

2006 PM_{2.5} and Ozone Update: Trends and Meteorological Representativeness

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Lake Michigan Air Directors Consortium
Presented at Regional Air Quality Meeting,
March 21, 2007

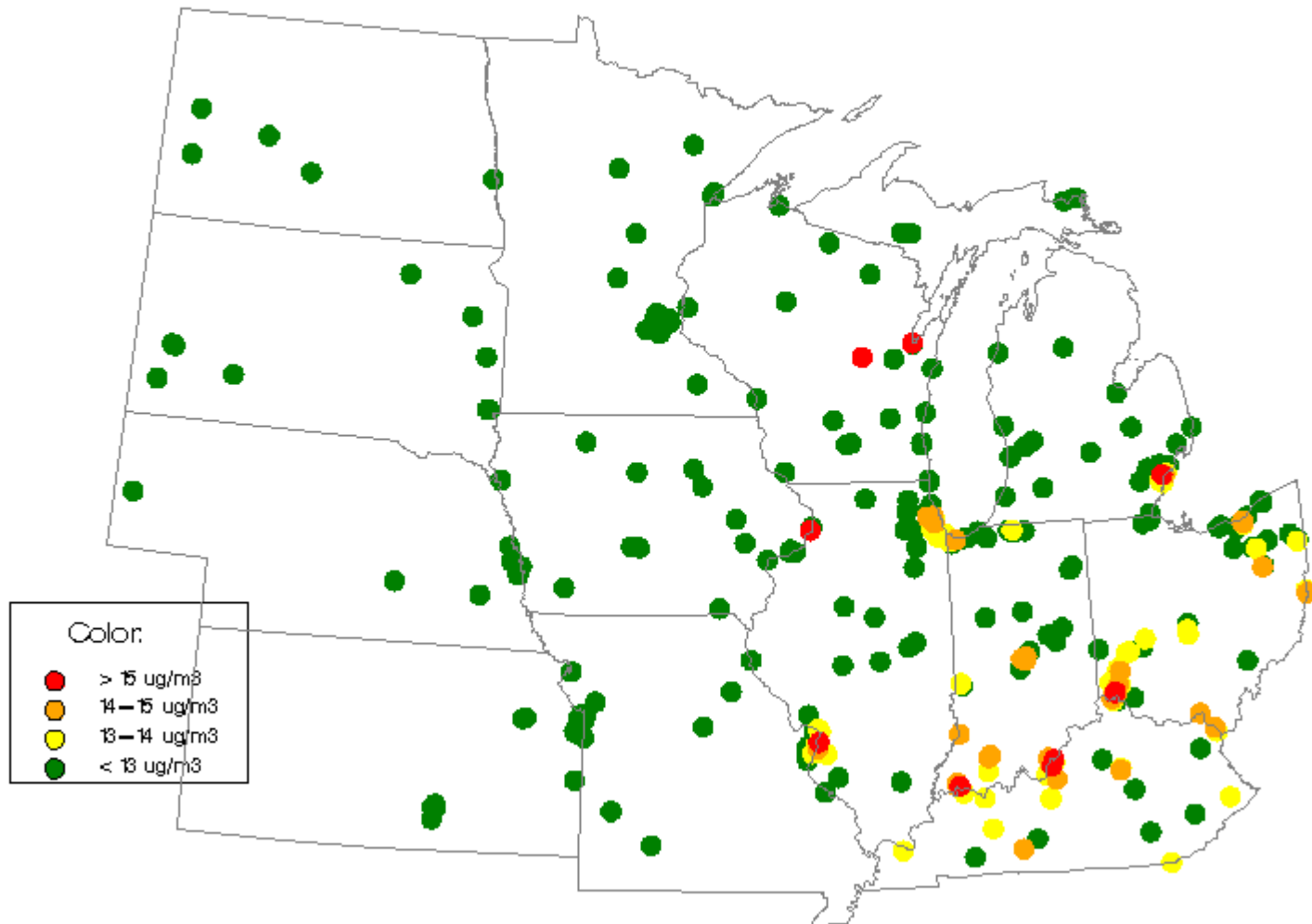


Goals

- Summarize 2006 PM2.5 and ozone concentrations, examine trends
- Grow CART tree for each urban area, using basic meteorological variables to explain ozone concentrations--result is 10-15 bins of days, where each bin characterized by a typical ozone concentration and met conditions
- Examine concentration trends in meteorologically adjusted bins
- Use bins to develop an index of representativeness to compare years – how ‘average’ was 2006?

PM2.5 FRM Mean Concentration, 2006

Preliminary results based on incomplete data

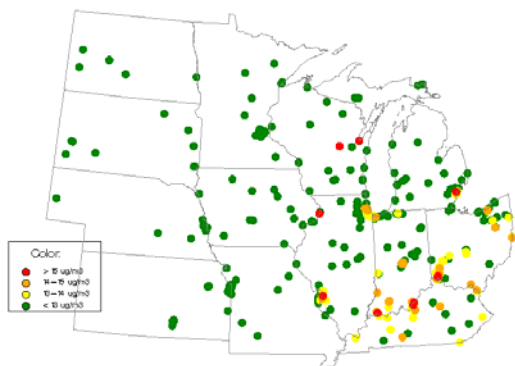


Annual Average PM2.5 by Year

2006

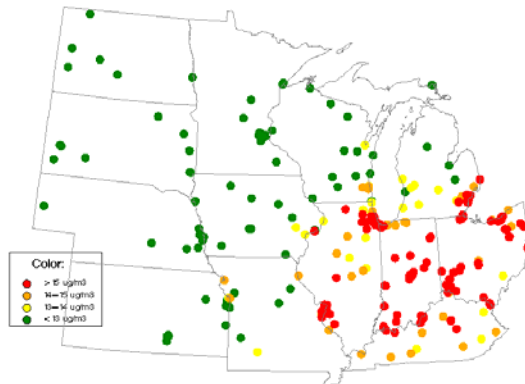
PM2.5 FRM Mean Concentration, 2006

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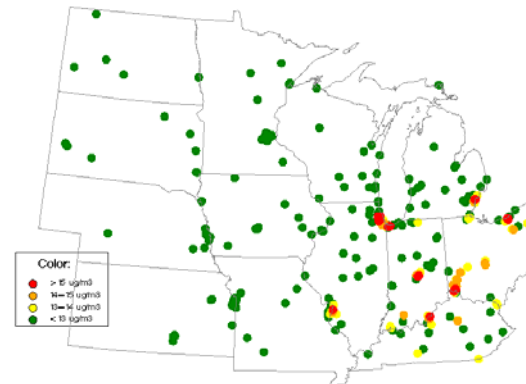
2005

PM2.5 FRM Mean Concentration, 2005



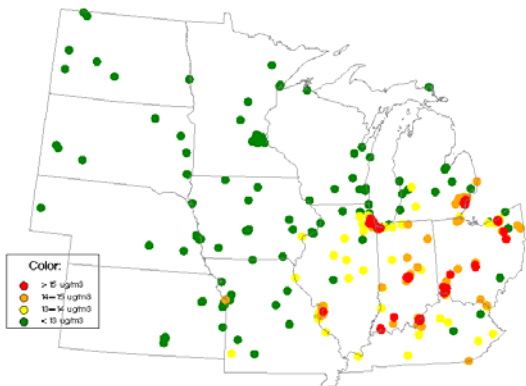
2004

PM2.5 FRM Mean Concentration, 2004



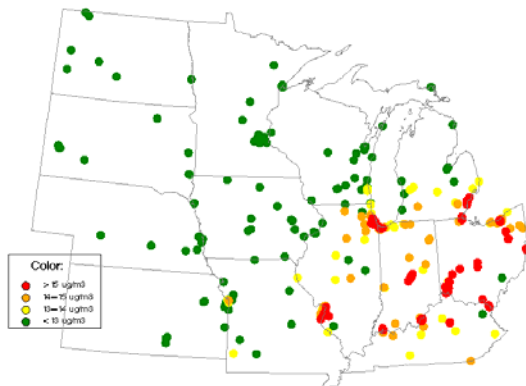
2003

PM2.5 FRM Mean Concentration, 2003



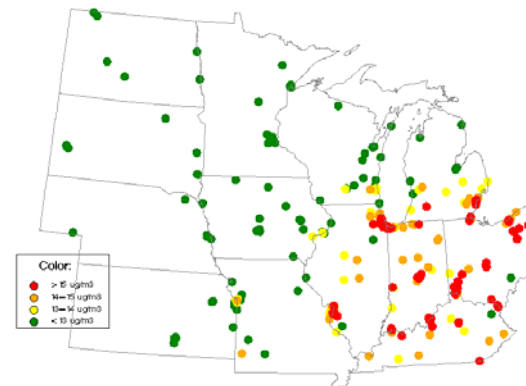
2002

PM2.5 FRM Mean Concentration, 2002



2001

PM2.5 FRM Mean Concentration, 2001

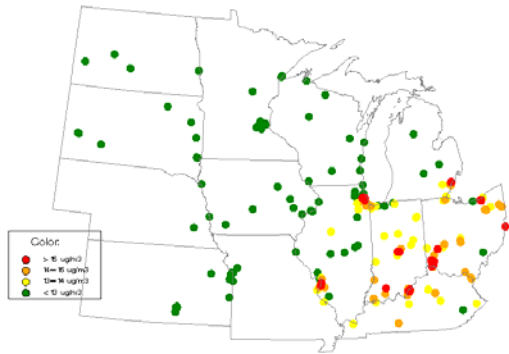


PM2.5 Design Values, Annual Standard

2004-2006

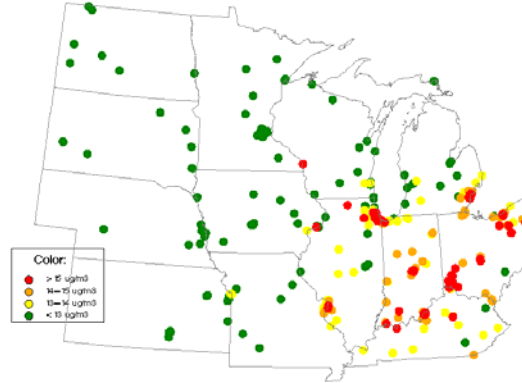
PM2.5 FRM Mean Concentration, 2004–2006

Preliminary Data --- Not Official!
Include some sites with incomplete data



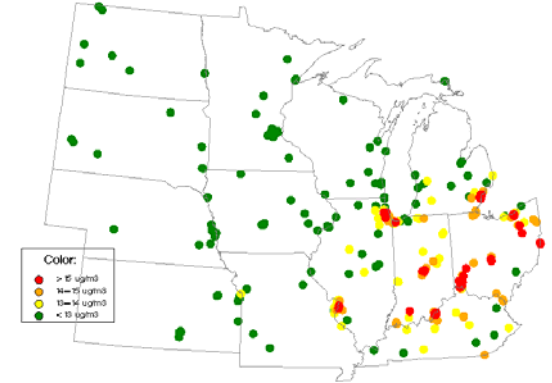
2003-2005

PM2.5 FRM Mean Concentration, 2003–2005



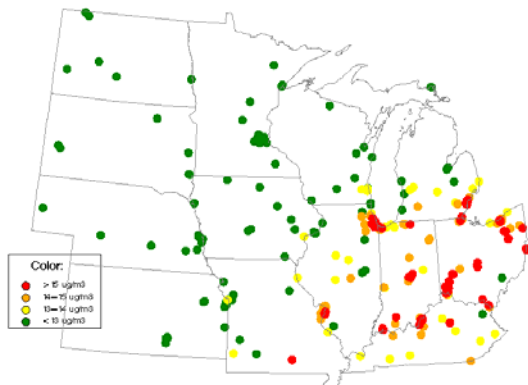
2002-2004

PM2.5 FRM Mean Concentration, 2002–2004



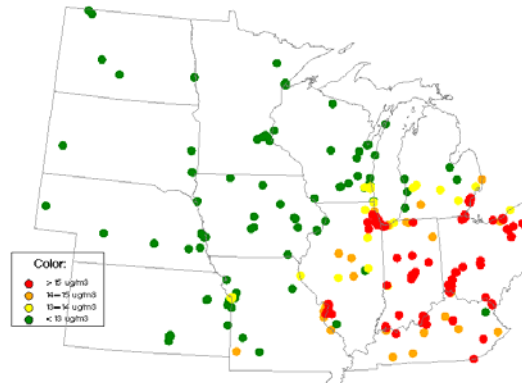
2001-2003

PM2.5 FRM Mean Concentration, 2001–2003



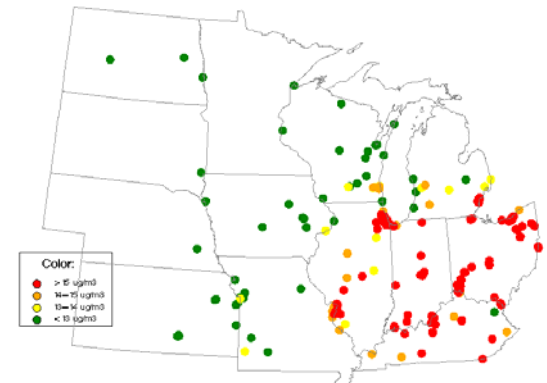
2000-2002

PM2.5 FRM Mean Concentration, 2000–2002



1999-2001

PM2.5 FRM Mean Concentration, 1999–2001

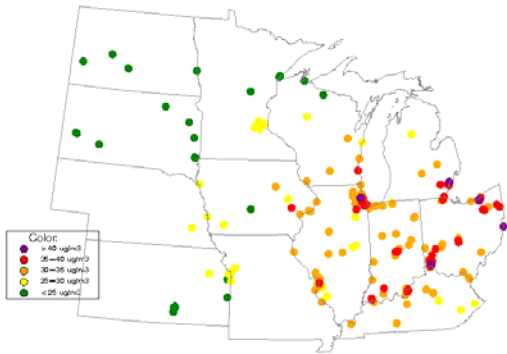


PM2.5 Design Values, Daily Standard

2004-2006

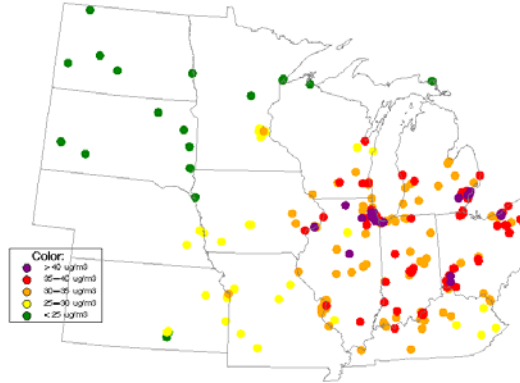
PM2.5 FRM 98th Percentile Concentration, 2004–2006

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Include some sites with incomplete data



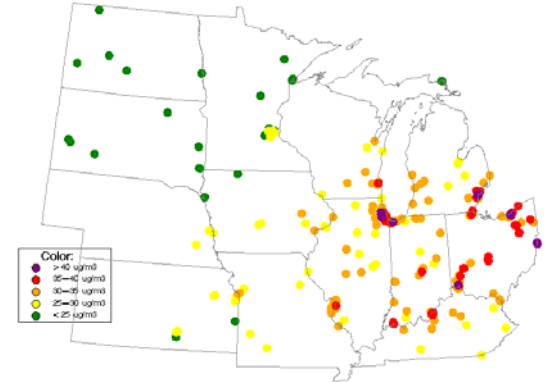
2003-2005

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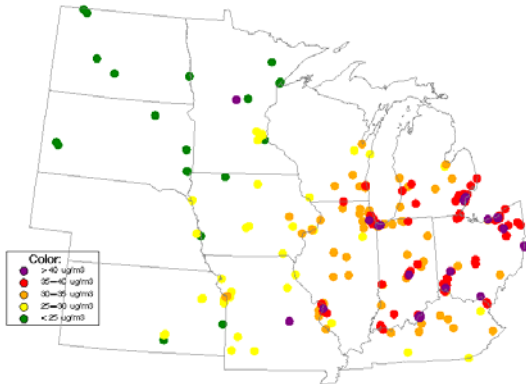
2002-2004

PM2.5 FRM 98th Percentile Concentration, 2002–2004



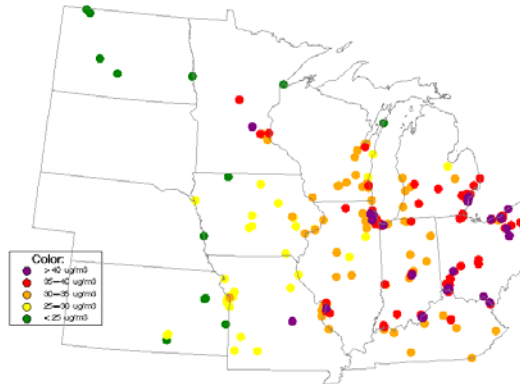
2001-2003

PM2.5 FRM 98th Percentile Concentration, 2001–2003



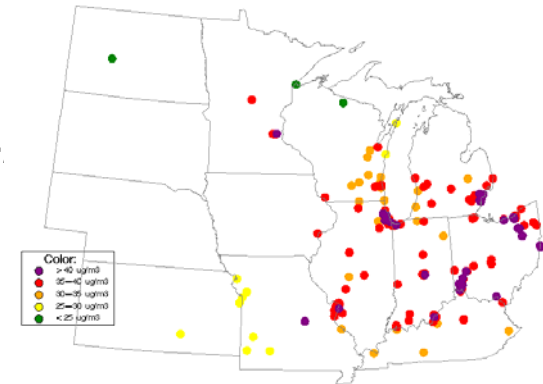
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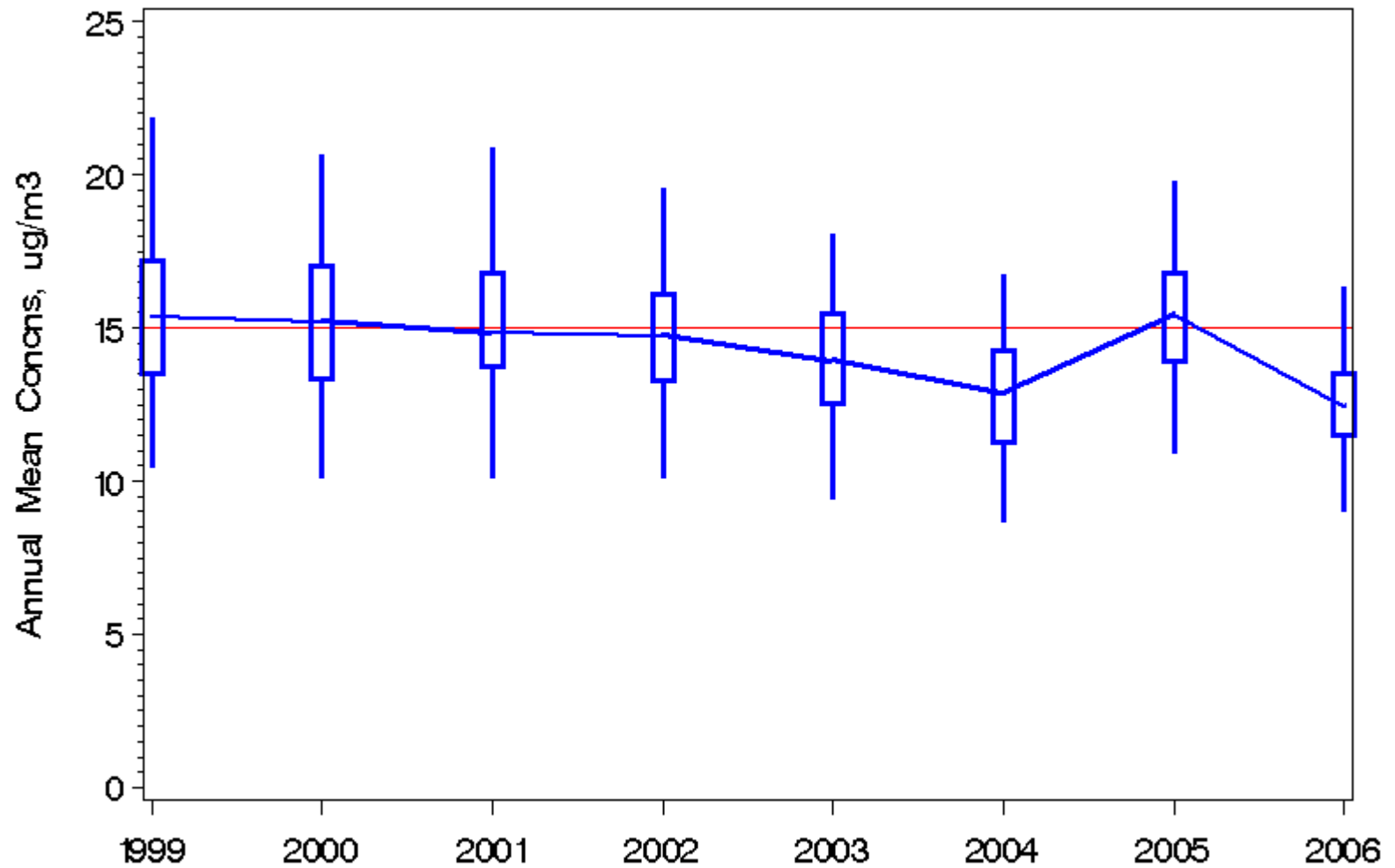


1999-2001

PM2.5 FRM 98th Percentile Concentration, 1999–2001

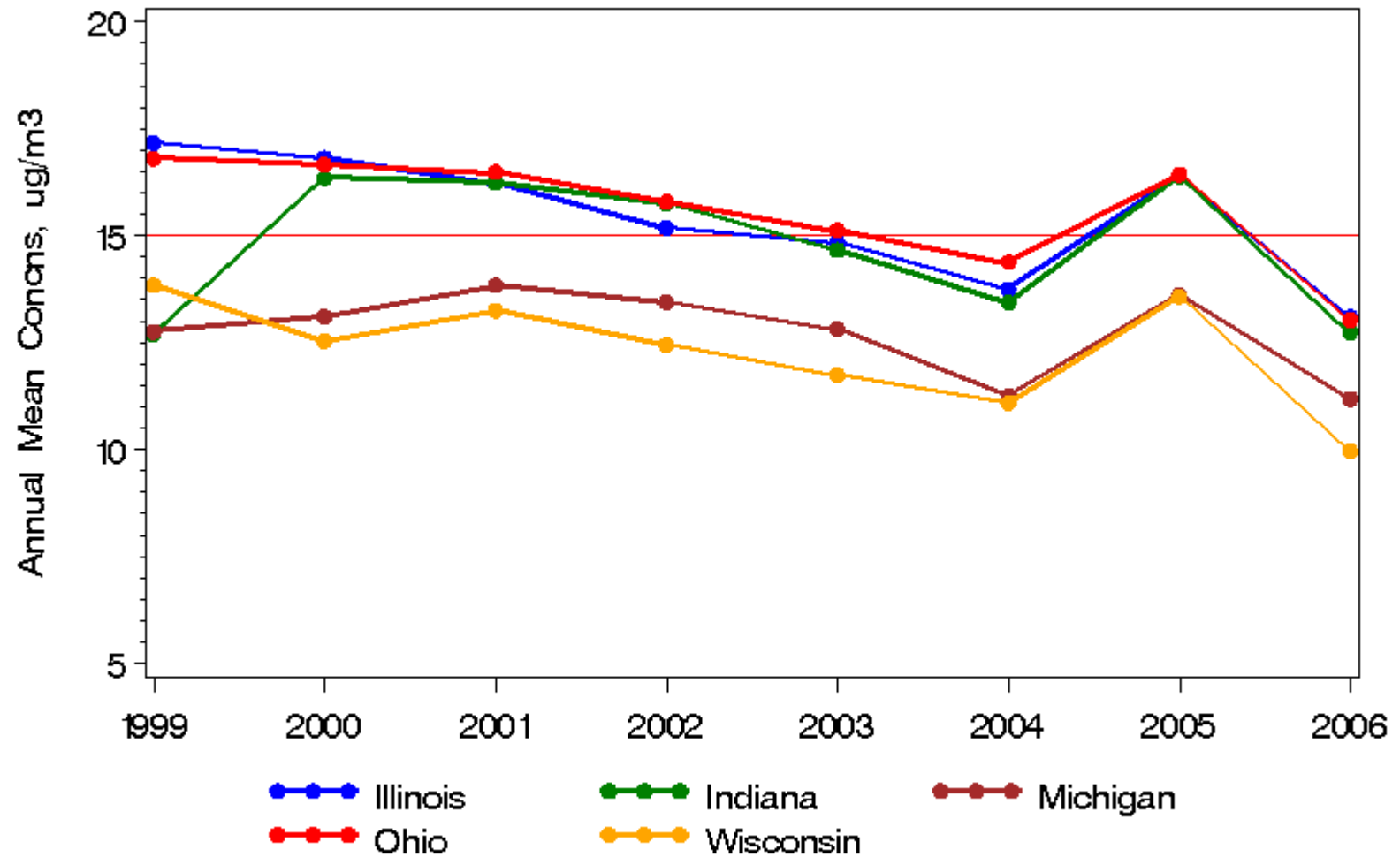


PM2.5 Annual Mean Trends, Midwest States, 1999—2006



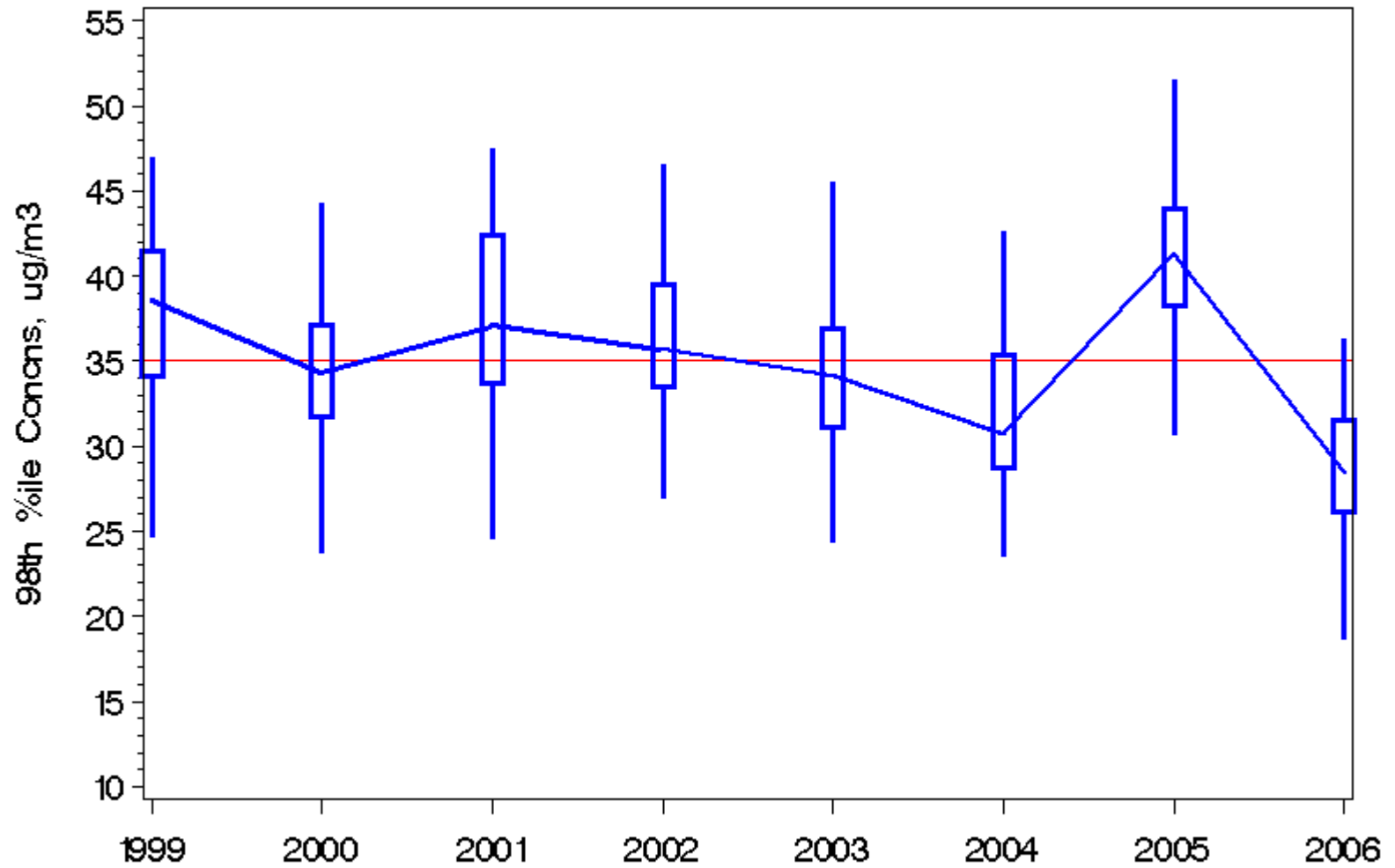
Preliminary data for 2006; trends for monitors with at least 7 years of data

PM2.5 Annual Mean Trends, LADCO States, 1999–2006



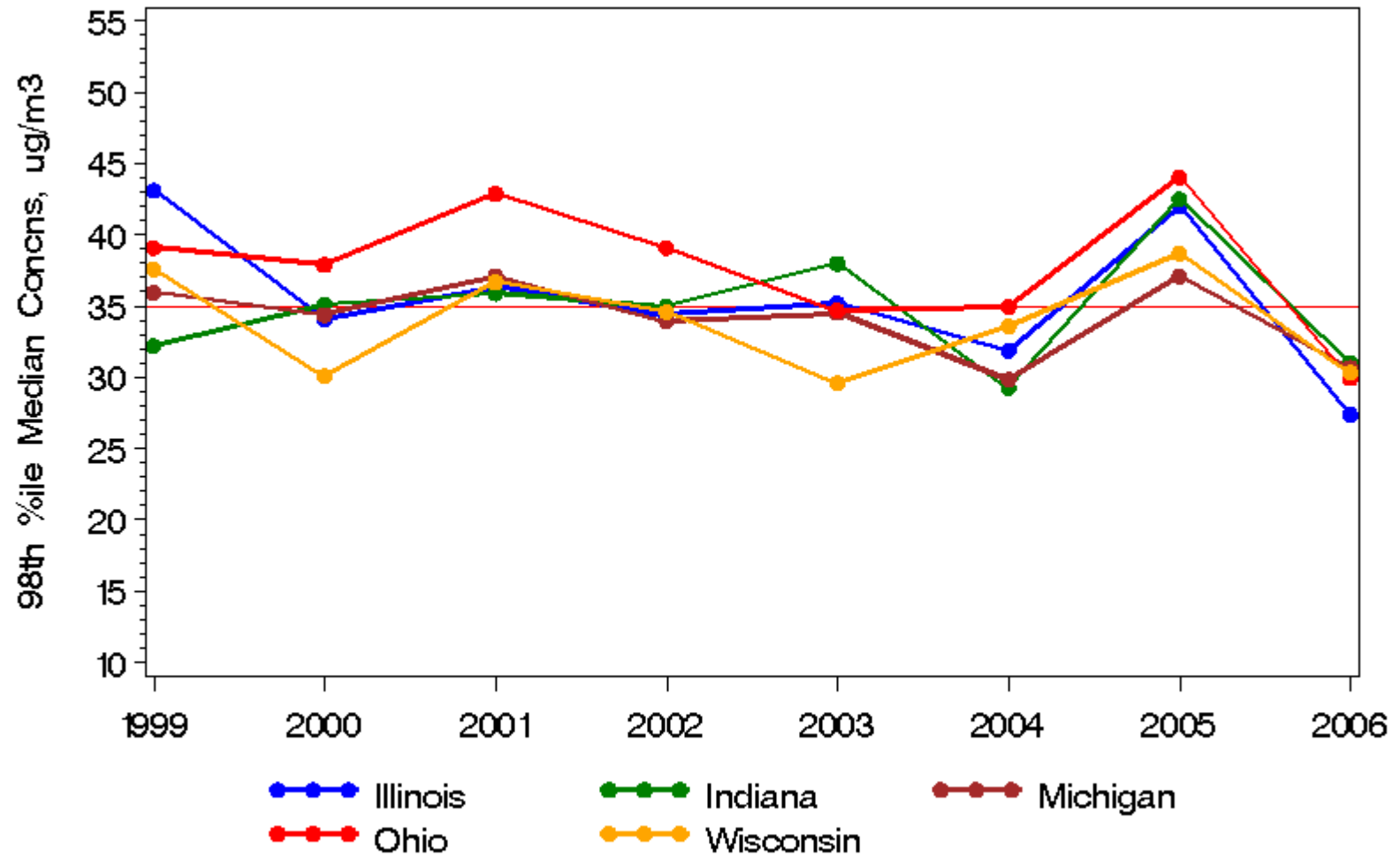
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PM2.5 98%ile Trends, Midwest States, 1999–2006



Preliminary data for 2006; trends for monitors with at least 7 years of data

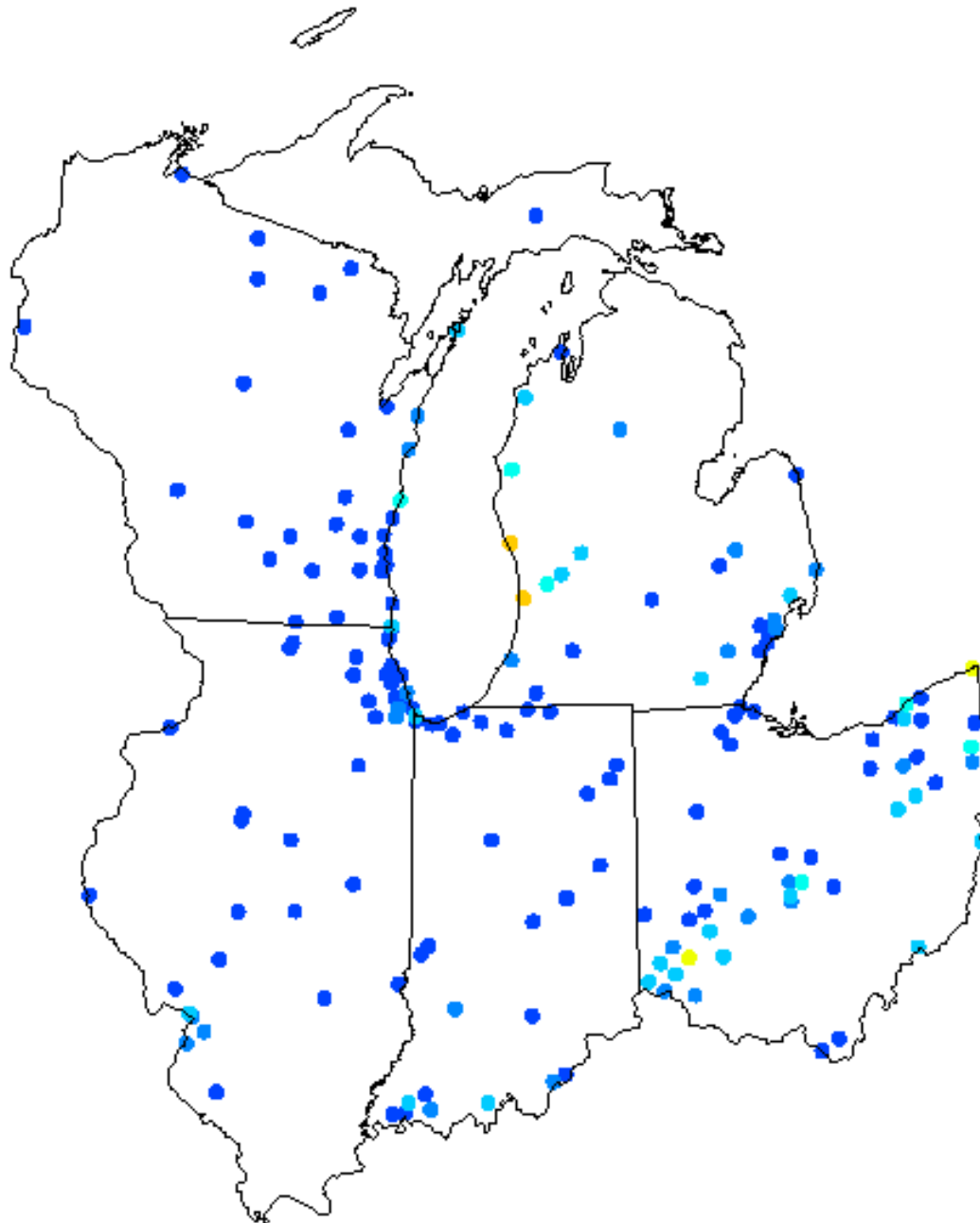
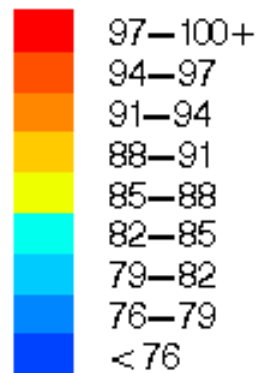
PM2.5 98%ile Trends, LADCO States, 1999–2006



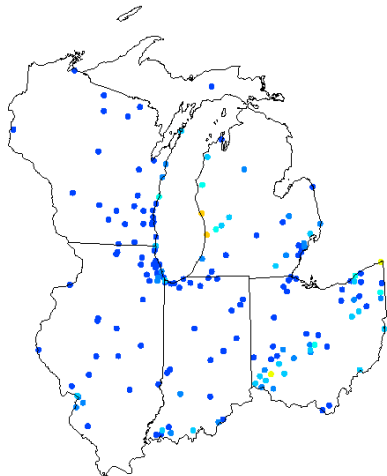
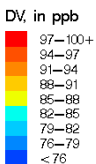
Preliminary data for 2006; trends for monitors with at least 7 years of data

Ozone Fourth High Values, 2006

DV, in ppb

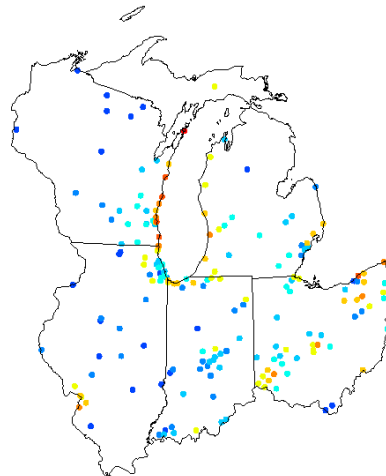
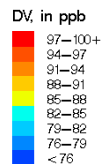


Ozone Fourth High Values, 2006



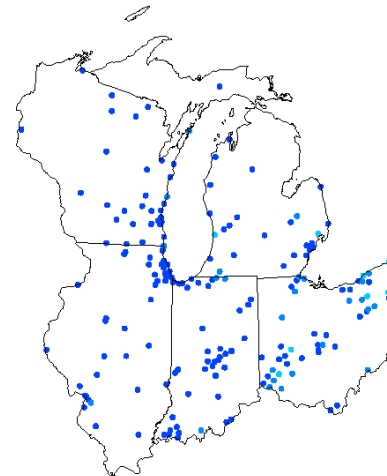
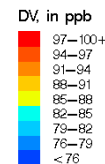
2006

Ozone Fourth High Values, 2005



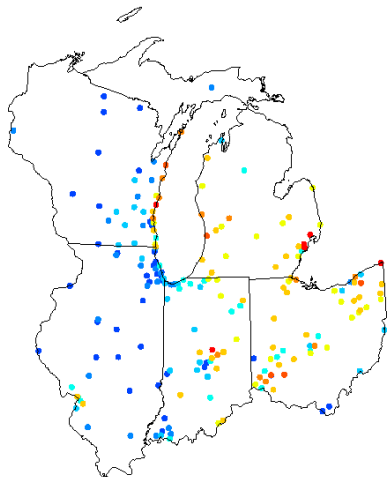
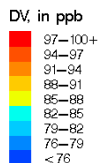
2005

Ozone Fourth High Values, 2004



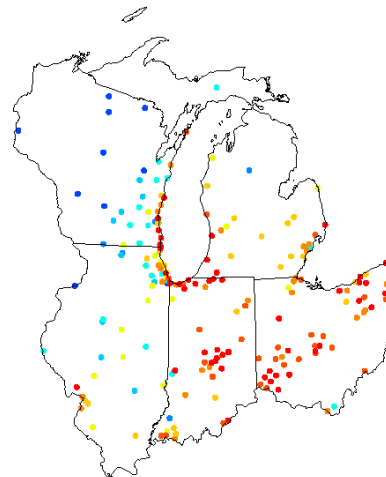
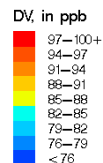
2004

Ozone Fourth High Values, 2003



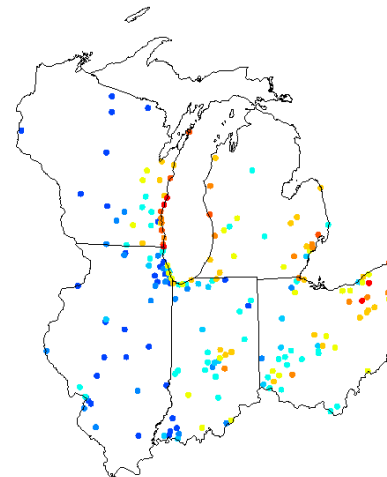
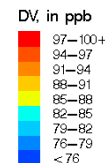
2003

Ozone Fourth High Values, 2002



2002

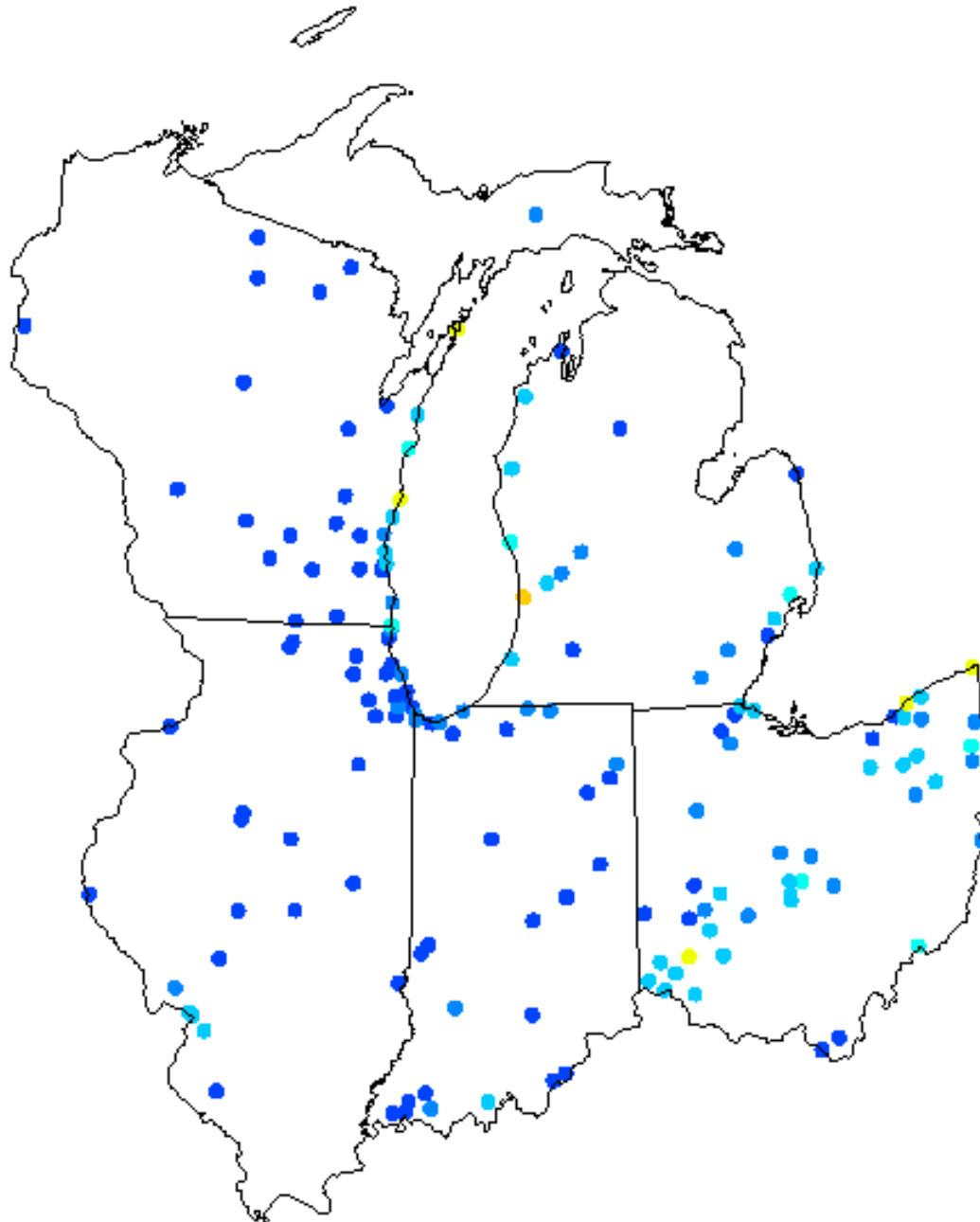
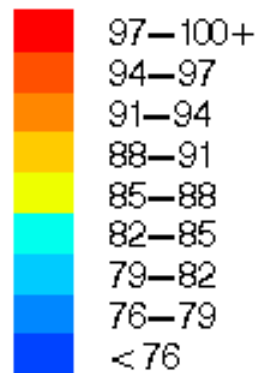
Ozone Fourth High Values, 2001



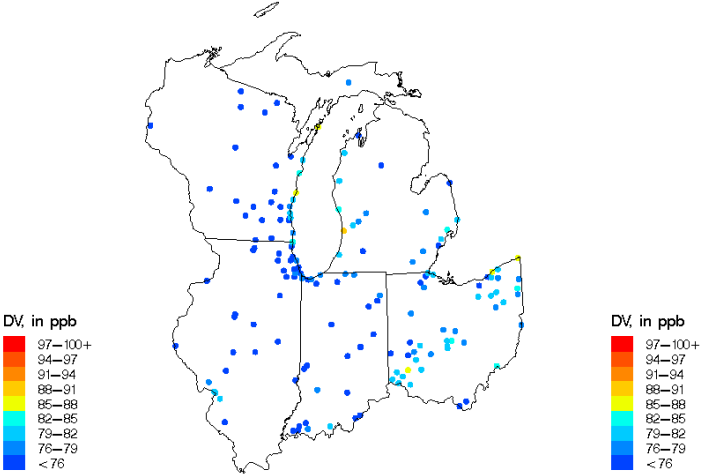
2001

Ozone Design Values, 2004_2006

DV, in ppb

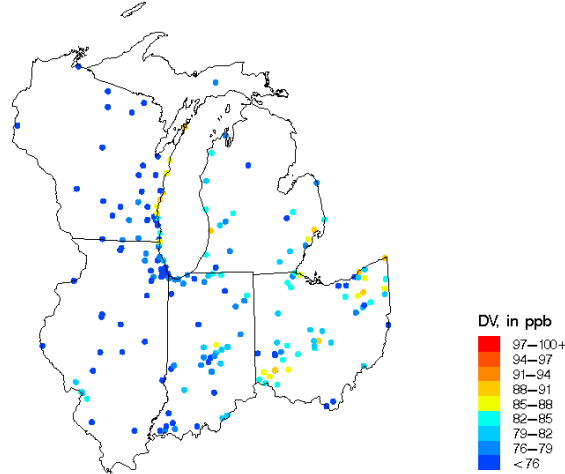


Ozone Design Values, 2004_2006



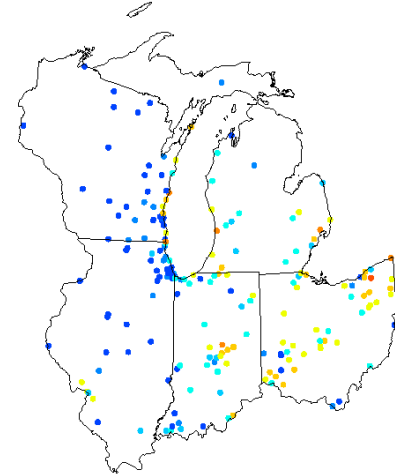
2004-6

Ozone Design Values, 2003_2005



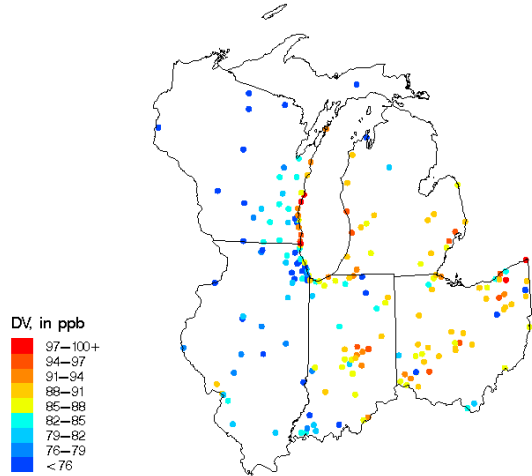
2003-5

Ozone Design Values, 2002_2004



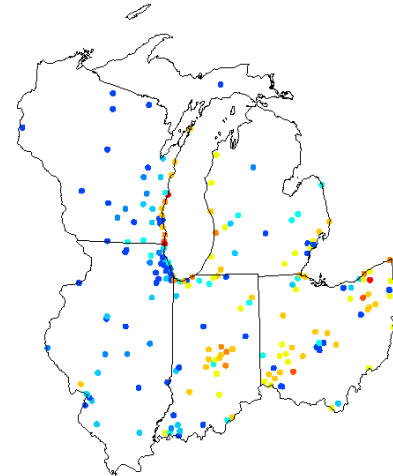
2002-4

Ozone Design Values, 2001_2003



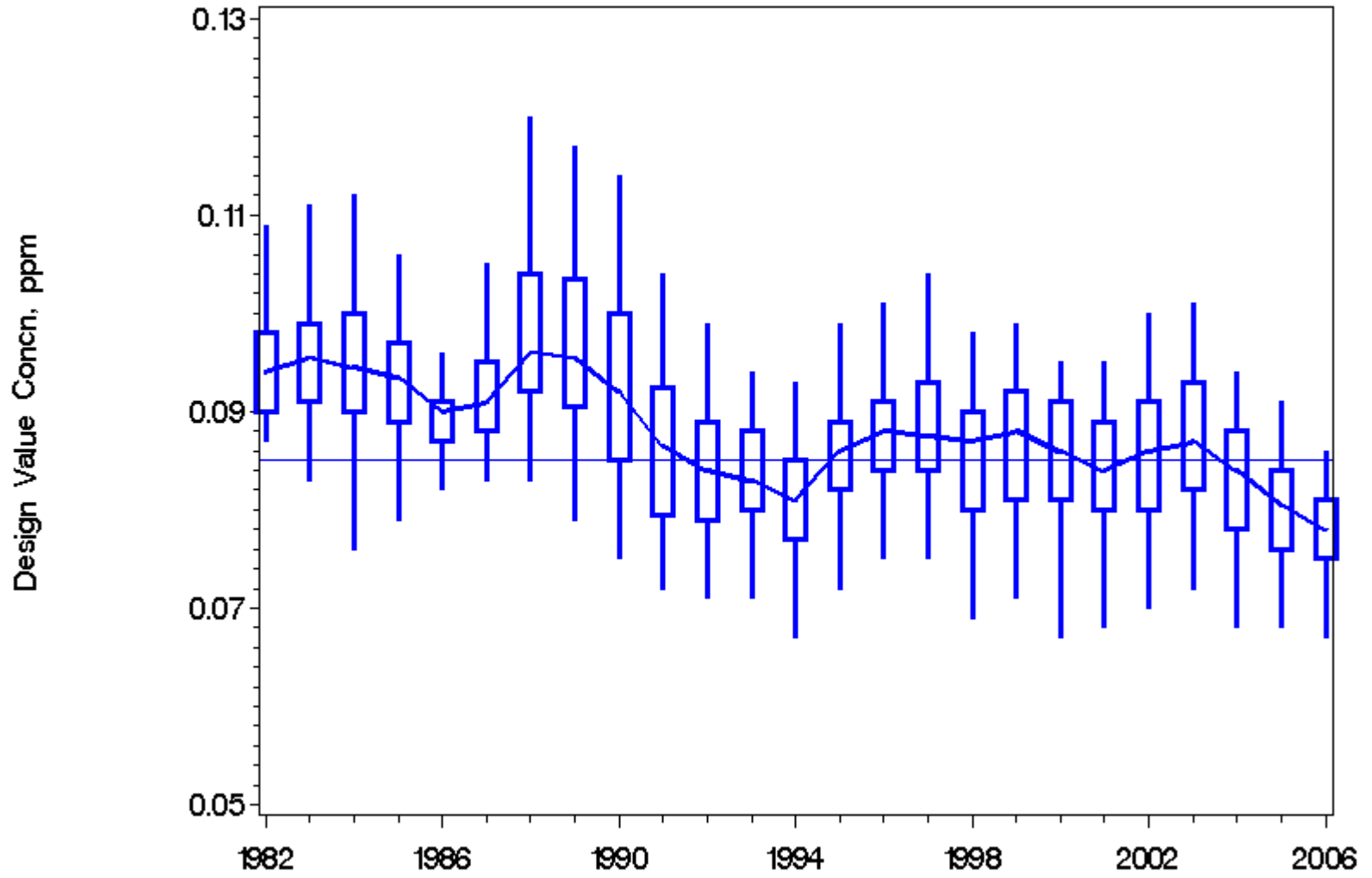
2001-3

Ozone Design Values, 2000_2002



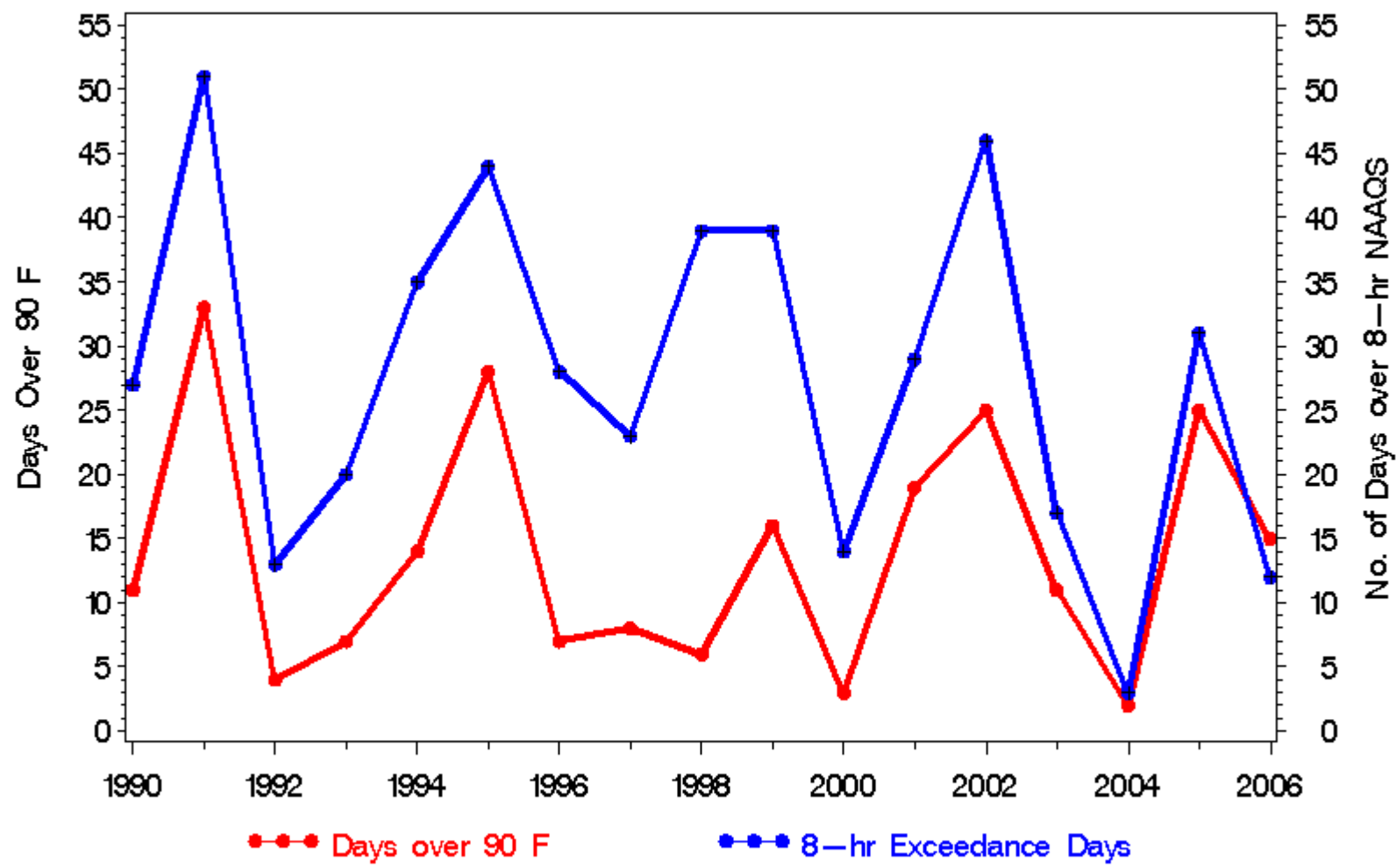
2000-2

Design Value Trends, LADCO States



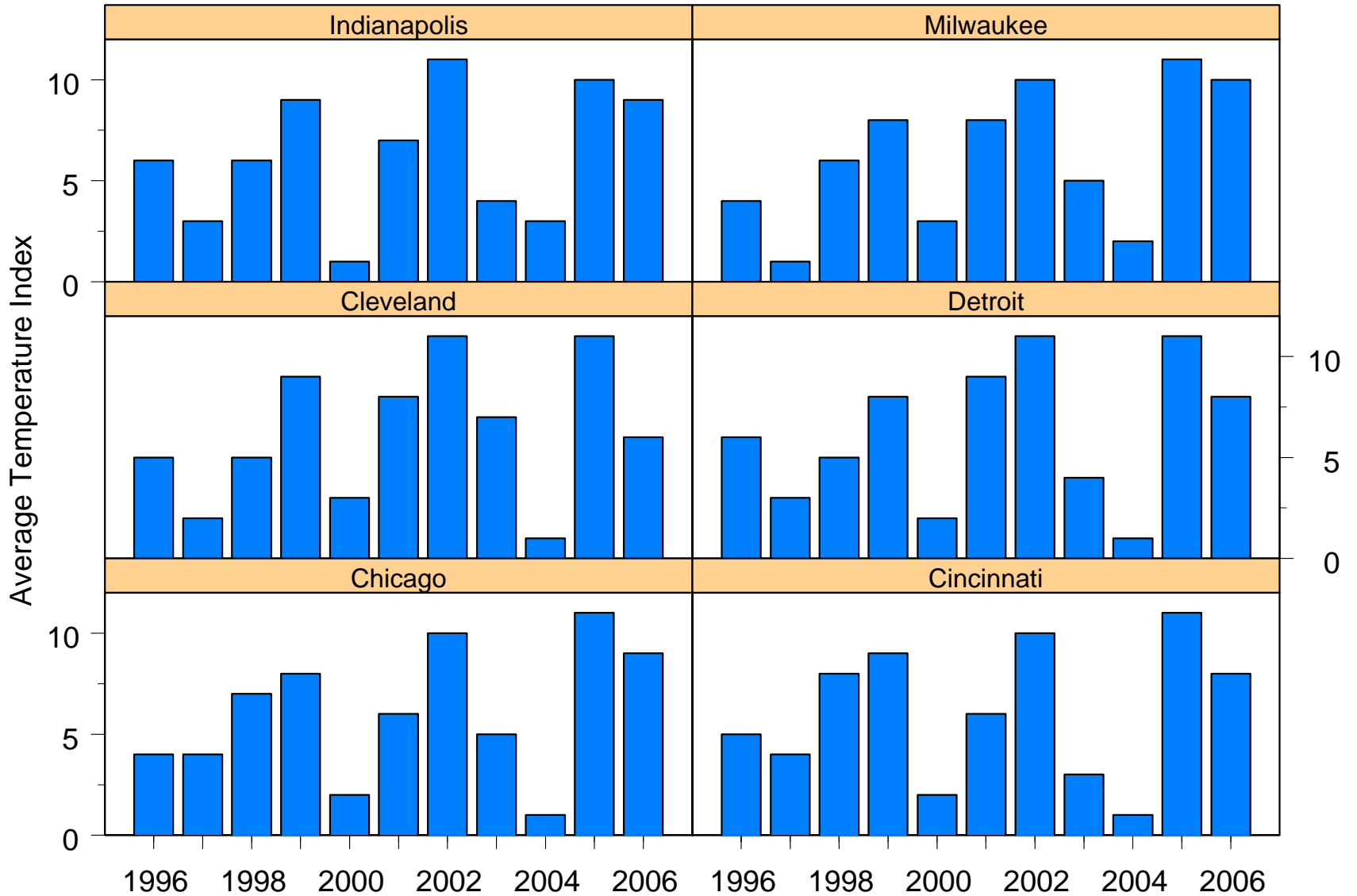
Design value plotted by end year of 3-year period. 2006 data are preliminary.

90—Degree Days and Site—Exceedance Days, LADCO States



Weather data from O'Hare International Airport. Exceedance days are days per year when NAAQS was exceeded at any site, among a selected set of longest running monitors.

Temperature Index, June-August



Indexed from 11 (warmest 3 months) to 1 (coolest 3 months).

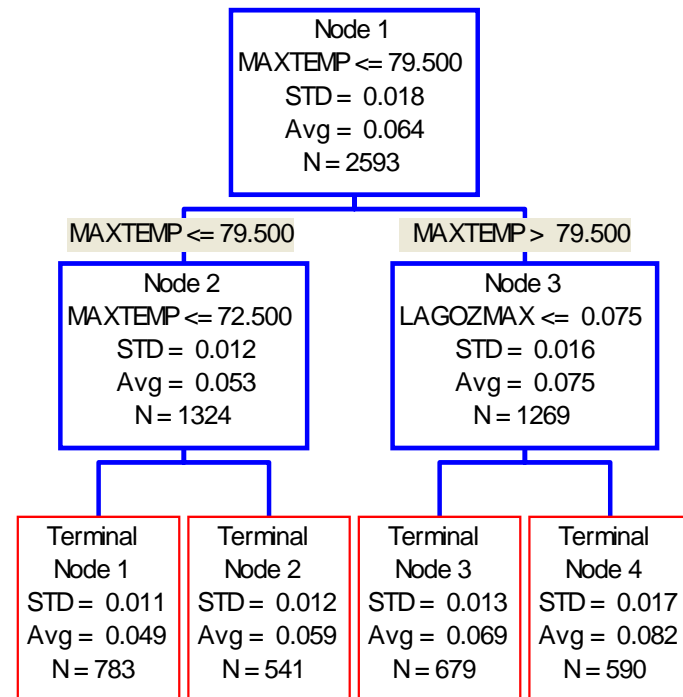
CART Model

- Incorporates 30+ meteorological variables
- Goal is to categorize each day by ozone concentration and associated met conditions
- Results in a decision tree with 10-15 branches, each describing the meteorological conditions associated with a particular ozone concentration

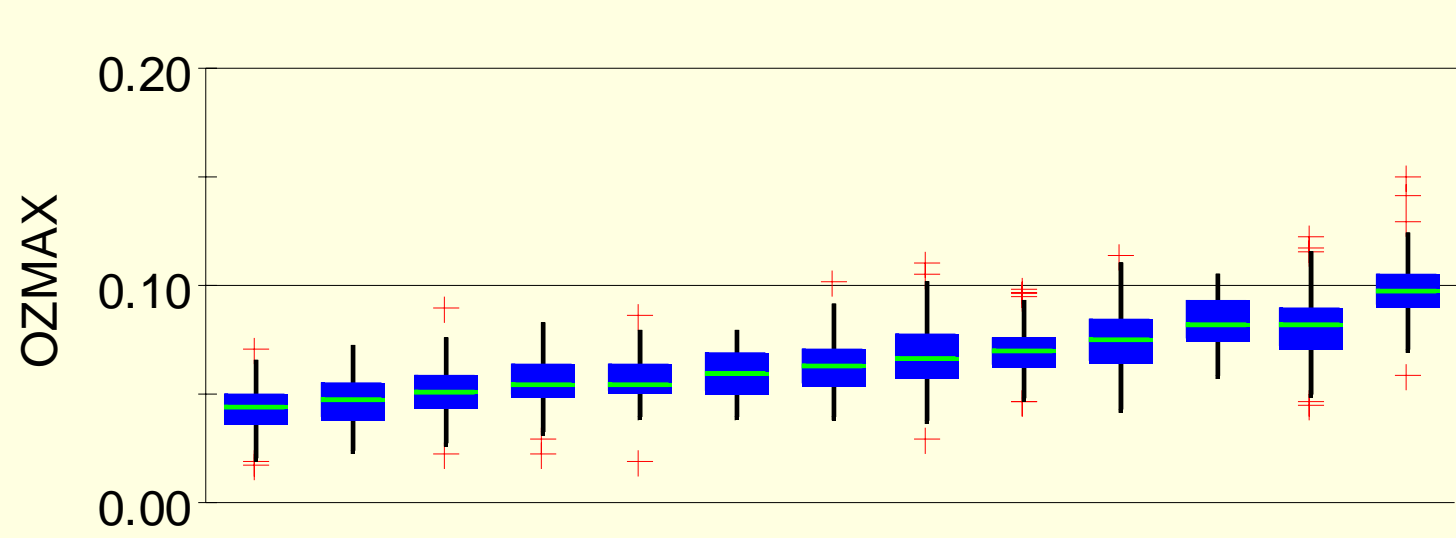
Example CART Tree

Variables included:

- Temperature
- Dew point
- Wind speed
- Temperature change
- Relative humidity
- Wind speed
- Wind direction (morning, afternoon, evening)
- Temperature, wind speed, wind direction at 700 and 850 mb
- Precipitation
- Cloud cover
- UV radiation
- Pressure
- Previous day's ozone, temperature, and wind speed



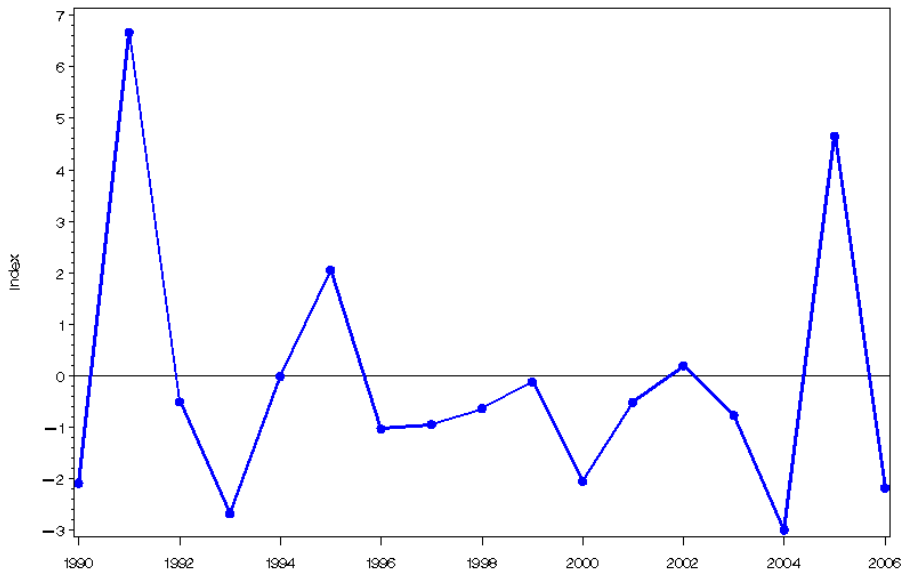
Terminal Nodes Sorted By Target Variable Prediction



CART Index of Ozone Conduciveness

- CART classifies days into bins, based on meteorological characteristics associated with ozone values (1990-2006)
- Index derived from the number of days in high-ozone bins each year, relative to average number of days in those bins
- Higher index=more-conducive ozone year, lower index=less-conducive ozone year (where 0 is average)
- More specific, more sensitive than previous methods of categorizing years

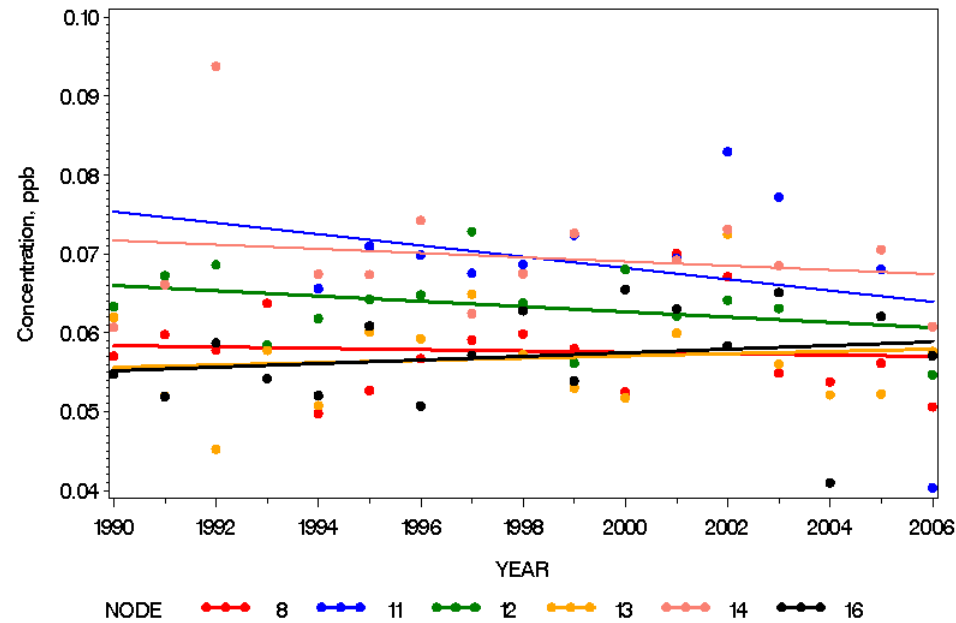
CART Index of Ozone Conduciveness, Chicago



Index represents fraction of ozone conducive days in each year, above or below 1990-2006 average
 1 = twice as many days as average year, -1 = half as many days as average year

Concentration Trends in CART Nodes—Chicago

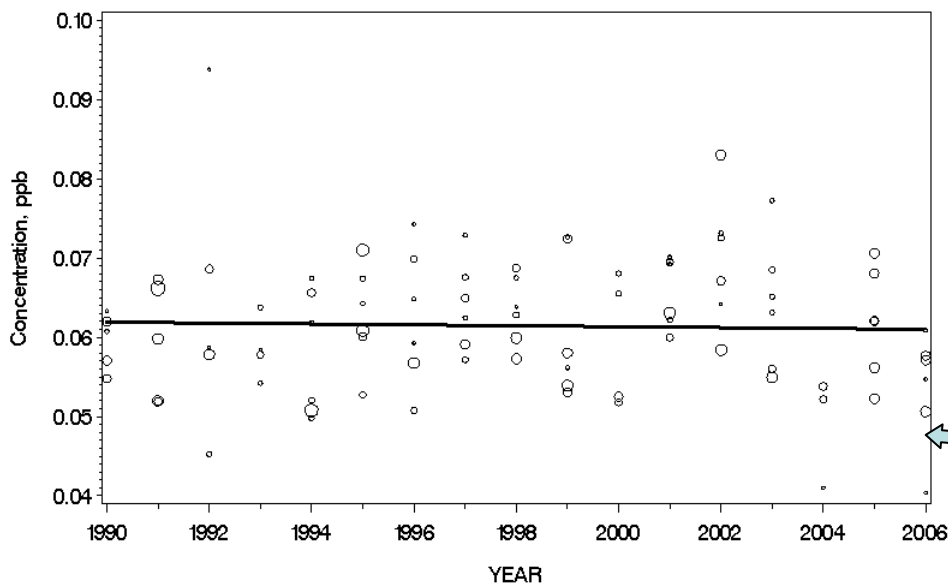
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



NODE 8 11 12 13 14 16

Concentration Trends in CART Nodes—Chicago

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.



Index -- assesses how many ozone-conductive days occurred in each year, relative to other years in same 1990-2006 period

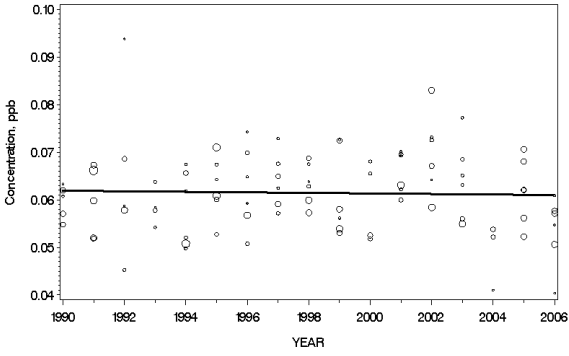


Concentration trends (above) – each node represents a set of meteorologically similar days, so trends in nodes are meteorologically adjusted



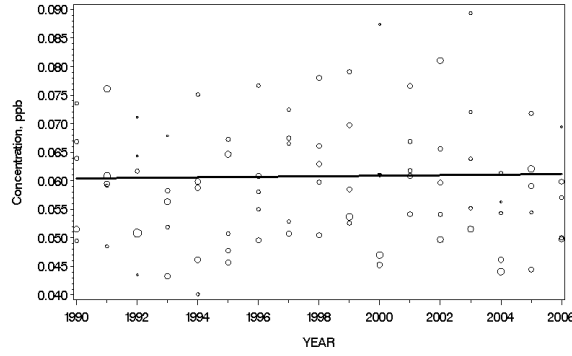
Concentration trends (left) – overall trend in high-concentration nodes, with number of days in each node represented by size of dot

Concentration Trends in CART Nodes—Chicago
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



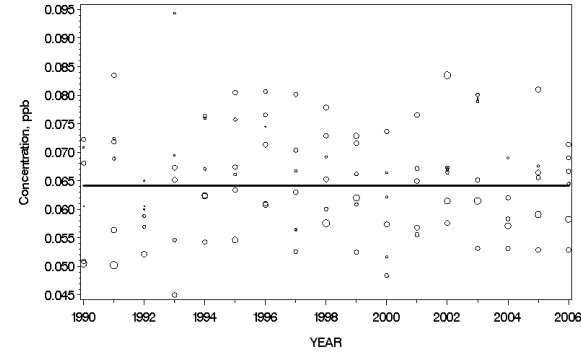
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—Detroit
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



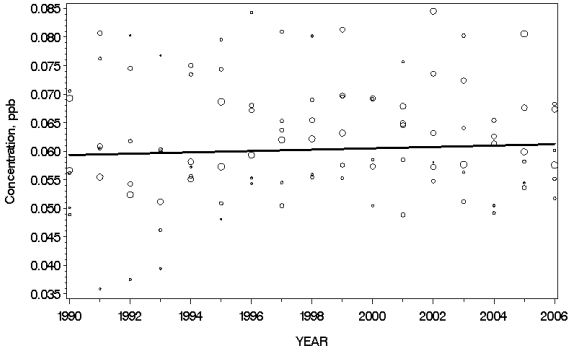
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—Cincinnati
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



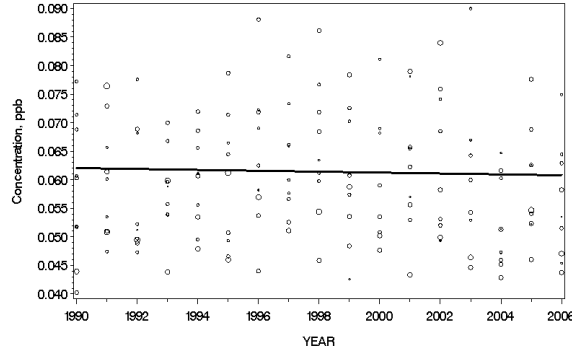
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—St. Louis
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



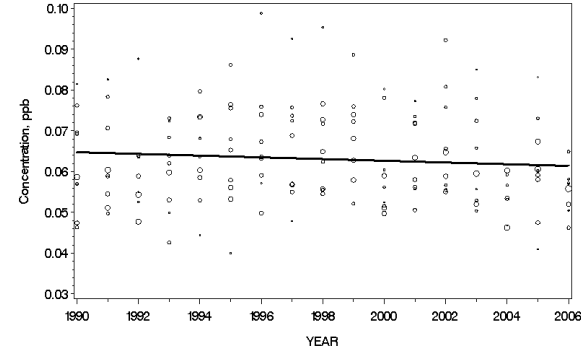
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—Cleveland
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



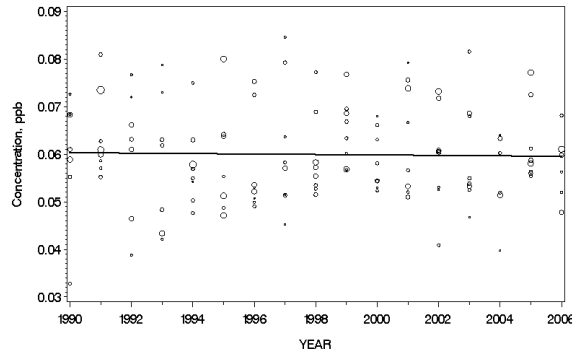
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—Indianapolis
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.

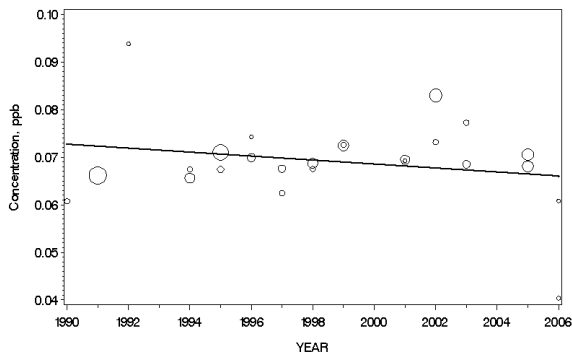
Concentration Trends in CART Nodes—Milwaukee
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.

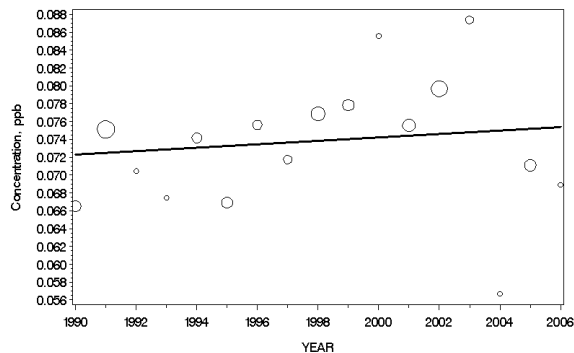
Trends in Nodes >0.05
ppm

Concentration Trends in CART Nodes—Chicago
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



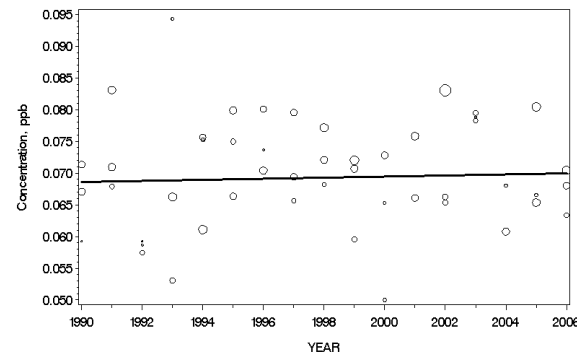
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—Detroit
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



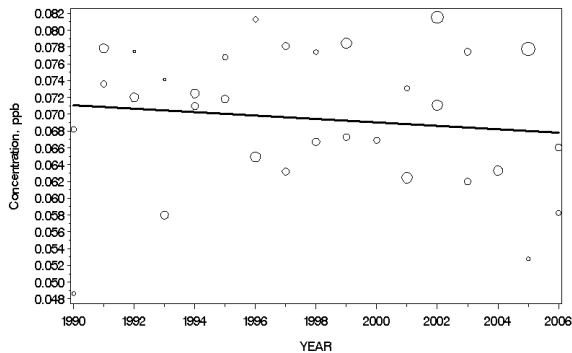
Size of bubble is proportional to number of days in node.

Concentration Trends in CART Nodes—Cincinnati
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



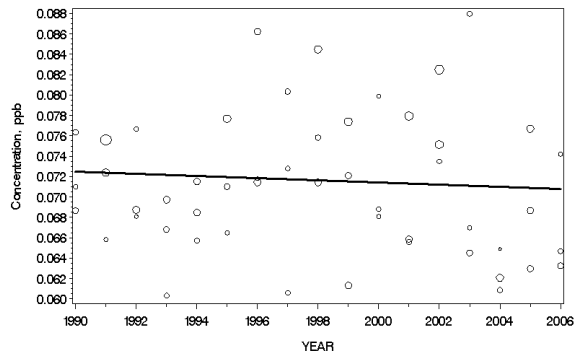
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Concentration Trends in CART Nodes—St. Louis
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



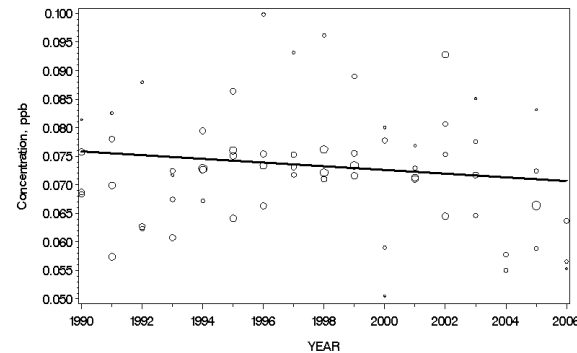
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Concentration Trends in CART Nodes—Cleveland
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



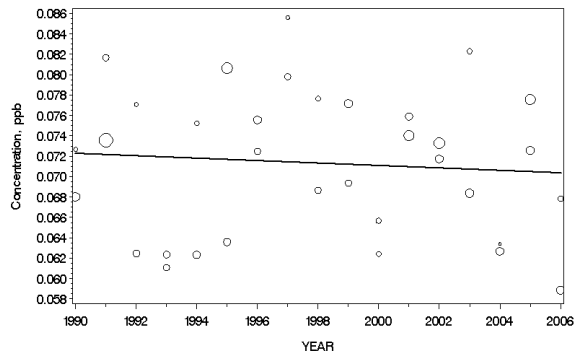
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Concentration Trends in CART Nodes—Indianapolis
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



Size of bubble is proportional to number of days in node.

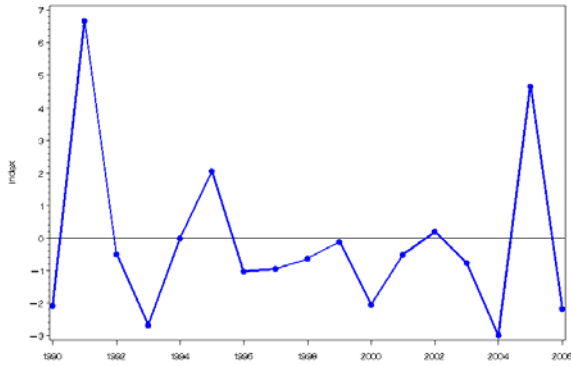
Concentration Trends in CART Nodes—Milwaukee
8-hr Ozone, Only Nodes With Concn > 0.065 ppm



Size of bubble is proportional to number of days in node.

Trends in Nodes >0.065 ppm

CART Index of Ozone Conduciveness, Chicago



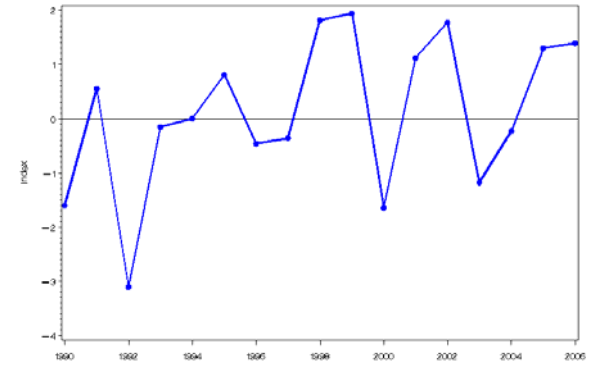
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CART Index of Ozone Conduciveness, St.Louis



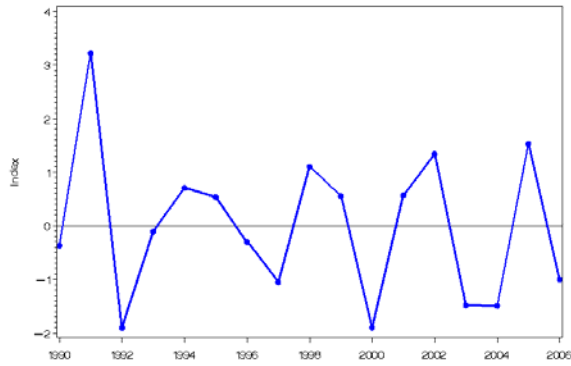
Index represents fraction of ozone conducive days in each year, above or below 1990–2005 average
 1= twice as many days as average year, -1= half as many days as average year

CART Index of Ozone Conduciveness, Cincinnati



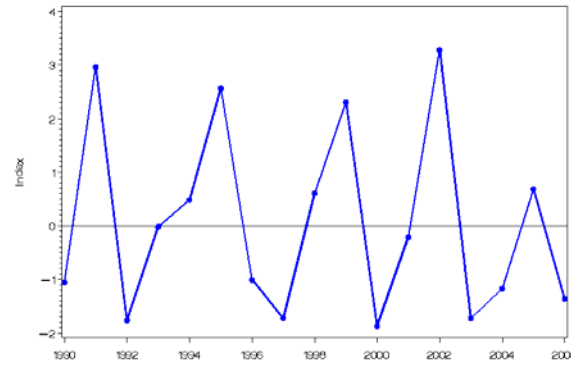
Index represents fraction of ozone conducive days in each year, above or below 1990–2005 average
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CART Index of Ozone Conduciveness, Detroit



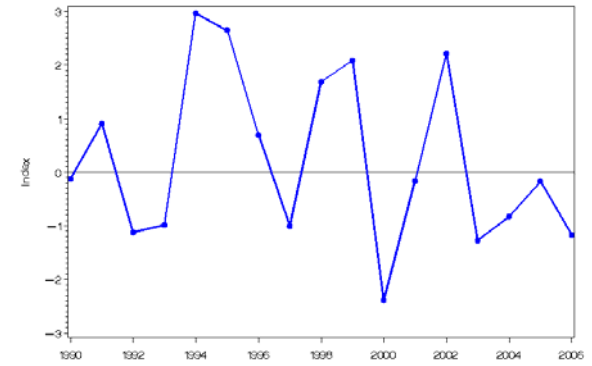
Index represents fraction of ozone conducive days in each year, above or below 1990–2005 average
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CART Index of Ozone Conduciveness, Cleveland



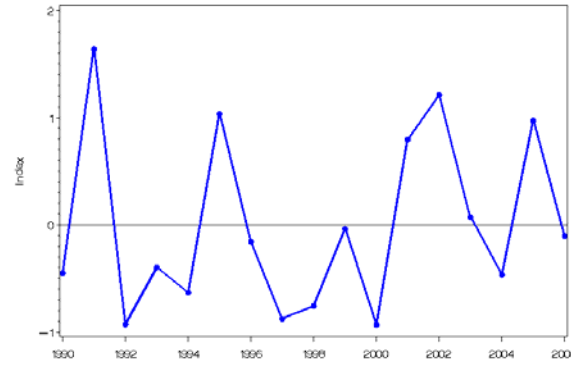
Index represents fraction of ozone conducive days in each year, above or below 1990–2005 average
 1= twice as many days as average year, -1= half as many days as average year

CART Index of Ozone Conduciveness, Indianapolis



Index represents fraction of ozone conducive days in each year, above or below 1990–2005 average
 1= twice as many days as average year, -1= half as many days as average year

CART Index of Ozone Conduciveness, Milwaukee



Index represents fraction of ozone conducive days in each year, above or below 1990–2005 average
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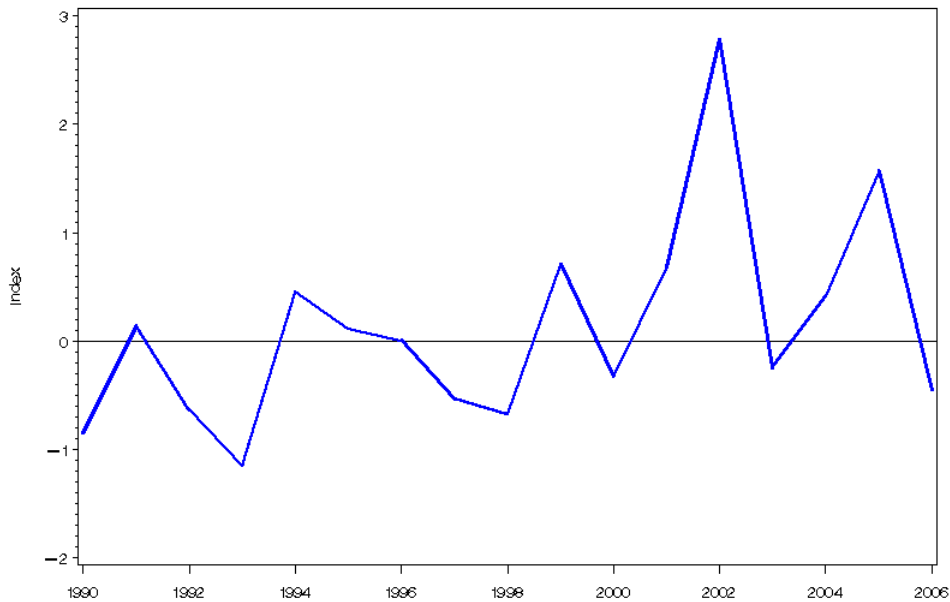
Take Home Message - I

- Summer 2005 had only moderate ozone concentrations (10th highest of last 27), despite:
 - very warm temperatures (well above average number of 90° days), lower wind speeds, and high solar radiation
 - well above average number of ozone conducive days (based on complete statistical analysis – CART)
- Summer 2006 had low ozone concentrations (2nd lowest in last 27—only 2004 was lower), despite:
 - warm temperatures (average number of 90° days), moderate wind speeds, and high solar radiation
 - near average number of ozone conducive days (based on complete statistical analysis - CART)

Take Home Message - II

- Meteorology for most recent 3-year period (2004-2006) is less severe than the meteorology for 3-year period (2001-2003) used for original nonattainment designations
- Recent improvement in ozone air quality is due, in part, to less severe meteorology and, more likely, emission reductions
 - Difficult to quantify meteorology and emission effects
 - Ozone values (4th highs) in 2005 and 2006 were lower than ozone values in previous years with similar meteorology, suggesting that emission reductions were an important factor
- CART trends analysis shows mostly flat trends from 1990-2006 (based on all days with 8-hr ozone > 50 ppb)
 - Trends based on higher 8-hr ozone (>65 ppb) show steeper declines (but less stable)

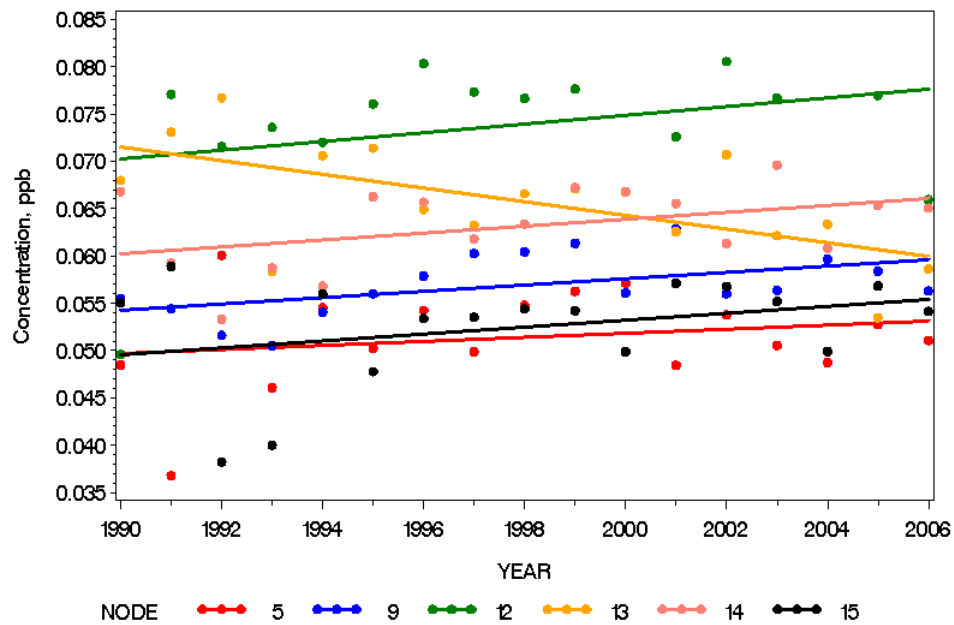
CART Index of Ozone Conduciveness, St.Louis



Index represents fraction of ozone conducive days in each year, above or below 1990–2006 average
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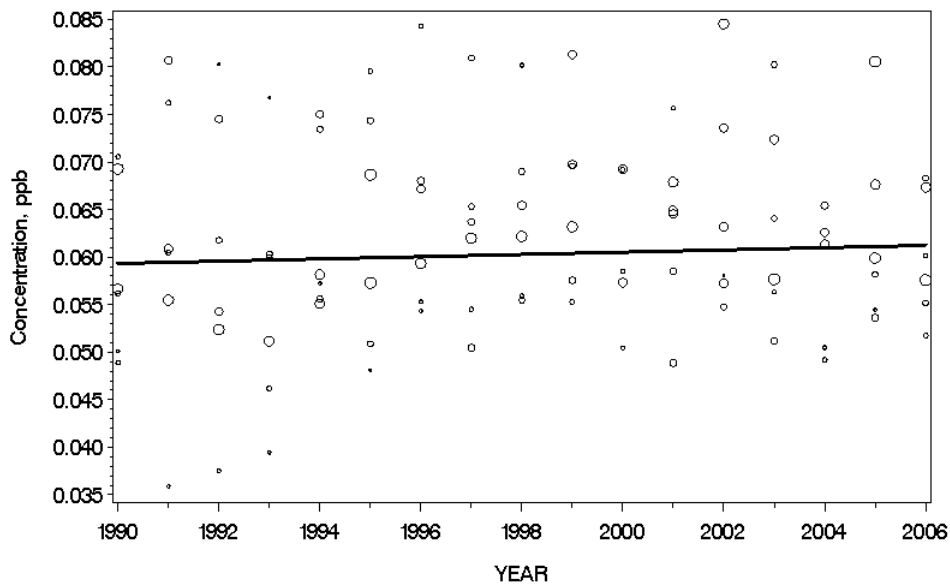
Concentration Trends in CART Nodes— St.Louis

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



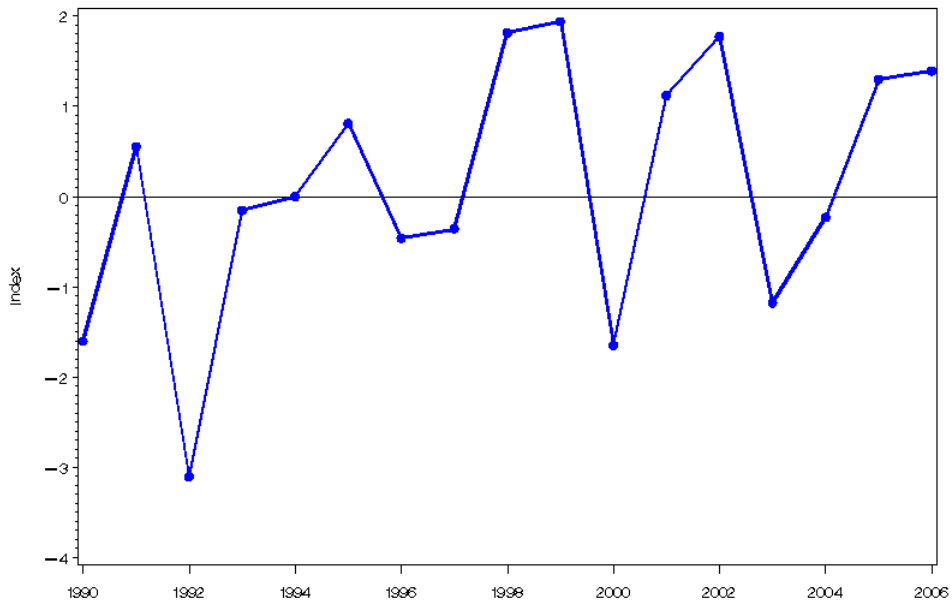
Concentration Trends in CART Nodes— — St. Louis

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.

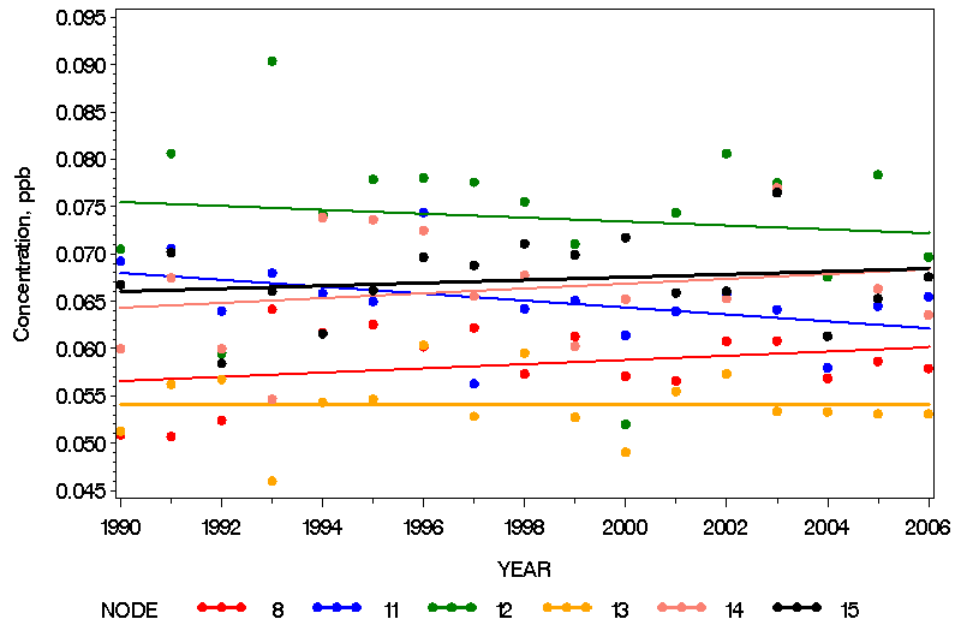
CART Index of Ozone Conduciveness, Cincinnati



Index represents fraction of ozone conducive days in each year, above or below 1990–2006 average
 1= twice as many days as average year, -1= half as many days as average year

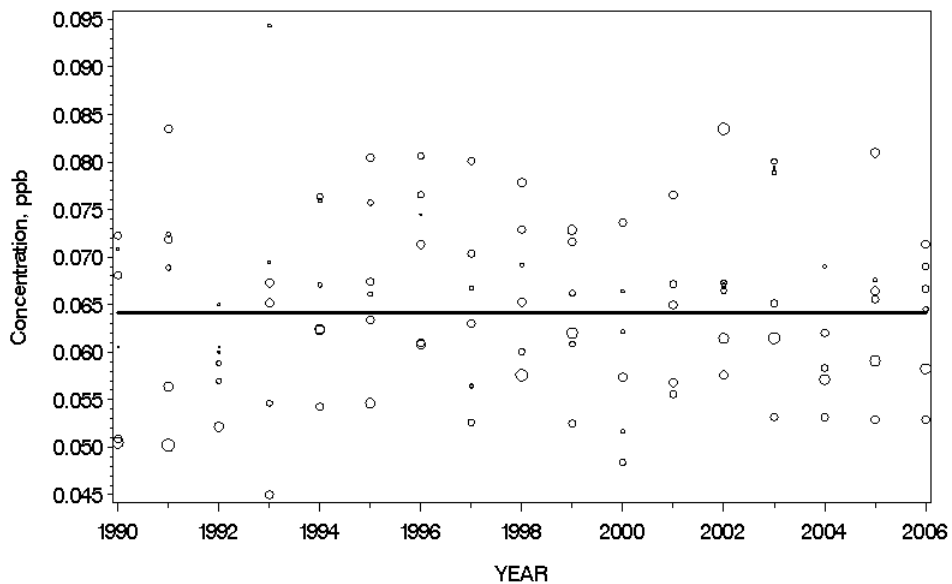
Concentration Trends in CART Nodes— Cincinnati

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



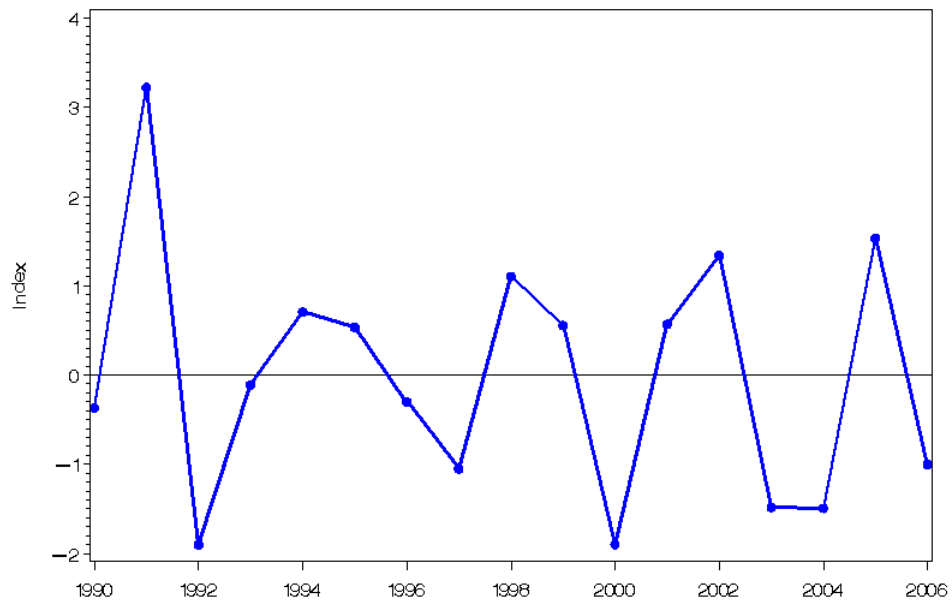
Concentration Trends in CART Nodes— Cincinnati

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.

CART Index of Ozone Conduciveness, Detroit

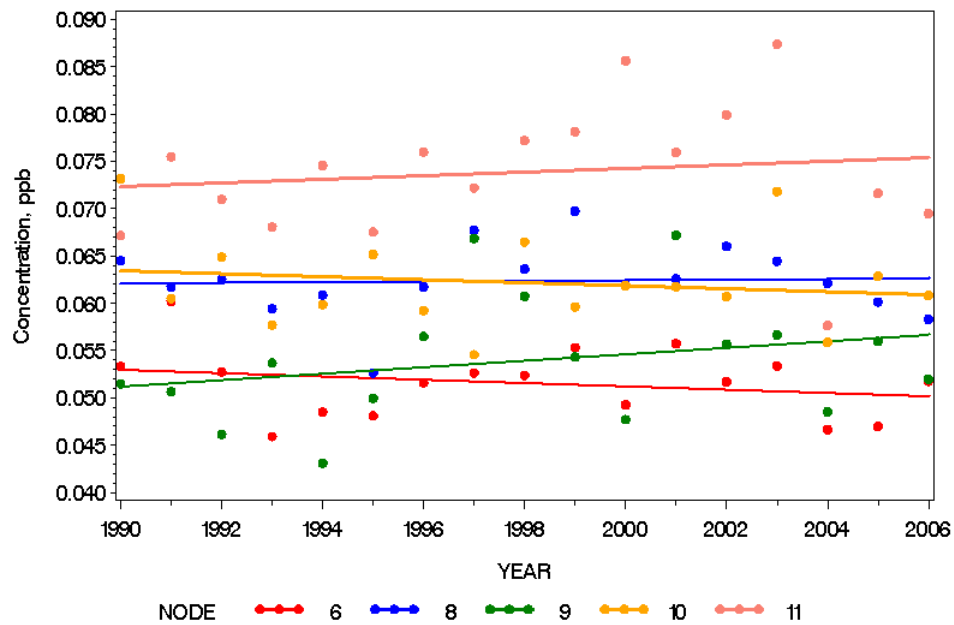


Index represents fraction of ozone conducive days in each year, above or below 1990–2006 average

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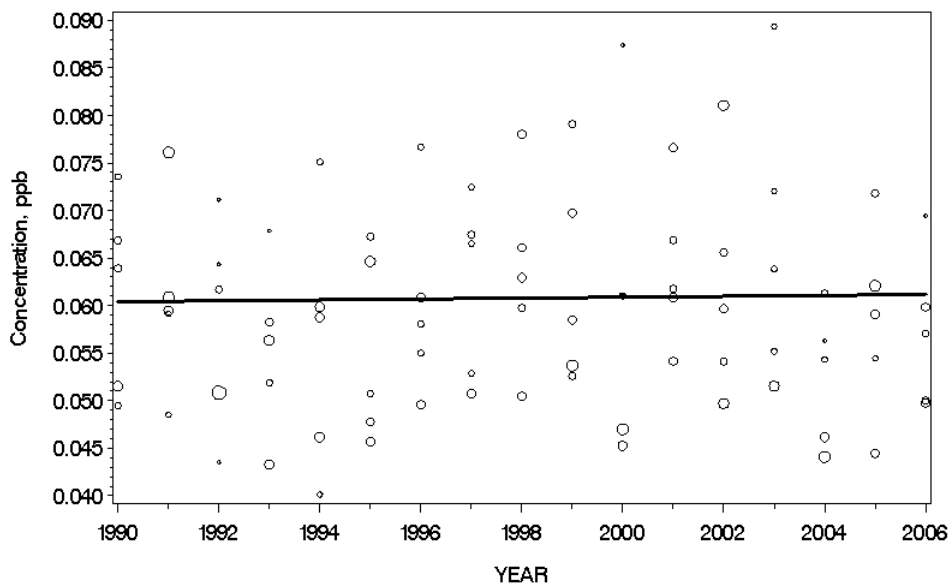
Concentration Trends in CART Nodes— Detroit

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



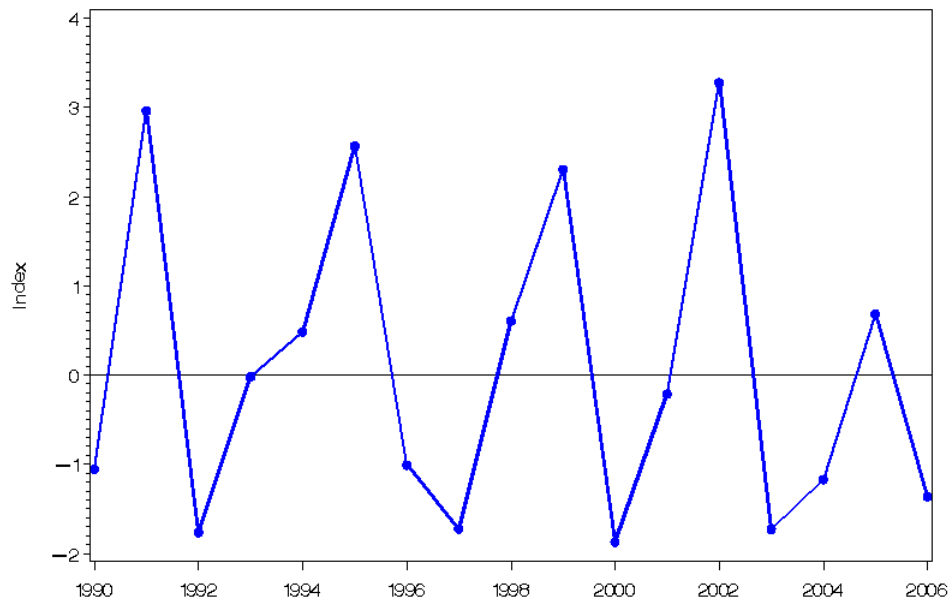
Concentration Trends in CART Nodes— — Detroit

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.

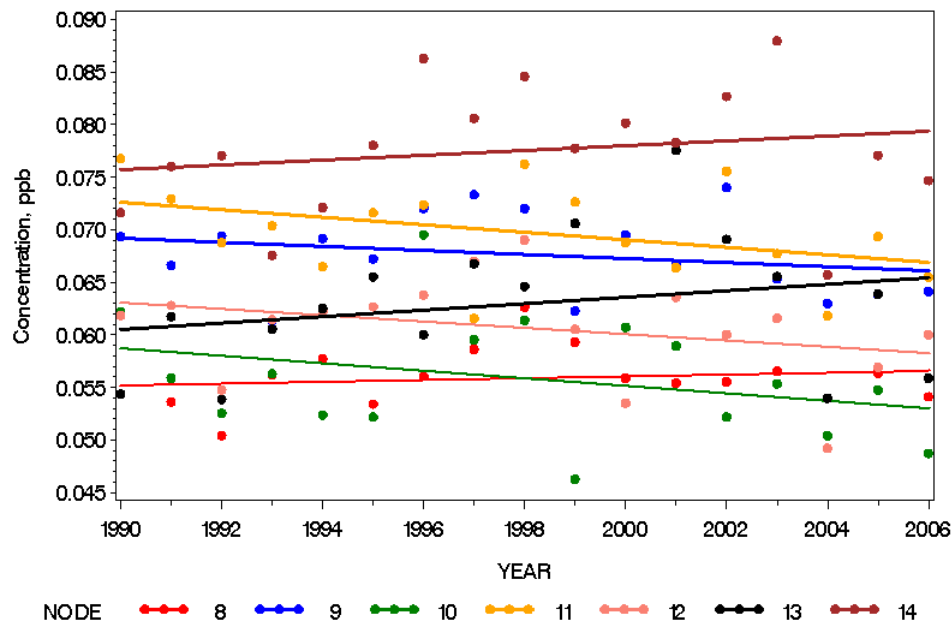
CART Index of Ozone Conduciveness, Cleveland



Index represents fraction of ozone conducive days in each year, above or below 1990-2006 average
 1= twice as many days as average year, -1= half as many days as average year

Concentration Trends in CART Nodes—Cleveland

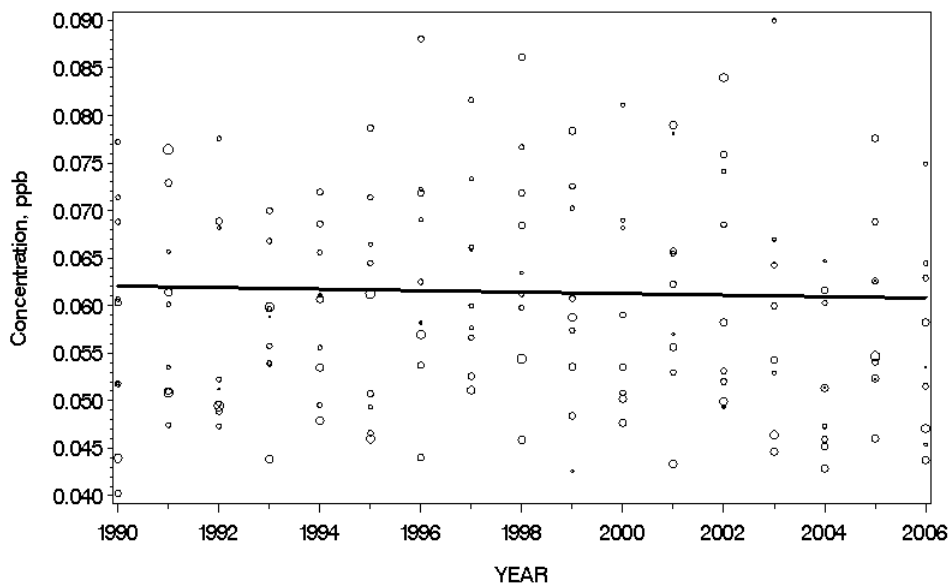
8-hr Ozone, Only Nodes With Concn > 0.05 ppm



NODE 8 9 10 11 12 13 14

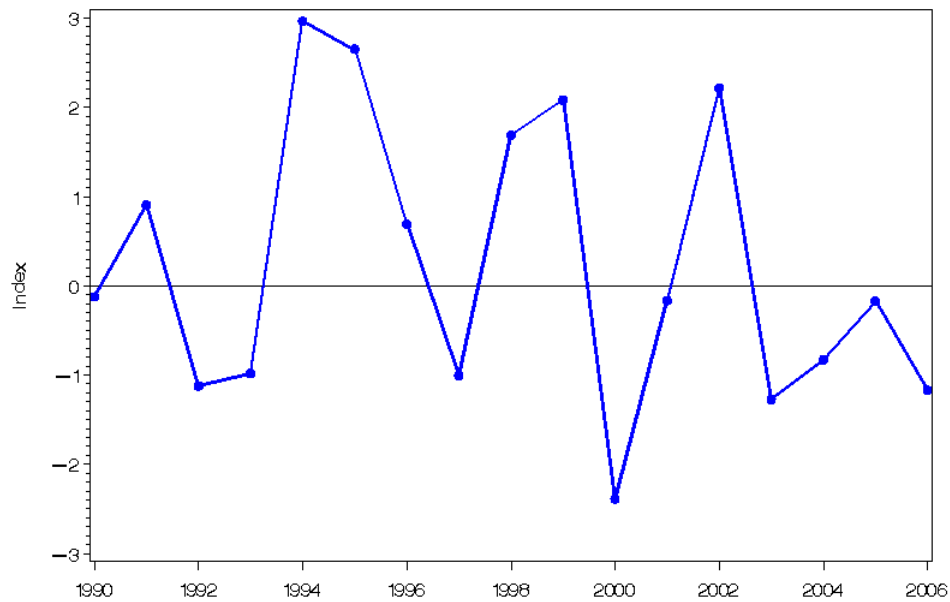
Concentration Trends in CART Nodes—Cleveland

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



Size of bubble is proportional to number of days in node.

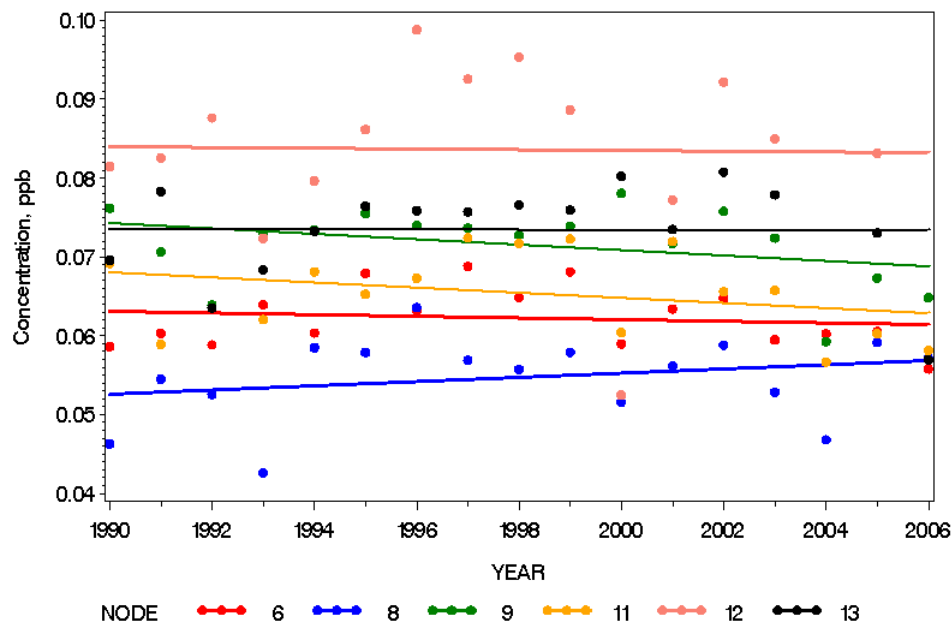
CART Index of Ozone Conduciveness, Indianapolis



Index represents fraction of ozone conducive days in each year, above or below 1990–2006 average
 1 = twice as many days as average year, -1 = half as many days as average year

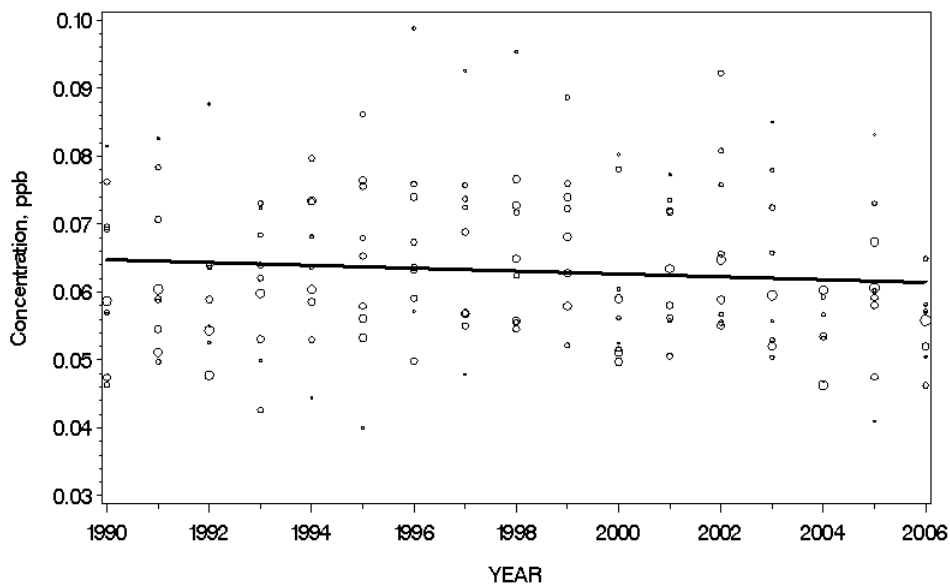
Concentration Trends in CART Nodes—Indianapolis

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



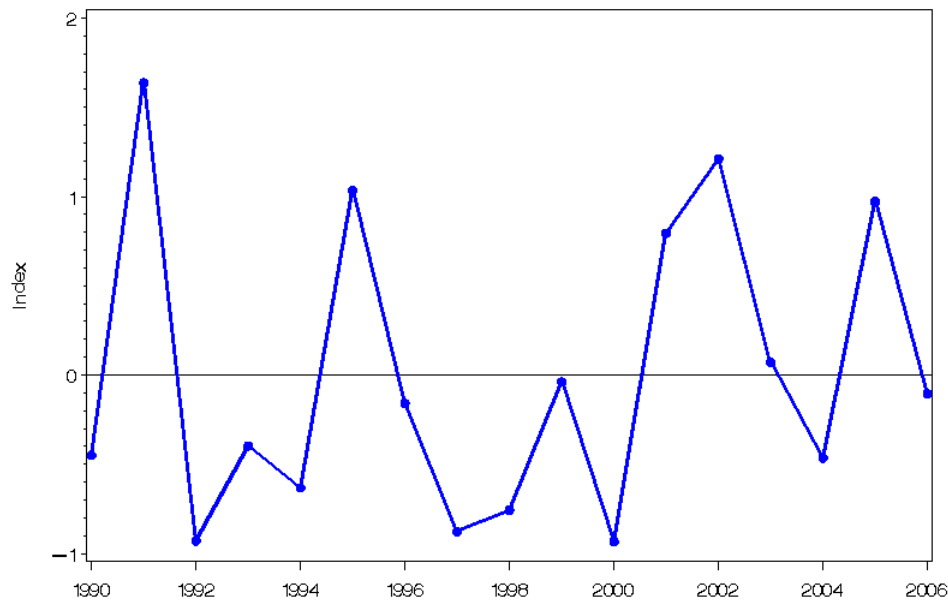
Concentration Trends in CART Nodes—Indianapolis

8-hr Ozone, Only Nodes With Concn > 0.05 ppm



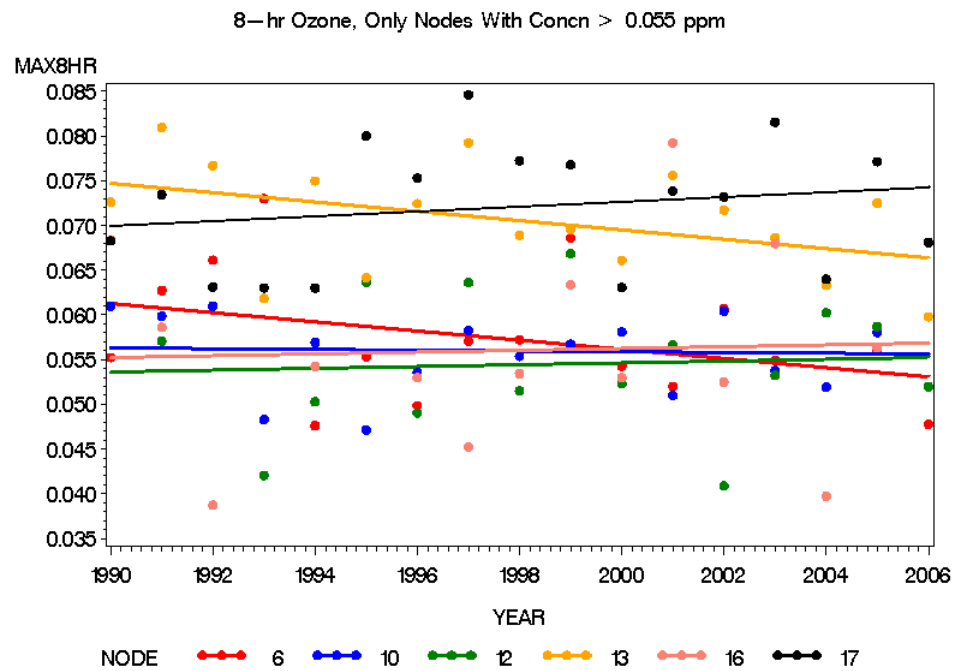
Size of bubble is proportional to number of days in node.

CART Index of Ozone Conduciveness, Milwaukee



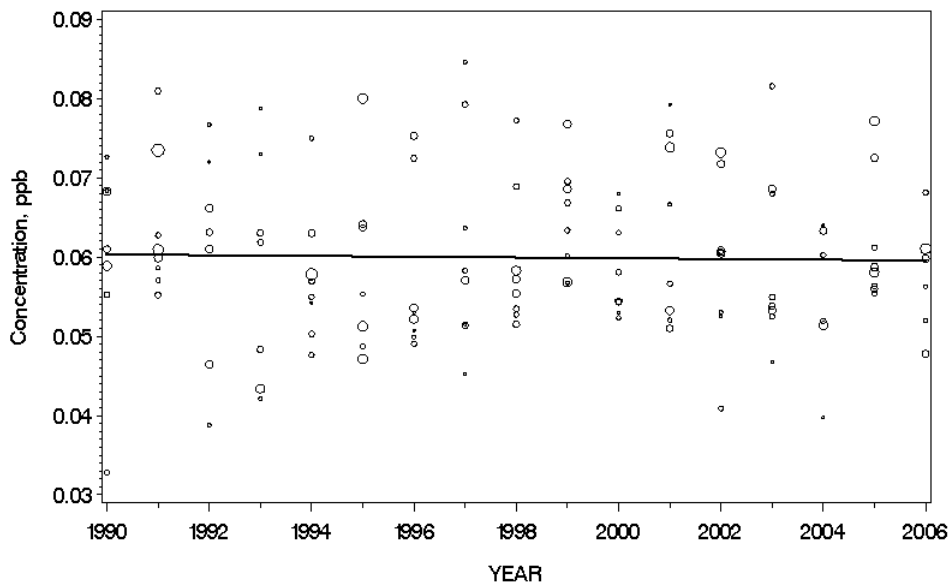
Index represents fraction of ozone conducive days in each year, above or below 1990–2006 average
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Concentration Trends in CART Nodes— Milwaukee



Concentration Trends in CART Nodes— Milwaukee

8-hr Ozone, Only Nodes With Concn > 0.05 ppm

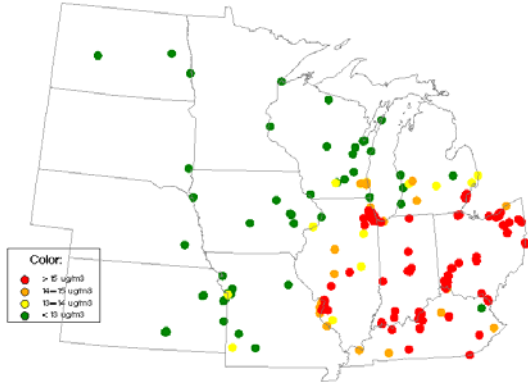


Size of bubble is proportional to number of days in node.

PM2.5 Design Values, Annual Standard

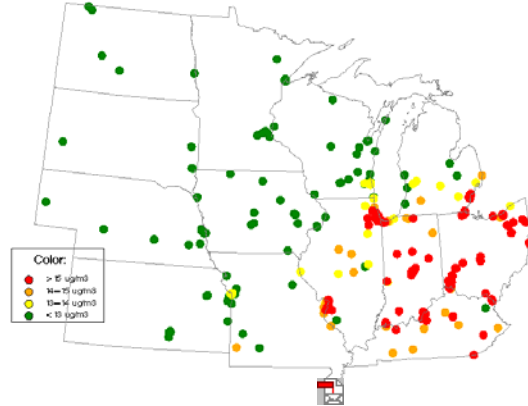
1999-2001

PM2.5 FRM Mean Concentration, 1999–2001



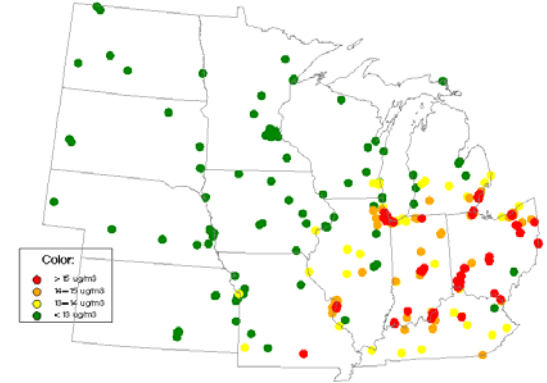
2000-2002

PM2.5 FRM Mean Concentration, 2000–2002



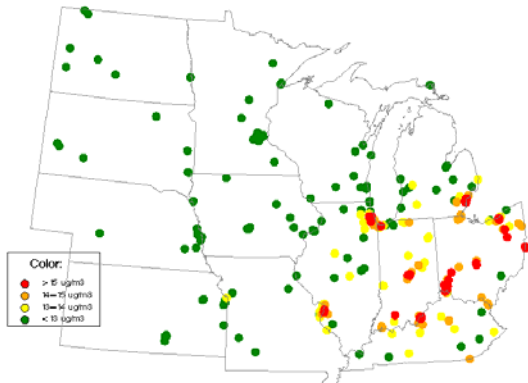
2001-2003

PM2.5 FRM Mean Concentration, 2001–2003



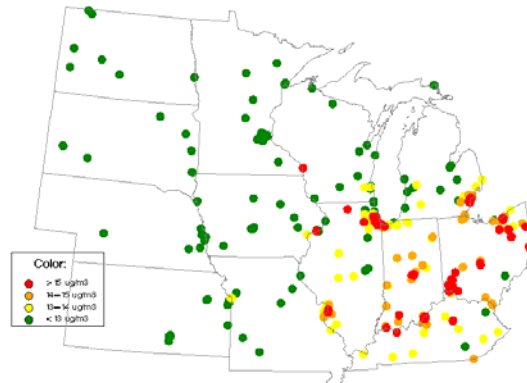
2002-2004

PM2.5 FRM Mean Concentration, 2002–2004



2003-2005

PM2.5 FRM Mean Concentration, 2003–2005



2004-2006

PM2.5 FRM Mean Concentration, 2004–2006

