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## GIS Applications for Ground-Level Ozone In Kansas City, MO

There are two types of ozone: tropospheric (ground level) and stratospheric. While stratospheric ozone protects the Earth's surface by absorbing harmful ultraviolet radiation, ground-level ozone is not beneficial. Ground level ozone is formed from nitrogen oxides (NOx) and volatile organic compounds (VOCs) (Stedman, 65). Together these chemical compounds are known as ozone precursors. In a complicated process of meteorological and chemical events, these precursors react with sunlight to form ozone. Anthropogenic sources increase these precursors within urban areas leading to elevated levels of ozone concentration. Over the last 125 years ozone concentrations in the troposphere have been increasing. Measurements taken 100 years ago hit highs at ten to twenty parts per billion (Allen, "Ozone in the Troposhere," para 3.). Ozone concentration levels have now exceeded the former 120 ppb per one hour standard set by the EPA in major metropolitan areas. Ground-level ozone is a toxic environmental substance that causes decreased lung function, asthma, and other respiratory problems. The young, elderly, and those who work or play outside are especially sensitive to elevated ozone levels. Even healthy individuals exposed to the previous EPA safe limit of 120 parts per billion of ozone over a study period of several hours have shown impaired the lung function (Sather, Varns, Mulik, Glen, Smith, & Stallings, 845). Interestingly enough, a recent study ranked Kansas City as the number two asthma hot spot in the nation (COPD International, #2). Asthma, decreased lung function, and respiratory problems are not the only results of high ground-level ozone concentrations. An increase of just ten ppb has correlated with an increase in total human mortality (Bell, Dominici, & Samet, 436). In addition to health effects, crops and other vegetation can be adversely affected by high levels of ozone.

Urban communities, where residents are mainly minorities and have a lower income, bear a disproportionate risk for disease due to air pollution as compared to suburban communities (American Lung Association, 357). Therefore, Kansas City is an ideal place to study the disproportionate impacts of urban air pollution because of the different social and economic statuses of the residents. Living within Kansas City urban core neighborhoods is 79% of the poverty level African-American metropolitan population (Mid-America Regional Council, Metro Outlook). The median household income for urban core residents is $37,900, while for suburban residents it is $52,800 (Metro Outlook). This represents a significant demographic and economic disparity between the urban core and the suburban area. Kansas City is also a regional transportation center. It is a place where east-west and north-south running interstate highways intersect. The transportation network is denser in the urban center where a greater minority, lower-income population lives. While traffic count maps show less traffic on Kansas City urban streets compared to heavily used suburban streets, the sheer number of interstates, collectors, and arterials in the urban core make up for certain exceptions in volume.

Past research done by the EPA and others has suggested that most ozone forms downwind of the source unaffecting the nearby populace. Recent studies of hospital-documented respiratory problems in proximity to nearby transportation networks have shown a correlation between the two (Ryan et al, 279). The dynamics of the thousands of VOCs that can form ozone can lead to formation in hours (National Research Council, 33-34). Stagnant air days, with average wind speeds less than five meters per second, are enough by themselves to warrant a detailed ozone concentration study for Kansas City. These low flow days in the summer lead to ozone concentrations at dangerous levels, because precursors and ozone are not always dispersed by meteorological processes. Exceedances of the EPA 8-hour standard occur, including 24 exceedances in 15 days during 2005 (Mid-American Regional Council, A Clean Air Action Plan).

Ozone concentration data was collected during the summer of 2005. The sampling was collected by a pilot ground-level ozone monitoring study, GLO, conducted by the Laboratory of Climate Analysis and Modeling of UMKC. The purpose of my research was to analyze the raw ozone concentration data from GLO using a geographical information system (GIS). With the aid of ArcGIS version 9.1, I was able to create an ozone concentration surface map. An example is Figure 1. The PSD on Fig. 1 refers to the Passive Sampling Devices which were the ozone samplers. The surface map gives the contiguous ozone concentration for much of Kansas City, Missouri. The major interstates of the Kansas City metro area were then buffered using the GIS to understand the extent of high ozone concentrations in their proximity.

The result was that the higher ozone measurements were found outside of all the interstate buffers of a quarter of a mile, one half of a mile, and one mile. The average ozone concentration inside the quarter-mile buffer shown in Figure 2 was 30.51 ppb while it was 34.49 ppb outside of the buffer. The average concentration inside the half-mile buffer shown in Figure 3 was 32.93 ppb while it was 33.62 ppb outside of the buffer. The average for the inside of the one-mile buffer shown in Figure 4 was 33.49 while it was just 33.72 outside the buffer.

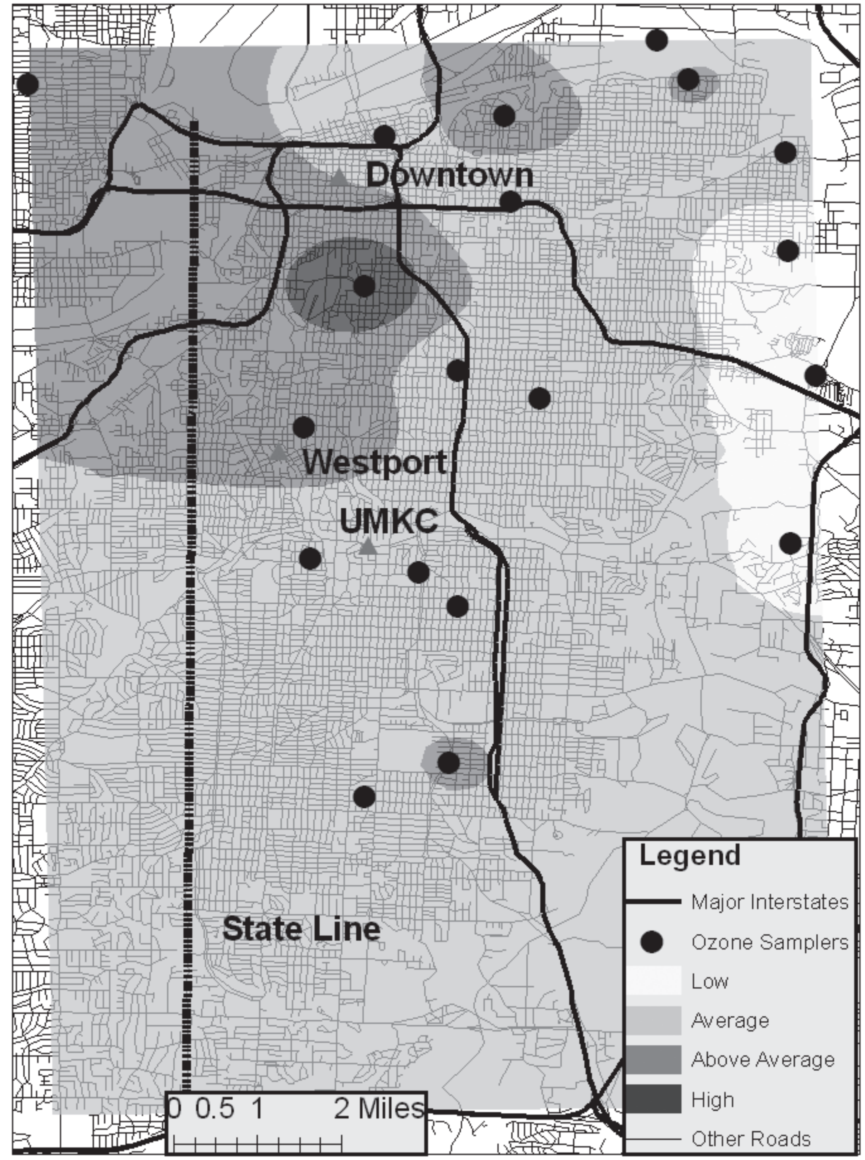


Figure 1: Ozone Concentration Surface Map

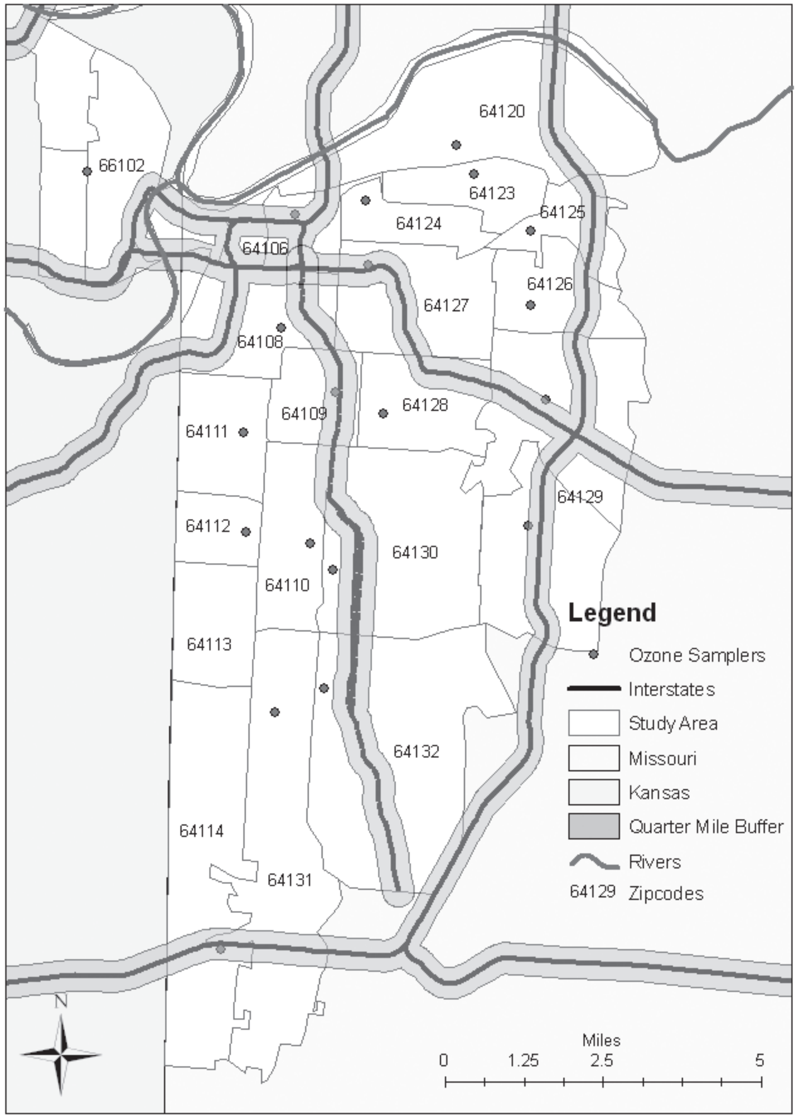


Figure 2: Quarter-Mile Buffer Around Major Interstates

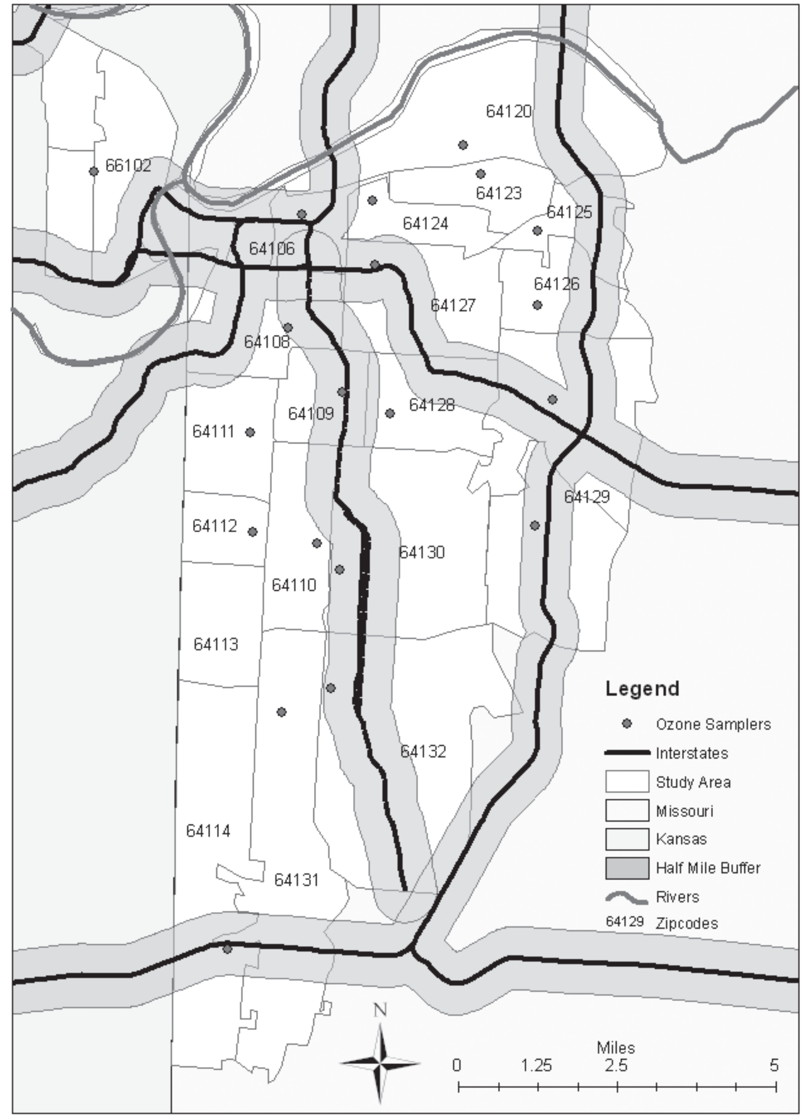


Figure 3: Half-Mile Buffer Around Major Interstates

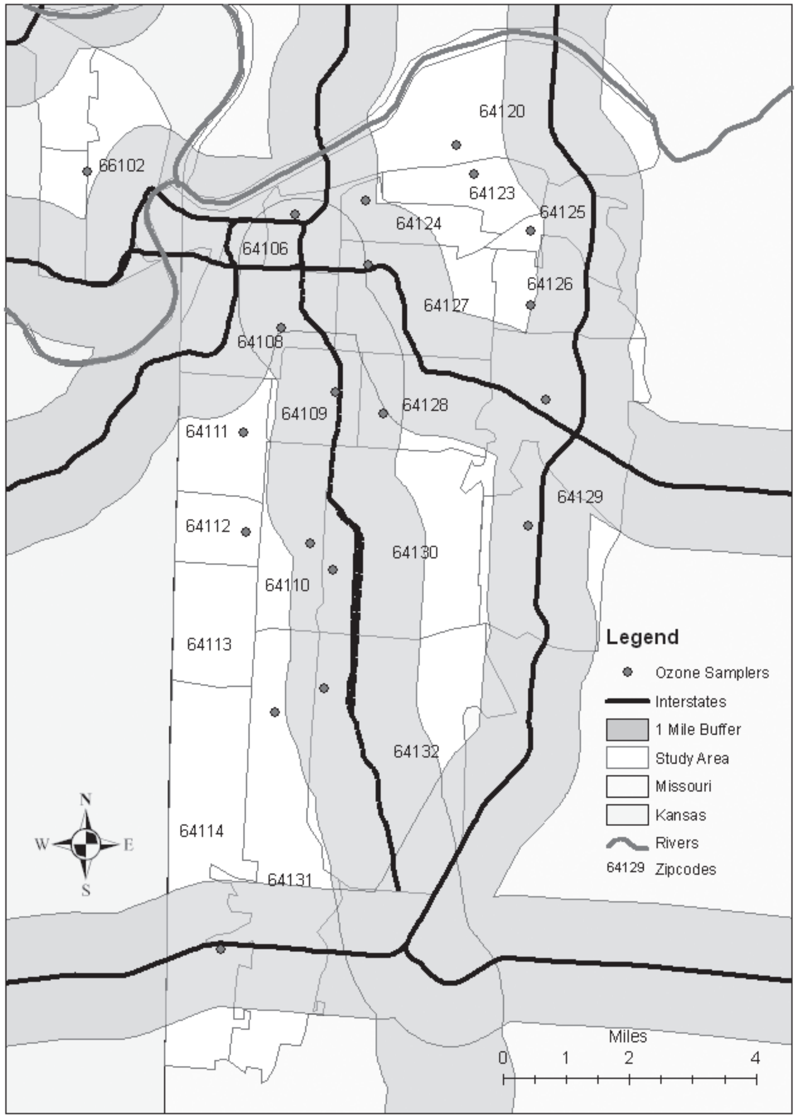


Figure 4: One-Mile Buffer Around Major Interstates

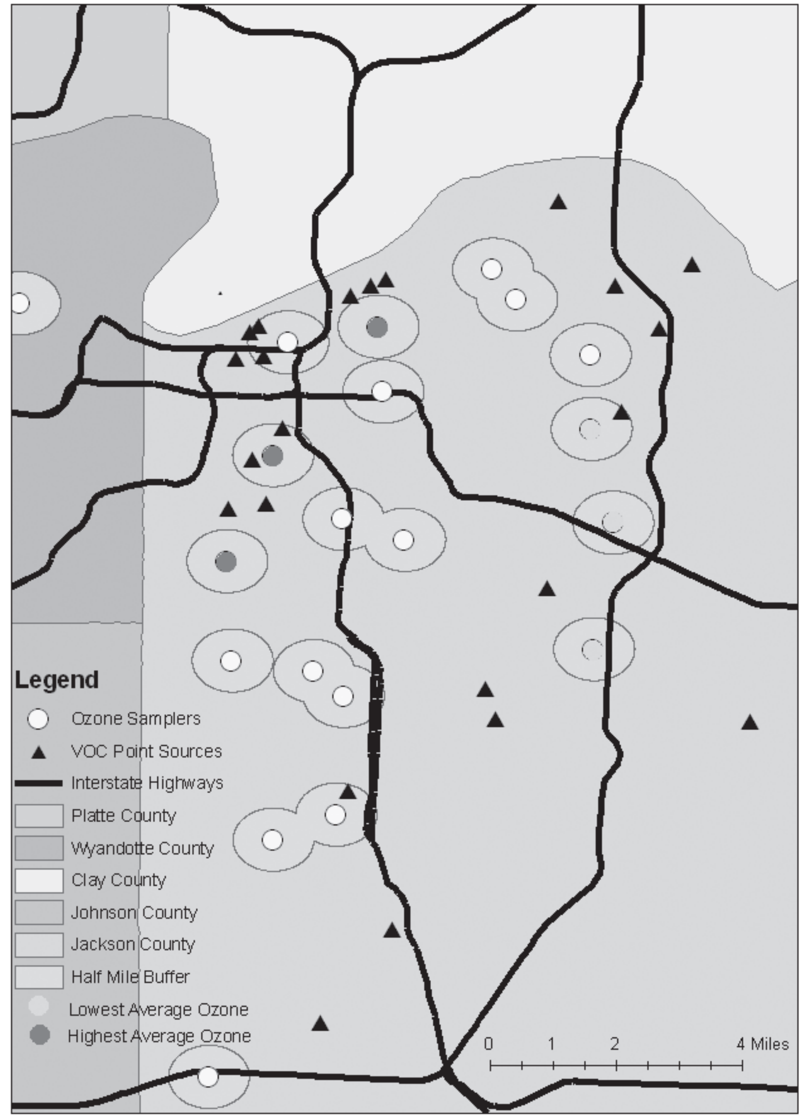


Figure 5: VOC Polluting Point Sources of the GLO Study Area.

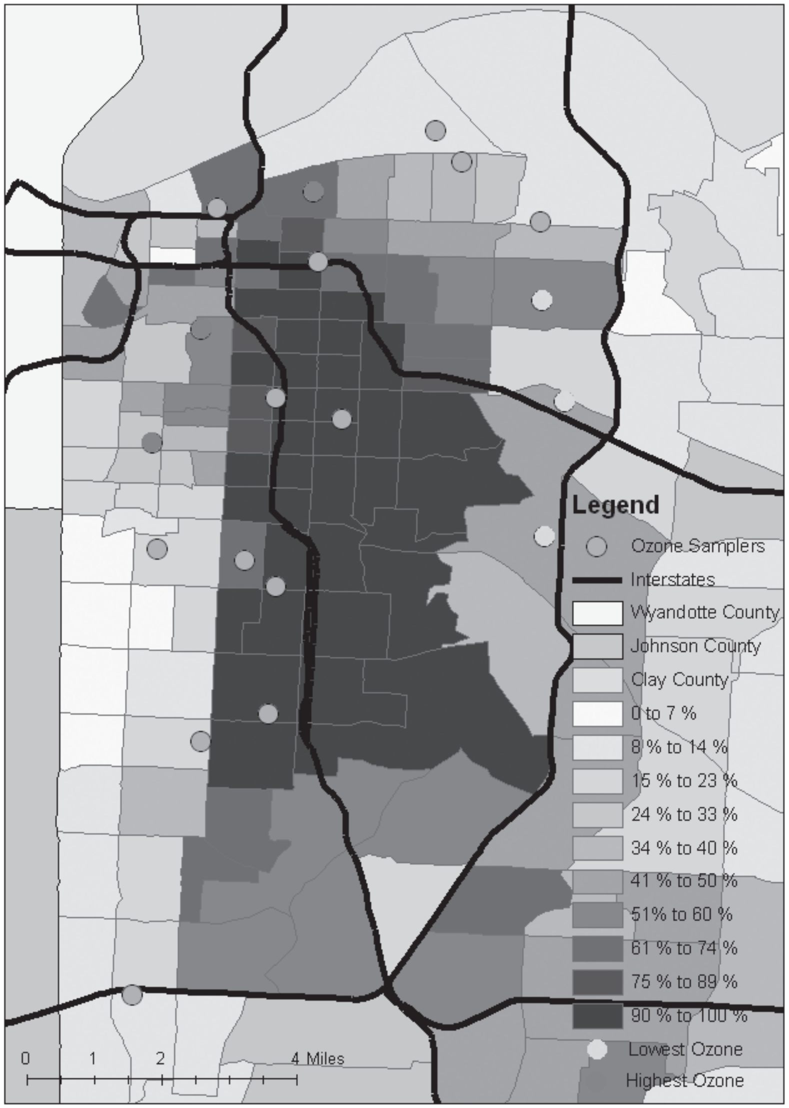


Figure 6: Minority Populations of the GLO Study Area

Further analysis of local point sources of VOCs was undertaken. Data for the point sources were drawn from the EPA National Emissions Inventory using EPA AirData's Facility Emissions Reports. A layer of point sources for ozone precursors applied on the GIS revealed dense clusters of industry in the northeast corner of the GLO study area as shown in Figure 5. Several buffers were applied around the ozone samplers to find if there was a spatial relationship between high average ozone concentration and VOC polluting industries. The three highest ozone sampler averages which where in the GLO study area's northeast corner had a cumulative average of 41 ppb. The three lowest ozone sampler averages were in the eastern part of the study area and had a cumulative average of 28 ppb. Buffer analysis showed no direct relationship between the location of VOC point sources and high ozone concentrations.

To examine the possibility that low-income and minority groups were more likely to experience high ozone levels, Census Bureau Tract data from the year 2000 was analyzed. Used in a GIS, the Census Tract 2000 data easily identified minority areas in the study area as shown in Figure 6. Census tracts were divided into two groups. One group was the census tracts where minority groups comprised 25% or more of the local population. The other group was the census tracts where minority groups comprised less than 25% of the local population. The 25% or more group of tracts had an average ground-level ozone concentration that was three parts per billion higher than the less than 25% group.

In conclusion, ArcGIS 9.1 was found to be a very valuable tool in understanding Kansas City ozone concentrations and their spatial relationships to transportation, industry, and demographics. The effectiveness of buffers in determining any sort of connection between variables is questionable. As a visual aid however, this GIS was useful in searching for spatial relationships between transportation networks, VOC point sources, and minority populations and ozone concentrations. Ozone samplers that were in the midst of dense transportation networks or VOC point sources were easily identified. The concentration data could then be extracted from attribute tables, and statistical analysis could then be conducted in Microsoft Excel.

# References

Allen, Jeannie. (2003). Watching our ozone weather. Retrieved September 9, 2005 from the National Aeronautics and Space Administration website: http://earthobservatory.nasa.gov/Library/OzoneWx/printall.php.

American Lung Association. (2001). Urban air pollution and health inequities: a workshop report. *Environmental Health Perspectives*, 103.3, 357-374.

Bell, M.L., Dominici, F., & Samet, J. M. (2004). A meta-analysis of time-series studies of ozone and mortality with comparison to the National Morbidity, Mortality, and Air Pollution Study. *Epidemiology*, 16.4, 436-445.

COPD International. (2003). Asthma Hot Spots. Retrieved April 12, 2005 from Chronic Obstructive Pulmonary Disease International website: http://www.copd-international.com/Library/asthma-hot-spots_2003.htm.

Mid-America Regional Council. (2005). A clean air action plan for the Kansas City region [Electronic version]. Retrieved October 23, 2005, from http://www.marc.org/airq/pdfs/CAAP%20FINAL%2005-10-05.pdf.

Mid-America Regional Council. (2001). Metro outlook [electronic version]. Retrieved October 20, 2005, from http://www.marc.org/Metro%20Outlook.pdf.

National Research Council. (1999). Ozone-forming potential of reformulated gasoline. Washington D.C.: National Academies Press.

Ryan, P.H., LeMasters, G., Biagini J., Bernstein D., Grinshpun S.A., Shukla R., et. al. (2005). Is it traffic type, volume, or distance? Wheezing in infants living near bus and truck traffic. *Journal of Allergy and Clinical Immunology*, 116.2, 279-284.

Sather, M.E., Varns, J.L., Mulik, J.D., Glen G., Smith L., & Stallings C. (2001). Passive ozone network of Dallas: a modeling opportunity with community involvement. Environmental Science & Technology, 35.5, 845-855.

Stedman, D. (2004). Photochemical ozone formation, simplified. *Environmental Chemistry*, 1.2, 65-66.