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Do State Regulatory Institutions Matter: Using Network Theory to Explore Linkages between Air Policy Boards and Pollution Outcomes

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This is to certify that the dissertation prepared by Debra A. Jacobs, entitled:

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has been approved by her committee as satisfactory completion of the dissertation requirement for the degree of Ph.D. in Public Policy and Administration.

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By Debra Anne Jacobs

A Dissertation Proposal submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

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In addition, Mrs. Haskell provided an introduction to Randy Becker, head of the National Association of Clean Air Administrators. Mr. Becker also gave up a significant portion of his day to discuss his advocacy of clean air issues. I also credit him for suggesting that boards, to the degree that they are successful, move states to more successfully benefit the public interest. This conversation led me to hypothesize that the higher number of citizen members on an air board will be positively correlated to a reduction in ground-level ozone exposure over time.

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of ground-level ozone pollution, especially in relation to monitoring. He also introduced me to Lance McCluney, a statistician with the EPA. He stepped in to provide the monitoring data that served as the basis of the dependent measure. He also spent countless hours explaining the data to me. Thank you both for taking the time to engage me in the importance of your work. I believe this work is the better for it for it and for that I am exceedingly grateful.

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Abstract

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The purpose of this study is to test an adapted model of network theory against state air pollution control institutions. Air pollution control presents a regulatory problem that has interstate, intrastate and multiple federal dimensions. It is one of extreme complexity and uncertainty, from both a regulatory and scientific perspective. The changing political environment federally has enabled states to redefine their roles in the regulatory process (Adler, 1997; Krane, 2007).

Drawing from network theory in intergovernmental policy processes my research tests three key factors in explaining state air pollution levels: tenure in office of the air policy administrator, the use of air policy boards, and networking encompassing agency

heads, air boards and the public. Theoretically this research builds upon important work by William Berry, Paul Teske, Lawrence O'Toole, Kenneth Meier and Mark Schneider in empirically investigating the network theory of policy behavior. Network theory, as envisioned by O'Toole and Meier, provides for systematic empirical research on intergovernmental management. This research expands the network model to incorporate citizen participation and information access in agency policy-making. Further, this research develops the ozone exposure index as the dependent measure and metric of agency performance.

The study limits itself to the time frame of 1999-2007. This time-frame enables me to pool data on the instances of nonattainment of National Air Quality standards for ground-level ozone. This study limits itself to ground-level ozone as the dependent measure. Ground-level ozone is primarily regulated at the state level. It and $PM_{2.5}$ represent the greatest threats to human health nationally. A series of panel data statistical models are tested revealing that the two-way generalized least squares random effects regression proves the best fit for the data. Results support the hypothesis that the tenure of the air administrator positively impacts pollution reduction. The number of citizen members on air policy boards is also found positively correlated to pollution reduction.

This research contributes to the field by expanding the reach of the network model to air policy. It also incorporates citizen participation into the model. Lastly, it also posits that institutional structure can be successfully tied to performance.

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CHAPTER 1

Introduction

This research seeks to empirically investigate the linkage between structural administration and performance outcomes in the context of air pollution control policy. Drawing from the network theory of public management and performance as devised by Lawrence O'Toole and Kenneth Meier (1991), I test the stability of the tenure of the air administrator, the presence of an air policy board, and the number of citizen members against the ozone exposure index where ground-level ozone exceeds the national standard as set forth in the Clean Air Act (CAA). In the context of air quality administration the model is adapted to accommodate the insights of William Berry (1984) and Paul Teske (1991) to integrate questions of public accessibility and information sharing.

This research potentially contributes to the field of public management and public administration in two key respects. Previously network theory has been utilized successfully in studying the dynamics of education administration. This research seeks to apply network theory within the context of air pollution control. Second, I expand the network model to incorporate citizen board members to integrate the role of the public in achieving agency ends. Additionally, I create a measure of information access to further test the inclusion of the public in the policy process.

Air Quality shares many of the same components that drive the study of education administration, such as a multi-tiered federal system with its vast web of information and power sharing networks. Overall goals are often defined at the federal level, but states tend to be given wide latitude in achieving those goals and often further decentralize decision-making down to the local level. Research often focuses on politics, interests and institutions at the federal level. Yet the federal context also presents an opportunity to uncover a great diversity of approaches to administration across the states (Krane, 2007).

This research is premised on two core assumptions. There is insufficient research that incorporates state engagement in the regulatory policy process. Second, a central focus on the state agency that does not incorporate citizen participation and engagement is equally incomplete. Therefore, two important measures are incorporated in the network model. The use of an air policy board is hypothesized to create an additional avenue for stakeholder and citizen participation in the policy process.

Air boards with regulatory functions are surmised to present expanded opportunities for citizen engagement because state and federal sunshine laws, as well as requirements within the Clean Air Act, mandate open meetings and public comment periods. It is therefore anticipated in this research that the presence of boards heightens opportunities for citizens to air their concerns publically at earlier stages of the policy process. Further, the appointment of citizen members of the boards are anticipated to help to drive policy making toward furthering the public interest, in this case reducing air pollution.

Citizen engagement is only possible if citizens are aware of the potential and avenues for participation. Therefore our next measure of participation is access to detailed documentation via the air agency website on citizen participation. The CAA mandates that the public has the right to public comment periods during the development of regulations and other key aspects of air policy development such as New Source Review (to be addressed further below with definition to be found in Appendix A.) Yet, if they are unaware of this access such participation may be meaningless.

Studying the variation between state institutions and correlating them to performance outcomes will potentially provide new insight into public management. This research seeks to present a viable performance measure: the ozone exposure index. This index accounts for number of days of exposure to ground-level ozone that exceeds the national air quality standard by the state population impacted. Ground-level ozone pollution is chosen as a viable performance measure because it is not generally emitted from a direct "point" source such as a utility or industrial plant. Vehicular emissions are key non-point sources of the precursors to ground-level ozone of oxides of nitrogen (NOx) and volatile organic compounds (VOCs). Although other precursor emissions do emanate from point sources, they may travel in the atmosphere hundreds of miles before chemically converting to ground-level ozone in the presence of sunshine. Ground-level ozone is largely a weather related phenomenon, with the highest incidence of excessive ground-level ozone in the summer months. Many factors lay outside states direct control including cross border emissions, weather, and sunlight. Still, the CAA mandates a reduction of ground-level ozone to protect human health. States must find effective means for doing so and have been given wide latitude in determining those means.

I apply an adaptation of network theory to discern whether the institutional structure of the air agency positively correlates to the reduction of pollution over time.

This research aims to demonstrate that structure does matter, especially in relation to three key components: the tenure of the air administrator, the presence of air policy boards, and the role of the citizen in the policy-making process via representation on the air board and through information access on the web.

The structure of this analysis is as follows: Chapter One will provide the introduction, definitions and the historical context of air regulation, beginning with the earliest attempts to control pollution to the present. Chapter Two will provide the theoretical framework for policy innovation that informs this study. Chapter Three will present the methodological foundation of the study, the hypotheses and the operationalization of all variables. Chapter Four will constitute the data analysis and the conclusions drawn from the analysis. Chapter Five will present the continuing challenges for policy innovation and options for future research.

Context

The health threats posed by ground-level ozone are many and well documented. 144.8 million Americans lived in counties in the U.S. with ground-level ozone concentrations above the national standard in 2007 (www.epa.gov/ airtrends/sixpoll.html, retrieved May 3, 2009). For humans lung function is of greatest concern. Ground-level ozone causes reduced lung function characterized by wheezing, coughing and reduced inspiration capacity (Suh et al., 2000). In sensitive populations ground-level ozone can cause a 10% reduction in pulmonary function (USEPA). Serious clinical outcomes may include increased emergency room visits, chronic illness and possible death (Suh et al., 2000). Ambient ground-level ozone concentrations are shown to be related to increased hospital admissions for pneumonia, chronic obstructive pulmonary disease (COPD), asthma, and other respiratory ailments (Burnett al., 1994).

Air pollution, as with other environmental problems, often spans traditional boundaries, requires scientific diagnosis, and is costly to remedy (Hajer, 2003; John, 1994; Rinquist, 1993). The technical nature of environmental problems presents a specific challenge to democratic governance at all levels (Fiorino, 2001; Fischer, 1993). For instance in air quality, the specific environmental problem analyzed in this study, the average citizen is likely not cognizant of the potential threats to their person and as such does not avail him or herself to the means of recourse available to them by statute both state and federal. Most pollutants do not come with distinctive smells or immediately experienced impacts. Thus, unless citizens are properly informed of the dangers and these dangers are salient to their unique circumstances it is unlikely that they will alter their behavior to seek change.

This presents a complex problem for those seeking both to maximize public participation in governance (Box, 1998, Fischer, 1993) and those seeking technical solutions to remedy the effects of pollution. How might government regulatory strategies be devised that both engage the citizenry and lead to efficient, just and reasonable means to reduce pollution without undermining the industrial base of the community?

Academic research on environmental issues aims at devising models of regulatory policy-making (Ringquist, 1993, Mazmanian and Sabatier, 1980), the economic success of Cap and Trade features of the 1990 Clean Air Act amendments (Burtraw and Palmer, 2003; Ellerman, 2003; Goulder et al., 1997) and the increasing role of market based initiatives in reducing pollution (Eisner, 2007). The locus of inquiry in these cases has generally been either political institutions or specific policies. To date, the literature is largely silent at the micro level as to how state government bodies devise regulatory institutions to meet this critical need and whether they are effective in doing so.

Elizabeth Haskell's exploratory work on state environmental management is an important but dated exception (1973). She presents cases studies of nine state environmental agencies. Her in-depth exploration of agency structures in the nine states included analysis of boards present. However, more recent work does not drill down to the board level in analyzing regulatory policy. For instance, a recent study on Clean Air Agencies (Potoski and Woods, 2000) focused on the interaction between agencies, politicians and interest groups. Because boards are often charged with implementing key provisions of the Clean Air Act (CAA) it is deemed critical to better understand their role in the regulatory process.

Proponents of the network model of administration posit that the role of the primary administrator, in this case the air agency head, is of key importance to the organization. Long serving administrators improve performance outcomes, because high performing administrators create and maintain information and policy networks necessary to achieve organizational aims. High turnover would likely fragment such networks and delay or undermine important policy goals. In O'Toole and Meier's study of education test scores improved by at least five percent in cases where long serving administrators were present (2004). In their view, administration is no longer a hierarchical as characterized by the standard organization chart. Instead, today's public management relies on cooperation spanning agencies and organizations, and often where no clear lines of authority exist. The multi-tiered structure of air policy regulation offers an excellent opportunity to apply the network model outside of the education context.

Further, the federal model also provides for nationwide regulation that targets point sources (the locus of emissions, often utilities, factories and other polluting sources that can be pinpointed). The remaining non-stationary sources, vehicles for instance, are left to the states to regulate. Also, pollutants that result from the derivation of secondary compounds from criteria pollutants, as in the case of ground-level ozone, are largely left to the purview of the states. This also provides a key opportunity to apply the network model. The pollution remaining after traditional regulatory tools are applied provide an opportunity to explore how networks operate at the state level to engage in pollution reduction efforts.

This research seeks to fill this gap in the literature by investigating how states regulate air pollution. Do long-serving air administrators have positive impacts on pollution reduction outcomes? Do states utilize Air Policy Boards to regulate air pollution in their state? Are citizens given a seat at the table? Do states provide citizens with the information to engage in the policy process effectively and if so is there an impact on pollution reduction? These questions will guide the study and adaptation of the network model of administration.

Key Research Question

1. Given the importance of reducing air pollution to protect public health does the institutional structure within state departments of environmental quality coupled with citizen participation and information access correlate to quantifiable differences in pollution reduction over time?

Selection Criteria for Pollutant

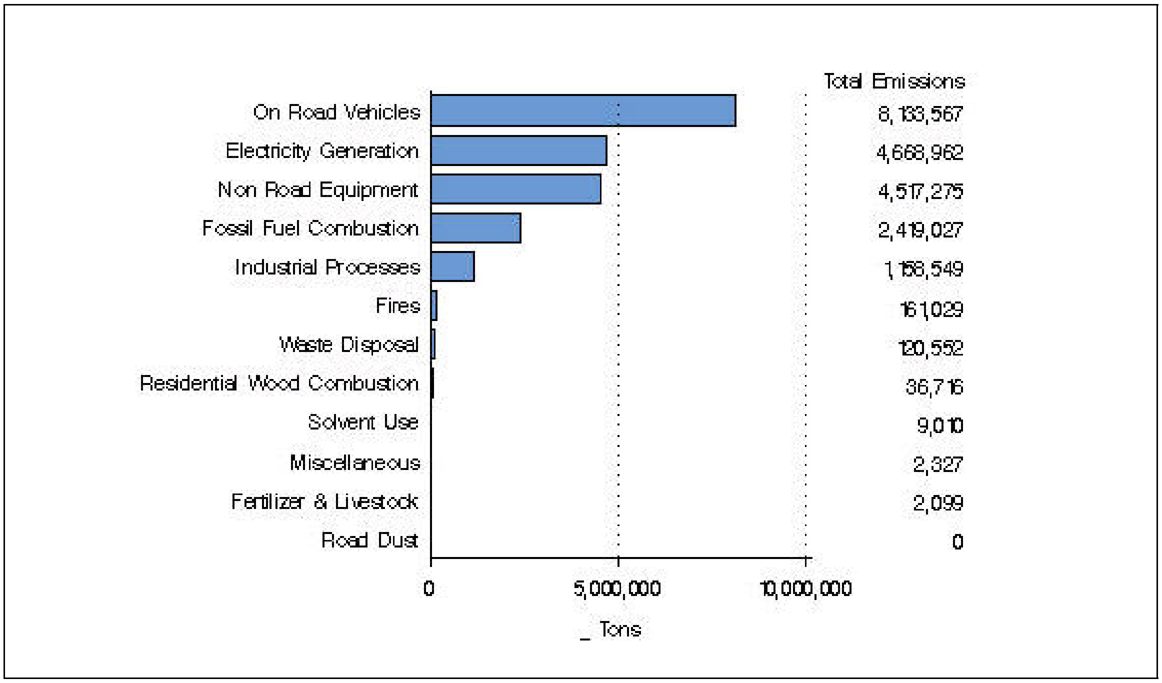
The Environmental Protection Agency (EPA) presently has six main pollutants targeted under the Clean Air Act of 1970. These pollutants are deemed the greatest threats to public health and are therefore labeled "criteria air pollutants." The Environmental Protection Agency is charged with setting the acceptable standards for these pollutants, known as National Ambient Air Quality Standards (NAAQS). In the case of criteria air pollution the Clean Air Act of 1970 specifically requires that the reduction strategy be linked only to public health and that no consideration to economic costs be tied to the setting of the national ambient air standards. Such performance measures are known as "primary standards."

Ground-level Ozone

The focus of this study is ground level-ozone. Ground-level ozone is of particular interest because it is not directly emitted from a source and is the result of a chemical reaction of volatile organic compounds (VOCs) and oxides of nitrogen (NOx) in the presence of sunlight. While federal efforts of the EPA have had some success in reducing ground-level ozone, especially in regard to reducing NOx emissions, the states still play an important role in reducing ground-level ozone. Therefore ground-level ozone provides an excellent target of study to discern the role of the state air administrator, the use of air boards and the degree to which citizens are engaged and provided opportunities to participate in pollution reduction strategies. Ground-level ozone has two main precursors, Nitrogen oxides (NOx) and Volatile Organic Compounds (VOCs). Each will be described below.

Nitrogen oxides (NOx) is a generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are both colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2) along with particles in the air can often be seen as a reddish-brown layer over many urban areas (EPA). NOx is one of the key precursors to ground-level ozone. Figure 1. below demonstrates the sources of NOx emissions in the US. On the road vehicles account for the highest incidence of emissions in the U.S.

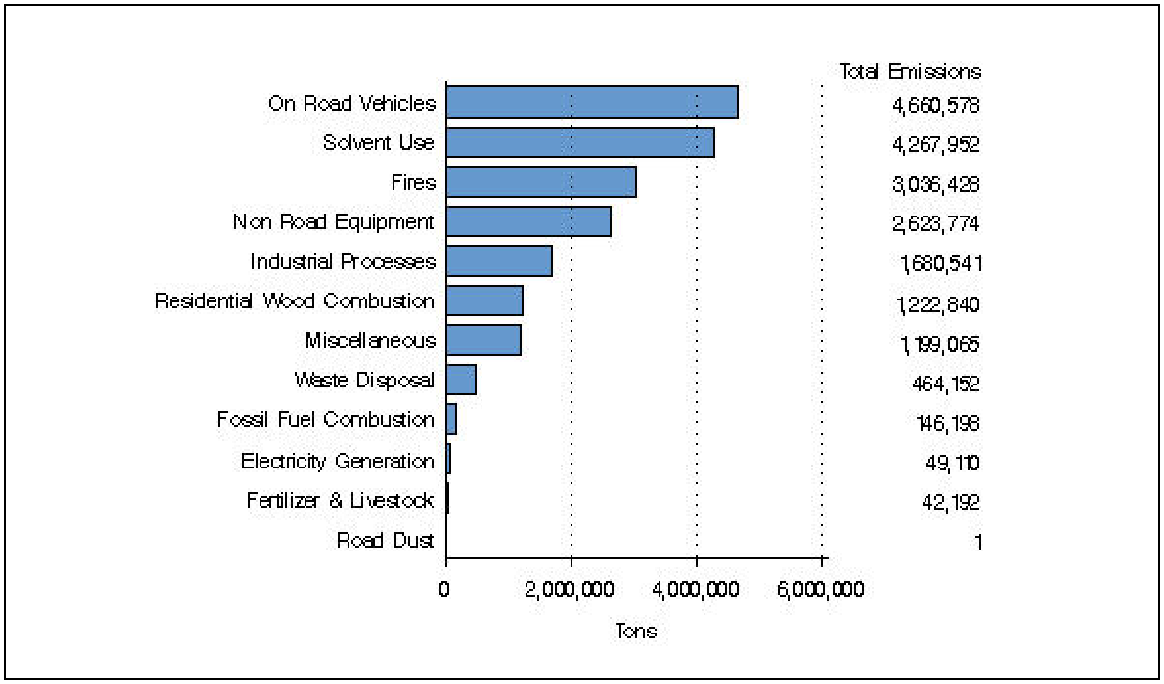
Figure 1. National Nitrogen Oxides Emissions by Source Sector



Source: http://www.epa.gov/air/emissions/nox.htm#noxnat retrieved May 1, 2009

Volatile Organic Compounds (VOCs) represent the second precursor to ground-level ozone. VOCs are compounds that have a high vapor pressure and low water solubility. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. VOCs typically are industrial solvents, such as trichloroethylene; fuel oxygenates, such as methyl tert-butyl ether (MTBE), or byproducts produced by chlorination in water treatment, such as chloroform. VOCs are often components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents(USGS, http://toxics.usgs.gov/definitions/vocs.html, retrieved May 4, 2009). Figure 2. below demonstrates the main sources of VOCs in the U.S. As with NOx emissions, the primary source is on road vehicles.

Figure 2. National Volatile Organic Compounds Emissions by Source Sector, 2002



Source: http://www.epa.gov/air/emissions/voc.htm#noxnat retrieved May 1, 2009

Figure 3. below demonstrates the air quality guide for ground-level ozone. The CAA mandates that states provide access to "AIRNOW," a website that displays real-time pollution levels nationally and locally on the state agency website. AIRNOW is an interactive program that enables a citizen to view national maps of ground-level ozone trends, and to drill down to the state and city to determine the current status of air quality. In the investigative stages of this research I determined that all but one state provided a link to AIRNOW from either the front page of the umbrella agency website or from the main page of the air agency website.

Figure 3. Air Quality Guide for Ground-level Ozone

Air Quality Index	Protect Your Health
Good (0-50)	No health impacts are expected when air quality is in this range.
Moderate (51-100)	Unusually sensitive people should consider limiting prolonged outdoor exertion.
Unhealthy for Sensitive Groups (101-150)	The following groups should limit prolonged outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors
Unhealthy (15-200)	The following groups should avoid prolonged outdoor exertion: • People with lung disease, such as asthma • Children and older adultsPeople who are active outdoors Everyone else should limit prolonged outdoor exertion.
Very Unhealthy (201-300)	The following groups should avoid all outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors Everyone else should limit outdoor exertion

Source: (http://www.airnow.gov/index.cfm?action=static.consumer, retrieved April 17, 2009)

According to the EPA, one in three Americans is at heightened risk for the health consequences related to ground-level ozone (Air and Radiation, 2003, pg. 10). Participating in outdoor activities creates the greatest risk for ground-level ozone exposure. Children are considered at the greatest risk. They are the most likely group to spend their summers outdoors participating in vigorous activities. Children are also more likely to suffer from asthma and other respiratory illnesses that are most likely to be aggravated by ground-level ozone exposure. The next group in danger of ground-level ozone exposure includes all adults who are active outdoors. This is due to the fact that physical activity causes ground-level ozone to more deeply penetrate lung tissue (Air and Radiation, 2003, pg 10).

Adults with asthma and other respiratory diseases are also considered to be at heightened risk for the effects of ground-level ozone exposure for the same reasons ground-level ozone is a danger to children. For this group, even lower levels of ground-level ozone may be unsafe. Some otherwise healthy individuals are especially susceptible to the impacts of ground-level ozone and scientists still are uncertain as to why. Ground-level ozone can inflame and damage the lining of the lungs. If this damage occurs repeatedly over time lung tissue can be permanently scarred (Air and Radiation, 2003, pg. 10).

Ground-level ozone is one of the main constituents of smog. Smog is often the dark haze found hanging over a city skyline. Sulfur Dioxide (SO_2) is a criteria air pollutant that is implicated in smog. While ground-level ozone is unseen, smog is the charcoal haze often seen hanging over urban areas in the summer months. Smog is the combination of ground-level ozone, particulate matter and secondary compounds, often that flow from chemical reactions of SO_2 and NOx. It is for this reason that the analysis below will often incorporate discussions of SO_2, VOCs, and NOx. Although there is some ambient air monitoring that detects the primary compounds of these two criteria air pollutants, it is now known that their secondary compounds pose the greatest health effects. As smog is not directly measured, I will limit this analysis to ground-level ozone monitoring with the knowledge that the secondary compounds of SO_2 and NOx are likely implicated in the development of ground-level ozone.

The 1970 CAA amendments require each state to create a state implementation plan (SIP) for all criteria air pollutants. The SIP details the emissions limits for all individual sources in order to achieve National Ambient Air Standards (NAAQS) statewide. Emissions limits are geographic-specific and are therefore different given the conditions at each site. The EPA creates regions within states based on modeling information to ensure that no particular area precipitously fails the prevailing standards. Conversely, select pristine areas with good air quality may be subject to Prevention of Significant Deterioration (PSD) requirements (generally set up to protect National Parks and other sites of national importance-signified by a Class One designation) that must exceed New Source Performance Standard (NSPS) limits set by the EPA in order to maintain the pristine air quality of Class One sites.

Nitrogen Oxide (NOx) is also targeted under Title IV and is also a precursor to ground-level ozone. In what has become known as the NOx-SIP call, the EPA has addressed the interstate transport of NOx. It provided for cap-and-trade mechanisms like that of the acid rain program that resulted from the 1990 Clean Air Act amendments. States were required to present state implementation plans (SIPs) by 1999 and to begin further reductions of NOx by 2003. Both the acid rain program and the NOx SIP call allow for flexibility in implementing the required reductions. Through Title IV of the CAA amendments of 1990 SO_2 regulation has transformed to a market based approach in pollution credit trading. Similar results are anticipated from the NOx SIP Call. However, all action has not shifted to the federal level. Non-stationary sources such as vehicles remain under the purview of the states. States continue to be required to perform New Source Reviews (NSRs) for new facilities and for upgrades to current facilities. The determination of when an upgrade ought to trigger an NSR has remained controversial from the earliest days of implementation (NAPA, 2003). States also maintain reporting requirements, cross-over requirements to maintain National Ambient Air Quality Standards (NAAQS)-a program separate from Cap and Trade, and enforcement actions.

There remain key challenges for states to meaningfully reduce pollution. Cross boundary pollution remains an issue, and questions on adequate monitoring and the appropriate levels of NAAQS standards remain. Many in the health and legal community remain uncertain that current standards are stringent enough (Coglianese and Marchant, 2004). Despite the innovative features of Cap and Trade it appears to be equally litigious to its older command and control counterparts. This is demonstrated by a Supreme Court ruling in April 2007. Grandfathering of older coal fired plants and differing levels of enforcement related to NSR suggest that not all states have the means or the wherewithal to use a network based approach to reduce air pollution problems in their state. What are the impediments to progress? Where progress has occurred can it be correlated to board structure and/or to the longevity in office of the air administrator? Does the market-based innovation at the federal level induce innovation at the state level?

Also, there are a number of control variables that must be accounted for in order to isolate the role of boards in relation to pollution outcomes. The strength of utilities industries in each state in relation to state GDP, and the growth in the use of coal consumption over time in each state must be accounted for as well. The political context is hailed by many to be a contextual variable of importance (List and Mchone, 2000), but is downplayed by others (Ringquist, 1993, Potoski and Woods, 2003). State economic trends are also hypothesized to be a factor (Becker, 2003); therefore I will track annual unemployment rates for the period of study.

A Brief History of Air Regulation

Air is the quintessential "moving target" that creates pesky problems for public administrators at all levels. Pollution cannot be contained within the arbitrary borders of states, nor are there reasonable means to designate a single entity with all policy responsibilities. Thus, in the US context air policy is a complex web at the federal level engaging the Environmental Protection Agency, the Department of Energy, Federal Legislation and Congressional oversight to name but a few. At the state level the picture is less clear.

Early Action by US Cities

The first recorded attempts to regulate air quality in the United States were initiated by the cities of Chicago and Cincinnati in 1881 (EPA, 2000). The impetus was to control both smoke and soot emanating from furnaces and locomotives. At the time there was little hard scientific data on the health impacts of smoke and soot. The perceived need arose from anecdotal evidence and the obvious visual evidence of black pluming clouds of smoke and the legion of black soot found in urban areas. Other cities followed suit and began to pass their own laws by the early 1900s (see Table 1.) Evidence in these early days was characterized by a combination of coarse soot and dust fall with fine carbonaceous and acidic particles and gases from industrial and domestic sources (Bachman, 2007 pg. 655). A medical and scientific consensus was emerging that the emissions were harmful to public health, but at the time no hard data was available (Bachman, 2007).

Table 1. Development of principal American municipal smoke abatement Legislation before 1930

Decade	Cities
1880–1890	Chicago, IL; Cincinnati, OH
1890–1900	St. Paul, MN; Cleveland, OH; Pittsburgh, PA
1900–1910	Los Angeles, CA; Minneapolis, MN; St. Louis, MO; Milwaukee, WI; Indianapolis, IN; Dayton, OH; Detroit, MI; Akron, OH; Buffalo, NY; Rochester, NY; Syracuse, NY; Washington, DC; Baltimore, MD; Philadelphia, PA; Newark, NJ; Springfield, MA; New York, NY; Boston, MA
1910–1920	Portland, OR; Denver, CO; Kansas City, MO; Des Moines, IA; Duluth, MN; Nashville, TN; Birmingham, AL; Louisville, KY; Flint, MI; Toledo, OH; Atlanta, GA;Columbus, OH; Richmond, VA; Albany County, NY; Jersey City, NJ; Hartford, CT; Providence, RI; Lowell, MA
1920–1930	San Francisco, CA; Seattle, WA; Salt Lake City, UT; Sioux City, IA; Omaha, NE; Cedar Rapids, IA; Grand Rapids, MI; Lansing, MI; East Cleveland, OH; Wheeling, WV; Erie County, NY; Harrisburg, PA

Source: Bachmann pg. 646

Although there was some evidence of improvement in the various cities that had mandated reductions, World War I and the increase in industrial production that followed in many cases lead to an abandonment of legal enforcement of abatement and an increase in pollution (Bachman, 2007). Health effects remained largely unknown. Targeted study was hampered by an inability to systematically monitor emissions and gaps in scientific knowledge. For instance, in the early period very little was known about the formation of particulate matter that contributes to the creation of acid-rain. This knowledge gap led some to believe that simply building taller emissions stacks would solve potential smoke and soot problems. Although the EPA recognized that tall stacks and intermittent controls were insufficient to reduce secondary effects of SO_2, these dual problems did not receive regulatory treatment until the Clean Air Amendments of 1990 (Bachmann, 2007, pg. 683), which will be explained further below.

Health Effects of Air Pollution

In the early stages of industrial development the public understanding of the health risks of air pollution centered on smog events and corresponding deaths in urban areas. There was a lack of air quality monitoring, or even general know-how on the potential of monitoring, that persisted in the US until late in the 20th century. Health effects research was similarly slow to evolve. The EPA notes that studies began to correlate pollution levels to hospital records to show that high incidences of pollution were correlated to health conditions such as asthma, bronchitis and other respiratory illnesses (EPA, 2006, pg 4-25).

We now know that there are persistent and serious health impacts to children who live in highly polluted areas, including those considered “nonattainment areas” in the US. According to David Bates:

> [a]ir pollutants have been documented to be associated with a wide variety of adverse health Impacts in children. These include increases in mortality in very severe episodes; an increased risk of perineonatal mortality in regions of higher pollution, and an increased general rate of mortality in children; increased acute respiratory disease morbidity; aggravation of asthma, as shown by increased hospital emergency visits or admissions as well as in longitudinal panel studies; Increased prevalence of respiratory symptoms in children, and infectious episodes of longer duration; lowered lung function in children when pollutants increase; lowered lung function in more polluted regions; increased sickness rates as indicated by kindergarten and school absences; the adverse effects of inhaled lead from automobile exhaust. These impacts are especially severe when high levels of outdoor pollution (usually from uncontrolled coal burning) are combined with high levels of indoor pollution. In developed countries, where indoor pollution levels are lower, increasing traffic density and elevated NO^2 levels with secondary photochemical and fine particulate pollution appear to be the main contemporary problem. By virtue of physical activity out of doors when pollution levels may be high, children may experience higher exposures than adults. Air pollution is likely to have a greater impact on asthmatic children if they are without access to routine medical care. (Bates, 1995)

It bears noting that Bates included three non-attainment regions from the United States in his data, therefore the above should not be construed to reflect third world problems or problems external to the United States. Additionally, it is important to note that the contemporary problem of particulate matter in developed nations may be linked to the downwind chemical reaction of sulfur dioxide into particulate matter.

Environmental Effects of Air Pollution

As the industrial revolution advanced it became clear that there were environmental costs associated with most sectors of the industrial machine (Kessel, 2006). Soot, smelters, and coal combustion with black smoke billowing from pipes are the supposed price of the advance of civilization. Yet, at first, these issues were considered as aesthetic nuisances rather than through the lens of potential environmental degradation. It was widely assumed that pollutants released into the atmosphere would simply dissipate in the sky or otherwise disperse so as not to be a threat to human health. The high smokestacks of many polluting industries were considered innovations that helped to reduce pollution in urban areas. Many years passed before it was recognized in the scientific community that the pollutants were capable of traveling many hundreds of miles only to mix with other pollutants to create other chemical compounds reflecting new threats to both public health and the environment (Ackerman and Hassler, 1980). It is now suspected that the secondary compounds have more significant health and environmental impacts than the primary compounds of SO_2, NOx and VOCs (EPA, 2008).

Acid Rain

A significant threat for our purposes is the mixing of SO_2 , NOx and VOCs in the atmosphere with water, oxygen and oxidants. This mix forms a solution of sulfuric acid and nitric acid known as acid rain and is implicated in the potential secondary impacts on the amount of aluminum and methylmercury in lakes and fish (Burtraw and Palmer, 2003). Acid rain can do significant damage to crops, buildings and aquatic regions hundreds of miles from the site of the initial discharge of the pollutants (Schwartz, 1989). Acid rain is in some ways a misnomer because the compounds can fall to the earth in either wet or dry form. The wet form includes rain, snow and fog. The dry form falls to earth in either gaseous form or as dry particles. These dry particles are blown by wind and settle on buildings, cars and vegetation. The acidity can cause some of these items to be eaten away. For instance many buildings of historic significance have shown significant external deterioration in areas were acid rain is a persistent problem (http://www.epa.gov/acidrain/effects/materials.html, retrieved May 3, 2009).

When the dry materials are washed away by rain they enter lakes and streams and cause acidification. This can lead to fish die offs. Trees at high elevations have also shown significant damage. Acid rain also impacts visibility. The vistas at many national parks once beloved by Americans are now degraded at many important sites, including the Grand Canyon, the Smoky Mountains and along the Appalachian trail (http://www.epa.gov/acidrain/effects/visibility.html, retrieved May 3, 2009). This is true despite the fact that these areas may be in compliance with NAAQS standards. In a strange twist, the cleaner the air at the given location the more the visibility will be degraded by the presence of particulate matter.

Ground-level Ozone

Ground-level ozone is an unseen threat to human health. Unlike its counterpart smog, it is has no distinct odor or visual impact (http://www2.nsc.org/library/facts/ozone.htm, retrieved May 3, 2009). While stratospheric ozone is critical to maintain life on the planet, ground-level ozone is a stealth threat to human health and the health of vegetation. The EPA estimates that crop damage creates a $500 million loss annually to farmers. Ground-level ozone has no primary source; it cannot be traced to a utility stack or industrial emitter. Neither can it be traced to a car's exhaust pipe. However, all of these sources emit other chemical components that travel through the atmosphere until conditions are ripe to chemically react into secondary compounds that then lead to the production of ground-level ozone.

As noted above, there are widespread health effects across a number of at risk populations. The EPA notes the following health impacts on their website:

- airway irritation, coughing, and pain when taking a deep breath;
- wheezing and breathing difficulties during exercise or outdoor activities;
- inflammation, which is much like a sunburn on the skin;
- aggravation of asthma and increased susceptibility to respiratory illnesses like pneumonia and bronchitis; and,
- permanent lung damage with repeated exposures. (http://www.epa.gov/air/ozonepollution/health.html, retrieved May 3, 2009).

Further, the EPA notes these effects may lead to increased school absences, medical visits to both to doctors and emergency rooms, as well as hospital admissions. According to the EPA research also indicates that ground-level ozone exposure may increase the risk of premature death from heart or lung disease.

(http://www.epa.gov/air/ozonepollution/health.html, retrieved April 19, 2009).

The CAA amendments of 1970 included ground-level ozone as a criteria air pollutant. In 1971 the EPA established a 1-hour National Ambient Air Quality (NAAQS) of 0.08 ppm. This standard was revised in 1979, 1997 and new standards were in the review process during the period of this study. A comprehensive history of ground-level ozone standards is set forth below in Table 2.

Table 2. History of Ground-level Ozone Standards

1971	EPA established a 1-hour NAAQS ground-level ozone standard of 0.08 ppm.
1979	EPA revised the 1-hour standard to 0.12 ppm.
1991	The number of counties designated for non-attainment reached 371.
	Concerned about the new science indicating adverse effects at levels allowed by that NAAQS, the American Lung Association went to court to compel EPA to act.
1994	EPA obtained a voluntary remand based on a promise to consider the newer studies.
1995	EPA and 37 eastern states form the Ozone Transport Assessment Group - work with stakeholders to study ground-level ozone transport for two years.
1996	EPA issued a three-volume criteria document encompassing hundreds of new scientific studies, finding "strong" scientific evidence of adverse health effects from ground-level ozone at levels allowed by the 1979 NAAQS.
1997	(July) EPA revised the air quality standards for ground-level ozone replacing the 1979 standard with an 8-hour standard set at 0.08 ppm. Three states and dozens of industry plaintiffs quickly challenged the new standards.
	(October) EPA acted on the work of the Ozone Transport Assessment Group and proposes NOx regional reductions in the eastern US.
1998	EPA issued the final rule on regional NOx reductions, known as the NOx SIP Call.
1999	The DC Circuit Court of Appeals sent the 1997 standards back to EPA for further study. EPA appealed.
2001	The U.S. Supreme Court unanimously upheld the constitutionality of the Clean Air Act as EPA had interpreted it in setting the 1997 health-protective air quality standards. The Supreme Court also reaffirmed EPA's long-standing interpretation that it must set these standards based solely on public health considerations without consideration of costs.
2002	EPA began the process by which states (governors) and tribes submit recommendations for what areas would be designated non-attainment (failing to meet the 1997 standard).

Table 2. Continued.

2003	(June) EPA proposed the clean air ground-level ozone implementation rule with options for how areas would transition from the 1-hour ground-level ozone standard to the 8-hour ground-level ozone standard.
	(July) States and tribes recommended designations - 412 counties were included.
	(December) EPA responded to states and tribes describing intended modifications to their recommended designations - 506 counties were included.
	(December) EPA proposed the Clean Air Interstate Rule to help areas in the US meet the 8-hour ground-level ozone standard.
2004	(April 15) EPA finalized the Clean Air ground-level ozone designations and basic implementation rule.
2007	(June) State plans for meeting the 1997 health-based 8-hour ground-level ozone standard were submitted to EPA.
	(July) EPA proposed revisions to the National Ambient Air Quality Standards (NAAQS) for ground-level ozone.

Source: EPA http://www.epa.gov/air/ozonepollution/history.html, retrieved April 7, 2009

Early State Activity leading to Federal Involvement to reduce Air Pollution

Oregon became the first state to pass comprehensive statewide legislation in 1952 that included the creation of a state air pollution agency (Rinquist, pg 45 citing the EPA). Other states soon followed with legislation primarily aimed at curbing smoke and particulate matter. However, cities remained the key enforcers of air quality standards set by law in their locality, and most states had no institutional structure dedicated to air pollution control at this time.

The Federal government first stepped in and passed the Air Pollution Control Act in 1955 with the general aim of providing funding assistance to the states for research and training efforts. Public awareness of the potential threats to pollution remained low and states did little to combat the rise in pollution. The Federal government enhanced its role and began centralizing its power over air pollution with the Clean Air Act of 1963. The Act provided permanent funding streams for air pollution research, and federal assistance to states in creating air pollution agencies. Additionally, the Act provided assistance in resolving cross-boundary air pollution problems. Implementation of the Act was hampered by the requirement that states request assistance to trigger federal action. As of 1967 there were no requests for intrastate enforcement and only three for interstate enforcement (Bachmann, 2007, pg. 662).

Rachel Carson's ground breaking work *Silent Spring*, published in 1962, is credited with energizing a previously lethargic public on environmental issues. In the book, Carson eloquently explained bird and fish kills relating to pesticide use, speaking of the silence left in the wake of the bird kills. Her book galvanized the public, which until that time had seen mostly positive publicity relating to DDT, one of the main chemicals she railed against. It immediately became a best seller and by years end over 40 bills were introduced in state legislatures to regulate the application of pesticides (Hynes, 1989).

Air quality was increasingly shown to be a concern in polling results during the sixties. President Nixon recognized the opportunity to capture public sentiment. His administration crafted a 37 point environmental platform, making the environment the centerpiece of his state of the union address in 1970, the same year as the first Earth Day celebration.

The Clean Air Act Amendments of 1970

An early proposal achieved was the creation of the EPA. Numerous proposals also recognized that the CAA of 1963 had fatal flaws and revisions were needed. In what Bachmann deems as a "race to the top" following the success of *Silent Spring,* Earth Day and other works such as Ralph Nader's *Vanishing* Air, legislators in Washington were favorable to sweeping amendments to the CAA. The Amendments were signed into law when the fledgling EPA was only four weeks old.

Key provisions of the 1970 Amendments:

- The creation of National Ambient Air Quality Standards (NAAQS) for six criteria pollutants deemed to have substantial health risks for the general pollution. These include CO, Pb, NO2, O3, particulate matter, and SO_2.
- The EPA is required to establish source specific emissions (NSPS) limits for both stationary and mobile sources to meet emissions limits imposed by NAAQS.
- States are authorized to issue emissions permits to new facilities and to enforce the requirements of the act.
- Stricter requirements are established for HAPs and for new facilities.
- Provide additional funding for continued research and for professionalization and staff development of state agencies.
- Sources located in attainment areas may fact Prevention of Significant Deterioration (PSD) requirement to insure they do not slip into non-attainment.
- Sources located near a national park or other pristine area may also be required to meet additional limits such as those aimed at preserving visibility (Ellerman, 2003, pg 3)
- Areas designated in nonattainment are required to inventory their emissions and are subject to increasingly stringent control measures depending the level of severity.

Although the amendments had broader scope and signaled a more comprehensive commitment to pollution reduction, they suffered from a number of defects. First, many of the targets were overly ambitious, especially in regard to vehicle emissions. It imposed major duties on states when cities to that point had been the key actors in drafting and enforcing pollution reduction strategies. Thus the short time frames and scope of duties imposed hardships on the states that were resented at the state agencies (where they existed). State administrators largely perceived that budget allocations did not match new federal mandates.

Under the NSPS guidelines for SO_2 issued in 1971 as a result of the CAA amendments of 1970 new facilities that intended to burn high sulfur coals would be forced to purchase "wet scrubbers." Scrubbers are nicknamed as such because they would use a limestone solution to "scrub" flu gases clean prior to emitting in order to drain off sulfur dioxide- a process that results in toxic sludge that would require disposal. These scrubbers represented the best available control technology (BACT) for high sulfur coal when the EPA mandated NSPS for SO2 in 1971 (set as a condition of the 1970 CAA amendments) in spite of the fact that only three were in operation at the time. Utilities were skeptical about the reliability of the scrubbers and balked at their expense. It is noteworthy that the process was known to dispose of 70% of the sulfur dioxide only, leaving behind other criteria pollutants such as NOx. It was estimated that the annual cost would add at least 2% to consumer utility bills and cost utilities an estimated 35 billion dollars to install. The resulting wet sludge also created a new set of challenges for hazardous waste disposal.

Although an emissions ceiling was dictated for stationary sources, no percent reduction was specified. This meant that new plants could receive permits with emissions targets without requiring the facility to use any pollution control technologies whatsoever *if* planners intended to use low sulfur coal rather than high sulfur coal. This is a key issue for environmentalists because scenic impacts may be felt when criteria pollutants fall well below primary standards. New facilities could avoid the "burden" of adding control technologies by planning to use low sulfur coal found predominantly in the west rather than high sulfur coals found in the Midwest and Eastern states. Thus a competitive disadvantage resulted in heightening the relative value of low sulfur coal and had a demonstrable impact on employment levels in high sulfur coal regions.

The NSPS also differed from NAAQS standard setting in that the emissions limit is technology-based and is not mandated to consider only public health concerns. Rather, the EPA is directed to ensure that all new sources employ the best available pollution controls technology (BACT) to both minimize emissions without undermining the opportunity for economic growth (Haskell, 1982). This history amply demonstrates that NSPS was not fulfilling its intended purpose to avoid economic dislocations or create competitive advantages in regions where low sulfur coal was predominant.

In 1973 the Sierra Club in concert with the Navaho nation filed suit against the EPA demanding a uniform standard for SO_2 reduction. This was due to the reduced visibility in the four corners region of the Southwest due to a new power plant there that was built with no control technology. Although the suit was dismissed because the complainants had not exhausted their administrative remedies, it signaled that environmentalists had coalesced around scrubbing technology as a reasonable means to impose a uniform national standard. In 1976 the Sierra Club petitioned the EPA to revise the NSPS on the grounds that air pollution control technology had improved so that 90% improvement was both possible and required (Haskell, 1982, pg 11, EPA docket information omitted).

In 1977, Congress passed amendments that required both the emissions ceiling and a percent reduction, meaning that a NSPS for fossil-fuel fired power plants include both an emission limit and a requirement to reduce a specified percentage of pollution from fuel burned. This meant that if a high percentage requirement were promulgated all plants would require scrubbers. The focus was now on the EPA and its rule making process as it drafted the new NSPS standards. The stated intent of the revised NSPS was to balance the challenges posed by industry, environmentalists and those concerned with regional economic dislocations. While this proved a difficult goal, industry got the variable emissions targets they sought, environmentalists got required percent reductions that meant all new plants would have some form of pollution control technology built-in, and language was included that espouses a preference for local fuel sources to address the economic dislocations caused by the reduction in use of high sulfur coal. However, these changes continued to apply to new sources only leaving some of the heaviest polluters beyond the reach of state and federal regulators. It is clear from the text of the Clean Air Act that the grandfathered plants were not intended to maintain a long-term right to emit higher levels of pollution than their newer counterparts. The legislative intent assumed that the plants would either be phased out or that a NSR would be triggered when large scale alterations occurred at the plants.

From 1975 to 1990 the United States was only able to reduce SO_2 emissions by 18% (Bachmann, 2007, pg 683). The longevity of the most polluting coal fired plants is believed to have largely contributed to the less than admirable reductions, especially given evidence that ambient monitoring does not adequately capture emissions. Thus these percentages are based on modeling activity and may or may not adequately represent true emissions.

New amendments in 1990 created the first of a long awaited market-based approach to pollution reduction with the implementation of the SO_2 "cap and trade" program under Title IV of the amendments. Industry is allotted a fixed number of total allowances (2.25 million tons) comparable to the emissions rate of 1980 and firms are required to surrender one allowance for each ton it emits annually. Unused allowances may be sold or banked for future use. The great innovation of the cap and trade system is that only the end result was specified: a specific tonnage allotment based on prior emissions patterns for each facility with clear and concise consequences for those who exceeded the limits. Unspecified were the means to be used to meet the reductions. Unlike former efforts at what is commonly termed command-and-control regulation, detailed instructions down to technological specifications for cleaner technologies were not mandated. This created an opportunity for both the utilities and supporting/complementary industries to seek to innovate. This strategy has led to retooling of internal processes, the transition from high sulfur to lower sulfur coal mixes, and rail innovation all of which has contributed to pollution reduction (Burtraw and Palmer, 2003).

The downside of the cap and trade strategy as of the 1990 amendments is that it applies to SO_2 only and given that multiple criteria pollutants (including NOx) are being discharged from the same stacks it disincentivizes innovation that will achieve greater reductions across pollutants. Its implementation reflects the political recognition that the grandfathering of heavily polluting older plants was allowed to fester for too long a period to the detriment of air quality and public health. Title IV finally begins to bridge that gap by requiring emissions limits.

Additionally, the problem with tall stacks simply dispatching its polluting contents downwind (and hopefully out-of-state in classic tragedy of the commons fashion) would be tackled with the 50% reduction in the aggregate level of emissions. This clause was believed to reduce the amount of acid rain deposition in the Northeast and also contribute to the reduction in fine particulate matter. Finally, it was believed to close the gap on emission requirements imposed on old and existing sources (Ellerman, 2003.)

The NOx SIP call was the EPA's solution to the downside of the Acid Rain Program's exclusive emphasis on SO2. The program targets 21 Eastern states with cross boundary pollution problems and requires an emission trading program in NOx formulated along the lines of the Acid Rain Program. This means that states are provided some leeway in devising their reduction strategies, although it is required that they achieve a 60% reduction for large industrial boilers and turbines, a 90% reduction from stationary combustion engines and a 30% reduction from cement kilns. These reductions are required during harmful summer months. No targets were placed based on vehicular emissions, despite the fact that such emissions represent the highest percent of annual NOx emissions (as shown in the introduction on pg 15).

This Chapter has provided an overview of the health threats relating to ground-level ozone, smog and acid rain. Additionally, it has reviewed the legislative and regulatory history relating to ground-level ozone. Lastly, it demonstrates that scholars know far more about what has happened at the federal level across the various criteria air pollutants of interest. Further, scholars know very little about the state's activity devising institutional structures to best reduce air pollution within their borders. This study seeks to determine if institutional characteristics contribute to pollution reduction outcomes.

CHAPTER TWO

Literature Review

This chapter will present a review of the key literature that informs this analysis. I will begin by discussing the network theory of administration. Next, I will discuss public accessibility and information access. I will then broaden the discussion to themes within network theory beginning with the transforming role of federalism. I will then explore policy literature that disavows the earlier assumptions that agencies or boards are often "captured" by those they regulate to the detriment of the public good. In conclusion I will explore all known empirical studies of pollution reduction at the state level for clues to guide us in the present study.

The literature review is presented to provide a broad overview of network theory of administration, the importance of state institutions, and the role of citizen participation and information access in the regulatory process. It will serve to demonstrate that states have an ongoing and critical role to play in pollution reduction as a key player in the federal structure.

Toward a Network Theory of Administration

Laurence O'Toole Jr. and Kenneth Meier explore intergovernmental management as they develop their network theory of administration under the guise of studying school boards. They foresee the management of public institutions to be of central interest to researchers of the twenty-first century (2004, pg 470). This is due to the relevance of intergovernmental networks and the necessity to navigate uncharted waters where hierarchical organization charts with clear power relationships no longer exist. The fluid interchanges that arise from this new context require empirical investigation into the new institutions and their managerial networks.

Although not specifically advocating the network theory of administration, William Berry does foreshadow many of its key attributes in challenging the capture theory in regard to utility deregulation. Paul Teske also contributes to this discussion although again, not explicitly embracing the network theory of administration. Their joint contributions to the ensuing development of network theory will be addressed in the context of these three analytic structures.

Managerial Stability

Managerial stability is seen to have a critical role in the management of managerial networks. A key factor is the administrator's stability in office (O'Toole and Meier, 2002, 2003). High turnover for administrators likely fragments the managerial networks developed by prior administrators. Strong administrators are found to have a positive impact on performance. Where test scores are the dependent measures of performance, O'Toole and Meier found a 5% increase in test scores due to the stability of the state superintendent for education (2003).

Public Accessibility

Research has shown that public participation affects the nature of outcomes (Sabatier, 1987; Mazmanian and Sabatier, 1980; Schneider et al., 2003; Berry, 1984). Berry, for example, found that the public's participatory role in the regulatory process affects the nature of policy outcomes (1984). He finds direct evidence that the presence of the public at meetings where rates are set results in lower rates than if members of the public were not present (1984, pg. 554).

In his study of a regulatory commission in Chicago, Sabatier used a case study approach to determine the necessary conditions where a constituency supportive of aggressive regulation is able to monitor regulatory policy making (1975). Sabatier cites the case of the Clean Air Coordinating Committee of Chicago to demonstrate that an organized constituency was able to provide external technical expertise, and to effectively lobby for a legitimate role in the implementation of a statute (1975, pg 329).

The importance of an activist public was again confirmed in Sabatier's joint study with Daniel Mazmanian where they found that there was a positive correlation between the presence of the public at meeting voicing opposition and the commissioners voting behavior (1980, pg 455). Although Air Agencies do not use consumer advocates like those present in the study of utility regulation, it is hypothesized that the number and presence of citizen members on boards will have a positive impact on pollution reduction in a state. It is hypothesized that citizen membership on regulatory boards serves to broaden access and participation beyond that envisioned by the earlier studies of Sabatier (1975) and Mazmanian and Sabatier (1980).

Mark Schneider et al. (2003) also found information access to be a critical component in building consensual networks. They suggest that *requiring* public participation in order to qualify for financial resources (a criteria imposed by the 1987 amendments to the Clean Water Act that created the National Estuary Program (NEP)) was one of the key features leading to the success in building consensual networks. Public participation is also seen to be critical at the policy legitimation stage (Kraft, pg 62). Although the CAA requires open meetings and public notices, the extent to which citizens are apprised of their potential avenues of participation is deemed important. Thus for our purposes I will track whether public participation guidelines are provided via the web.

Information

Information access is a critical component of the regulatory process, especially where the issues are complex and cross-jurisdictional. Information sharing in consensual networks is found to positively contribute to greater cooperation (Schneider et al., 2003). An important success story under the Acid Rain program has been the transformation of reporting and emissions data into databases allowing for much greater data analysis and tracking than existed previously. Determining the degree to which states take advantage of such resources or provide their citizens with such data remains in question.

Setting the Stage for Policy Innovation

Academic treatment of the federal structure, especially in regard to state institutions, has undergone many phases. When the Clean Air Act was first enacted, the states were widely perceived as incapable and unwilling to make the hard choices to reduce pollution (Rinquist, 1993). As in other policy arenas, it is generally believed that the growth and centralizing tendencies of the national government were largely in response to the perception of corruption and "backwater" politics of the states (Lowry, 1992, pg 1). At the time of Lowry's writing he noted that this perception was beginning to change. States were beginning to be regarded as the locus for policy innovation. The Federal Government and its myriad agencies were getting too large, too bureaucratic and too sluggish to confront the policy challenges of the late twentieth century.

There is a renewed interest in federalism as states move to exceed the minimum standards set forth in the Clean Air Act (Potowski, 2001; Wood, 1991). This transformation of many states to proactive regulating entity did not happen overnight. As demonstrated in Chapter One, cities first began to regulate but the pollution spread beyond their boundaries, therefore states slowly stepped in to expand regulation. As the problems worsened and public sentiment reached a climax, the federal government stepped in, but only to a degree. National standards were set, but states retained both permitting and enforcement capacity.

There is, of course, much more to the picture. Students of federalism often explore constraints on institutional behavior such as interest group pressure (Rinquist, 1994; Potoski, 2001), partisanship (Lester, 1980) or economic conditions (Lubell, 2002). Academics have long shed the naïveté that all policy decisions are simply deemed the right thing to do by the right federal institution at the right time. Thus it is important to look at the distinct behavior of and between the institutions. What are the triggers or watershed events that cause major swings in policy behavior?

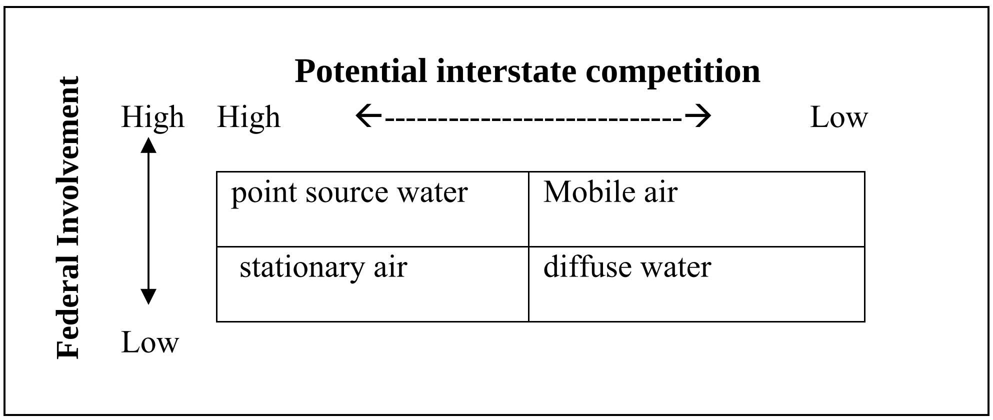
First I will explore federalism as it relates to pollution problems and the inherent difficulties in resolving them. Second, I will explore policy literature that disavows the earlier assumption in academic literature that agencies or boards are often "captured" by those they regulate to the detriment of the public good. Next, I will consider network theories of policy innovation and their relevance to our purposes here. In conclusion, I will explore all known empirical studies of pollution reduction at the state level for clues to guide us in the present study.

The Transforming Role of Federalism

Federalism, once thought to be the slow plodding political beast that dampens all hopes of progressive policy generation (see for instance Pressman and Wildavsky 1973) has received renewed interest from social science scholars. In his 1992 work, William R. Lowry provides an illustration of the dimensions of Federalism that posits both vertical and horizontal dimensions (see Figure 4. below). The vertical axis (Y) represents the level of federal involvement. At the highest level, the federal government might preempt state action. At the lowest level, the federal government might defer all action to the states. Lowry concedes that trends in the leading up to his research in the early 1990's make either case rare across the policy spectrum (Lowry, 1992, pg. 15).

Therefore, he suggests that vertical federal involvement generally varies between the two extremes (Lowry, 1992, pg. 15). The horizontal axis represents the potential for interstate competition for resources, and or the export/import of goods, including externatilities such as the case of cross-boundary pollution (Lowry, 1992, pg 10).

Figure 4. Dimensions of Federal Policies Affecting Leadership



Source: Lowry (1992, pg 11)

Lowry suggests that the axes of x (interstate competition) and y (federal involvement) should be thought of as scales rather than as dichotomous variables. Further, he argues that these dimensions significantly affect both the leadership and coordination of state behavior. Lowry posits that states are faced with trade-offs. On the one hand they may choose to eschew filling in the gaps in vaguely worded federal statutes on pollution and therefore present an "industry-friendly" posture to compete for economic resources. Alternatively, states may create more stringent regulations, or adapt innovative and experimental approaches to pollution control in an attempt to promote quality of life issues and attract non-polluting business. He believes that the potential for horizontal competition is therefore an important determinant of state behavior.

Lowry, like others after him (Rinquist, 1993; Potoski, 2001; Potoski and Woods; 2002) looks at state leadership in the context of severity of needs (extent of pollution within their borders), pressure of relevant interest groups, availability of resources (generally using agency budgets as a measure), political culture and federal aid. Yet none of these combinations have conclusively accounted for the variation of state programs. Is it possible that the institutional structure by which policy is devised and implemented is important in modeling the state pollution control within a federal model?

In an interesting twist on federal logic, Dan Wood found that enforcement actions in air quality substantially increased after three important events during President Reagan's tenure (his inauguration, budget changes in fiscal 1982, and the departure of EPA director Buford). Reagan's anti-regulatory stance and budget cuts at EPA signaled to the states that they once again had the reigns in environmental enforcement and in many cases states accepted those reigns with relish. In 1980 alone states enforced more cases with more personnel bringing enforcement levels higher than even in the Carter years. Yet, Reagan's intent was to curtail all financial supports to State Agencies and beginning in 1982 grants-in-aid to state environmental programs were cut by 12% (Woods, 1991, pg 852).

Scholars agree that multiple coalitions at both vertical and horizontal levels across institutions create strong intergroup cooperation to limit the impacts of political stimuli such as the three events in the Woods study (Waller, 2000; O'Toole and Meier, 2004;

Woods, 1991; Sabatier, 1987). The net effect is to dampen policy responsiveness to retrenchment stimuli caused by partisan activity (Woods, 1991). On a similar vein, Christopher Waller conducted a study of the Federal Reserve Board. He systematically explored the jarring effects of partisan politics and random election outcomes that generally produce policy uncertainty. He found that the introduction of an independent policy board with discretionary powers resulted in what he termed "policy smoothing" (Waller, 2000). His results mirror those of Woods in suggesting that removing decision-making from the political process and professionalizing those charged with specific duties will yield less fluctuation due to political cycles in critical policy areas.

The surprising results of Woods study empirically stress that state environmental programs proceeded as though the Reagan election and federal budgetary constraints never occurred. His study raises an interesting question, was the state response in this brief time period atypical? Consider for instance the following, extracted from the Acid Rain 2004 progress report:

> For 32 states and the District of Columbia, annual SO_2 emissions in 2004 were lower than emissions in 1990. Among these states, 13 decreased their annual emissions by more than 100,000 tons between 1990 and 2004: Alabama, Florida, Georgia, Illinois, Indiana, Kentucky, Massachusetts, Missouri, New York, Ohio, Pennsylvania, Tennessee, and West Virginia. The states with the greatest reductions were in the Midwest and include Ohio (1.1 million tons reduced), Illinois, Indiana, and Missouri, each of which reduced over 500,000 tons. **(**EPA, 2004, pg 6**)**

Can the reductions noted be attributed to the emissions trading market only? Or are other state level factors at work? Such reductions undermine prior theory that states avoid and or only marginally regulate important industries. In the NAPA report, it was determined that state regulators find that the New Source Review permitting process to be critical to maintain or improve air quality. Some states, where approved by state law, have also sought more stringent standards for both SO_2 and NOx (NAPA, 2003, pg 13). This again undermines the contention that states avoid making hard choices in regard to strong industries within their borders, or that they simply abide by the federal mandates however distasteful the reams of red tape.

According to NAPA, from a federal standpoint, the design of the NSR program has left too much uncertainty in requiring existing facilities to obtain permits prior to upgrading their facilities. Additionally, although it creates enormous red tape for the states, the paperwork is not streamlined or automated so that increased emissions can be checked against permitting databases. Facilities are allowed to determine whether plant upgrades will result in additional pollution leaves a gaping hole in enforcement, and it appears the air seeping out is not always clean. In many cases States wait for the EPA to recognize increases in pollution, yet the EPA is hamstrung because not all of the states were provided their permitting information electronically. Changes reflected in 1999 have enhanced the electronic submittal of data so that the problems reflected in the NAPA report should no longer be at issue. However, the problem of self-policing by polluting industries and utilities remains at issue.

On the flip side, states have stepped in where "policy voids" exist (Adler, 1998; Krane, 2007). Maarten Hajer suggests that institutional voids exist where established institutional arrangements lack the power or ability to resolve particular policy dilemmas (Hajer, 2003). Instead, "transnational, polycentric networks of governance" arise wherein power is dispersed (2003, pg 173). Cases such as air regulation where traditional regulatory solutions have failed to fully achieve policy goals are primary candidates for collaborative approaches. In cases of uncertainty or complexity, collaborative relationships can be effectively utilized to seek innovative solutions across jurisdictions and boundaries where more tightly controlled hierarchical solutions fail. The problems inherent in NSR represent such an opportunity.

In cases of uncertainty or complexity collaborative relationships can effectively leverage expertise that might otherwise be unavailable. A local group may have a much better handle on the sources of a particular problem and on solutions that would work for their communities, but they may lack the engineering or scientific expertise to design the needed solution (Fischer, 1993). Collaborations can supplant unnecessary duplications across local, state and federal levels by effectively sharing expertise across jurisdictions. Watershed partnerships represent a key demonstration of this (see for instance Lubell et al., 2002). O'Toole and Meier (2004) develop this concept further in regard to public education, noting that there is a heavy tilt toward collaborative intergovernmental arrangements in most national programs (pg 494). In fact, much national legislation now requires agencies with overlapping service areas to collaborate to gain greater efficiencies.

Federal and state officials can seek to build collaborative relationships at the local level where high levels of distrust undermine policy development. Engaging locals and entering power sharing relationships can help build trust across jurisdictions, and trust in government more generally. Frances Lynn argues that taking the time to build community trust is critical but time-consuming, but the establishment of trust is crucial to the effectiveness of the partnerships (Lynne, 2000).

Fiorino builds on the linkage between trust and the limits of technocratic expertise as he notes that environmental policy has gone through three distinct policy phases (2001). The first stage, entitled technical learning, entailed high levels of technical and legal proficiency with concomitant issues of institutional fragmentation and adversarial relations between actors and institutions. While scientific and technical expertise was brought to bear on important issues such as pollution and clean water, public trust slowly eroded over time as pesky problems remained unsolved and an engaged public felt disenfranchised. They believed that industry not people set the terms. See for instance the discussion of "capture theory" below.

"Conceptual learning," picked up where technical learning left off. There was a growing recognition that not all problems have technical solutions (see for instance the insightful discussion of this in Garrett Hardin, "the Tragedy of the Commons" (1962). This leads us to the "learning model of administration" proposed by Fiorino. The learning model suggests that actors can adapt past strategies to present circumstances, learn from the successes and failures of others. This knowledge-based orientation to policy-making assumes that policy is purposive. "Policy makers are seen less as passive forces driven by political and interest group pressure than as sources and implementers of ideas, information, and analysis that influence choices (2001, pg 322).

Social Learning

As environmental policy shifted from command and control to a more conceptual focus that recognized the interrelationship between problem definition and policy strategies, a new emphasis emerged on social learning. Fiorino envisions social learning as the capacity of the government unit, in conjunction with stakeholders and citizens, to work collaboratively and cooperatively both to define goals and implement shared decisions. He also envisions social learning to allow for a more adaptive network-based administrative focus, rather than the former command and control structure. Social learning is predicated on three key features: structural openness, different approaches to implementation and recognition of uncertainty (2001, pg 328). Fiorino's learning model shares important features with O'Toole and Meier's work on structural networks and public management (2004, 2003).

Structural Openness

For Fiorino, in the environmental context, the technical environment was premised upon top-down regulatory control that isolated regulants from regulators and fostered adversarial relations, social learning embraces structural openness premised upon continuous processes of interaction and communication (read deliberation) between social actors, groups, stakeholders, industry and governmental actors. Advisory boards can be seen to have risen out of this trend, and policy boards can be seen as the next step in the learning process in that they now allow for various actors to have greater power to impact the process beyond simple advisory mechanisms.

O'Toole and Meier's model also recognizes that today public managers must often coordinate with parties beyond their explicit control. Arrangements are necessarily informal, complex and across multiple bureaucracies and external entities. They note the current dearth of empirical research on intergovernmental networks (Watershed partnership research serves as important exception, see for instance Schneider et. al. 2003).

Different Approaches to Implementation

The top-down command and control regulatory model is supplanted by a more fluid process under a social learning model. Unlike the traditional adversarial approach, this model presupposes that all actors will work collaboratively and cooperatively both to define goals and implement shared decisions. There is a trade-off in this model that some in the activist environmental community have difficulty embracing, it does allow for more industry input in shaping policy, yet it also requires them to share responsibility in achieving government goals (2001, pg 328).

The Cap and Trade system represents an innovative approach to emissions reduction in that it does not dictate the precise details of the technologic alterations to plants in order to meet emissions targets; rather it sets both ceilings and floors for the purposes of regulation and gives firms the opportunity to make individualized decisions on how to effectively meet the standards. This, however, does pose a challenge for the states. How do they integrate this new strategy into their existing toolset? Do they relinquish all activity in regard to SO_2 utility generation to the Federal government? Or do they continue with prior efforts to maintain or exceed NAAQS standards as they have in the past? O'Toole and Meier's research suggest that Public Management matters, and in this context it suggests that continued reductions in SO_2 emissions may vary across states and may be correlated to the means by which states participate in this transforming intergovernmental network.

Recognition of Uncertainty

As Fiorino notes, time has tempered the optimism that scientific progress and technocratic administration can overcome all challenges in the environmental realm. He notes that Europeans have invoked the "precautionary principle" as a guide to policy action:

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action." - Wingspread Statement on the Precautionary Principle, Jan. 1998 (retrieved from the Science and Environmental Health Network http://www.sehn.org/precaution.html, January 12, 2008).

Rather than defend the classic presumption that all problems have technical solutions, the precautionary principle reminds us that policy decisions must be made in an environment bounded by a multitude of constraints ranging from political will, available resources to concerns about possible consequences of options chosen. Scientific uncertainty builds tentativeness into the policy process that was not available in the command-and-control regulatory approach. This opened a gateway to a cooperative integrated policy development stage such as the network approach advocated by Meier, Teske and others.

In air quality control it is noteworthy that continued uncertainty persists in many critical areas, such as uncertainty as to the appropriateness of current NAAQS standards (Bachmann, 2007), the lack of exhaustive monitoring networks, and the continued funding and enforcement challenges states face in these areas. The current lack of performance-based standards ties in to all of these key issue areas.

New Source Review (NSR) is key for states in maintaining National Ambient Air Quality Standards (NAAQS). NSR enables a state to evaluate all new sources of emissions and issue permits to ensure that state air quality is not degraded. In regard to New Source Review the National Academy of Public Administration found the EPA had never collected the following core data on basic aspects of the NSR program:

- Environmental effects;
- Market impacts and economic costs;
- How it was implemented by state and local agencies;
- How many facilities it may cover;
- Whether it has promoted markets for cleaner technologies;
- What actions require an application for an NSR permit;
- How regulated facilities can comply with NSR;
- How many facilities use netting; and

- How many facilities obtained synthetic minor permits (NAPA, 2003, pg. 27)

Had variation in how states implement NSR been tracked, it is possible that more effective strategies could be shared and cost-cutting measures better utilized. Instead we are left to wonder about the appropriateness of current methods.

The combination of scientific uncertainty with regulatory uncertainty complicates all levels of federal activity. Barring states taking matters in their own hands, industry, and for our purposes utilities, are able to operate without constraint. A troubling example is the discretion left to regulated entities in calculating potential future emissions, known as the WEPCO rule. Utilities are allowed to model their actual-to-projected actual emissions and are not required to submit a request for a NSR in the absence of projected increases of emissions. The rule requires utilities to maintain and submit records to the permitting authority citing evidence that modifications did not result in an emissions increase for five years. However, it does not detail verification procedures or consequences if greater levels of emissions are found (NAPA, 2003, pg. 28). NAPA found that from 1997 to 1999 there were only 850 NSR permits issued to facilities in PSD areas- this out of 17,000 regulated facilities (NAPA, 2003, pg 15)!

Further complicating matters, there is no standard for tracking permitting vs. pollution outcomes. Neither is there a standard for confirming that permits are attained prior to technologic alterations at facilities. It is unclear at this juncture how the Cap and Trade program has altered this landscape at the state level.

Capture Theory

The above cited lack of institutional coordination and information may lead one to believe that industry, and for our purposes here utilities, have "captured" the agencies charged with regulating them and have encouraged such loop-holes and reporting gaps to protect the status quo. Berry details the evolution of this theory (see for instance Bernstein, 1955 as quoted in Berry, 1984). Proponents of capture theory, as developed through a small series of case studies, suggest that regulated groups tend to develop close relations with their regulating agency personnel and thus "capture" the agencies to the benefit of their industry. Berry challenges this theory in his study of State Public Utility Commissions. Here he finds little evidence to support the capture theory. He finds that commission professionalism serves as a mediating influence on industry power. Additionally, he finds that public accessibility such as the right to participate in the regulatory process through attendance at public meetings and public comment periods is also a factor. Information access is also critical for both the commission representatives and the general public.

Trends in State Research

Randy Becker takes on Pollution Abatement Expenditures by US Manufacturing Plants. He hypothesized that areas with higher home ownership rates and per capita income would have more pollution abatement activity (defined in the Pollution Abatement Costs and Expenditures (PACE) survey as the sum of both pollution treatment and pollution prevention). Additionally, he anticipated that the higher the % of manufacturing employees the lower the pollution abatement expenditures. Finally, he anticipated political ideology would play an important role. He operationalized political ideology as the number of citizens voting democratic in the most recent presidential election.

Becker found that areas with high home ownership, a concentration of Democratic voters and domicile within a Metropolitan Service Area leads to higher pollution abatement expenditures. Conversely, in areas with a high incidence of manufacturing employees pollution abatement expenditures are reduced. He did not find any evidence that voter turnout (his measure of collective action) had an impact on pollution abatement expenditures. He also found evidence of raced-based spending mixed. In areas of non-white populations spending was lower, yet in areas with many foreign-borns spending was higher. It is in these two categories that an important fact arises for our purposes, once he controlled for state and county level regulation the negative impacts toward non-whites disappeared, suggesting an important role for state and local regulation (Becker, 2003, pg. 21).

Wayne Gray and Ronald Shadbegian also look at socio-economic and political factors in the siting of Paper mills and find results generally consistent with Becker. Of particular interest is their recognition that plants bordering states with more pro-environmental regulatory stances tend to emit less than those plants bordering more brown-leaning political environments. Additionally, they find that plants near the Canadian border tend to emit significantly less SO_2. Although they reflect that this may be due to political pressures, they are unsure of the source or mechanism by which this information is conveyed. This again confirms the need to better understand internal state dynamics in influencing policy outcomes (2004).

John Hoornbeeck conducts research in regard to water pollution policy in a similar vein to that envisioned here. As NAPA (2003) and others do, he laments the lack of performance based measures to track state success in improving water quality in order to test the value of the devolution strategy in place at the federal level. He uncovers a wide variance in policy activism state to state and correlates it with varying state capacity and the extent of interest group pressure exerted (2005). He does not look specifically at institutional structure as envisioned herein.

The evidence above suggests that states have an ongoing and critical role to play in pollution reduction as a key player in a federalized structure. However, systematic investigation of the primary regulating and enforcing actors is lacking. Do these state institutions have an important role to play? Do they create important policy networks as envisioned by Schneider and O'Toole and Meier to devise collaborative solutions to complex problems? If so, what characteristics distinguish such networks from those states that continue to lag behind in pollution reduction efforts?

CHAPTER THREE

Methodology

The purpose of this study is to test an adapted model of network theory against state air pollution control institutions. Air pollution control presents a regulatory problem that has interstate, intrastate and multiple federal dimensions. It is one of extreme complexity and uncertainty, from both a regulatory and scientific perspective. The changing political environment federally has enabled states to redefine their roles in the regulatory process (Adler, 1997). Therefore, I have the potential to uncover widespread variation in institutional processes.

Systematic empirical investigation may yield new insights into how states successfully reduce air pollution while at the same time demonstrating the viability of the network model of administration across bureaucratic settings. Further, this research may add to our understanding of how interagency management of air control impacts the effectiveness of the regulations. It is the measured judgment of many in the field that there is a dearth of empirical research on bureaucratic systems (Krause and Meier, 2003; Smith, 2003; O'Toole and Meier, 2004; Teske, 1991). The network model of public management and performance enables empirical investigation of the bureaucracy, rather than a classic study of political institutions. As such it is well suited to study links between process and performance in state agencies. To date the network model has been repeatedly tested in education settings (O'Toole and Meier, 2004; O'Toole, 2003; Meier, Wrinkle, and Plinard, 1999). I adapt it here to the environmental policy arena. These two areas have important similarities. Both have multi-layered bureaucracies beginning locally and moving to the federal level. In both cases important societal values underlie the bureaucratic imperatives, but performance measures may or may not be well defined across the local to federal spectrum. Thus a systematic empirical investigation that isolates institutional features such as behavioral and managerial networking and correlates them to performance measures may lead to important insights. Lester and Lombard note that the field would benefit from more rigorous theoretical arguments, greater awareness of intergovernmental relations and less emphasis on single points in time, as well as a 50 state strategy (Lester and Lombard, 1990). This research seeks to achieve these goals by generating empirically testable hypotheses with time series data across the 48 contiguous states and Alaska.

While the state represents the unit of analysis, it is the Air Agency with its associated air board that is our primary focus. Why is a focus on agencies important? Incorporating the what, why and how of agency structure and networking behavior may help to explain variations among states that other scholars fail to account for by focusing exclusively on political and legislative institutions as well as interest group behavior. Failing to account for the state air agency as an important institution within the federal structure leaves us with an incomplete picture of the democratic process as it plays out in policy implementation.

This study adapts the Network Model to empirically investigate the importance of administrative structure within state air agencies and their impact on performance measures of air quality. This study seeks to gather data over the period of 1999-2007 and therefore a panel data time-series design is deemed appropriate. This time period is chosen due to changes in EPA reporting that will enable a robust sample (in regard to our dependent measure, pollution outcome) to be drawn for the period in question. The data prior to 1999 is not considered directly comparable to 1999 and beyond due to retooling of the database maintained by the EPA.

The data will be structured as a pooled time series dataset. The analysis plan is as follows, a pooled regression model will be fit to the data first. Next, a Least Squares Dependent Variable (LSDV) approach will be used under the assumptions of a fixed effects model. This methodological tool combines the advantages of both a cross-section and a time series, and removes the unit-specific error from the error term by fitting dummy variables to estimate a fixed effect (Sayrs, 1989). Additionally, the LSDV model allows us to use an intercept to capture effects unique to cross-sections as well as those that may be unique to time (Sayrs, 1989, pg 28). As with any regression technique, especially within time-series analysis there remains some level of autocorrelation and heteroskedasticity. This basically means that it is likely that what happened at time T in state A likely impacts what happens at time T+1 in state A.

A fixed-effects model essentially omits any variable that is invariant. As many of our key variables of interest are invariant, including the number of citizen members of boards, the presence of an air board and the presence of citizen participation guidelines, I also fit the model to two random models: the generalized least squares model (GLS) and the GLS with AR(1) disturbance. The first GLS model assumes a one-way interaction in the data. This basically means that the model is able to anticipate differences across groups, in this case the states. GLS with AR (1) disturbance assumes some level of autocorrelation between x and y variables and therefore enables us to comprehend differences across both states and years in our analysis. A Hausman test and a Breusch and Pagan Lagrangian multiplier test for random effects will be applied to determine the appropriateness of the LSDV or GLS models.

Research Question:

> Given the importance of reducing air pollution to protect public health does the institutional structure within state departments of environmental quality coupled with citizen participation and information access correlate to quantifiable differences across states in pollution reduction over time?

Research Subject:

The Unit of analysis of this research is the state institution or institutions charged with enforcing criteria air pollution reductions under the Clean Air Act of 1970. This act initially applied to the 48 contiguous states. Subsequent amendments incorporate Alaska and Hawaii. Hawaii is not included in this analysis because of its initial exclusion from the CAA and due to the fact that its air quality problems often stem from problems associated with volcanic ash producing VOG (a relative of smog). Therefore all states but Hawaii are included in this analysis.

Clean Air Agencies are the generic term used throughout for all state institutions charged with air control, even if that grouping or division falls within a broader agency such as a Department of Environmental Quality. Air policy boards are a subset of the agency that will represent a critical focus of this research. In regard to public management variables I will focus on the top official for air control, labeled here as the air administrator.

Dependent Variables

Ozone exposure index: The ozone exposure index represents the number of days per year that pollution outcomes are not in the healthy range (i.e. they exceed the minimum 8-hour standard for ground-level ozone as defined by the EPA) within each state. This data is derived from monitor readings for the 8-hour ground-level ozone standard as defined by the EPA rule process. (EPA officials removed any instances where the readings were deemed to be extreme events.) The index is computed from county level EPA records and divided by county population size to create state-level exposure levels for a given year that are standardized by population size. For instance, a value of one represents a single day in a given year where every person in the state experienced ground-level ozone pollution exceeding the standard. Conversely, an ozone exposure index of zero would mean that no one in the state was subjected to ground-level ozone above the standard during that year. The mean for the ozone exposure index is 7.55 with a range of zero to 63.5 for a total of 441 cases (49 states x 9 years).

For instance, a value of one represents a single day where every person in the state experienced ground-level ozone pollution exceeding the standard. Conversely, an ozone exposure index of zero would mean that no one in the state was subjected to ground-level ozone above the standard.

Below I demonstrate how Alabama's1999 Ozone exposure index is generated in Table 3. I begin by dividing the county population impacted by the state population total and then multiply that figure to come up with the persondays figure by county. Each county's figures are then aggregated for the state total resulting in the ozone exposure index. As the table demonstrates, in 1999 a subset of Alabama citizen's experienced a total of 230 days outside of the NAAQS standard for ground-level ozone. The ozone exposure index is 13.35 meaning that on average the total population of the state can be said to have been impacted by 13.35 days where ground-level ozone exceeded the standard.

Table 3. Alabama Ozone Index 1999

County Name	Number of Days Above Standard Ozone	County Population Impacted	State Population	County Population divided by State Population	PERSONDAYS
Clay	33	14012	4369862	0.00320651	0.105815
Elmore	5	63488	4369862	0.01452861	0.072643
Jefferson	39	657422	4369862	0.15044457	5.867338
Lawrence	28	33795	4369862	0.00773365	0.216542
Madison	31	280381	4369862	0.06416244	1.989036
Mobile	31	399652	4369862	0.09145644	2.835149
Montgomery	15	215813	4369862	0.04938669	0.7408
Shelby	45	146392	4369862	0.03350037	1.507517
Sumter	3	15615	4369862	0.00357334	0.01072
	230		4369862	0.41799261	**13.34556**

Source: Data generated by merging of EPA and Census data (2009)

Justification for Measure

The adverse health effects of ground-level ozone exceeding the 8-hour standard are well documented (Bates, 1995). Populations negatively impacted annually are in excess of 160 million across the United States (www.4cleanair.org retrieved March 24, 2008). Further, ground-level ozone is one of two pollutants considered to have the most widespread health effects of any of the criteria air pollutants (http://www.epa.gov/air/urbanair/6poll.html, retrieved March 24, 2008). Ground-level ozone is often correlated with emissions of other criteria pollutants such as SO2 and NOx from point sources such as coal fired power plants. Precursors to ground-level ozone also include non-point sources from NOx and VOCs. The state level impacts are found through ambient air monitoring as mandated by the National Ambient Air Quality Standards(NAAQS). Because state air agencies are charged with the implementation and enforcement of these standards, the ozone exposure index per year represents our dependent measure. Positive performance outcomes will be seen as evidence of a reduction in the incidence of ground-level ozone pollution experienced over time by the state population, as represented by the ozone exposure index.

By combining census data to standardize across states I present a measure that has utility for statistically testing. At the same time the measure connects local impacts of ground-level ozone pollution. This dual connection between a standardized measure and its real-time public health impact, is, to my mind, the strength of this index.

Other research has often utilized the toxic release inventory as a dependent measure(Ringuist, 1994). What the toxic release inventory cannot tell me is where the emitted toxins transform into ground-level ozone and represent a danger to human health. This is where ambient air monitoring comes into play. Because I am concerned with how states reduce pollution within their borders to specifically protect public health, the ozone index measure I have developed better serves me in answering this question.

Potential Limits of Ozone Exposure Index

A noteworthy limitation in gathering accurate data on monitoring of the NAAQS is that the monitoring network does not provide full coverage of all potential areas in the United States that may be subject to unsafe levels of ground-level ozone. Although an increasing number of monitors have been installed since the 1990 CAA amendments, it is possible that not all pollution is captured in our dependent measure. However, since this problem is deemed widespread throughout the US it is considered sufficient to use the monitoring data available through the EPA. Annual nonattainment data is provided by county beginning in 1999 through 2007.*[*]

Independent Variables

Intergovernmental Management

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[*] the proposed methodology included particulate matter as a dependent measure. However, I discovered that there are various sampling schedules for monitors but to date some monitors continue to report daily while others do not, regardless of sampling schedule. This fact makes it difficult to provide a viable ozone exposure index measure and therefore the second dependent variable was dropped from this research.

Intergovernmental management captures the trend wherein managers no longer rely on organizational hierarchies to achieve their goals. Instead managers engage in networking activities with others who may not necessarily be subordinates. Developing relationships and shared goals across previously hierarchical organizations requires skilled interpersonal relations. Further, pollution control requires an ability to integrate the highly scientific aspects of pollution control while at the same time juggle the entangled web of networks across federal and state levels. I hypothesize that administrators more effectively manage such tasks as their time in office increases. Following O'Toole and Meier I break down intergovernmental management into two items: Managerial Networks and Behavioral Networks. Each will be addressed in turn.

Stability of Managerial Networks

Managerial networks focus specifically on the key administrator of an organization and his or her role in contributing to organizational stability and agency operations. A key factor is the administrator's tenure in office. Brief tenure in office with the resultant high turnover for air administrators would likely fragment the managerial networks developed by prior administrators.

This variable will be operationalized by capturing the air administrator's length of time in office for each of the years under study. For instance, in state X, if 1999 represents the administrators second year in office, it is coded as a two. In 2000 it is coded as a three. If there is turnover in the office in 2001, the variable is coded as a one again, and we begin to repeat the pattern for each additional year in office. An alternative variable could have been administrative pay. Meier and O'Toole note that it is challenging to create quantitative measures of managerial quality, especially in relation to individuals in specific positions (2002, pg. 631). Unfortunately, I was unable to obtain data on pay across all fifty states Meier suggests that comparisons of administrative pay often help us to isolate high performing individuals in a network model (Meier and O'Toole, 2002).

Studies done to date are often cross-sectional and thus lacking a longitudinal component,. Others view effectiveness from the employees' perspective rather than as a determinant of agency performance (Meier and O'Toole, 2002, pg 631 citations omitted). Although it can be argued that pay may be a viable measure of performance, in the present case it would not be anticipated to vary across time substantially within a state, and additionally we may anticipate variations across states more akin to standard of living differences than to measurable differences in administrative performance. Therefore tenure in office is selected to best represent the stability of managerial networks. The data collected have a mean tenure of 6.69 years in office and a range of one to 29 years of service.

Although I anticipated capturing different means of appoint, ranging from civil service promotion, direct election and governor's appointment, I found that all administrators for the period 1999 to 2007 where appointed by their state governors.

The following hypotheses represent intergovernmental management:

H_1: States with greater stability in office of the Air Administrators demonstrate lower pollution over time than states with high turnover rates.

H_0: The tenure in office of Air administrators has no impact on pollution levels.

Air Boards as Behavioral Networks

Behavioral Networking represents the interaction with diverse actors potentially beyond the bounds of a manager's control. Air board members and local regions created to oversee pollution prevention efforts constitute a similar class to the school boards studied under O'Toole and Meier (2004) and the utility rate and telecommunications commissions studied under Berry (1984) and Teske (1991). In each case the board and/or local region is statutorily authorized to regulate (to varying degrees) but operates quasi-independently of the hosting agency. In the case of air pollution, the Air boards often rely on agency staff to provide all technical support, yet in many cases have final authority to approve regulations or convene hearings on enforcement.

Boards serve many important functions in air policy regulation much as they do in the context of utility regulation and education administration. In the context of this research boards are hypothesized to contribute to citizen engagement within an agency by providing a forum for the public to engage in policy debates about air policy. They introduce a singularity of focus on a specific problem, in this case air pollution, and in many cases draw upon the various stakeholder populations across a state to allow a diversity of voices and levels of expertise. For this variable I will capture the presence of an air board by state. The mean is .18 with a range of zero to one. In essence this is a fixed effect variable, as all but one state had a board under all years of study.

The following hypotheses represent behavioral networks:

H_2: States with Air Policy Boards demonstrate lower pollution over time than states without Air Policy Boards.

H_0: States with Air Policy boards have no impact on pollution levels over time than states without Air Policy Boards.

Public Accessibility

Although in both the case of utility deregulation and telecommunications regulation some agencies chose to create citizen advocate staff positions to represent the interests of the general populace before the commissions, it is this authors understanding that this practice has not spilled over into air pollution control. The transformative use of the internet offers an opportunity for agencies to disseminate information to state citizens easily. Public participation is built into the Clean Air Act in a variety of ways, from requiring time periods for public comment in some but not all instances of state action to requiring public notice of meetings. However, states must educate citizens about their rights to participate for that participation to be widespread and meaningful. Therefore for our purposes a measure of information access is whether or not the umbrella agency such as the department of the environment, or the air agency provides specific instructions via the web on public participation. This dummy variable was coded as "1" where explicit "public participation guidelines" were found on the website, or in lieu of such document a clear and detailed webpage was present that outlined avenues for public participation. All others were coded as zero. This too was a fixed effect variable. The year measured was 2007.

Additionally, the presence of citizen members on the air boards is also hypothesized to contribute to public accessibility. It is surmised that citizen members of boards will serve the public interest in working to reduce pollution in their state by increasing access to decision-making by the general public and by encouraging broader information dissemination to the public at large. This variable is coded as a count of citizen members of air boards. Although a more robust measure capturing average tenure in office for all board participants was proposed, that data proved difficult to gather across all states. Therefore, I use the count as a measure of citizen participation in policy making at the board level. The mean for this variable is .5 and the range is zero to nine. I did not find any variability over time for the numbers of citizen members on single boards and therefore it is a fixed effect variable.

The following hypotheses represent public accessibility:

> **H_3:** States that provide public participation guidelines via the Air Agency website will demonstrate lower pollution levels over time**.**
>
> **H_0:** The availability of public participation guidelines via the web has no impact on pollution levels over time.
>
> **H_4:** States that allow for more citizens to serve on Air Policy boards have lower pollution levels over time.
>
> **H_0:** The presence of citizens on Air boards has no impact on pollution levels over time.

Control Variables

The following control variables reflect other factors that may affect the outcomes under study.

Political Context

Policy literature continues to assume that republicans are generally less aggressive in pursuing regulation against polluting industries (Konisky, 2007). Additionally, it is anticipated that appointments to boards will generally be politically controlled. Therefore party control of the governor's term of office for each year will be tracked. It is anticipated that split legislatures will also be more pro-environment because public opinion in the period under study remains positively correlated to enhanced enforcement. Ringquist found similar trends in his research in the early 1990's (Ringquist, 1993).

Control of Legislature (dummy variables- means provided)

Split Control – mean of .27
Democratic Control- mean of .36
(Republican Control is the baseline)

Control of Governorship (dummy variable)

Democrat Governor-mean of .44

The following hypotheses represent political context:

H_5: Democratic control of state legislatures leads to lower pollution levels over time.

H_0: Democratic control of the state legislature has no impact on pollution levels over time.

H_6: Split control of state legislatures leads to lower pollution levels over time.
.

H_0: Split control of the state legislature has no impact on pollution levels over time.

H_7: States with Democratic Governors tend to have lower pollution levels over time.

H_0: Democratic governors have no impact on pollution levels over time.

State Political Conservatism/Liberalism of the Legislature

To account for ideological differences not represented solely by party affiliation I will utilize the adjusted voting scores generated by Anderson and Habel (2009). These scores replicate the original adjusted scores of Groseclose, Levitt, and Snyder (1999). The adapted scores begin with the Annual Americans for Democratic Action(ADA) Legislative scores for US House of Representative state delegations. These scores are produced annually based on roll call votes on a select number of bills as determined by the ADA. As Groseclose et al. (1999) note, this raises issues about the use of scores over time and across legislative bodies. Their work, and the update and replication of Anderson and Habel, allow for indexing to achieve comparability over time.

This variable allows me to provide a potentially more complex picture of partisanship than party affiliation provides, especially in regard to regional differences and levels of conservatism. This then provides an additional test beyond party control as to whether the ideological climate in the state legislatures impacts pollution reduction outcomes A score of 100 represents a perfect liberal record. . Then mean for the adjusted ADA score is 40.5 with a range of -8.56 to 98.98.

The following hypotheses represent political ideology:

H_8: More liberal states will demonstrate lower pollution levels over time.

H_0: State ideology has no impact on pollution levels over time.

Importance of Coal Consumption Per Capita 1999-2007

Coal consumption, especially in relation to utility generation, is responsible for high levels of SO_2 and NOx emissions and their associated health impacts (Environmental Integrity Project, 2007). Therefore I will track consumption per capita. (Source- US Department of Energy). The mean for consumption is 4.9 with a range of zero to 53.78.

The following hypotheses represent coal consumption per capita:

H_9: States with higher levels of coal consumption per capita will demonstrate lower pollution levels over time.

H_0: Coal consumption per capita has no impact on pollution levels over time.

Importance of Utilities to State Gross Domestic Product 1999-2007

As noted above, utilities are the main consumers of coal and coal fired power plants are heavily implicated in precursor emissions of ground-level ozone. Utilities have the greatest revenue streams of any regulated industry in the United States (Berry, 1984). Therefore an alternative explanation I must explore is whether the strength of the utility in a given state correlates with changes in pollution over time. It is anticipated that states where utilities contribute a higher percentage to state GDP will correlate to lower pollution reduction outcomes over time.

(-Source-Bureau of Economic Analysis, US Department of Commerce)

Evidence from litigation and from the lack of self regulation when completing facility upgrades (see for instance Environmental Integrity Project, 2007) suggests utilities are resistant to regulation. This expectation is by no means certain; as Becker (2003) shows utilities perceive it in their interest to adapt to pollution reduction strategies. The mean for utilities is .02 and the range is .004 to .059.

The following hypotheses represent the importance of utilities to state GDP:

H_{10}: States where utilities represent a higher percentage of state GDP will demonstrate higher pollution over time.

H_0: The strength of utilities in relation to state GDP has no impact on pollution levels over time.

State Population Density

Public Health research has shown that the higher the state population density the greater the incidence of pollution in excess of National Ambient Air Standards. Ground-level ozone is often an urban phenomena due to the higher levels of vehicle miles confined within urban boundaries coupled with the greater heat generated by the expanse of pavement. Therefore it is important to control for population density. However, there is some evidence that NOx from the excessive car exhaust in cities actually causes ground-level ozone to decrease in the city limits and travel outside the city limits into the surrounding suburbs and rural areas. This suggests that suburbs and rural areas are not immune from the dangers posed by ground-level ozone. The mean for population density is 186 with a range from 1.1 to 1183.9.

The following hypotheses represent population density:

H_{11}: States with higher population density will demonstrate higher pollution levels over time.

H_0: Population density has no impact pollution levels over time.

Local Agencies

As part of the rule-making process, the EPA designates local regions within each state due to specific characteristics and geographic boundaries to isolate specific areas where pollution is evident (or, where pristine areas exist that require heightened maintenance). In some cases states choose to create local agencies within these regions. The mean for local agencies is 3.58 and the range is zero to 35. Local agencies are a fixed effect variable and where measured in 2007.

The following hypotheses represent local agencies:

H_{11}: States with more local agencies will demonstrate higher pollution levels over time.
H_0: The number of local agencies has no impact on pollution levels over time.

Unemployment

Becker (2003) found that higher unemployment rates often led to higher pollution levels. Therefore I am adding a control for state unemployment levels. The mean for unemployment is 4.66 and the range is 2.3 to 8.1.

The hypothesis for unemployment is as follows:

H_{12}: States with higher unemployment rates will demonstrate higher pollution levels over time.
H_0: High unemployment rates have no impact on pollution levels over time.

Adapted Network Model of Administration

My proposed adaptation of the model is as follows:

> Ozone exposure index$_{it}$= $\alpha + \beta_1$ stability of air agency head$_{it}$ + β_2 presence of air policy board$_{it}$ + β_3 number of citizen members$_{it}$ + β_4 public participation guidelines$_{it}$ + β_5 strength of utility industry$_{it}$ + β_6 strength of coal industry$_{it}$ + β_7 democratic governor$_{it}$ + β_8 democratic legislature$_{it}$ + β_9 split control of legislature$_{it}$ + β_{10} ideology score$_{it}$ + β_{11} population density$_{it}$ + β_{12} number of local agencies$_{it}$ + β_{13} unemployment + ε.

Analysis Plan

This research entails the capture of both primary and secondary data. The structure of the data is a panel dataset by state for the period 1999-2007. The EPA modernized its data collection techniques for the period chosen, and suggests that correlations across prior years would not be deemed appropriate. This period should yield sufficient data to allow for appropriate analysis. Because I begin with a panel dataset I must forgo the use of descriptive statistics attempt to weed out potentially flawed variables. Time-series analysis introduces potential serial correlation that renders descriptive statistics suspect.

The alternative is to test correlations of the variables to discern whether they are appropriate or should be dropped. The second is to use the XTSUM function in Stata. XTSUM provides statistical information to designate variables that are time invariant and will therefore drop out of the fixed effects models. Additionally, it provides statistical information about whether a variable is well indentified. Therefore both correlations and XTSUM will be generated at the outset of the analysis. The results of XTSUM will be used to determine whether to drop or merge variables to best deal with potential multicollinearity among variables.

Next, I will use a variety of regression models to study the impact of the variables on ground-level ozone and to best fit a model. Because this research is seeking to explore new ground in adapting the network model to the environmental context, the methodological assumptions will remain fluid and adaptive as the data is explored.

CHAPTER FOUR

Data Analysis

The agency centered focus at the core of the Network Model of Administration has not been tested in the realm of environmental policy. Although environmental policy has received extensive treatment at the federal level very little is known about it at the state level (Ringquist, 1993). State centered research of environmental policy often depends on external measures of commitment such as the Free index developed by the Fund for Renewable Energy (Ringquist, 1993, Potoski and Woods, 2001) or the Green index developed by the Institute for Southern Studies (Woods, 2006). These indices are used as dependent variables to demonstrate commitment to environmental outcomes, but do not provide a mechanism to verify pollution reduction. This research aims to both fill this gap in the literature on state agencies dealing with air policy and to apply the Network model outside the context of education.

Despite the primary role for the states, federal regulation is expected to exhibit national trends in the reduction of ground-level ozone over time. For instance, what is known as the "Acid Rain Program" targeting Sulfur Dioxide (SO_2) was considered a major success story with a 22% reduction in SO_2 emissions despite increasing utility power generation in the 1990s. This program was followed by the "NOx SIP Call Program" creating a cap and trade system similar to the Acid Rain program targeting nitrogen oxides. Beginning in 2003 this program has also seen unprecedented success with a reduction of 60% of NOx point source emissions based on 2000 levels (EPA, http://www.epa.gov/airmarkt/progress/nbp07.html, retrieved April 7, 2009). Therefore, I anticipate national trends to be evident in the data, on average all states should demonstrate a decline in ground-level ozone during the period of study. However, there remains an opportunity to uncover remaining variation across the states and test the validity of the Network Model of Administration.

In ranking the fifty states based on the percent reduction from 1999-2007 a number of issues become evident. Although some states made excellent progress in reducing pollution, their mean pollution over time may not have been very high. Thus I provide two tables, Table 4. State Ranking by Percent Change in Ozone exposure index, 1999-2007 and Table 5. State Ranking by Percent Change in Mean Pollution, 1999-2007. Table 4. sorts the rankings by percent reduction over the time period. Table 5. sorts mean pollution over the time period. These two tables enable a more complex picture of pollution reduction to emerge, as some states did have great success in their percent reduction of ozone exposure index of air pollution, yet had very little pollution to begin with, as the mean scores of ozone exposure index demonstrate.

Interestingly, only one of the top ten ranked states for percent reduction in ozone exposure index has an air policy board. Six of the bottom states had air policy boards. The top and bottom ten states both had a total of 19 different administrators. The key difference between the top and bottom states in terms of the number of administrators is that California (ranked in the bottom group) topped out at 4 administrators. In the top ten, no state had over three administrators during the period of study.

The tables and graphs demonstrate that states have been achieving a reduction in ozone exposure index of ground-level ozone over the period in question. The graphs on the relationship of the ozone exposure index to length of service of the air administrators within states also suggest that there is wide variation across states in pollution reduction across years, and in the linear relationship of ozone exposure index to length of service. This sets the stage for our regression analyses.

Next I provide a chart demonstrating the relationship between ozone exposure index of air pollution and the length of service of Air Administrators. This chart provides a preliminary look at our dependent measure in relation to a key independent variable tenure of the air administrator. It suggests that there is a pattern that may emerge in the statistical analysis.

Table 4. State Ranking by Percent Change in Ozone exposure index, 1999-2007

	State	Percent Change 1999-2007	Mean Pollution	Rank	State	Percent Change 1999-2007	Mean Pollution
1	Nebraska	100.00%	0.209879056	26	Alabama	45.62%	7.254853667
2	Oklahoma	95.20%	6.276105278	27	Vermont	42.80%	1.094738756
3	New Hampshire	84.76%	1.7936726	28	New York	39.90%	5.530135
4	Florida	83.30%	5.061485	29	Minnesota	39.50%	0.305594733
5	South Carolina	80.35%	5.700223333	30	Arkansas	37.03%	2.138598344
6	Mississippi	71.78%	3.006802889	31	Michigan	36.63%	8.224776778
7	Arizona	71.21%	27.55849222	32	Illinois	34.55%	8.685247667
8	Louisiana	68.83%	7.046595444	33	Connecticut	29.67%	15.06735622
9	Wyoming	66.03%	0.122248011	34	Nevada	26.21%	21.56771556
10	New Mexico	64.14%	3.048566778	35	Ohio	19.43%	10.56696989
11	Kansas	62.45%	1.308865133	36	Maine	17.25%	3.728203278
12	Delaware	60.43%	19.44188056	37	Massachusetts	12.30%	7.956268
13	Texas	60.34%	18.60308067	38	Missouri	7.34%	6.2915568
14	Georgia	59.70%	10.40006367	39	Idaho	-5.12%	0.892311922
15	Wisconsin	59.26%	5.615446378	40	West Virginia	-8.11%	3.223666433
16	Iowa	58.15%	0.548787522	41	California	-12.91%	48.88424556
17	Kentucky	56.72%	7.082143456	42	Rhode Island	-17.02%	9.477623778
18	Tennessee	56.11%	10.94554144	43	Colorado	-29.61%	4.166795333
19	Oregon	54.91%	0.399420122	44	Utah	-55.41%	7.824008444
20	Indiana	53.97%	7.907427889	45	Washington	-70.33%	1.284039044
21	North Carolina	52.91%	9.705268667	46	South Dakota	nominal exposure	0.021833256
22	Virginia	52.31%	7.173347222	47	North Dakota	nominal exposure	0.000986267
23	New Jersey	47.61%	12.96711622	48	Montana	no exposure	0
24	Maryland	46.71%	10.01313856	49	Alaska	no exposure	0
25	Pennsylvania	46.42%	13.67786433		**National Average**	40.07%	7.546959

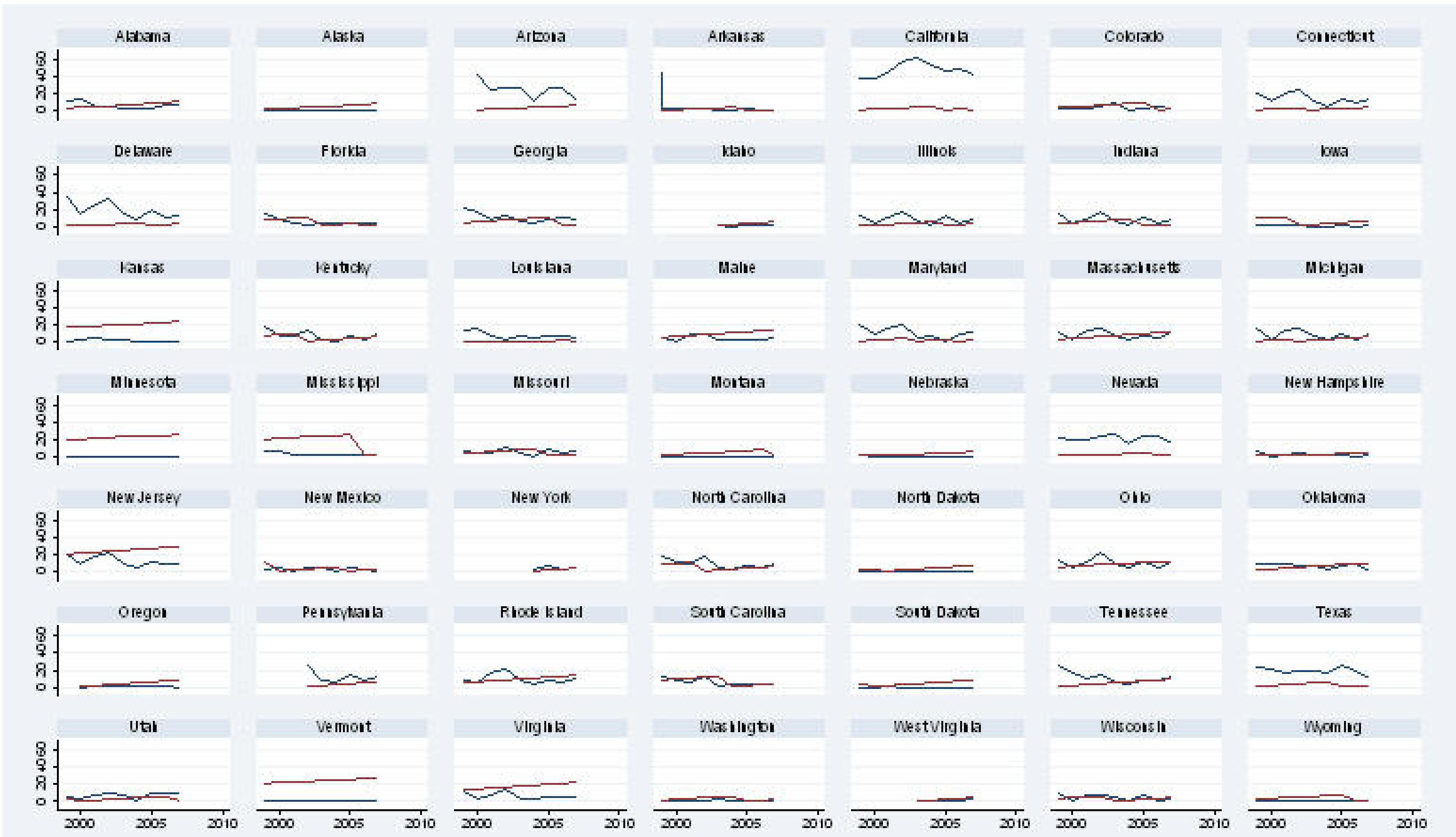
Source: primary source data generated by author by combining EPA monitoring data with census population estimates.

Table 5. State Ranking by Percent Change in Mean Pollution, 1999-2007

Rank	State	Percent Change 1999-2007	Mean Pollution	Rank	State	Percent Change 1999-2007	Mean Pollution
1	Alaska	no exposure	0	26	Missouri	7.34%	6.2915568
2	Montana	no exposure	0	27	Louisiana	68.83%	7.046595444
3	North Dakota	nominal exposure	0.00098627	28	Kentucky	56.72%	7.082143456
4	South Dakota	nominal exposure	0.02183326	29	Virginia	52.31%	7.173347222
5	Wyoming	66.03%	0.12224801	30	Alabama	45.62%	7.254853667
6	Nebraska	100.00%	0.20987906	31	Utah	-55.41%	7.824008444
7	Minnesota	39.50%	0.30559473	32	Indiana	53.97%	7.907427889
8	Oregon	54.91%	0.39942012	33	Massachusetts	12.30%	7.956268
9	Iowa	58.15%	0.54878752	34	Michigan	36.63%	8.224776778
10	Idaho	-5.12%	0.89231192	35	Illinois	34.55%	8.685247667
11	Vermont	42.80%	1.09473876	36	Rhode Island	-17.02%	9.477623778
12	Washington	-70.33%	1.28403904	37	North Carolina	52.91%	9.705268667
13	Kansas	62.45%	1.30886513	38	Maryland	46.71%	10.01313856
14	New Hampshire	84.76%	1.7936726	39	Georgia	59.70%	10.40006367
15	Arkansas	37.03%	2.13859834	40	Ohio	19.43%	10.56696989
16	Mississippi	71.78%	3.00680289	41	Tennessee	56.11%	10.94554144
17	New Mexico	64.14%	3.04856678	42	New Jersey	47.61%	12.96711622
18	West Virginia	-8.11%	3.22366643	43	Pennsylvania	46.42%	13.67786433
19	Maine	17.25%	3.72820328	44	Connecticut	29.67%	15.06735622
20	Colorado	-29.61%	4.16679533	45	Texas	60.34%	18.60308067
21	Florida	83.30%	5.061485	46	Delaware	60.43%	19.44188056
22	New York	39.90%	5.530135	47	Nevada	26.21%	21.56771556
23	Wisconsin	59.26%	5.61544638	48	Arizona	71.21%	27.55849222
24	South Carolina	80.35%	5.70022333	49	California	-12.91%	48.88424556
25	Oklahoma	95.20%	6.27610528		National Average	40.07%	7.546959

Source: primary source data generated by author by combining EPA monitoring data with census population estimates.

Figure 5. Graph of linear trend in ozone exposure index and the length of service of air administrators



1999-2007

------------------ ground-level ozone ------------------ years of service of air administrator

Source: primary source data generated by author by combining EPA monitoring data with census population estimates.

To begin I create four models, a pooled ordinary least squares (OLS) model, a least squares dependent variable (LSDV) model, and two random effects (GLS) models. The pooled OLS model assumes no consistent temporal (annual) or spatial (by state) effects. As noted in Chapter Three, although this is not probable given the theory that led to the analysis, it serves as an initial test of our variable's adequacy given the inability to use standard descriptives across a panel dataset.

Pooled OLS Model

The pooled OLS model yields significant coefficients for all of the key independent variables (See Table 6. below for complete results). Tenure of Administrator is significant with a negative coefficient of -0.18 and a probability of 0.00. Presence of an air board is significant with a coefficient of 4.02 and a P of 0.00. Number of Citizen Members has a coefficient of -1.23 with a P of 0.00. The availability of public participation guidelines has a coefficient of 2.97 and a P of 0.00.

The pooled OLS suggests that air boards are present in states with higher and more persistent levels of pollution. This is not in the expected direction and requires further analysis outside of the scope of this inquiry. See the recommendations for future research below for further discussion.

This model also shows that greater coal consumption per capita has a negative correlation with pollution reduction. In other words as coal consumption increases, pollution decreases. This is consistent with other findings (Teske, 1991; Becker, 2003). Population density is not significant with a P value of 0.66.Increasing numbers of local agencies per state is in the anticipated direction, demonstrating a correlation to higher pollution levels, with a coefficient of 0.96 and a P of 0.00.

The time period 2000-2002 is significant in this model and positive. Prior to the implementation of the NOx SIP call, national trends for the period were positive. 2003-2004 is dropped due to collinearity and the period 2005-2007 is not significant.. Although the drop in ozone exposure index during 2003 to 2004 was sizeable around the nation, much more variation was seen in the data for the period 2005 to 2007.

The pooled OLS model treats each observation of a states ozone exposure as completely independent of the next observation and therefore does not account for differences across the timeframe under study or across the states. The use of a pooled model is only acceptable if I was able to account for all possible variation among states within the model. The R^2 of 48% suggests that this model accounts for only 48% of the variation. Given this lack of full specification of the model it is appropriate to move to test both fixed and random effects models. Theoretically, I am arguing that states are different and that their differing institutional practices impact pollution reduction. Theoretically, I anticipate that state pollution levels are dependent, in part, on pollution levels from prior years. Therefore, I proceed to tests models that anticipate group effects.

Table 6. Pooled OLS Regression

Source	SS	df	MS		Number of obs	411.00
					F(11, 398)	37.65
Model	17840.36	10.00	1784.04		Prob > F	0.00
Residual	18953.03	400.00	47.38		R-squared	0.48
					Adj R-squared	0.47
Total	36793.40	410.00	89.74		Root MSE	6.88

Person Days	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Tenure of Administrator	-0.18	0.05	-3.23	0.00	-0.28	-0.07
Air Board Presence	4.02	1.18	3.42	0.00	1.71	6.33
# of Citizen Members	-1.23	0.29	-4.23	0.00	-1.81	-0.66
Public Participation Guidelines Available	2.97	0.88	3.37	0.00	1.24	4.70
Coal Consumption	2.69	1.11	2.43	0.02	0.52	4.86
Unemployment Rate	0.83	1.10	0.76	0.45	-1.33	2.99
Population Density	-0.38	0.86	-0.44	0.66	-2.07	1.31
Local Agencies	0.96	0.07	13.70	0.00	0.82	1.10
2000-2002	2.26	0.85	2.66	0.01	0.59	3.93
2005-2007	-0.40	0.84	-0.47	0.64	-2.06	1.26
Constant	4.22	1.84	2.30	0.02	0.61	7.80

Preliminary analysis showed that several variables could be dropped from the model: Democratic and split party control of the state legislature, Democratic Party control of the governor's office and state ideology as predicted by the adjusted ADA scores. Tests for multicollinearity showed that there was a .55 correlation between democratically controlled legislatures and split legislations. Therefore, I fail to reject the following null hypotheses:

H_0: Party control of the state legislature has no impact on pollution levelsover time.

H_0: State ideology has no impact on pollution levels over time.

H_0: Democratic governors have no impact on pollution levels over time.

Rinquist's study of air quality mirrored the results in regard to party control where he also found no significance (1993). However, in regard to ideology Ringuist did use a slightly different test to capture state ideology that was found to be significant (1993). The measure used by Ringuist and a similar measure used by Hays et al. (1996), although found to be significant could not be replicated here. . Further research is necessary to better isolate the role of ideology in air policy outcomes and for the purposes herein the variable is dropped.

Additionally, initial review of the data using the xtsum function available in Stata for panel data suggested that the Utility variable (strength of utility in relation to State GDP) was not well specified within the panels. Therefore, I fail to reject the null hypothesis:

H_0: The strength of utilities in relation to state GDP is uncorrelated to a reduction in ozone exposure index of ground-level ozone.

Review of the year variables found significant similarities between coefficients leading me to pool the years as follows: 1999 is dropped from the model as the first instance. 2000 through 2002 are coded together. 2003 and 2004 are coded together.

These two years represented the beginning of the NOx SIP Call implementation and displayed a precipitous drop in pollution that was not sustained over the following period. 2005-2007 demonstrated a continued drop in pollution levels nationally, but more consistent with the drops witnessed in 2000-2002. Note that Stata dropped the 2003 through 2004 variable due to collinearity with other variables. These included the other time periods and coal consumption per capita.

Least Squares Dummy Variable Model

Next, I test a fixed effect model with dummy variables. This is known as the Least Squares Dummy Variable (LSDV) model. The advantage of this model is that it allows me to account for differences across cross sections and/or across time. However, as our data has 49 panels (states) and 9 time periods, the fixed effect model requires 48 dummy variables for states. Given the small size of the dataset (N=411 where ozone exposure index of ground-level ozone pollution > 0), the large number of dummy variables may consume the degrees of freedom. This potentially introduces multicollinearity thereby increasing the standard errors and depriving the model of statistical power (Yafee, 2003; Wooldridge, 2006). An additional pitfall of the LSDV fixed effect model is that all variables that are constant across time must be dropped. In this case I lose important independent variables such as the presence of an air board and the availability of public participation guidelines, as well as the control variables local agencies, 2000-2002 and 2005-2007. It is also evident from the data that there is little variation in most of the independent variables across time within states, also potentially undermining the utility of the LSDV model.

None of the key independent variables tenure of administrator, public participation guidelines present, air board presence and number of citizen members are statistically significant in the LSDV model. The dummy year variables for 2000-2002 and 2005-2007 achieve significance with P values of 0.00 and 0.03 respectively. The overall R^2 suggests that very little variance is explained via the fixed effects model.

In this model population density actually demonstrates a negative relationship to the ozone exposure index with a coefficient of -0.22 at the 0.00 level of significance. It may simply be the lack of variation across both the control and independent variables within states that is causing all variables to either lose significance or not move in the expected direction. See Table 7. Least Squares Dependent Variable Regression for complete results.

Table 7. Least Squared Dependent Variable Regression

Fixed-effects (within) regression		Number of obs =		411
Group variable: State		Number of Groups:		49
		Obs per group:		
R-sq: within	0.16	=	min	4
between	0.06		avg	8.4
overall	0.05		max	9
		F(16,	357)	6.71
corr(u_i, Xb)	-0.99	Prob	> F	0

Ozone exposure index	Coef.	Std. Err.	t	P>t	[95% Con	f. Interval]
Tenure of Air Administrator	-0.10	0.07	-1.28	0.20	-4.28	-0.97
Presence of Air Board	6.39	4.43	1.44	0.15	-2.32	15.09
# of Citizen Members	-0.41	1.40	-0.29	0.77	-3.17	2.35
Public Participation Guidelines Available	-0.48	3.14	-0.15	0.88	-6.66	5.71
Coal Consumption	-0.01	0.05	-0.11	0.91	-0.10	0.09
Unemployment Rate	0.35	0.28	1.26	0.21	-0.20	0.90
Population Density	-0.22	0.04	-5.56	0.00	-0.30	-0.14
Local Agencies	0.15	0.99	0.15	0.88	-1.79	2.10
2000-2002	1.91	0.50	3.84	0.00	0.93	2.89
2005-2007	1.15	0.54	2.14	0.03	0.10	2.22
Constant	45.37	8.05	5.64	0.00	29.54	61.19

sigma_u	59.10	
sigma_e	3.94	
rho	1.00	(fraction of variance due to u_i)

F test that all u_i = 0:	F(48, 352)=	18.13	Prob	> F = 0.0000

Generalized Least Squares Random Effects Model

Because many of the independent and control variables are either time invariant or marginally so I also test a random effects model (generalized least squares.) The random effects model assumes that the error term (the function of a mean value plus a random error) must be uncorrelated with the regressors. It also allows for time invariant regressors as noted above. In this model, the Air Board is positively correlated to ozone exposure index of ozone pollution with a significance level of 0.08. As in the pooled OLS model, the positive correlation is unexpected with a coefficient of 4.68.

Local agencies have a significant and positive relationship to increases in ozone exposure index of ozone exposure as expected. Local agencies represent an opportunity to create additional networks to tackle pollution problems in a state. However, they are initially defined as regions via EPA designations due to characteristics specific to its geographical location. Therefore I anticipate that more regions in a state will more likely demonstrate more pollution problems in the state. The data confirms this with a positive coefficient of .94 with a probability of 0.00.

The number of citizen members present on air policy boards is in the expected negative direction with a coefficient of -1.18 with a probability of 0.08. Public participation guidelines fail to achieve significance although the coefficient is in the expected negative direction. None of the control variables are significant in the random effects model.

The dummy variables for 2000-2002 are statistically significant and positive with a coefficient of 2.28 and a probability of 0.00. The time period 2003-2004 drops out of the model due to multicollinearity with other variables. These years represent the initial implementation of the NOx SIP call and demonstrate the greatest annual pollution reduction nationally for the period under study. The years 2005-2007 exhibit a negative correlation of .11 but are not statistically significant. This suggests that the main variation in ozone exposure index during this period is at the state level rather than a national trend represented by the time dummy variable of 2005-2007.

The rho test within the generalized least squares model tests as to whether there are significant group effects within the model. The rho of .70820794 suggests that 70% of the variation in ozone exposure index is related to significant state level effects, which implies that the pooled OLS is inappropriate and a group effects model such as GLS is appropriate. See Table 8. Random Effects GLS model for complete results.

Table 8. Random Effects GLS Regression

Random-effects GLS regression		Number of Obs	=	411
Group variable: State		Number of Groups	=	49
R-sq: within =	0.08	Observations per group	=	4
between=	0.54		avg =	8.40
overall=	0.48		max =	9.00
Random effects u_i Gaussian		Wald	chi2(10) =	76.60
corr(u_i, X)=0 (assumed)		Prob	> chi2 =	0.00

Ozone exposure index	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Tenure of Air Administrator	-0.11	0.07	-1.64	0.10	-0.25	0.02
Presence of Air Board	4.68	2.68	1.75	0.08	-0.57	9.93
# of Citizen Members	-1.18	0.69	-1.71	0.09	-2.54	0.18
Public Participation Guidelines Available	-0.80	1.71	-0.47	0.64	-4.16	2.56
Coal Consumption	-0.03	0.05	-0.52	0.60	-0.12	0.07
Unemployment Rate	0.02	0.27	0.07	0.95	-0.52	0.55
Population Density	0.00	0.00	1.27	0.21	0.00	0.01
Local Agencies	0.94	0.18	5.11	0.00	0.58	1.30
2000-2002	2.28	0.51	4.49	0.00	1.29	3.28
2005-2007	-0.11	0.51	-0.21	0.83	-1.10	0.89
Constant	3.26	2.00	1.63	0.10	0.67	7.19
sigma_u	6.14					
sigma_e	3.94					
rho	0.71	(fraction of variance due to u_i)				

Generalized Least Squares Random Model with AR(1) disturbance

A final model will be tested that enables a two-way interpretation of the panel data across both time and states. This model recognizes the potential for serial correlation across time in a random effects model. The theory that guides this model anticipates that there are nationwide effects resulting from EPA rule-making that can be attributed to some level of pollution reduction across the states. This model allows me to test for the residual impact left to the states while providing for the serial auto-correlation anticipated across time.

Teasing out first order serial auto-correlation only slightly alters the correlation coefficients for most variables and also marginally improves their significance (as compared to the first GLS model). The number of years of service of the air administrator is positively correlated to a reduction in ozone exposure over time with a coefficient of -0.15 and a P value of 0.04. States with air boards continue to exhibit higher levels of ozone pollution with a coefficient of 4.81 at the 0.05 level. The number of citizen board members continues to be significantly related to a reduction in ozone exposure index of ozone exposure with a coefficient of -1.18 at the 0.06 level. Public participation guidelines is not statistically significant.

The time frame 2000-2002 remains significant, and represents an upward trend in ozone pollution. 2003-2004 continues to drop out of the model due to multicollinearity, and the years 2005-2007 is not significant.

The R^2 remains at 48% with the Wald test confirming the significance of state level impacts at the 0.00 level. The estimated autocorrelation coefficient suggests that approximately 14% of the remaining variance in the model can be explained by autocorrelation across years. Complete results are available in Table 9. below.

Table 9. GLS regression with AR(1) disturbances

Random-effects GLS regression with AR(1) disturbances				Number of Obs=			411
Group variable: State				Number of Groups=			49
R-sq: within =	0.08			Obs per group=			4
between=	0.54				avg =		8.40
overall=	0.48				max =		9.00
corr(u_i, xb)=0 (assumed)				Wald	chi2(10)	=	81.52
				Prob	> chi2	=	0.00

Ozone exposure index	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Tenure of Air Administrator	-0.15	0.07	-2.06	0.04	-0.29	-0.01
Presence of Air Board	4.81	2.47	1.95	0.05	-0.02	9.65
# of Citizen Members	-1.18	0.53	-1.87	0.06	-2.42	0.05
Public Participation Guidelines Available	-0.63	1.55	-0.41	0.68	-3.67	2.41
Coal Consumption	-0.02	0.05	-0.52	0.60	-0.12	0.07
Unemployment Rate	0.13	0.29	0.46	0.65	-0.44	0.71
Population Density	0.01	0.00	1.7	0.09	0.00	0.01
Local Agencies	0.92	0.16	5.65	0.00	0.60	1.24
2000-2002	2.21	0.53	3.97	0.00	1.07	3.16
2005-2007	0.05	0.54	0.1	0.92	1.01	1.12
Constant	2.80	1.95	1.43	0.15	-1.03	6.62
rho_ar	0.14	(estimated autocorrelation coefficent)				
sigma_u	5.37					
sigma_e	4.14					

The Hausman test confirms the appropriateness of accepting the Random Effects model with a chi-square of 42.39 with a probability of 0.000. See Table 10. below. The Breusch and Pagan Lagrangian multiplier test for random effects also confirms the appropriateness of the random effects models with a chi-square of 611 with a probability of 0.000 See Table 10. below. Therefore, the results of these tests and the underlying theory outlined above leads me to recommend the GLS with AR(1) disturbances regression as the best fit for the data.

Table 10. Hausman Test

	Coefficients (b) fixed	(B)	(b-B) Difference	sqrt (diag(v_b-V_B)) S.E.
Tenure of Air Administrator	-0.10	-0.15	0.05	0.02
Presence of Air Board	6.39	4.81	1.57	3.68
# of Citizen Members	-0.41	-1.18	0.77	1.25
Public Participation Guidelines Available	-0.48	-0.63	0.15	2.73
Local Agencies	0.15	0.92	-0.77	0.98
Coal Consumption	-0.01	-0.03	0.02	0.01
Unemployment	0.35	0.13	0.22	.
Population Density	-0.22	0.01	-0.22	0.04
2000-2002	1.91	2.12	-0.20	.
2005-2007	1.16	0.05	1.11	.

b = consistent under Ho and Ha, obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtregar

Test: Ho: difference in coefficients not systematic

chi2(10) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 42.39
Prob>chi2 = 0.00
(V_b-V_B is not positive definite)

Table 11. Breusch and Pagan Lagrangian Multipler Test

Ozone Exposure Index[statenum,t] = Xb + u[statenum] + e[statenum,t]

Estimated results:

	Var	sd = sqrt(Var)
Ozone Exposure Index	89.73999	9.473119
e	15.50842	3.938074
u	37.64047	6.135183

Test: Var(u) = 0
chi2(1) = 611.40
Prob > chi2 = 0.0000

While the GLS regression with AR(1) disturbances appears to be the most appropriate model for the data, I also find the statistical significance of the coefficients on the key independent variables is fairly stable across the pooled, GLS and GLS with AR(1) disturbance models. Table 12. demonstrates the results of the four models across the independent variables of interest. These results demonstrate that the years of service of the air administrator, the presence of air boards, and the number of citizen members of air boards are statistically significant with little variance in coefficients across the pooled, GLS and GLS with AR(1) disturbance regressions.

Table 12. Comparison of Pooled, LSDV and Random Effects Models

Hyptheses	variables tested	Pooled Regression coefficients	P>|z|	Random Effects Model coefficients	P>|z|	Random Effects GLS with AR(1) disturbance Model coefficients	P>|z|
H1: States with long serving Air Administrators demonstrate a greater reduction in ground-level ozone pollution over time than states with high turnover rates.	# of years of service of the air administrator	-0.175151	**0.001***	-0.1133864	**0.101**	-0.1474886	**0.04**
H2: States with Air Policy Boards demonstrate a greater reduction in ground-level ozone pollution over time than states without Air Policy Boards.	Have air policy boards	4.018272	**0.001**	4.681364	**0.081**	4.814962	**0.051**
H3: States that provide public participation guidelines via the Air Agency website demonstrate a greater reduction in ground-level ozone pollution over time.	Have public participation guidelines on web	-0.7207265	NS**	-0.8002467	0.641	-0.6311454	NS
H4: States that allow for more citizens to serve on Air Policy boards demonstrate a greater reduction in ground-level ozone pollution over time.	number of citizen board members	-1.234099	**0.000**	-1.183366	**0.088**	-1.181583	**0.061**

Summary of Findings

Intergovernmental Management

Two variables represent intergovernmental management for the purposes herein: tenure of the air administrator and presence of an air board. The statistically significant results in relation to the tenure of the air administrator demonstrate that as the number of years of service increase pollution decreases. This result was captured across the pooled, GLS and GLS AR(1) models. In regard to air boards, although a statistically significant relationship is found, it is not in the expected direction. This research finds that air boards are more likely to be found in states with higher pollution levels and that the pollution is not reducing at the pace of other states.

Therefore in regard to intergovernmental management I reject the null hypothesis in the case of Tenure of the air administrator.

> **H_0**: The tenure of the Air administrators has no impact on ozone exposure index of exposure over time.
>
> In regard to air boards, I fail to reject the null hypothesis.
>
> **H_0:** States with Air Policy boards do not demonstrate a greater reduction in ozone exposure index of exposure than states without Air Policy Boards.

Public Accessibility

Two variables represent public accessibility: number of citizens on air boards and availability of public participation guidelines. In regard to number of citizens on air boards I found statistically significant relationships across the pooled, GLS and GLS AR(1) models. In each case as the number of citizen members increased pollution levels decreased.

Therefore, I reject the null hypothesis in regard to number of citizen members of the air boards.

H_0: The presence of citizens on air boards has no positive impact on pollution reduction over time

Conversely, in regard to public participation guidelines, the variable did not obtain significance in any of the models. Due to the lack of significance across all models I fail to reject the null hypothesis in regard to public participation guidelines.

H_0: The availability of public participation guidelines via the web has no impact on pollution reduction over time.

Control Variables

Political Context

Variables based on political control of the legislature and governor's offices were created, as well as an ideology variable to test for the influence of party and liberalism/conservatism on pollution levels. I found no statistically significant impacts across any of the models and therefore dropped all variables.

Coal Consumption

I captured coal consumption per capita for all years under study. It was statistically significant only under the pooled OLS model.

Utilities

Early testing of the Utility variable demonstrated that it was not well specified within the model and it was dropped.

State Population Density

Population density is significant in the LSDV model only.

Local Agencies

Local agencies are significant in both GLS models. As anticipated, states with more agencies tend to have higher pollution levels.

This research leads me to confirm the utility of the Network Model of Administration in the context of ground-level ozone reduction across the states. This model demonstrates the importance of public management factors such as the longevity in office of the Air Administrator. It also demonstrates the importance of behavioral networking due to the presence of air boards and the numbers of citizen members of air boards. The vitality of air boards without the presence of citizen members remains in question as a result of this analysis. The information component demonstrated by the presence of public participation guidelines via the web did not achieve significance for this model.

One key finding is that the longevity in office of the Air Administrator is an important factor in reducing pollution over time. The highly scientific aspects of pollution control coupled with the entangled web of networks across federal and state levels suggests that longer serving administrators will effectively navigate these webs of networks and serve their organizations well by enhancing pollution reduction over time. The second key finding is that the presence of Air Boards with higher numbers of citizens also leads to greater pollution reduction overtime. This suggests that citizen participation may have an important role in enhancing network cooperation in the public interest. More research on the role of citizens on boards and how they correlate to pollution reduction is of interest.

CHAPTER FIVE

Summary, Conclusions and Suggestions for Further Research

This research sought to cover new ground in two significant respects. First, it attempted to apply a revised network model of administration that incorporated citizen participation in a new policy arena- air pollution control. Second, it sought to develop a performance measure upon which the success or failure of pollution control efforts could be judged. Performance measures are used extensively in the private sector but have been slow to develop in the public sector. However, this has started to shift.

Adapting Network Theory to Air Policy Administration

This research develops a model of air policy administration that incorporates three key elements:

- *institutional professionalism*
- *the use of air policy boards*
- *networking encompassing agency heads, air boards and the public*

The specifically agency centric orientation seeks to shed new light on intergovernmental relations by linking institutional process to well defined performance measures. To achieve these aims the network model of administration developed by Lawrence O'Toole and Kenneth Meier (2004, 2003, 2002) is adapted. Their research on state education institutions, share key features with air policy administration. The federal structure is multi-tiered and multi-layered. States are mandated to fulfill certain criteria but are given latitude in devising their instructional strategies. Their research targets a number of key factors in public management: managerial effectiveness and stability, networking behavior, and administrator's ability to exploit the environment and buffer environmental shocks. These measures are adapted for the purposes of this research. Managerial effectiveness and stability are represented by the length of the term of office of the air administrator. This variable is coded by the number of years in office of the current and former administrators.

The next two variables of interest in exploring air policy are adapted from Teske's research into utility boards (1991) and medical licensing boards (2003) and Berry's work on alternatives to capture theory (1984). Following Gormley (1989) who notes that citizens engaged in representing the public is a commonly observed procedural innovation that came out of the New Public Management movement, Teske and Berry find that citizen advocates and citizen board members serve important public interests in their capacity of representing the public on both utility regulatory boards (Teske, 1991, Berry, 1984) and medical licensing boards (Teske, 2003). This research incorporates this key function into the network model of administration by constructing two variables. The first is the presence of an air board at the agency that is charged with regulatory functions. This is a dichotomous dummy variable coded as one for states utilizing boards. The second is the presence of citizens on the board. This is a simple count of the number of citizen members on each board.

Information access is deemed a crucial component of citizen engagement in institutional processes that are similarly multi-tiered, complex in nature and having both scientific and public health implications. Information access is represented by the presence of citizen participation guidelines on the air agencies website. Dozens of studies have noted the importance of organized constituencies to influence agency behavior to accommodate the public interest. However, in a case such as air policy where most of the public is oblivious to the primary threats to their person represented by threats such as ground-level ozone, basic information dissemination is seen as a key to engaging the public. This is measured by the presence of citizen participation guidelines via the web.

Performance Measures for Air Policy Administration

This research developed a new performance measure, the ozone exposure index, which can be used to evaluate air pollution control efforts. The ozone exposure index represents a standardized measure which enables me to compare states. The measure accounts for ambient air quality drilled down to the county level. This enables me to both standardize without losing the core connection to the public health impacts of ground-level ozone pollution. As a performance measure, it provides a reasonable means to test whether states are able to reduce pollution levels over time.

Robert Behn (2003) suggests that there are eight key reasons for developing and using performance measures in public management: (1) evaluate; (2) control; (3) budget; (4) motivate; (5) promote; (6) celebrate; (7) learn; and (8) improve. By using ambient air monitoring data in regard to pollution reduction at the state level, I am using real-time data on the exceedances of the air quality standard for ground-level ozone. Although the state is certainly not responsible for the weather patterns that give rise to much ground-level ozone, they are responsible for its consequences. This measure provides a robust and easily available method for tracking progress in reducing pollution over time.

Key Findings in regard to the Network Model of Intergovernmental Management

Stability of Managerial Networks

In regard to the stability of managerial networks the model produces robust results across the pooled and GLS and GLS AR(1) models. The length of service was negatively correlated with the ozone exposure index in both models demonstrating that the longer an administrator serves in office, ceteris paribus, ground-level ozone pollution is reduced.

This finding suggests that the Network Model of Administration has utility in policy arenas beyond education. As others note, "public management matters" (Meier and O'Toole, 2002). The implication in regard to tenure of the administrator is that there is potential in tying performance measures such as the ozone exposure index to managerial effectiveness. The findings support a reasonable expectation that expertise develops over time and that the longer the tenure the more adapt a manager is at maintaining the networks necessary to pursue organizational aims; in this case pollution reduction.

If public management matters in regulatory functions, then having an administrator adept at managing a complex federal network is seen as key. The public is beginning to coalesce around the idea that global warming is a serious problem, especially for future generations (66% consider it to be a major problem for future generations in a Marist College Poll conducted April 1-3, 2009). This telling statistic suggests that air policy may become more politicized and high profile. This may create more pressures for change. Therefore the importance of stability to performance-driven policy is an important consideration as political turnover routinely occurs in governors' mansions across the country and typically entails turnover of their appointed heads of the state air board.

. New blood in high-level administrative management positions such as the air administrator may not be what the doctor ordered. This is not to suggest that all administrators should keep their jobs. As Meier and O'Toole have noted, there is a paradox of organizational management: "At the highest levels of performance, stability is a good thing. As performance in an organization declines, stability has less value simply because the organization is reproducing poor performance (Meier and O'Toole,2003 p 695). With the introduction of the ozone exposure index as a performance measure, governors now have a means to judge the performance of current air administrators.

Intergovernmental Management

Air boards are constituted as quasi-independent rule making bodies with the ability to promulgate regulations. Some but not all boards are also given enforcement duties. Boards without regulatory powers were excluded from this study. Many states have moved to multi-media boards for the purposes of approving regulations agency wide but these were excluded from analysis as well.

Boards serve many important functions in air policy regulation much as they do in the context of utility regulation and education administration. In the context of this research boards are hypothesized to contribute to citizen engagement within an agency by providing a forum for the public to engage in policy debates about air policy. They introduce a singularity of focus on a specific problem, in this case air pollution, and in many cases draw upon the various stakeholder populations across a state to allow a diversity of voices and levels of expertise.

A positive view of boards suggests that the purpose of the board is to allow for adequate citizen representation, in conjunction with other stakeholders. The board then works in tandem with the agency to tackle the pesky problem of pollution reduction. A negative view is that the board is constituted to deflect criticism of failing pollution control efforts. Such boards are likely to be weakly constituted and ineffectual in engaging in meaningful pollution reduction efforts.

Statistically accounting for both boards and the number of citizen members does present a challenge. Obviously there are strong correlations between the presence of boards and the number of members serving on boards, for there can be no members without the boards. However, these variables do test for different things and I would argue that the presence of a board does not in any way dictate the number of citizen members chosen to serve. In this research I found boards had anywhere from zero to nine citizen members. There were not sufficient numbers of boards to create dummy variables for each count of members, therefore I chose to allow both the airboard variable and the count of citizen member variable to remain but to note the multicollinearity present.

Contrary to expectations, this research found that air boards are more often present where pollution is increasing, rather than decreasing. However, the presence of citizen members on the boards turns the table. Where more citizens are present on boards greater pollution reduction outcomes are achieved. This is consistent with research that citizen engagement is important even in cases of technical, regulatory and scientific complexity. This outcome is tempered by the fact that the two variables are statistically multicollinear, for there would be no citizen members if there were no boards. However, the variable for citizen members takes in account the specific number of members on a board and it is the increasing numbers of citizens that are shown to be correlated to a reduction in pollution in states having boards.

The limited measure for the presence of an air board does not capture whether or not the board is effective. Issues such as internal expertise, budgets and the extent of the pollution problems in the state likely play a role in board success. Future research could delve more deeply into performance measures which capture board success or failure. Such measures might include levels of expertise, term of office and funding for boards.

Citizen Participation

The findings herein demonstrate that the presence of citizen members on the boards has a statistically significant impact on pollution reduction. This finding suggests that states with more intransigent pollution problems use air policy boards, and that the boards have a more significant impact on pollution reduction strategies if more citizen members are present. This is consistent with the findings of Gormley (1989) and Teske (1991, 2003). Further, this finding is consistent in confirming the importance of a participatory role of citizens as demonstrated in the context of water quality networks (Schneider et al., 2003). Their research went a further step to analyze the degree to which the networked consensual institutions built trust and established cooperation with local stakeholders while at the same time devising regulatory institutions that were more adaptive, fluid and locally based. While the citizen participation measure in this research is of more limited scope, its significance in the model does suggest that citizen participation in matters of both regulatory and scientific complexity is a societal benefit.

Information Access

The Clean Air Act (CAA) with its amendments requires states to provide information on air quality via the AIRNOW system from their primary website. Additionally, both the CAA and the NEPA legislation require avenues of citizen participation including the right to attend public meetings, to comment on proposed changes that impact state pollution levels and so forth. Yet, if citizens are not aware of their rights as set forth in these acts they may not be compelled to participate. This study measured information access as a simple dichotomous variable as to whether a clear and concise webpage or accessible document labeled public participation guidelines is available to the public via the air agency website. This measure failed to achieve significance in any of the models. It was not robust enough to capture what citizens know and the means they use to obtain such information. More research on the role of information in engaging citizens will be addressed below in suggestions for future research.

Policy implications in relation to the effectiveness of Air Quality Regulations

As noted above, there are important policy implications in relation to the effectiveness of Air Quality Regulations. I have demonstrated that public management matters in that stability in office of the air administrator. The tenure of the air administrators is positively correlated to a reduction in ground-level ozone pollution over time. Further, I have demonstrated that Air boards with higher numbers of citizen participants serve an important role in helping to reduce statewide pollution.

Air quality continues to resonate with the public as more and more damaging health reports come to the surface. Additionally, more and more citizens accept the scientific consensus that global warming is a man-made phenomenon. Therefore, as all air administrators in this study were political appointees, this research suggests that incoming Governors would be wise to approach replacing their Air Agencies heads cautiously. High turnover of the air administrator following political election cycles does not bode well for long term impacts of pollution reduction as demonstrated by this research. Further, dedicated air boards with citizen membership may help to serve an important function in reducing pollution.

More research is needed on how best to engage the citizenry in the reduction of air pollution. The limited dichotomous variable for the presence of public participation guidelines did not provide robust results on which to generalize the adequacy of public information efforts. Building consensual institutions in the case of water pollution demonstrates the importance of engaging the citizenry and building levels of trust needed to serve the public interest (Schneider et al., 2003). More research is needed on the role of the citizen in the regulatory process in regard to air policy.

Limits of Study

Although this study limited itself to an exploration of the reduction of ground-level ozone across the continental states as mandated in the CAA and its amendments, the fact that it mirrors results obtained via the network model of administration in the context of education suggest the vitality of the network model of administration in other regulatory contexts. This study also limits itself to the role of state air agencies and intergovernmental management at the agency level. This research does not extend to the various levels of the federal system, for instance the regional EPA, the federal EPA or the assorted oversight panels at the congressional level.

Though the variable of length of service was limited in scope, I considered it adequate to demonstrate stability in office of the air agency administrator. Secondary sources on salary trends, staffing levels and annual budgets proved difficult to obtain across all fifty states. Further research may benefit from collecting this data to further develop the network model in this regard. Further research might explore the lack of readily available budgets that drill down to the air agency level, including the lack of access to staffing levels. What inhibits the annual capture of this information across states?

The presence of an air board demonstrates an important component of the intergovernmental network within air policy. This research ignores the presence of multi-media boards and advisory boards and their relations in the agency. Further, it ignores potential differentiation in how agencies are organized and under what umbrella they are found. For instance, some air agencies are a subdivision of departments of environmental quality, others are under the department of natural resources or the department of public health. The research also ignores the internal structural differences that may be of significance to a broader understanding of intergovernmental relations. Returning to these variations may enhance our understanding of the network model.

The role of citizen participation is demonstrated through the count of citizen members present on air policy boards. While other research demonstrated the importance of an energized citizen constituency (Sabatier, 1975), this research limited itself to an understanding of citizen presence on the air board. As with Teske (1999, 2003) and Berry (1984), this research found that the presence of citizens on the air board did serve to improve pollution reduction outcomes over time. Unlike Schneider et al. (2003) who looked at consensual networks and were able to develop measures that incorporated the role of citizens in pollution reduction strategies, the measure utilized herein was more limited in scope but significant nonetheless. Further research might seek to incorporate measures of citizen engagement that were outside the bounds of this research such as the presence and number of citizen advocacy groups.

Directions for Future Research

Although the presence of air boards and local agencies are found to be significant in this analysis, the fact that pollution is actually greater in those states and reducing at a slower rate than others suggests that more research is needed. For instance, many states now use multi-media boards that incorporate air, water and waste. Further research could explore whether important differences in pollution reduction are found based on the makeup of multi-media boards. Are citizen members equally important on multi-media boards? Do the boards serve an important function in generating more public support for a pesky problem? Or do they take the fall for agency inaction? A next step would also be to explore whether citizen participation on other types of boards also correlates to reduced pollution in a state. The question remains as to whether their presence on other types of boards is also significant.

It is also important to explore the reasons boards are present in states with more pesky pollution problems where reductions over time are less significant than in other states. What factors give rise to this outcome? Delving into board authority and the membership criteria for non-citizen members may shed light on this unexpected outcome.

As noted previously, additional measures of the managerial effectiveness including salary and FTE variables may enrich our understanding of the agency. Additionally, incorporating other intergovernmental structures and relationships may shed additional light on the network model. A better understanding of role of the public in the policy process is crucial to a holistic understanding of the policy process. Such research could entail researching public information campaigns at the agency level to alert the public to health threats posed by high pollution levels and incorporating such efforts into the network model as devised herein.

Additionally, the introduction of the ozone exposure index as a performance measure yields new opportunities for research. The ozone exposure index could be adapted to test agency performance in regard to other types of pollution to include other criteria air pollutants such as nitrogen dioxide or other hazardous air pollutants such diesel exhaust from school buses that also threaten public health.

Further, current efforts are underway to develop compatible and accessible data for health professionals to have access to environmental data that has important implications for public health (Kyle et al., 2006). The criteria air pollutant under study here, ground-level ozone, is known to be responsible for increases in hospital visits and mortality rates for at risk populations. The forgoing analysis seeks to better understand the relationship of the agency charged with reducing this pollutant and the outcome of its regulatory policies. Testing the utility of tracking monitoring data as a dependent may inform current efforts to develop data tracking and sharing techniques to better understand the ongoing issues in pollution reduction across the states.

A next step in this research could be to merge the data generated herein with public health data to develop additional health related dependent measures of interest. If this data could also be merged with meteorological data it is plausible that forecasting models could be developed to predict hospital admissions during periods of high ground-level ozone. This may serve the dual purpose of enabling hospital staffs to estimate staffing requirements based on advance predictions of impending pollution, while at the same time provide concrete data on which to gauge the true costs of pollution and to disseminate that information to the general public.

Disseminating more detailed information to the public raises another important avenue for further research. A recent Gallup Poll (March 3-5, 2009) demonstrated that American's view the safety of their drinking water as their top concern (59% of respondents). Only 45% perceived air pollution to be a significant problem. This stands in stark contrast to the reality that there are far greater patterns of mortality, doctor's visits and lost work days tied directly to air pollution than to impacts relating to drinking water quality. Exploring the psychology of citizen's perceptions of risk is vital to better inform efforts to combat air pollution and to bring citizens on board in that effort. Directions for research could begin with a comparative analysis of higher performing states with low performing states and directly comparing citizen's perception of the risks associated with air pollution. Do citizens in higher pollution states understand the health risks of ground-level ozone pollution that they are exposed to? To what degree does the state agency inform them of those risks? Such questions might yield fruitful opportunities for enhanced research designs utilizing the information component lacking in this research.

In conclusion, this research successfully demonstrated the potential for linking institutional structure to institutional effectiveness

by creating the ozone exposure index. Further, it demonstrated the utility of applying network theory outside of the context of education policy. In regard to air policy, this research demonstrated a robust positive correlation between the years of service of the air administrator and the reduction of ground-level ozone exposure experienced by the state population. Further, it demonstrated that larger numbers of citizen members on air policy boards also had a robust positive correlation with the reduction of ground-level ozone exposure experienced by the state population.

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Appendix A. Definitions

Definitions

The following are the definitions that will be used throughout this study.

Ambient Air Standards limit the concentration of a given pollutant in the ambient air. Ambient standards are not emissions limitations on sources, but usually result in such limits being placed on source operation as part of a control strategy to achieve or maintain an ambient standard (Eastern Research Group).

Best Available Control Technologies (BACT): Best available control technology to reduce pollution in accordance with NSPS determinations by the EPA.

Criteria Pollutants are carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOC), and particulate matter of aerodynamic diameter less than or equal to 10 micrometers (PM_{10}). The National Ambient Air Quality Standards (NAAQS) were mandated by the Clean Air Act of 1970, and are based on criteria including adverse health or welfare effects. NAAQS are currently used to establish air pollutant concentration limits for the six air pollutants listed above that are commonly referred to as **criteria pollutants** (Eastern Research Group).

The nomenclature "criteria" is derived from the requirement that they be regulated by developing health (human) based criteria and/or environmentally based criteria using the best available scientific assessments for setting permissible limits. Limits based on human health are considered primary standards. Areas said to be in compliance with NAAQS are geographic areas where air quality meets the primary standard. (EPA)

***Hazardous Air Pollutant*:** A substance or compound known or suspected to be a cancer causing agent, or to cause other series health effects such as birth defects or neurological disorders.

Lowest Achievable Emission Rate (LAER) is the emissions requirement imposed on any new facility requiring a permit inside a non-attainment zone for NAAQS, Generally, LAER is more stringent than BACT.

National Ambient Air Quality Standards (NAAQS) are the main ambient standards for the following six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), sulfur oxides (SO_x), ground-level ozone (O_3), and particulate matter of aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) (Eastern Research Group).

Netting a practice wherein utilities are allowed to decommission equipment and install or upgrade equipment without triggering an NSR. Unfortunately many of the oldest polluting plant used this loophole to install new equipment without adding any pollution control devises. Thus they continued to emit pollution at far greater rates that those built under NSR standards.

New Source Performance Standards (NSPS) are promulgated for criteria, hazardous, and other pollutant emissions from new, modified, or reconstructed sources that the U.S. Environmental Protection Agency (EPA) determines contribute significantly to air pollution. These are typically emission standards, but may be expressed in other forms such as concentration and opacity. The NSPS are published in 40 Code of Federal Regulations (CFR) Part 60 (Eastern Research Group).

NSR: New Source Review (The collective name for the Part D New Source Review and Prevention of Serious Deterioration programs.) (BEST)

Open Meeting**:** A scheduled board meeting that is held in an accessible location that is advertised to the public in advance to allow for their attendance.

Part D NSR: This is the NSR program that applies to sources seeking permits in areas whose air quality violates the NAAQS. (BEST)

Point Sources are large, stationary, identifiable sources of emissions that release pollutants into the atmosphere. Sources are often defined by state or local air regulatory agencies as point sources when they annually emit more than a specified amount of a given pollutant, and how state and local agencies define point sources can vary. Point sources are typically large manufacturing or production plants. They typically include both confined "stack" emission points as well as individual unconfined "fugitive" emission sources (Eastern Research Group).

Process Emissions are emissions from sources where an enclosure, collection system, ducting system, and/or stack (with or without an emission control device) is in place for a process. Process emissions represent emissions from process equipment (other than leaks) where the emissions can be captured and directed through a controlled or uncontrolled stack for release into the atmosphere (Eastern Research Group).

Process Fugitive Emissions occur as leaks from process equipment including compressors, pump seals, valves, flanges, product sampling systems, pressure relief devices, and open-ended lines. Emissions from the process that are not caught by the capture system are also classified as process fugitive emissions (Eastern Research Group).

Secondary Particulate Matter: Secondary PM is particles that form through chemical reactions in the ambient air after dilution and condensation has occurred. Secondary PM is formed downwind of the source. Precursors of secondary PM include SO_2, NO_x, ammonia and VOC. (EPA)

State Advisory Board: A group of individuals that provide expertise for a specified purpose. The board may be constituted by the legislature or by an executive order of the governor. It shall not have regulatory powers, permitting powers or enforcement powers.

State Policy Board: A board authorized via state legislation to achieve defined aims, including but not limited to regulating specific functions as set forth in the authorizing legislation. The policy board may be called a "commission" but the distinction between these entities and advisory boards is that they have regulatory functions authorized by the state legislature. For the purposes of this analysis all entities with regulatory, permitting and enforcement powers will be called Policy Boards.

Sulfur dioxide: or SO_2, belongs to the family of sulfur oxide gases (SOx). These gases dissolve easily in water. Sulfur is prevalent in all raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. SOx gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil, or metals are extracted from ore. SO_2 dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and their environment.

Over 65% of SO_2 released to the air, or more than 13 million tons per year, comes from electric utilities, especially those that burn coal. Other sources of SO_2 are industrial facilities that derive their products from raw materials like metallic ore, coal, and crude oil, or that burn coal or oil to produce process heat. Examples are petroleum refineries, cement manufacturing, and metal processing facilities. Also, locomotives, large ships, and some non-road diesel equipment currently burn high sulfur fuel and release SO_2 emissions to the air in large quantities. Source: (http://www.epa.gov/air/urbanair/so2/what1.html) retrieved January 3, 2008

Volatile Organic Compounds: Volatile organic compounds are compounds that have a high vapor pressure and low water solubility. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. VOCs typically are industrial solvents, such as trichloroethylene; fuel oxygenates, such as methyl tert-butyl ether (MTBE), or byproducts produced by chlorination in water treatment, such as chloroform. VOCs are often components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents.(USGS)

Vitae

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Education

Virginia Commonwealth University, Richmond, VA

Ph.D. in Public Policy and Administration **2009**

Dissertation: "Do State Regulatory Institutions Matter: Using Network Theory to Explore Linkages between Air Policy Boards and Pollution Outcomes"

Arizona State University, Phoenix, Az

M.A. in Political Science **1994**

Thesis: "Embracing Life: The Integration of Work and Family in Intentional Communities"

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Major: Political Science

AWARDS

- Phi Alpha Alpha Honors society of public administrators **2000**
- Phi Sigma Alpha, National honors society for political science **1994**
- Phi Beta Kappa Society **1991**
- Maynard Smith Prize for Top Graduating Political Science Student

Teaching Experience

Virginia Commonwealth University

Adjunct Instructor **2000- 2008**

Developed syllabi and overall course structure and exams, lecture and administer all grades.

Courses taught include:

- VCU101 Introduction to the University
- Poli103 Introduction to Government
- Poli107 Introduction to Political Theory
- Poli210 Introduction to Politics
- Poli310 Public Policy

Teaching Assistant – to Professor Stuckey in "Constitutional Law." **1992-1994**

Lectured as needed, met with students upon request,
and graded all written work, including all exam papers for classes of 100 or more students

Research Assistant – to Professor Kim Kahn **1992-1994**

Did content analysis of newspaper articles for senate campaigns.

Related Experience

Department of Professional and Occupational Regulation

Citizen Advocate, Waste Facility Operator Licensing Board **2003 to present**

Serve as citizen advocate on Governor's Policy Board. Promulgate regulations, hear petitions brought before the board. Grant and revoke licenses. Approve training literature and tests.

Virginia Commonwealth University, Richmond, VA

Associate Director for Technology, Undergraduate Admissions **1996 - 2004**

Responsible for market and trend analysis of prospective student populations. Work closely with upper management to define and target marketing efforts to attract new students. Responsible for implementation of new student system for Undergraduate Admissions. Programming, analysis and design of all production processes, ranging from batch transactions, development of user interfaces and adhoc reporting, utilizing SAS, Focus, MS Access and Visual Basic. Responsible for testing of all system processes. Act as resource to admissions staff in the proper utilization of technology to achieve admissions goals. Programming resource to other functional areas for testing of processes. Supervise operations staff and student employees.

Virginia Commonwealth University, Richmond, VA

Research Associate, Institutional Research **1996 - 1998**

Database analyst. Reporting and analysis in SAS to query large student and faculty databases to produce summary reports for senior management and government agencies. Responsible for Federal Financial Aid Report (FISAP), extracting information from the Human Resource System, Financial Resource System and Student Systems. Responsible for the production of University Profiles, a statistical profile of the University, in both paper and html versions. Coordination of data collection and analysis for external survey responses and adhoc requests.

McGuire, Woods, Battle and Booth, Richmond, VA

Legal Assistant **1996**

Lead paralegal for cases of national importance requiring supervision of staff, hiring of temporaries and project management. Structure and implement databases and tools to successfully track document flow. Statistical analysis of cases and report generation.

University of Phoenix, Phoenix, Az

Research Specialist, Institutional Research **1994**

Responsible for the generation of the semi-annual demographic survey report of the University, including its satellite campuses. Successfully revamped the survey reporting mechanism in SPSS, substantially improving the accuracy and readability of the report. Developed and implemented graduation rate study and reported directly to the President and CEO.

Publications and papers

- "Alterity and the Environment: Making the Case for Anti-Administration." In Administrative Theory and Praxis. 2001
- Earlier version: "Alterity and the Environment: Making the Case for
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- "Abortion Rights" in *Encyclopedia of American Political Thought* CQ Press: Washington D.C, 2001