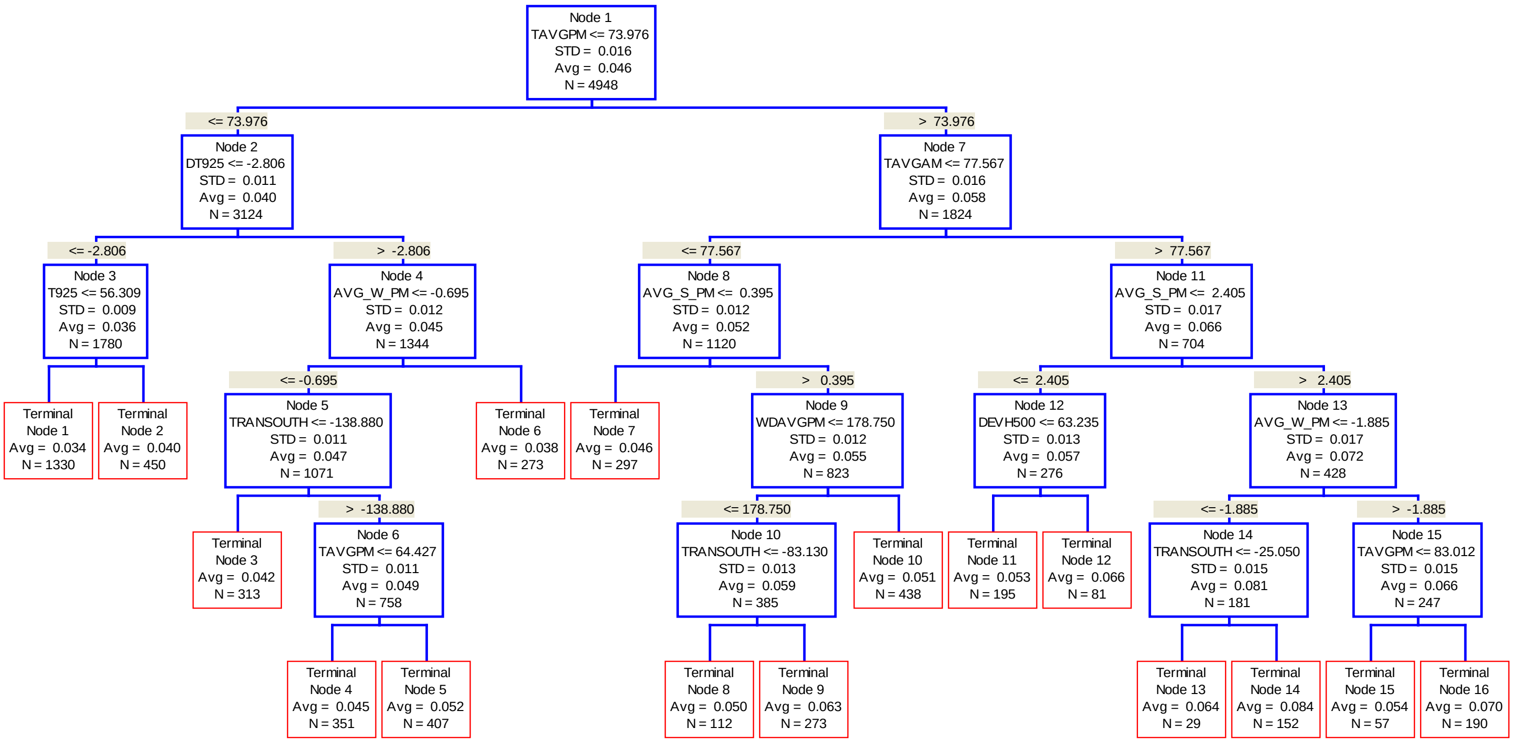
## Indianapolis



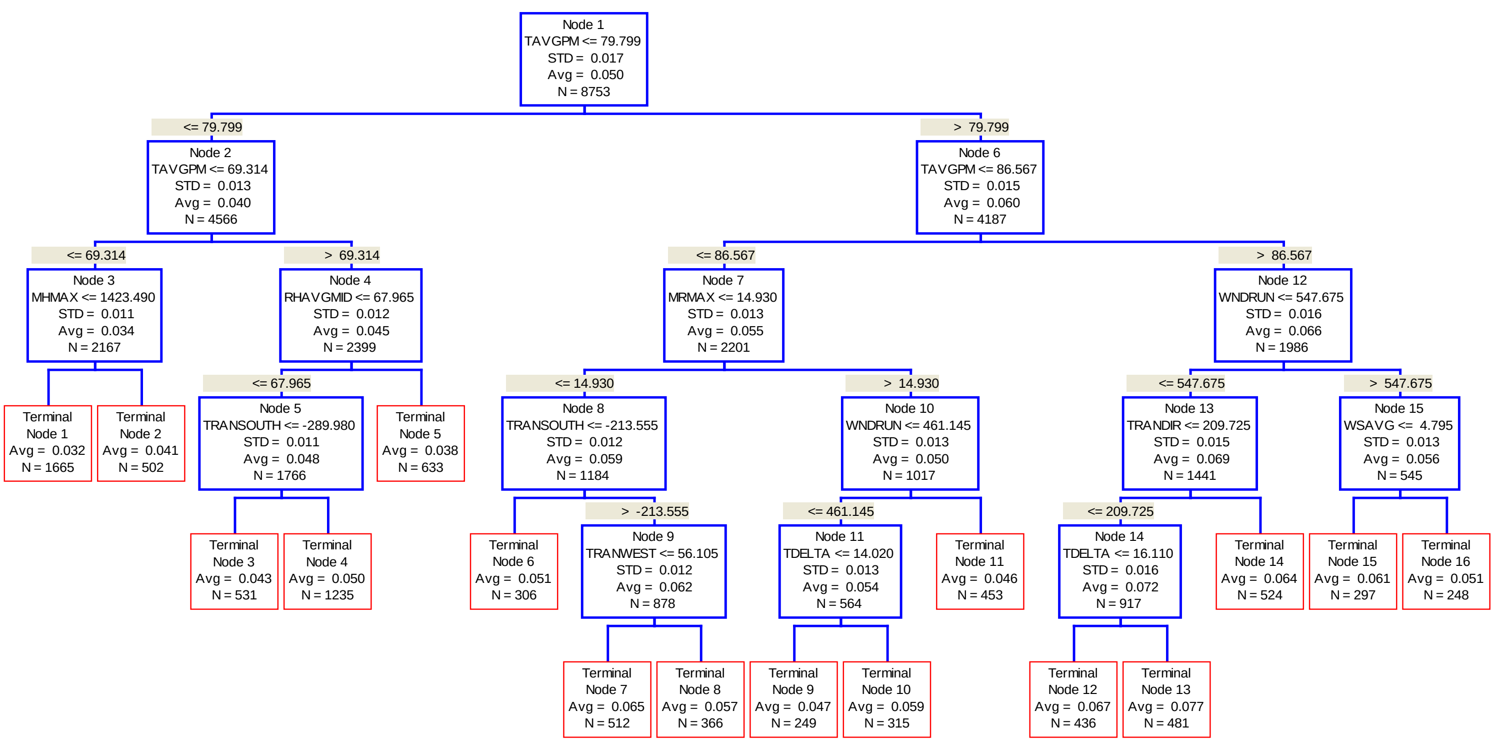

## NE Illinois – Lake County/Chiwaukee



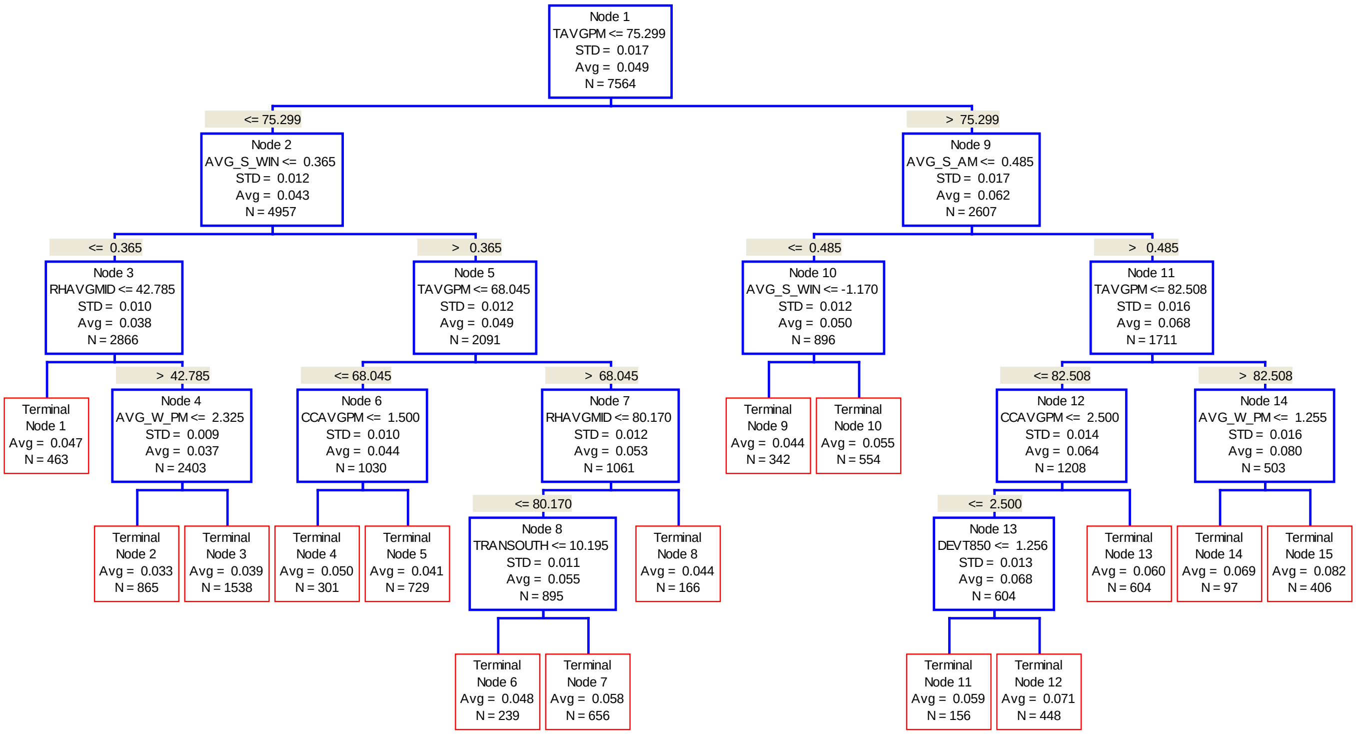
## Milwaukee



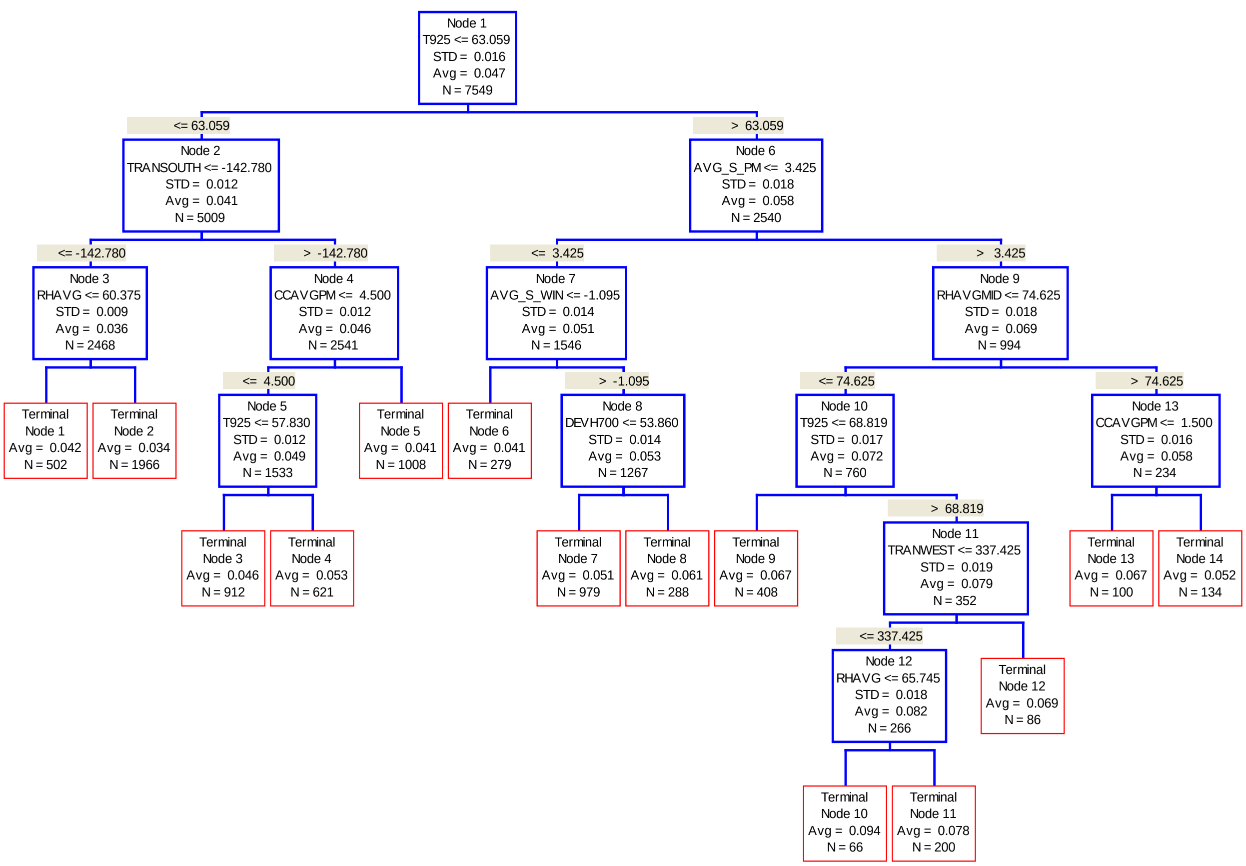

## St.Louis



## W. Michigan

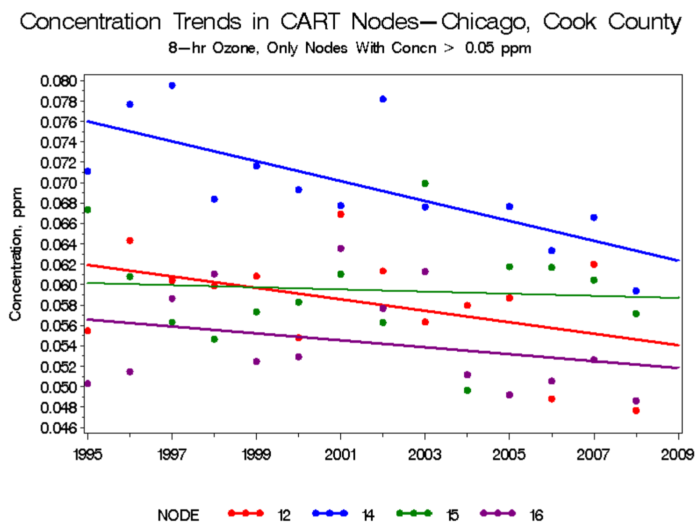


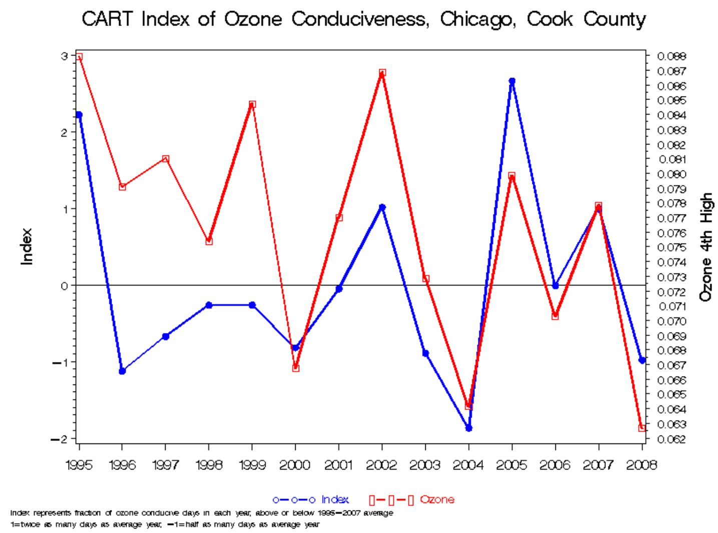

## WI Shoreline

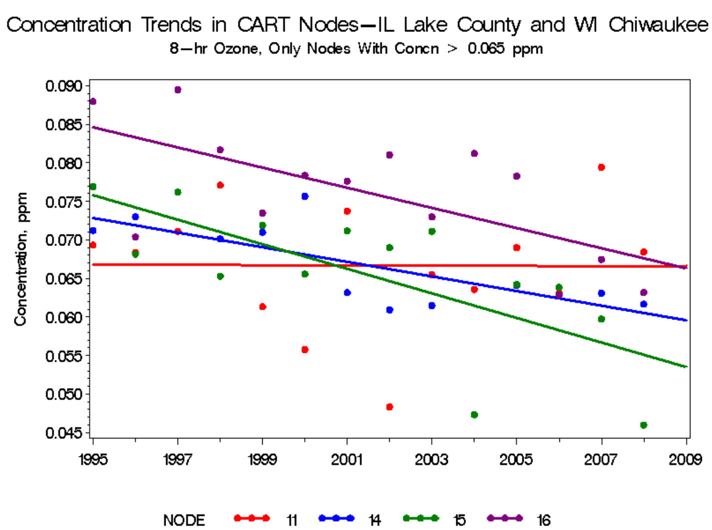


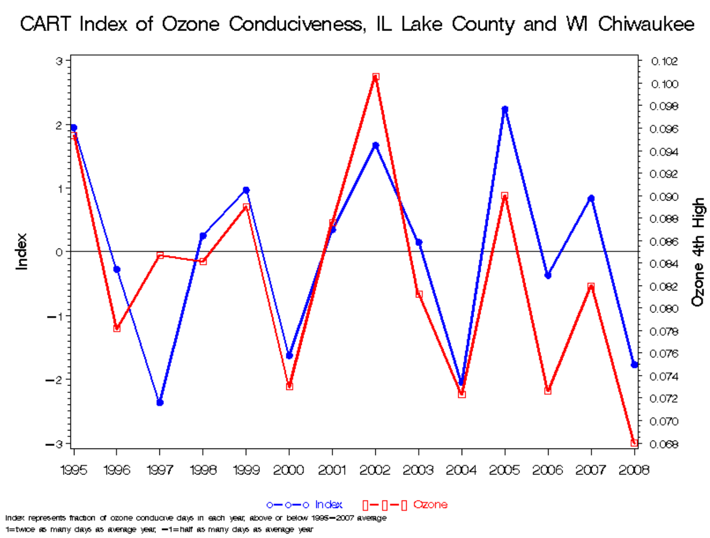
## Attachment 2
## Trends in Higher Concentration CART Nodes and Ozone Conduciveness Index

Ozone trends in CART nodes (each trend line depicts average ozone concentrations on meteorologically similar days) and ozone-conducive Index. Blue line shows the ozone index, where higher values mean more days with ozone conducive conditions and lower values mean fewer days with ozone conducive conditions. The red line plots the 4th-high ozone concentration each year at the site.



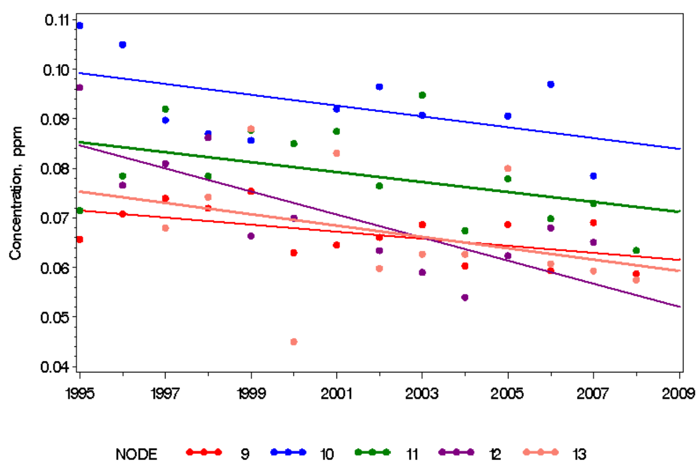



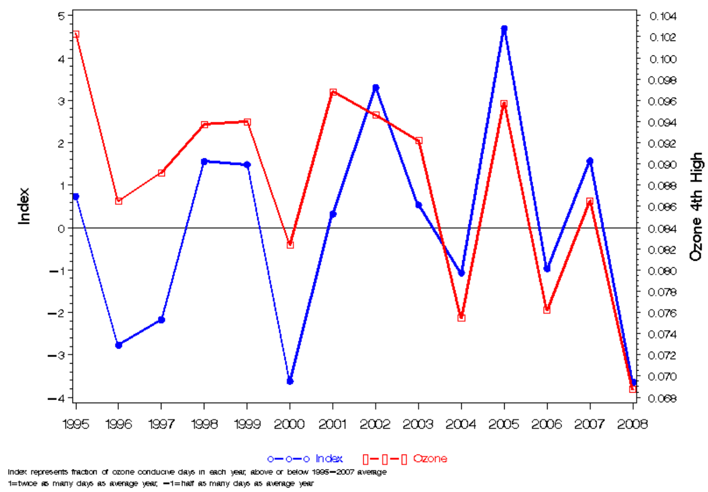



Concentration Trends in CART Nodes—Wisconsin Shoreline Monitors

8—hr Ozone, Only Nodes With Concn > 0.065 ppm

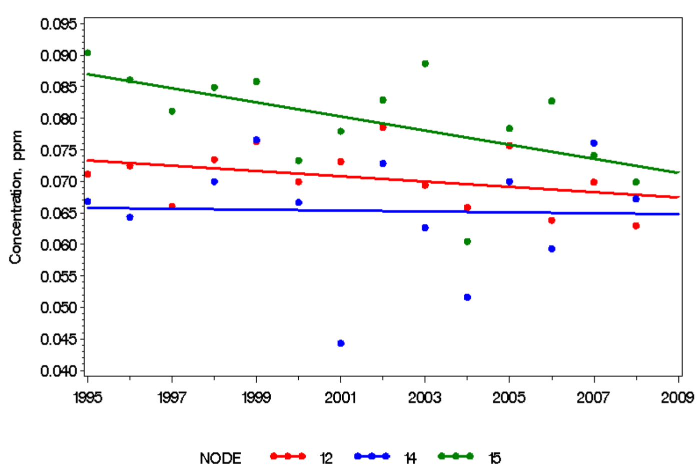



CART Index of Ozone Conduciveness, Wisconsin Shoreline Monitors

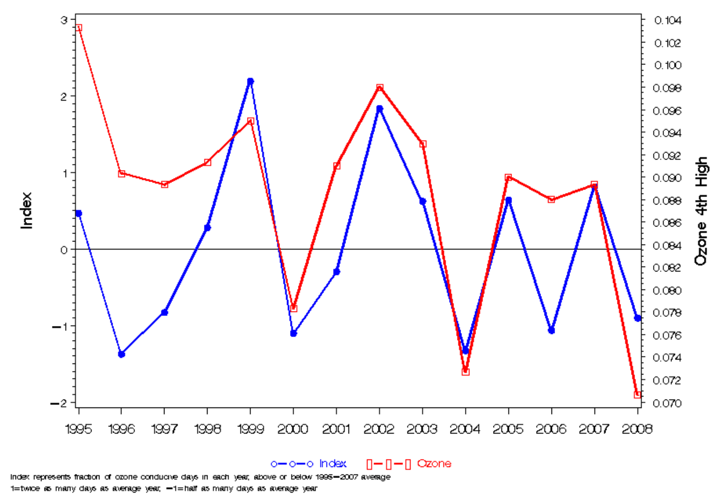



Concentration Trends in CART Nodes—Western Michigan

8—hr Ozone, Only Nodes With Concn > 0.065 ppm

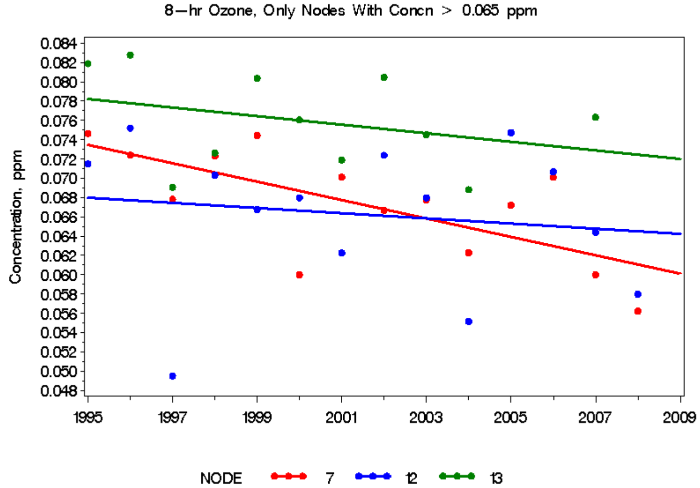



CART Index of Ozone Conduciveness, Western Michigan

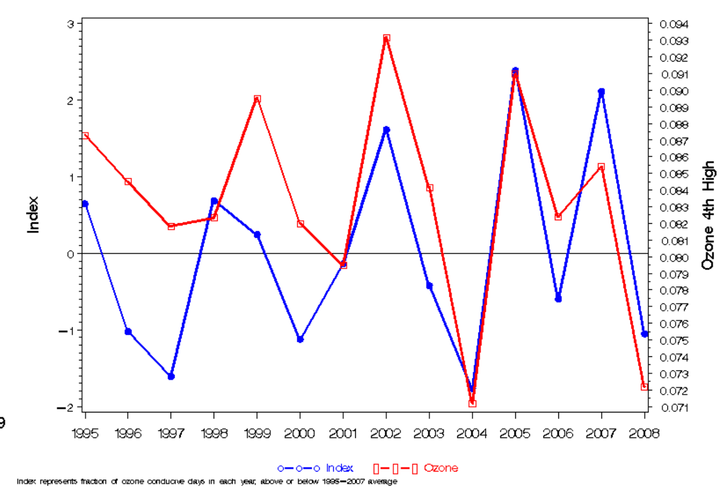


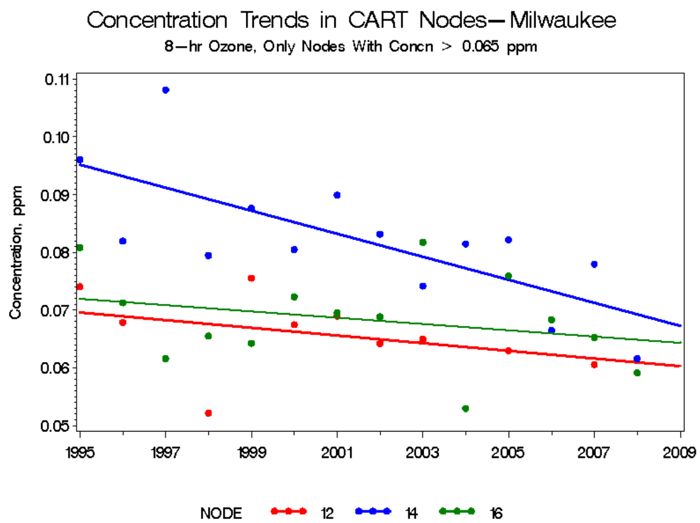

Concentration Trends in CART Nodes—St. Louis

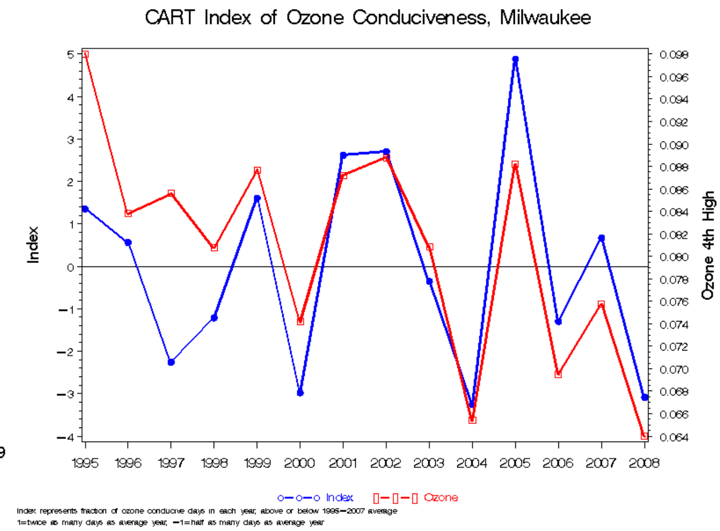
8—hr Ozone, Only Nodes With Concn > 0.065 ppm

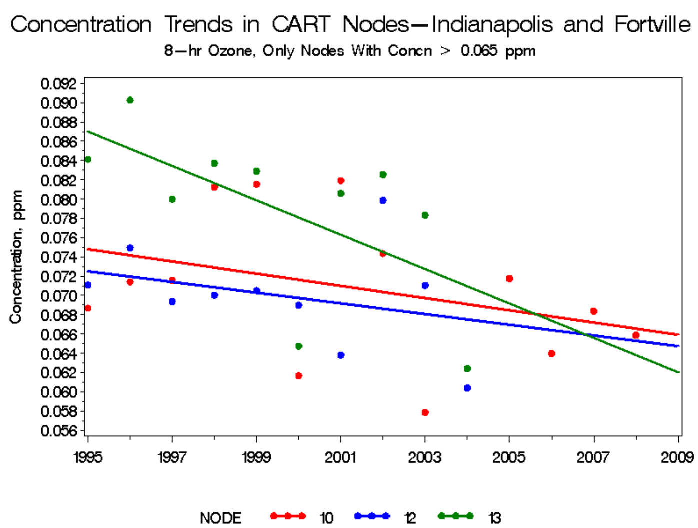


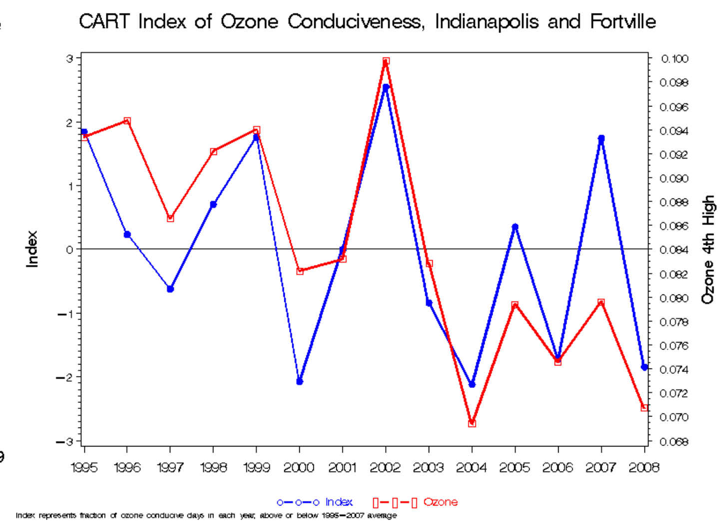

CART Index of Ozone Conduciveness, St. Louis




Concentration Trends in CART Nodes—Milwaukee
8—hr Ozone, Only Nodes With Concn > 0.065 ppm
Concentration, ppm
NODE 12 14 16


CART Index of Ozone Conduciveness, Milwaukee
Index
Ozone 4th High
Index Ozone
Index represents fraction of ozone conducive days in each year, above or below 1995—2007 average
1=twice as many days as average year; −1=half as many days as average year


Concentration Trends in CART Nodes—Indianapolis and Fortville
8—hr Ozone, Only Nodes With Concn > 0.065 ppm
Concentration, ppm
NODE 10 12 13


CART Index of Ozone Conduciveness, Indianapolis and Fortville
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Ozone 4th High
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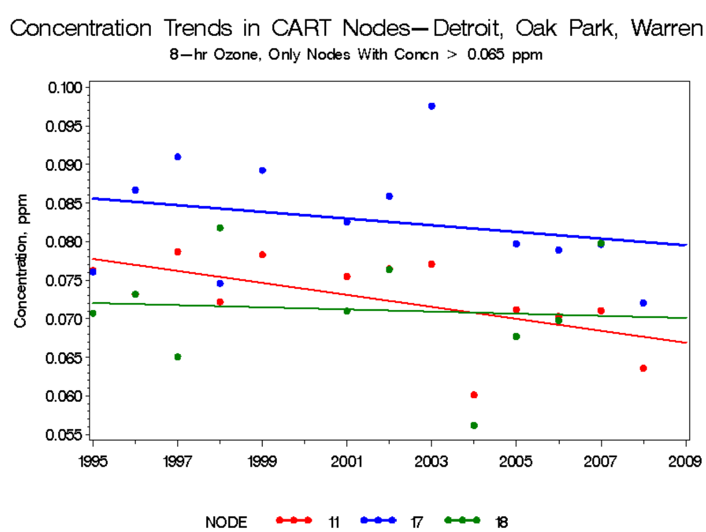
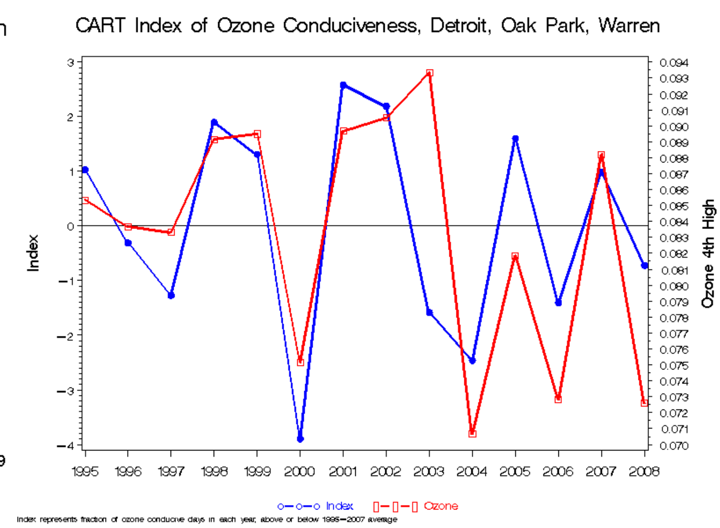

Concentration Trends in CART Nodes—Detroit, Oak Park, Warren
8—hr Ozone, Only Nodes With Concn > 0.065 ppm
Concentration, ppm
NODE 11 17 18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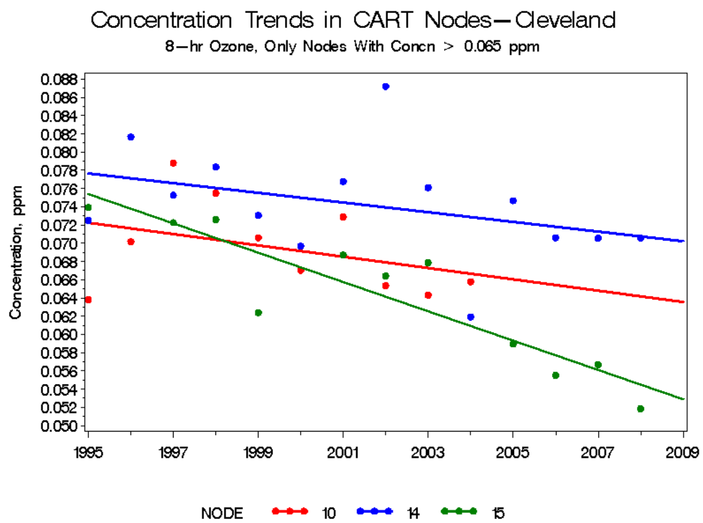
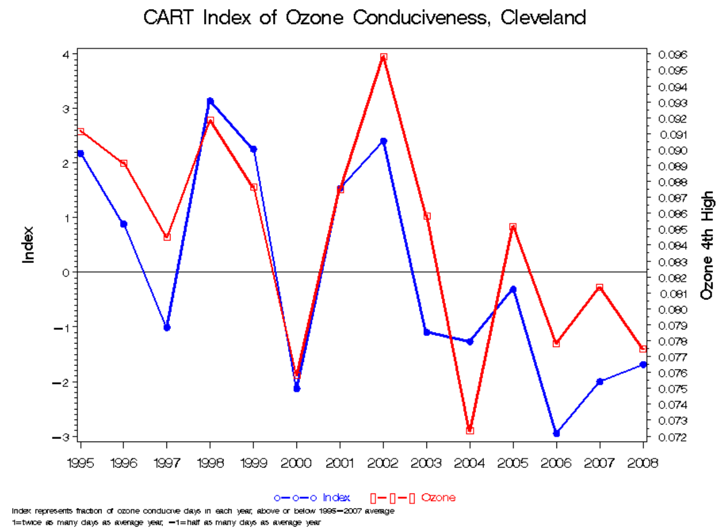

Concentration Trends in CART Nodes—Cleveland
8—hr Ozone, Only Nodes With Concn > 0.065 ppm
Concentration, ppm
NODE 10 14 15


CART Index of Ozone Conduciveness, Cleveland
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Ozone 4th High
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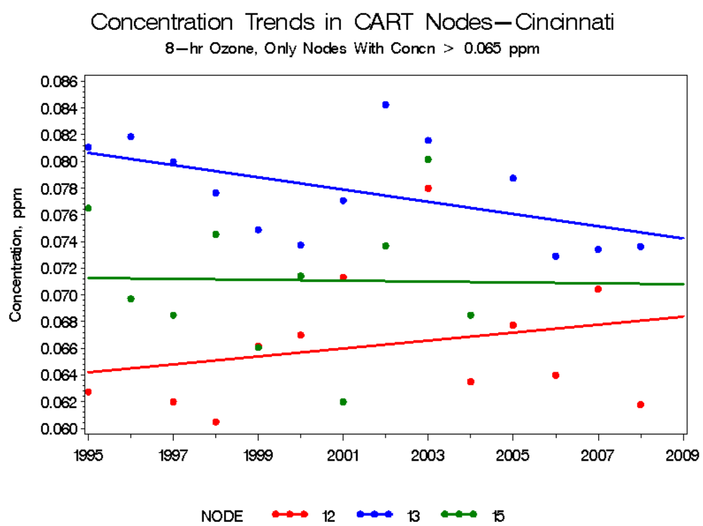
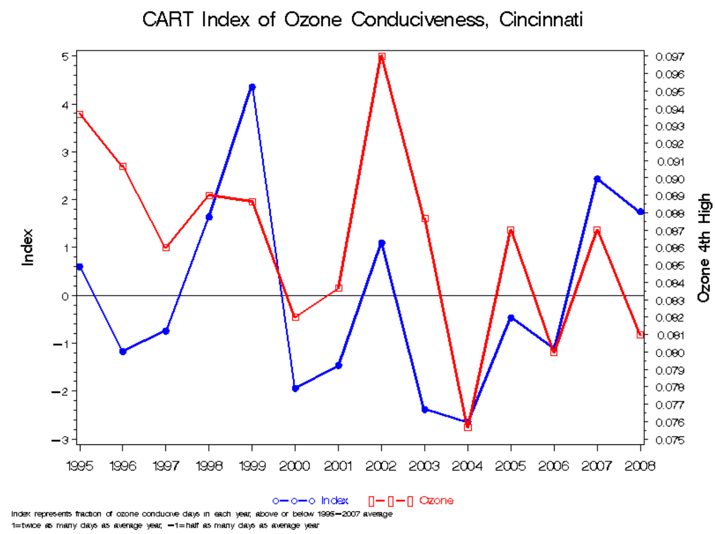

Concentration Trends in CART Nodes—Cincinnati
8—hr Ozone, Only Nodes With Concn > 0.065 ppm
Concentration, ppm
NODE 12 13 15


CART Index of Ozone Conduciveness, Cincinnati
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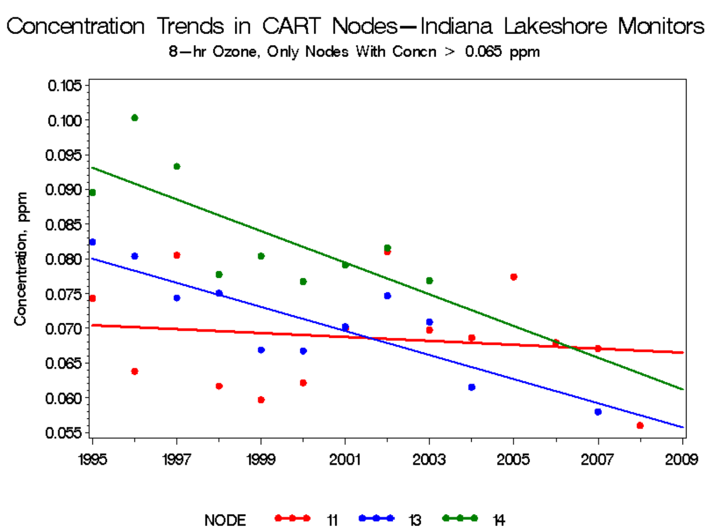
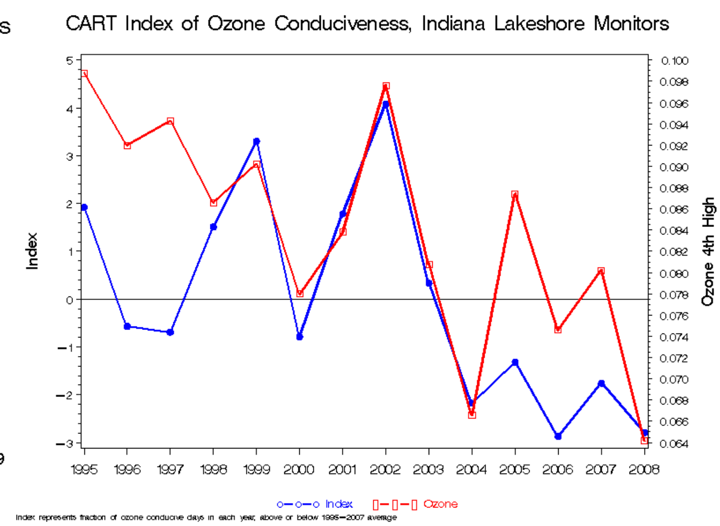

Concentration Trends in CART Nodes—Indiana Lakeshore Monitors
8—hr Ozone, Only Nodes With Concn > 0.065 ppm
Concentration, ppm
NODE 11 13 14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