Is Population/Area Weighting the Right 'Fit' for Air Pollution Trends?

Kristen Immen[1] and Alissa Anderson[2]
[1]Statistics, North Carolina State University, Raleigh, NC 27695
[2]Environmental Science and Statistics, North Carolina State University, Raleigh, NC 27695

Introduction

One of the major missions of the United States Environmental Protection Agency (USEPA) is to improve air quality. They create new regulations to help make the air we breathe cleaner and protect the Earth that we live on. They are required by law to develop National Ambient Air Quality Standards (NAAQS) that must be achieved throughout the United States. Annually, they produce the Air Quality and Emissions Trends Report to tell the public if the standards have been met. Currently, all air monitoring sites meet historical and data completeness criteria. Each air monitoring site is weighted equally. We were asked by our client, Mr. David Mintz of the USEPA, to look at how population weighting and other approaches impact the trends for the following pollutants: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ground level ozone (O_3), particulate matter (typically measured in PM_{10} and $PM_{2.5}$), and sulfur dioxide (SO_2). Population weighting would give greater weight to more populous areas while an approach based upon spatial analysis would give more weight to the spatial area being monitored. The purpose of this project is to see how use of weighting factors compares with the current approach and to recommend alternative ways of describing air pollution trends. If the population weighting, for example, shows that there is a significant difference, the USEPA may want to change how they report the air quality trends.

Methods

Phase 1

In order to get a grasp of what we were asked to find, we started our analysis on the state level. We expect to find similar results on smaller levels of analysis for both population and area weighting.

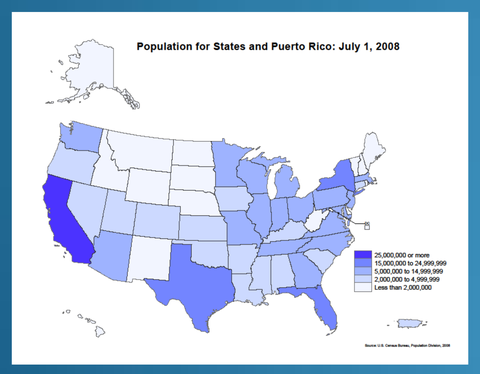
Methods for Calculating Weighted Trends

•To calculate a new trend that is population weighted by state, the following equation is used:

• National Average (Population Weighted) for any given year=∑(State Average Statistic for year)*(State Population)/∑(Populations for Each State/Territory that have sites).

•To calculate a new trend that is land area weighted by state, the following equation is used:

•National Average (Area Weighted) for any given year=∑(State Average Statistic for year)*(State Land Area in Square Miles)/∑(Land Areas for each State/Territory that have sites).



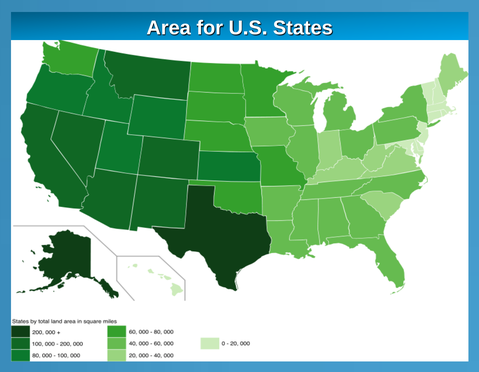
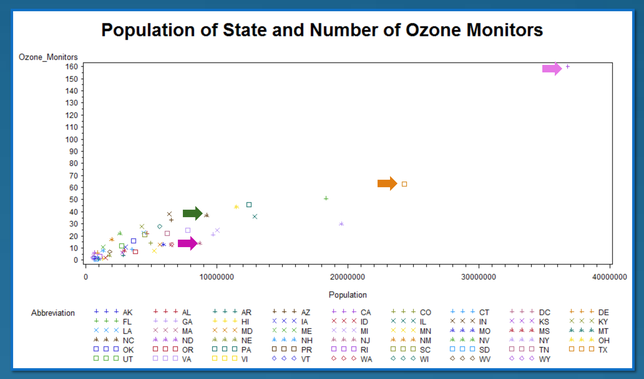
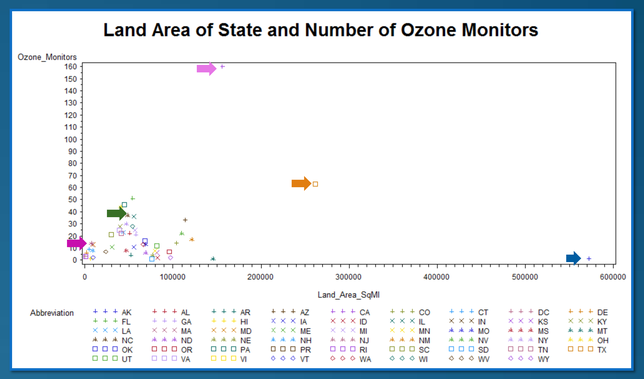
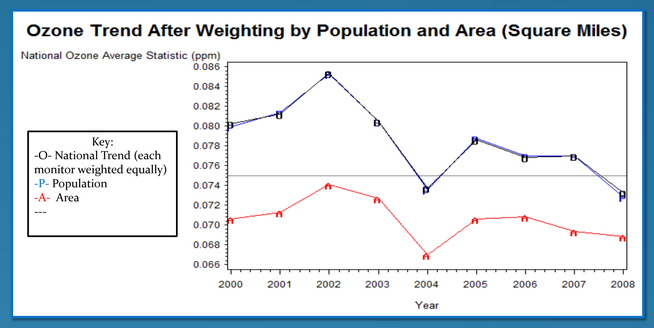


Figure 1. (Left) Population of states from July 2008 and (Right) Area for states.

Results







- The arrows on the two prior graphs correspond with the following:
  - North Carolina
  - New Jersey
  - California
  - Texas
  - Alaska

Discussion

•Both NC and NJ have similar populations, but NJ has 14 trend sites while NC has 37 trend sites. This would suggest population weighting may be appropriate. Overall, the number of monitoring sites per state to state population seems a reasonably good fit at this level of analysis. The number of monitoring sites per state to state area in square miles is a significantly weaker relationship.
• Correlation is affected by California and Texas in the relationships based on population and Alaska greatly skews the correlation for the relationships based on land area of state.
• There was a significant change in trends due to population/area weighting. When taking land area into consideration, the national average trend creates a situation where all states from 2000-2008 are in compliance with the standard for ozone.
• When comparing the actual national trend with the population weighted national trend, they are very similar with only minor differences suggesting that the current approach of weighting each site equally produces a similar result as weighting by population. The trend based on area weighting is significantly different from the actual national trend, yet this is probably due to the inclusion of Alaska in the data.
•We will continue this project by looking at weighting national trends on a county basis for both population and land area for all criteria pollutants.
•We will look at the feasibility of weighting the area weighted trend based upon the scale of measurement and its associated area of coverage.
•We recommend looking at the possible impact of budget cuts by states and hopefully simulating the impact of reductions in the trends network on the national trends.

Reference

•Population map is from the U.S. Census Bureau
•Area Map is from < http://en.wikipedia.org/wiki/File:US_States_by_Total_Land_Area.svg>

Acknowledgements

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