THE GEOGRAPHICAL AND STATISTICAL ASSOCIATIONS BETWEEN
NOXIOUS LAND USE, MORTALITY, AND ENVIRONMENTAL DISPARITY
IN SALEM COUNTY, NEW JERSEY

By

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A thesis submitted in conformity with the requirements
for the degree of Master of Arts
Graduate Department of Geography
University of Toronto

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ABSTRACT

This study explores the geographical patterns and statistical associations between facilities that report to the US EPA Toxic Release Inventory, contaminated sites defined by the New Jersey Department of Environmental Protection, mortality rates, and various socio-economic groups in Salem County, New Jersey. Salem County has a concentration of chemical industries and power utilities, with high pollution levels relative to the State of New Jersey and a history of pollution related health issues. There is a moderate statistical association between mortality rates for persons under 65 and emissions levels, and a stronger association between cancer mortality rates for persons under 65 and emissions levels. The most polluted townships have a higher number of cancer deaths relative to the expected number of cancer deaths for a population of their size, based on the US average. A clear determination regarding the issue of environmental disparity by race and class could not be made.
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Chapter 1
INTRODUCTION

Overview

Exposure to synthetic chemicals has become a fact of life in modern society, and stories in the media regarding hazardous waste dumping, dioxins in food, and chemical accidents are commonplace. Tens of thousands of synthetic chemicals are released into the environment, but only a small fraction have been studied to determine their effects on the human body. For most public health officials, the issue is “not whether we are exposed to a mixture of chemicals, but whether the exposure levels exceed the human body’s ability to detoxify or adapt to them in order to maintain an un-compromised level of health” (Mumtaz et. al. 2000: 220).

A number of studies have identified relationships between the presence of hazardous chemicals in waste dumps (NRC 1991: 48-54) or as emissions from chemical plants and increased rates of diseases. For example, a concentration of petro-chemical plants, waste dumps, and other heavy industries in largely African American communities in southern Louisiana, known as “Cancer Alley” has been the focus of much debate. Clusters of asthma, stillbirths, miscarriages, neurological diseases, and cancers have been detected and many residents and doctors believe that the factories are to blame, while critics contend there are a number of confounding factors, such as poverty and lifestyle, make correlations between chemical exposure to cancer and other diseases difficult to determine (Koeppel 1999: 11-16).
Concerns over the inequitable distribution of pollutants have risen in conjunction with health concerns. The environmental justice movement arose as a result of the unequal distribution of noxious sites in communities of colour and low income. Studies have demonstrated strong relationships between poverty and pollution, and even stronger evidence suggests that the location of noxious industry or hazardous waste is related to race (Mohai and Bryant 1992: 924-927).

Is the concentration of noxious industry and synthetic chemicals associated with increased health problems in a surrounding community? And if so, are the pollutants and health effects equally distributed amongst the surrounding community, or do certain groups shoulder a disproportionate amount? This paper will attempt to address these questions by surveying the literature and by examining Salem County, New Jersey as a case study. New Jersey has a long industrial history in which the chemical industry has played a significant role, particularly in the mid to late 20th century. Despite a history of tough pollution regulation, New Jersey continues to suffer from high levels of pollution due to its high population density and high concentration of industry (Stansfield 1998:38).

Salem County is located in the southwest corner of the state along the Delaware River. Unlike the state at large, Salem County is very rural in character, with the lowest population density out of all twenty-one counties in New Jersey. It also ranks last in population overall, comprising less than one percent of New Jersey’s total population. Salem has a heavy concentration of chemical industries and power plants despite its rural character. In 1999, fifteen percent of all New Jersey’s toxic releases came from Salem County and out of all the industrial facilities in New Jersey; two in Salem were in the top
ten for total emissions (US EPA 2001a). The DuPont Chambers Works Plant, the largest chemical company in Salem County, was responsible for producing ninety-five percent of all New Jersey's hazardous waste in 1995 (McGlinn 2000:13). The Environmental Defence Fund has ranked the county in the top percentile for added cancer risks from hazardous air pollutants and non-cancer risks from hazardous air pollutants (EDF 2001). The county also has a history of chemically induced illness: the National Cancer Incidence Report of 1974 showed that Salem County had the highest rate of bladder cancer for white males in the U.S. from 1950 to 1969. The cancer was linked to employees at the Chambers Works Plant who were involved with chemicals used to manufacture dyes (Colby 1984: 693). Mortality rates in Salem County in 1998 are among the highest in all of New Jersey, ranking third out of twenty-one in the crude rate of mortality and second in age-adjusted rate in 1998 (NJDHSS 1998a). It cannot be assumed that the rates are higher solely because of environmental pollutants, but the fact that the rates are so high is significant and may suggest a possible association. Finally, the county has certain traits that make it ideal for an epidemiological study, such as stagnant population growth between 1990 and 2000, which helps minimize the number of residents who may have moved into the county and contracted their illness at their previous residence.

This study will attempt to determine whether the concentration of noxious industry is associated with health issues in a surrounding community by mapping mortality in Salem County in relation to the presence of noxious facilities, the level of emissions from noxious facilities, and the number of sites with soil and/or ground water contamination greater than acceptable standards. Mortality data will be used as a measure
of health, with mortality rates and cancer mortality rates per township as the principle variables. Analysis of the maps, statistical correlation, and knowledge of Salem County’s pollutants, demographics, and history will be utilized to examine the relationship between pollutants and health. Pollutants and health will also be compared to certain socio-economic indicators, such as race and income, to determine whether other factors confound the relationship between health and pollution, and to elicit evidence of environmental justice.

This chapter discusses the links between pollutants and disease and provides an overview of epidemiology’s role in this discussion. This is followed by an examination of competing theories of environmental degradation and environmental justice. The chapter concludes with the reasons why Salem County was selected as the case study for this project.

Chapter two will focus on methodology and the strengths and limitations of the four databases used, the US Census Bureau, the US EPA’s Toxics Release Inventory (TRI), the New Jersey Department of Environmental Protection (NJDEP) Site Remediation Program’s (SRP) Known Contaminated Sites in New Jersey Report (NJDEP 2001a), and the New Jersey Vital Events Public Use Data Files for Mortality (State of New Jersey Department of Health and Senior Services, 2001).

Chapter three is a descriptive study of Salem County that provides a basic geographical overview. The industrial history of the county is discussed and each facility listed in the Toxics Release Inventory (TRI) is described in terms of the economic role it plays, and the types, levels, trends, and health effects of the pollutants it emits.
Chapter four examines the statistical and geographical relationships between pollutants and mortality, followed by an examination of factors that could possibly confound these relationships. Some of these socio-economic factors are also examined to determine whether environmental disparity exists by race or class. Chapter five summarizes the major findings of this study and offers suggestions for policy and future research.

**The Environment and Health**

The production of synthetic chemicals has risen substantially since World War II, doubling every seven to eight years, and has coincided with a dramatic increase in the incidence of cancer (Steingraber 1997: 40-44, 89-90), which may suggest a link between the two. The most commonly sited study of cancer deaths, which is twenty years old, attributes only two percent of cancer deaths to pollution, and about eight percent to synthetic chemicals in general (Doll and Peto 1981, cited in Upton and Graber 1993:135). The relative proportions of the Doll and Peto study are still accepted, but the total percentage of cancers caused by environmental factors is still a matter of fierce debate with estimates ranging from ten to seventy percent (Upton and Graber 1993:135). The number of scientists that believe that alarming public health trends and patterns are caused by environmental factors, as opposed to genetic factors, is increasing (Goldman 1994:16). The existence of places like Cancer Alley, Louisiana, support this belief, while the fact that “...the total burden of contamination on health could be greater than is demonstratable directly from current evidence or exposures or effects in populations...” (Matthew 1992:23) raises scepticism regarding claims that chemicals have little or no effect on human health.
This section provides an overview of toxicology, scientific techniques that establish the effects of chemicals on human health, and some of the issues surrounding these techniques. Epidemiology is presented as an additional technique to biological testing for establishing links between pollution and health.

Toxicology is the study of the adverse effects of chemicals on health. "Toxic chemicals are generally defined as substances that are fatal to over fifty percent of test animals at given concentrations" (Miller 1993:227). Hazardous chemicals are harmful because they can be flammable or explosive, damaging to the skin and lungs, disruptive of the uptake and distribution of oxygen within the body, or they incite allergic reactions and weaken the immune system (1993:227). Chemicals can be classified as carcinogens (causing or promoting cancer), teratogens (causing birth defects), and mutagens (causing changes in genetic material) (Upton and Graber 1993:25). Chemicals vary widely in their potency; some can be harmful after acute (immediate) exposure at low doses, while at the other extreme, some chemicals require such huge doses to cause harm that it is practically impossible to become ill from them (Miller 1999:224-25). Some chemicals are naturally occurring while others are synthetic. They pervade our environment and every aspect of our lives.

The known effects of toxins on the human body are based on extrapolating tests of chemicals on bacteria or laboratory animals to humans, and on the historical effects of various chemicals on humans, often from occupational exposures. The US EPA, OSHA (Occupational Safety and Health Administration), NIOSH (National Institute for Occupational Health and Safety), and a number of other federal and state agencies within the U.S. (as well as others nations and international bodies) have set standards for
acceptable limits or thresholds for chemical exposure. Despite the considerable amount that is known, there is still a much larger amount of uncertainty regarding the effects of toxins on people and the natural environment. There are five principle reasons that contribute to this uncertainty.

First, it is difficult to set a standard of thresholds for chemicals because of the great degree of variability that exists in the human population or in any species.

"Within any given population of organisms, there will be some that will respond to a drug or toxin at the lowest concentration, and others will only respond at the very highest concentration, while most subjects will be grouped around the mean response" (Philp 1995:14).

Despite the threshold level for a chemical, there will always be a portion of the population that will experience harm below the given threshold for that toxin, because of variations in the population due to genetic and environmental factors, such as nutrition, disease, temperature, the presence of other chemicals, body composition (such as the ratio of fat to lean), age, and gender (Philp 1995:15,21-24).

Second, it is difficult to set standards for chemical thresholds because a chemical's toxicity varies depending on the route of exposure (ingestion, inhalation, or skin contact), its phase (solid, liquid, or gas), the presence of other chemicals, and the state of the compound. For example, metallic nickel has low toxicity and while skin contact with nickel could result in a reaction, little would be absorbed into the body. Small amounts of nickel are ingested because it is a naturally occurring substance, present in foods and as residue from cookware. While the effects of ingesting trace amounts of nickel are limited or non-existent, the inhalation of nickel oxide fumes could result in severe illness. Acceptable thresholds are different for soluble compounds of inorganic nickel, insoluble
compounds, and nickel carbonyl (Upton and Graber 1993: 398-99). Illness from nickel, or from any other chemical, will vary depending the exposure and the period of time over which a person is exposed.

Third, the sheer number of chemicals presents a huge task for scientists and researchers, who simply do not have the time and resources to test them all. The U.S. National Academy of Sciences estimated that of the 72,000 chemicals in commercial use, only ten percent have been adequately tested for toxicity and only two percent have been thoroughly examined to determine if they are carcinogens, teratogens, or mutagens (Miller 1999:229). There is considerable uncertainty regarding the effects of large numbers of synthetic chemicals that human beings are routinely exposed to. Industry proponents state that people have been exposed to chemicals throughout our history because of their abundance in nature, and that we have adapted to them. They also point to the technological and economic advances that chemicals have made possible, including technology that has radically increased the effectiveness of medicine. Critics contend that humans have had millions of years to adapt to natural toxins, but have only been exposed to the thousands of new synthetic chemicals for only fifty years (the chemical revolution began around World War II), and that natural toxins are rarely deadly at the levels found in nature, except when they are concentrated into human-made products (Fagin and Lavelle 1999:2-4). An average of one thousand new chemicals are introduced each year (1999:229), adding an increased burden to scientists and researchers.

Fourth, the methods and politics surrounding chemical testing slows the process down immensely. Existing laws assume that a chemical is harmless until harm is proven, and no agency is required to investigate whether chemicals are harmful (Miller 1999:
229). It often requires concerned citizens, environmental groups, victims of toxic poisoning, or independent researchers to initiate action in order for tests to be carried out. The sheer expense and expertise required to conduct a toxicology study is beyond the means of government agencies on limited budgets, so the US EPA mandates that the company that produces the chemical perform the tests (Fagin and Lavelle 1999:11). This raises allegations of a conflict of interest, because it is in the company’s best interest to prove that a chemical is not harmful. Critics point out that experiments can be designed so that they purposefully show that a chemical is not harmful (1999:44). Repeated replications of studies can be deemed as necessary in order to reduce scientific uncertainty, so studies may take years to complete, while the chemical under investigation remains on the market (1999:229). Critics accuse industry of exploiting the uncertainties regarding causal mechanisms of diseases (Gottlieb, Smith, and Roque 1995:177) and claim that industry has set up research institutions with the sole intent of countering knowledge about the environmental workings of chemicals and their effects of health (Hays 2000:117). The industry dismisses such accusations as nonsense, and claims that they are merely attempting to provide regulators with the information that they request regarding chemicals and health. Outside of this debate, there are some scientists who challenge the validity of studies that extrapolate the results of tests on animals to human beings all together (Miller 1999:226). Some scientists and government entities favour the enactment of the Precautionary Principle, which would reverse the current system and force industry to prove that a chemical is not harmful before it can be marketed (Jordan and O’Riordan 1999: 15-33).
Finally, the chemicals that have been tested were tested independently of other chemicals. There is a great deal of uncertainty regarding the effects of the interactions of chemicals in the environment and their joint effect on human health and ecosystems (Miller 1999:29). Most people are not exposed to single chemicals, but to complex mixtures of chemicals that can affect health through many routes and media (air, water, land) of exposure (Mumtaz et. al. 2000: 221-2). Chemicals can be additive (response is equal to the sum of the individual effects of each chemical), synergistic (total response of the combined effect of two chemicals is greater than the sum of their individual effects), or antagonistic (one chemical stops or reduces the effect of another) (Philp 1995:26). Given the current regulatory system in the United States, it would take untold years and enormous sums of money to test the interactions of just a few of these chemicals.

**Epidemiology**

In addition to experimental, biological studies, case studies of workers exposed to chemicals and citizens living near waste sites have also been used to determine the degree to which chemicals cause harm. For example, neighbors of the Lipari landfill in southwestern New Jersey (in Gloucester County, which is the county directly to the north of Salem County) complained about a wide variety of health problems and the stench of the landfill, so it was closed in 1971. This prompted researchers to study the area, and they discovered that newborns had very low birth weights during the same years that the leaching from the landfill into nearby surface waters and the gases it was emitting were at their peak. They also discovered birth weights were much higher before the landfill opened and did not increase to that level again until five years after the landfill was closed. Meanwhile, birth weights in surrounding communities that were some distance
from the landfill remained the same. The time series data and the correlation between the source of the pollutants and the areas of low birth weight provide strong evidence that the landfill was the source of the problem (although absolute causation cannot be assumed, and no specific chemical can be pinpointed) (Raloff 1997:166). This is an example of an epidemiological study, which is defined as follows:

Environmental epidemiology is the study of the effect on human health of physical, biologic, and chemical factors in the external environment, broadly conceived. By examining specific populations or communities exposed to different ambient environments, it seeks to clarify the relationship between physical, biologic, or chemical factors and human health (NRC 1991: 3).

This study will utilize methods of geographical or spatial epidemiology, which attempts to describe the spatial patterns of disease incidence and mortality with respect to a number of demographic values, such as age, race, sex, place, and time (English 1992:3).

Spatial epidemiology also falls under the broader discipline of geography, under the sub-discipline of medical geography. Medical geography views subjects in holistic terms and “…draws freely from the facts, concepts, and techniques of other social, physical, and biological sciences… medical geography is an integrative, multi-stranded sub-discipline…” (Meade and Earickson 2000:1-2).

Geographical epidemiology is a useful first step for investigating possible associations between disease and environmental exposure (English 1992:11). A famous historical example is John Snow’s dot map of the location of cholera deaths in relation to water pumps in London in 1854. A clustering of deaths around one pump led authorities

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1 The landfill had severely polluted nearby Alcyon Lake, which was closed in 1981. The landfill and lake were declared as a Superfund site shortly thereafter, but not as a result of the study, which was not published until 1997. Alcyon Lake and the landfill were de-listed as a Superfund site in 1999 and re-opened as a park and recreation area in 2000 (Lautenberg 2000).
to shut it down, and subsequently the number of cholera deaths in that part of the city plummeted and a link between cholera and contaminated water was established (Monmonier 1996: 157-58).

A more modern example of geographical epidemiology is the *Atlas of Cancer Mortalities for U.S. Counties: 1950-1969* (Mason, et. al 1975 cited in Walter 2000: 227-228) which displays the predominance of all types of cancer in the Northeast United States, and a clustering of bladder cancers in Salem County, NJ. A National Cancer Institute Report from 1974 confirmed these findings, stating that Salem County had the highest rate of bladder cancer for white males in the United States, and an article publicizing this fact was printed in the *New York Times* in January of 1975 (Colby 1984:693). Under increasing pressure, the DuPont Company admitted that 330 workers at the Chambers Works plant in Salem County had developed bladder cancer since 1919, and further investigation was able to link the cancers to certain chemicals used in the manufacture of dyes (Colby 1984:693, Tufte 1983:16). In this particular case, maps provided leads into the causes, and avoidance, of cancer (Tufte 1983:16). The Chambers Works plant ceased most of its dye manufacture during the late 1970s and shifted its focus of production to many of its other chemical products.

Although epidemiology has been successful in linking a number of illnesses to environmental causes, it is certainly not perfect and free of limitations.

"The world of epidemiology, as that of any human science, seldom permits elegant inferences to be drawn about causation. The object domain of epidemiology consists of numerous uncontrollable aspects… With human sciences, causation usually must be inferred, and is never proved absolutely” (NRC 1991:34).
A number of confounding issues exist, such as the enumeration district or level of analysis (Pickle 2000: 246-247), emission patterns of industry (Cuzick and Elliot 1992:19), limitations of mortality and morbidity data (Lopez 1992:36-49), socio-economic confounding (for example impoverished areas often have higher mortality rates due to many factors in addition to environmental pollutants) (Jolley, Jarman, and Elliot 1992:115-16), migration and lifestyle (Elliot et. al. 2000:3-5, Braus 1996), the long latency period of many diseases, like cancer (Greenburg, quoted in Fitzgerald and Pillets 1999), the occupation of residents (chemical workers are exposed to higher levels of contaminants than nearby residents of a chemical plant), and the statistical problems inherent with working with small populations (such as the odds that a cluster of disease occurred by chance) (Elliot et. al. 2000:8). Statistical correlation between variables could be strong and even statistically significant, but it does not necessarily indicate causation (NRC 1991:34-37). The uncertainty regarding the effects of certain chemicals and their interactions, as previously discussed, make it difficult to link a particular substance with a particular disease.

This study is a broad, scoping examination of a number of issues and variables to discover associations between the pollution and health that could be explored more fully in a more detailed study. Unlike many epidemiological studies that often examine very specific diseases and their link to specific chemicals, this study, as an introductory analysis, will examine aggregate mortality and cancer mortality rates and aggregate pollutants while accounting for as many confounding variables as possible. The epidemiological limitations and limitations of other data in this study will be examined in detail in the next chapter. The distribution of pollutants and health problems amongst the
population is another issue, since evidence demonstrates that this distribution is inequitable. The link between environmental disparity, pollution, and health is also an important association examined by this study. The next section discusses the environmental justice paradigm.

**Political Economy and Environmental Justice**

In the introductory chapter of the “Political Ecology” section in *Environmental Philosophy*, John Clark outlined environmental attitudes along a broad spectrum ranging from various degrees of Liberalism, to Marxism, to other ideologies classified as “Green” (1998: 345-363). A brief examination of some of these ideologies frames some of the important issues in this study and leads into a discussion of environmental justice.

Clark classifies the group at the conservative end of the liberal spectrum as Free-Market Environmentalists, who deny that market forces have led to environmental degradation in the past or that they will produce environmental degradation in the future, and believe that the free market is the best medium for solving environmental and social problems (Anderton and Leal 1998: 367-70). Green-Market Environmentalists fall more to the left of the spectrum. They support the market system but favour changes that would internalize pollution costs using environmental accounting and “green” taxes on environmentally unfriendly products (Clark 1998:348). Both ideologies have a shared confidence that technology is an important tool in overcoming environmental problems.

Liberal Environmentalists fall even further to the left on the political spectrum, rejecting the idea that the free-market, even with environmental adjustments, can solve environmental problems. For instance, they reject the idea that all environmental costs can be internalized, because “of the difficulty of placing a price on sickness and
suffering, and the obvious impossibility of assigning cost to human lives and the
destruction of animal life...” (Clark 1998:349-50). Liberal Environmentalists believe that
liberal societies offer a firm foundation for the promotion of environmental philosophies
and attitudes. Respect for others is ingrained in liberalism, and this can be extended to
respect for the environment because of its own intrinsic value and because degrading an
environment that belongs to every form of life, including humanity, violates the rights of
others. The private sector should not make the decision on where to pollute, because the
pollution becomes a public problem (de-Shalit 1998: 387-397). Liberal Environmentalists
promote greater democracy in regard to environmental matters, which equates to greater
freedom to access information that is necessary to make informed decisions.

Liberal Environmentalism raises the important issue of information as a tool for
greater democracy, a concept that is an important aspect of this study, which uses
publicly available data sources to address an environmental and public health issue. The
passage of “Right to Know” legislation created the Toxics Release Inventory (TRI) to
provide comprehensive information to government regulators and to the public, regarding
the types and amounts of pollutants being released from a number of facilities (Gottlieb
et. al. 1995:131-32). The growth of the Internet and new information technology has
made the TRI (which started recording emissions in 1987) even more accessible to
researchers, activists, and the general public. The chemical industry fought bitterly
against the TRI (Mullin 1997:S25) and as a result not all industries or chemicals are
reported, which places some limitations on the data (Gottlieb et. al. 1995: 134-39) that
will be discussed in the following chapter on methodology.
Even further to the left on the political spectrum is Socialist Ecology, which is a revision of traditional Marxism. It asserts that an ecological crisis exists and that it can only be resolved through a radical transformation of capitalist production relationships and forces (O’Connor 1998: 407). According to Social Ecologists, capitalist forces are jointly exploiting labour and the environment.

“Given the relatively slow rate of growth of world-wide market demand since the mid-1970s, capitalist enterprises have been less able to defend or restore profits by expanding their markets and selling more commodities in booming markets. Instead, global capitalism has attempted to rescue itself from its deepening crisis by cutting costs, by raising the rate of exploitation of labour, and by depleting and exhausting resources… Cost cutting has led big and small capitals alike to externalize more social and environmental costs, or to pay less attention to the global environment, pollution, depletion of resources, worker health and safety, and product safety (meanwhile increasing efficiency in energy and raw materials use is in the factories)” (O’Connor 1998: 410).

A recent accident exemplifies the above statement. An explosion at the Motiva Refinery in Delaware City, Delaware, on July 17, 2001, killed a contract worker, injured others, discharged 263,000 gallons of sulphuric acid into the Delaware River, and created a pollution plume that winds carried to the northwest, over Salem County. The tank that exploded had a history of leaks and internal corrosion, and investigations revealed that previous safety inspections stating that the tank required extensive and immediate reparations were ignored. The company had been cutting back on routine maintenance while boosting production to profit from higher gasoline prices. The plant has a number
of past fines and is facing criminal charges in connection with two earlier spills. The investigation was continuing as this paper was written (Montgomery 2001).

Socialist Ecologists claim that industry often forces workers and communities to choose between jobs and the environment. If workers or communities lobby for better safety or less emissions, the company can threaten to locate elsewhere (Levenstein and Wooding 1998:71-74). This could devastate an economy, like Salem County’s, where the chemical industry is one of the major sources of income, employment, and investment.

Socialist Ecologists dismiss mainstream environmentalism because it is seen as continuing to support environmental regulations that favour the status quo. For instance, the DuPont Chamber’s Works in Salem County has been recognized by the U.S. Department of Energy for working hard to achieve energy efficiency by upgrading technology, thus increasing profits and decreasing energy use and greenhouse gas emissions (Island Press 1998). Socialist Ecologists would criticize these initiatives, because even though the plant operates more efficiently, it still produces products, such as paints and plastics, that are unsustainable and hazardous to produce, use, and dispose of. Even though certain greenhouse gases have been cut, the plant continues to release a number of chlorofluorocarbons.

Social ecologists acknowledge that while liberal policies have regulated capital and improved environmental quality for some segments of the population, they have failed to do so in other segments where the population has less economic and political clout (Faber 1998: 30). Social ecologists, and some liberal environmentalists, claim that government policies and business practices have resulted in an unfair distribution of environmental pollutants.
Environmental justice is the belief that social processes, economic and racial, have resulted in a disproportionate distribution of pollutants among certain groups within the population, and that these imbalances must be corrected. The socialist ideology (although it must be noted that many liberal environmentalists are also advocates of environmental justice) provides a suitable foundation for the discussion of environmental justice, because of its focus on how inequities are created by economic forces. Many socialists argue that the historical evolution of capital, and its spatial implications, has created a societal imbalance.

"First, those who live in the older industrial areas (which are those, by and large, who are too poor to move) bear the historical contamination that is a legacy of an earlier industrial stage (Soil contamination, old dump sites, etc). Second, it also means that new polluting industries, such as waste disposal facilities that are part of the newly emerging waste industry, searching opportunistically for areas of low property values and communities with less political power, locate in the hollowed-out areas of former industrial activity. Third, because this flight from urban industrial areas was shaped by historic patterns of racial discrimination, minorities who are prevented from relocating outside the inner city were and are forced to live in formerly industrialized areas. These factors tend to ensure that industrial pollution will fall most heavily upon poor and minorities" (Field 1998: 90-91).

A subdivision of the environmental justice movement is the environmental racism movement. Environmental racism recognizes the historical and economic forces that create inequities, but stresses that racism and its institutionalization in society, in areas such as government, industry, and real estate, is largely responsible for the creation of pollution inequity.
“A polluter locates near a black neighbourhood because the land is relatively inexpensive and adjacent to an industrial zone. This is not a malicious, racially motivated act. Instead, many would argue that it is economically rational. Yet it is racist in that it is made possible by the existence of a racial hierarchy, reproduces racial inequality, and undermines the well-being of that community” (Pulido 2000:16).

Thus, environmental racism is not necessarily the result of overt actions, but is a function of a history of racism that is ingrained in society. Empirical studies tend to justify the importance of race over class or income as a factor in the distribution of pollutants. Paul Mohai and Bunyan Bryant’s survey of empirical works in environmental justice in the US found that race was more strongly related to the incidence of pollution than income in six out of nine cases (1992:927).

A range of attitudes towards environmental issues exists, and some of these viewpoints are important to this study. The liberal belief in freedom of access to information to make informed decisions has manifested itself in publicly available databases, such as the Toxics Release Inventory, that have made this study possible, while the analysis and findings of this study will refine information drawn from several databases to illuminate connections between pollutants, health, and socio-economic indicators, thus adding new information to the public realm. The Marxist / Socialist perspective raises the issue of jobs versus the environment and health, a pertinent issue in Salem County given its economic dependence on the chemical industry and power utilities. Both perspectives also raise the issue of the unequal distribution of pollutants and health effects through the environmental justice paradigm. The next section explores the body of evidence that has confirmed the existence of environmental disparity.
Environmental Justice: The Evidence

There is a large body of empirical research that dates back over twenty years, confirming that environmental disparity exists. The United States General Accounting Office conducted the first major study, *Siting of Hazardous Waste Landfills and Their Correlation With Racial and Economic Status of Surrounding Communities*, in 1983.² The study was sparked by protests over the citing of a PCB landfill in a North Carolina county where African Americans represented the majority of the population (Bullard 1993:27). The analysis of four hazardous waste landfills in the southeastern U.S. was conducted based on delineated census areas. The study revealed that African Americans comprised the majority of the population in three out of four communities where the landfills are located, and that at least twenty-six percent of the population in all communities were impoverished, and the majority of the impoverished were African Americans (US GAO 1983:1).

The Commission for Racial Justice for the United Church of Christ conducted a more comprehensive study in 1987, which is often considered as the landmark study in the environmental justice movement. It examined the entire United States and compared commercial hazardous facilities and uncontrolled toxic waste sites in relation to race and income, with postal codes used as enumeration districts. The study found that in communities with one commercial hazardous waste facility, the minority population was twice the average minority percentage of the population in communities without these facilities, and the more waste facilities a community had, the higher the composition of racial or ethnic immigrants. Three out of every five African or Hispanic Americans lived
in communities with uncontrolled toxic waste sites, and almost half of all Asian/Pacific Islanders and Native Americans also lived in such communities. Incomes and home values were lower when communities with hazardous facilities were compared to communities in surrounding counties without such facilities. Even though socio-economic status was considered an important factor, it was not as significant as race. All of the national findings were statistically significant at a 99% level of confidence (UCC 1987:ix-xiv).

Numerous studies have since confirmed these findings. A review of empirical environmental justice studies examined sixty-four studies conducted from the 1970s (before the GAO and the UCC studies) to the early 1990s and found that all but one of the studies confirmed that environmental disparities exist either by race or income, regardless of the type of environmental concern or the geographic scale of study, and that racial disparities were found more often than income disparities (eighty-seven percent versus seventy-four percent) (Goldman 1994:7-8). Twenty-six out of twenty-seven studies of noxious facilities and noxious releases found environmental disparities by race or income (1994:8) and twenty-one studies of exposures and health effects also found racial or income disparities, meaning people of colour and lower income suffer from higher levels of disease and mortality than whites and people of higher income (1994:15-16).

A waste management company sponsored the one study in disagreement. Environmental justice advocates claim that studies which conclude that environmental disparity does not exist are often financed by industry, and that they adjust the scale of analysis in order to reach the desired outcome (Goldman and Fitton 1994:14-15).
Fundamental opposition to the environmental justice paradigm comes from liberal Free-Marketers, who assert that the agenda of environmentalists is the redistribution of income. Free-Marketers firmly believe that economic growth is the best way to improve living standards for all people (Stelzer 1998:10-12), and that individuals who make conscious choices about living near noxious facilities only have themselves to blame. Environmental justice advocates dismiss this argument, based on the historical forces previously discussed and due to the fact that individuals are not aware of all risks (such as illegal waste dumps).

In summary, there is extensive empirical evidence that environmental disparity is a real phenomenon, with only minor dissent. Historical socio-economic processes have resulted in environmental disparity between race and income. Studies have shown that race is more strongly associated with environmental disparity than income, although this subject is still under debate.

**Selection of Case Study**

This section examines the principle reasons that made Salem County the object of this study. The county fits into the broader context of the State of New Jersey, which has a history of manufacturing, pollution, and extensive environmental regulation. Salem County also fits into a regional context as part of the Philadelphia metropolitan area, which has a large concentration of petro-chemical industries, and as part of the smaller Wilmington metropolitan area, which is known as the “Chemical Capital of the World” because it serves as the corporate headquarters for the DuPont Company. Even though Salem County seems to fit into these larger contexts in terms of industrial concentration, it stands apart from the state and the region because it is a rural county, with very low
it stands apart from the state and the region because it is a rural county, with very low population density and with approximately forty-three percent of the land in agricultural use (NJDL 1998). Despite its rural nature, it possesses pollution levels and pollution-related health risks that are typical of urban areas. This situation was one of the launching points of this study, and this section outlines the six factors that made Salem County the focus.

First, Salem County has a high concentration of chemical industries and power utilities that are clustered in one specific area, making it possible to compare variables in areas of the county that have facilities emitting hazardous pollutants versus areas that do not have facilities. In broader context, New Jersey has a long history as a manufacturing state, and has been described as a “microcosm of the global chemical industry” (D’amico 1999:55). New Jersey has over eight hundred chemical plants and eight hundred and fifty chemical product distributors, and is the largest chemical employer in the United States (1999:55). The chemical industry and power utilities are the most important segment of Salem County’s manufacturing sector, and arguably of the county’s entire economy. Salem County relies more heavily on manufacturing than the state in spite of its rural character; its proportion of jobs to the state’s was 18.9% vs. 12.9% in manufacturing and 14.3% to 6.9% in transportation / communications / public utilities (NJDL 1998). The chemical industry has been present in Salem County for over one hundred years, since The DuPont Company opened its first factory there in 1893 (Sickler 1937: 365), while power utilities have been part of the economy since the 1930s (Sanderlin 1988: 51). These issues are important because the longevity of facilities in the county makes it possible to examine the link between pollution and mortality, because residents have
economic over-dependence on these industries may make it difficult for the county’s
government and citizens to assert themselves in terms of environmental and health issues,
because they risk losing their main economic base.

Second, because of the high concentration of industry in Salem County, it suffers
heavily from pollution. New Jersey generally suffers from high levels of pollution
because of its concentration of industry, high population density\(^1\), and relative location to
other polluting states (Stansfield 1998:47). Salem County represents New Jersey’s
extremes in both population and pollution, as it comprises less than one percent of the
state’s total population, but accounts for fifteen percent of all of New Jersey’s on site
toxic releases, representing 3.6 million pounds\(^4\) of hazardous pollutants (Figure 1.1) (US
EPA 2001b). Of the twenty-one counties in New Jersey, Salem ranks second for total
amount of emissions released in 1999. Two facilities in Salem County were ranked in the
top ten for facilities emitting the most pollutants in the state; the Dupont Chambers
Works held second place and the Deepwater Generating Station ranked tenth (US EPA
2001a). Of the top ten polluters in the tri-state area (Pennsylvania, New Jersey, and
Delaware) that discharged toxic chemicals into the Delaware River in 1997, the DuPont
plant was responsible for seventy percent of the total amount (EPA, cited in The City of
New Hope, PA 2000).

Third, the heavy concentration of industry and pollutants has led to health
problems. Nearly one third of the state’s residents live in areas where the concentration of
hazardous air pollutants is at least twenty times above healthy levels set by the US federal

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\(^1\) With 1134.5 persons per square mile (1825.4 sq km), New Jersey is the most densely populated state. In
contrast, Salem County has only 190 persons per square mile (305.7 per sq km), making it the least densely
populated county in the state (US Census 2000a).

\(^4\) One pound is equal to .454 kilograms.
Figure 1.1 New Jersey Population and TRI Emissions
Population data provided by US Census Bureau
TRI Emissions provided by US EPA
Basemap data provided by ESRI

Population
64,280 - 146,440
- - 252,550 - 350,770
- - 423,390 - 615,300
- - 750,160 - 884,120

TRI - Toxics Release Inventory
Emissions (lbs)
13,870 - 424,230
- - 714,850 - 857,520
- - 1,775,440 - 2,764,830
- - 3,503,370 - 4,094,090
government, and exceeding these levels can lead to respiratory problems, allergies, and other illnesses (Tedeschi and Jackson 1999). The Environmental Defence Fund ranks New Jersey second out of the fifty states for added cancer risks due to hazardous air pollutants, third for added non-cancer risk due to hazardous air pollutants, and eleventh for health risks due to criteria air pollutants (EDF 2001). Salem County has a history of health issues related to the environment, such as the cluster of bladder cancers due to certain chemicals used in dye making, which was previously discussed. The county is ranked in the top ten percent of all counties for added cancer risks and added non-cancer risks from hazardous air pollutants (EDF 2001). The county has high mortality rates relative to the state, and an imbalance in cancer mortality is evident between townships within Salem County (Table 1.1). When estimated cancer mortality, which is calculated using a multiplier from the American Cancer Society for estimating local cancer statistics (ACS 2001), is compared to actual mortality, nine of the fifteen townships have cancer mortality cases that are higher than expected and the top three townships for surplus cancer mortalities are separated from the other townships by a wide margin. A majority of the county's TRI reporting facilities are located within these three townships. The association between the presence of industry and emissions and high mortality is one of the primary relationships examined in this study.

Fourth, the population characteristics of the county make it a sound choice for an epidemiological study. Salem County's population is more homogenous compared to the state, with 81.2% white residents and 14.8% black residents, with small percentages of other races (Table 1.2). This simplifies the study of environmental justice because the focus is limited to two racial groups. African-Americans are clustered in specific areas in
Table 1.1 Estimated and Actual Cancer Mortality in Salem County

<table>
<thead>
<tr>
<th>Township</th>
<th>Estimated Cancer Deaths</th>
<th>Actual Cancer Deaths</th>
<th>Difference</th>
<th>Confidence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salem</td>
<td>11.7</td>
<td>23.4</td>
<td>+11.7</td>
<td>96 – 98%</td>
</tr>
<tr>
<td>Pennsville</td>
<td>26.4</td>
<td>37.4</td>
<td>+11.0</td>
<td>98 – 99%</td>
</tr>
<tr>
<td>Carneys Point</td>
<td>15.4</td>
<td>24.6</td>
<td>+9.2</td>
<td>99.5 – 99.8%</td>
</tr>
<tr>
<td>Woodstown</td>
<td>6.3</td>
<td>11.2</td>
<td>+4.9</td>
<td>90 – 95%</td>
</tr>
<tr>
<td>Penns Grove</td>
<td>9.8</td>
<td>12.8</td>
<td>+3.0</td>
<td>95 – 96%</td>
</tr>
<tr>
<td>Alloway</td>
<td>5.5</td>
<td>8.4</td>
<td>+2.9</td>
<td>96 – 98%</td>
</tr>
<tr>
<td>Elmer</td>
<td>2.8</td>
<td>4.8</td>
<td>+2.0</td>
<td>70 – 80%</td>
</tr>
<tr>
<td>Elsinboro</td>
<td>2.2</td>
<td>3.4</td>
<td>+1.2</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Mannington</td>
<td>3.1</td>
<td>3.6</td>
<td>+0.5</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Lower Alloways</td>
<td>3.7</td>
<td>3.6</td>
<td>-0.1</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Creek</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oldmans</td>
<td>3.6</td>
<td>3.4</td>
<td>-0.2</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Pilesgrove</td>
<td>7.8</td>
<td>7.4</td>
<td>-0.4</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Pittsgrove</td>
<td>17.8</td>
<td>16.8</td>
<td>-1.0</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Quinton</td>
<td>5.6</td>
<td>4.6</td>
<td>-1.0</td>
<td>60 – 70%</td>
</tr>
<tr>
<td>Upper Pittsgrove</td>
<td>6.9</td>
<td>5.6</td>
<td>-1.3</td>
<td>60 – 70%</td>
</tr>
</tbody>
</table>

Estimated cancer mortality was calculated using a multiplier from the American Cancer Society for estimating local cancer statistics. The value (0.0020) was multiplied by the population in each township.

Actual cancer mortality was calculated by averaging cancer mortality in each township over the five-year period from 1994 to 1998.

The difference is the actual number of cancer mortalities greater than or less than the expected number of cases.

Source: Data derived from the NJDHSS New Jersey Vital Events Public Use Data Files, 2001.
Table 1.2 2000 Population Demographics for Salem County and New Jersey

<table>
<thead>
<tr>
<th></th>
<th>Salem County</th>
<th>New Jersey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Density (per sq mile)*</td>
<td>190.2</td>
<td>1134.5</td>
</tr>
<tr>
<td>Population change 1990 – 2000</td>
<td>-1.5 %</td>
<td>8.6 %</td>
</tr>
<tr>
<td>Persons under 18 years old</td>
<td>25.6 %</td>
<td>24.8 %</td>
</tr>
<tr>
<td>Persons 65 years and older</td>
<td>14.5 %</td>
<td>13.2 %</td>
</tr>
<tr>
<td>Female population</td>
<td>51.7 %</td>
<td>51.5 %</td>
</tr>
<tr>
<td>White persons</td>
<td>81.2 %</td>
<td>72.6 %</td>
</tr>
<tr>
<td>African American persons</td>
<td>14.8 %</td>
<td>13.6 %</td>
</tr>
<tr>
<td>Native American persons</td>
<td>0.4 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Asian persons</td>
<td>0.6 %</td>
<td>5.7 %</td>
</tr>
<tr>
<td>Persons of Hispanic or Latino Origin</td>
<td>3.9 %</td>
<td>13.3 %</td>
</tr>
<tr>
<td>White persons, non-Hispanic</td>
<td>79.6 %</td>
<td>66.0 %</td>
</tr>
<tr>
<td>Median Household Income (1997 estimate)</td>
<td>$42,378</td>
<td>$47,903</td>
</tr>
<tr>
<td>Persons below poverty (1997 estimate)</td>
<td>10.5 %</td>
<td>9.3 %</td>
</tr>
</tbody>
</table>

* Density per sq km is 306.0 for Salem County and 1825.4 for New Jersey.

Source: U.S. Census Bureau, *State and County Quickfacts*. 
the county, which facilitates a comparison of the location of polluting industries and high mortality rates and the presence of African American communities. In addition, the county does not have a disproportionate amount of younger or older people when compared to the state, which is significant because disproportionate age groups could skew mortality rates in a particular direction.

Fifth, population growth rates in the county have remained fairly static. This is important because it reduces the significance of migration as a confounding factor. Population estimates from 1990 to 1997 demonstrate that population change in the county was a function of natural increment (estimates between these years indicated a slight population increase) as opposed to migration (NJDL 1998). The likelihood that persons contracted their disease from an outside region and carried it into the county when they moved is reduced, while the likelihood that residents have lived for years in the same location is increased. Salem County’s population grew by only 8.5% between 1960 and 2000, and declined by 1.5% between 1990 and 2000 (US Census 2000a).

Finally, New Jersey has led the United States in environmental reform and is at the forefront of a number of states that are seeking to become environmentally sustainable (NJ Future 1999). When Congress established the TRI, its list of regulated chemicals was based on “right to know” acts in New Jersey and Maryland (Gottlieb et. al. 1995:135). The NJDEP adopted strict regulations to control air toxics in 1979 (NJDEP 2001b), well ahead of the federal government. This is significant to this study, because it means that more environmental information is available for New Jersey than for most other states. The list of Known Contaminated Sites in New Jersey is an example of a
database that is maintained by New Jersey but is not readily available (or in existence) for all of the fifty states.

High levels of pollution, higher than average health risks due to pollution, a history of health-related pollution problems, a historical concentration of industry in one area of the county, the relative homogeneity of the population, a concentration of African American residents in certain parts of the county, and a population that has remained relatively stable over the past forty years make Salem County an ideal site for a case study that examines relationships between pollution, mortality, and environmental disparity.

**Conclusion**

This chapter has provided some important introductory and background information regarding this study. An overview of techniques used to study the effects of chemicals and the issues, benefits, and limitations of these methods was provided, with special emphasis given to geographical epidemiology, which serves as the primary basis for examining pollution and mortality in this study. This was followed by a discussion of environmental justice, which is the other major issue in this study. The chapter concluded with the factors that made Salem County the focus of this study. The next chapter discusses the methods that will be used to examine the associations between pollutants, health, and socio-economic variables to examine whether concentrations of pollutants are associated with high mortality rates, and to discover if certain groups within the community shoulder a disproportionate amount of pollutants and their health effects.
Chapter 2

METHODOLOGY

Introduction

This study is a scoping examination of many issues and variables from a holistic perspective, under the broad discipline of medical geography. This paper examines the distribution of pollutants in Salem County, NJ, followed by an analysis using Geographic Information Systems (GIS) and statistics in order to discover associations between concentrations of pollutants and areas of poor health, and whether or not these pollutants and health risks are evenly distributed across the community. The specific variables that are examined are as follows:

- Pollution variables include emissions from industry catalogued in the Toxics Release Inventory (TRI), the number of reporting TRI facilities, and the number of sites where soil and ground water has been contaminated by chemicals.

- Mortality rates and cancer mortality rates serve as the variables that measure health, and are adjusted for age.

- Certain variables are examined to determine whether they are alternative factors that could explain geographical patterns and statistical associations. These variables include: place of birth, population density, population change, age, and gender.

- Race, median income, and incidence of poverty are examined for similar reasons, but also are used to determine whether or not pollutants and mortality are evenly
distributed amongst the population. An imbalance may indicate environmental disparity.

Geographical patterns and statistical correlation are used to explore relationships between variables. Statistical correlation between variables does not necessarily indicate causation (NRC 1991:34), but can draw attention to an otherwise unidentified relationship. Scatter plots with lines of best fit are created for certain variables in order to better understand why an association is strong or weak, and a test of statistical significance is made, to determine the degree to which an association may exist simply by chance. These are the basic statistical methods outlined in the text *Medical Geography*, 2nd edition (Meade and Earickson 2000: 422-425, 435-437). This chapter describes the methods and techniques used in this study, followed by a detailed description of each of the four databases used, an explanation as to why they are used, and a discussion of their benefits and limitations.

**Methods**

Chapter three provides basic information about the county's history and economy and provides details concerning the industries, types and levels of pollutants, and an overview of the known health effects of pollutants. This information is drawn from a variety of sources, including the Census Bureau, the TRI, the New Jersey Department of Environmental Protection (NJDEP), The New Jersey Department of Labor (NJDL), The Environmental Defence Fund (EDF), company websites, local newspapers, and miscellaneous texts.¹ This information provides a framework for the study, establishes associations between pollutants and health based on the distribution of pollution and the

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¹ In many instances information is summarized in tables that were created using Microsoft Word. In no instance was a table or figure directly copied from the Internet and pasted into this report; the author created all formats.
known health effects of the pollutants, and raises the issue of economic dependence on noxious industry.

The purpose of this study is not easily supported by field observations, since pollution is not always visible. In some instances, pollution could be seen rising from stacks over the horizon, and no trespassing signs signalling contamination dotted the roadside in a few places. Generally, pollution is not visible. Factories are often set back from the road and surrounded by shrubs and fences that hide their infrastructure, and one cannot observe the direct discharge of pollutants into the Delaware River. Contaminated sites are often undetectable; they could be in a resident’s back yard. While pollution is not always visible, it exists nonetheless and has implications that this study will examine. Field observations did provide a sense of place for different regions within the county that is not easily obtained from detached research. Urban and rural parts of the county were easily distinguishable, as were areas that were economically sound and visually pleasant versus areas that were depressed and decayed.

The fourth chapter contains the empirical aspect of the study that scans for associations between pollution and health by using statistical and geographic techniques. Statistics were compiled at the township level from the Census, TRI, contaminated sites list, and mortality databases into a spreadsheet in Microsoft Excel. This spreadsheet was exported to S-Plus, a program that is more sophisticated and suitable for performing statistical calculations than Excel. S-Plus was used to calculate averages and medians for each data set, as well as a correlation matrix that compared pollution variables to all other variables. A correlation coefficient summarizes a statistical relationship and indicates whether or not an association may exist between two variables. Plotting the variables on a
graph adds insight by visually demonstrating the association. The strongest associations were selected and plotted on a graph with a line of best fit in order to explain why the relationship exists, and a test of statistical significance was made. The significance level indicates the likelihood that an association did not occur by chance.

The Excel spreadsheet was also exported to ESRI's ArcView GIS to produce maps for the study. Geographical associations between pollution, health, and socio-economic characteristics are explored by mapping variables to determine whether any patterns exist. Data from the U.S. Census Bureau's Tiger Line Files is available from ESRI's website, and provided the base map information for the study that includes state boundaries, county boundaries, township boundaries, and bodies of water. The text file containing the variables was joined to the file containing the base map information by matching the two files based on a common field (township). Once this was achieved, maps were produced for variables that demonstrated strong statistical associations or for data that provided other pertinent information. Socio-economic data and health data were displayed in choropleth maps, with pollution variables displayed as symbols. All variables were classified using the natural breaks methods, which creates data intervals based on break points between values. All maps were exported to the graphics software package Corel Draw, which is more suitable for creating maps of a higher aesthetic quality than ArcView. Corel Draw was used to create text labels, colour schemes, and to correct imperfections in boundary lines.

Pollution variables and mortality are examined first, because they are the primary variables in this study. After these associations are explored, other variables, such as population density, population change, place of birth, age, and gender will be examined
in lesser detail, to determine whether or not they may affect an association between pollution and mortality. Race, income, and incidence of poverty are also examined for this reason, but are also important measures of environmental disparity. The significant findings are summarized in a matrix that conveys the overall pattern.

**Limitations**

Despite the benefits of the study, there are three general limitations which apply to the entire study. The first limitation is statistical, in that the level of analysis permits a search for associations, but cannot establish causal relationships. The associations can, however, reveal connections that were previously not apparent, which can lead to more detailed analysis in particular areas.

The second limitation is geographical and pertains to the spatial aggregation of data. The most specific geographical designation for the mortality database is the township, so in order to make equal comparisons all other data must be provided at the township level. Aggregating the data in this way presents a limitation to all the data in some form, because a higher level of detail (that can easily be given at the census tract level) is lost. For example, poverty within a township may be higher in one area and much lower in another area, but due to the enumeration level, the level of poverty is averaged over the entire area.

A third limitation is that the data sets pertain to only Salem County. Pollution sources from outside the county, as well as other variables that might show a geographic pattern that crosses county boundaries, are excluded. This is a limitation as Salem County certainly does not operate in a vacuum, but the collection of data for all outside townships that border the county would have doubled the amount of data that would have to be
processed and analyzed, which is beyond the scope of this investigation. Townships within Salem will be the main focus.

In addition to these three general limitations, each database possesses specific limitations regarding its source, format, and contents. The next four sections discuss the limitations as well as the benefits of each of the four databases, and provide an overview of the source, format, and content of each database, as well as the purpose for using it in this study.

**Census Data**

The U.S. Census is the first of four databases that will be used in this study, and its data is available via the bureau’s web site. The census variables that are mapped at the township level are population, population change between 1990 and 2000, African American population, median income, and poverty level. The last three variables are used to look for associations between pollution and environmental justice. Census data from the county level, and from the Economic Census, are used to place Salem County within the context of New Jersey.

The main limitation of the census data is that the data for the 2000 census was still in the process of being released while this study was being conducted, and will not be available in its entirety until 2003. Two of the variables, median income and poverty incidence, were not available at this time, so data from the 1990 census must be used. It is unfortunate that some of the data is ten years old, but the slow rate of change in Salem County implies that it is still relatively accurate. All other census variables are from the 2000 Census.
Toxic Release Inventory

The US EPA’s Toxics Release Inventory is one of two databases used to measure pollutants in Salem County (US EPA 2001bc). The TRI was established in 1987 as “a computerized national database of toxic chemical releases by individual manufacturing facilities” (Gottleib et. al. 1995:131). Facilities listed under nine different industry sectors that have ten or more full-time employees and manufactures or processes more than 25,000 pounds or uses more than 10,000 pounds of any listed chemical must report to the TRI during that calendar year. The TRI currently regulates over 650 individually listed chemicals; double the number that was initially regulated in 1987. Companies must report the amount of a chemical that was emitted to the environment, the media to which it was emitted (air, water, land, or underground injection). The quantity of waste that was managed (recycled or treated) is also recorded. These are classified as on-site releases. The TRI also tracks off-site releases, or transfers, which is the amount of waste that was transferred to a different facility or company for recycling, treatment, storage, or disposal (US EPA 1999a).

The TRI is the most comprehensive source of information on national toxic pollution at both a chemical and facility-specific level (Gottlieb et. al. 1995:131-32), but it does possess some limitations. Emission trends over time are affected by the inclusion of new chemicals under regulation for certain years. Industry lobbying led to the exclusion of a number of sectors from reporting requirements (1995:134). The mining and power utility sectors, which are some of the most highly polluting industries, were not included in the TRI until 1998. Certain concessions granted to specific industries still exist; utilities are not required to report the amount of mercury coming from their stacks.
(Associate Press 2001), and some industries, including all facilities under the required thresholds, do not report their releases. Facilities often report estimated data to the EPA by using a variety of estimating techniques and models, because the program does not stipulate that they must monitor their releases (US EPA 1999a). The TRI data provides only a portion of all toxic chemical releases, and the portion of the releases that it does provide has increased over time. Finally, the EPA emphasizes that the TRI reports reflect releases and waste management, and are not sufficient to determine exposures to the public and affects on health, but the data is useful for identifying areas of potential concern (EPA 1999a).

The TRI is a relatively comprehensive data source for toxic releases despite its limitations. Historically, the chemical industry has been the number one consumer and generator of toxic substances, as a developer of chemical products and as a source of toxic pollution (Smith and Gottlieb 1995:209-211). Therefore, the TRI and industrial point sources will be used as indicators of pollution. Although other sources, such as mobile air pollution from automobiles, are extremely important sources of pollutants, they are more difficult to quantify, making industrial point sources the measurement of choice for this study. On-site releases of chemicals between 1987 and 1999 are used to measure pollutants in Salem County. A description of the types of chemicals and their known health effects are provided for releases in 1999. Aggregate releases for all available years and media are compared to other variables, because other variables are temporal (mortality, population change) and because certain illnesses have long latency periods (cancer). The main purpose of aggregating the data is to illustrate where the concentration of emissions / contamination have occurred over time, and given the ability
of certain chemicals to remain persistent in the environment over long periods of time and the ability of some chemicals to move between different media after their release, the aggregation of data is justified.

Pollution measurements do not include off-site transfers for two reasons. First, wastes that are transferred out of the county would pose a more direct threat or problem for whatever jurisdiction is receiving them, and would be less of health issue for Salem County. Second, if the wastes were transferred between facilities within the county, the receiving facility would have to report some emissions in their on-site releases, because the waste was treated or disposed on their site. By counting on and off site waste, emissions may be counted twice. For the purposes of this study, it is sufficient to count only on-site releases.

As stated previously, the intervals used for mapping are determined using the natural breaks method, which divides a data set into intervals based on major break points between data values. The amount of emissions for each plant within each township was aggregated in order to perform the statistical analysis. This poses a limitation to the study, necessary in order to compare the different variables. In reality, pollution drifts over boundaries and floats downstream. The inaccuracy is increased due to a heavy concentration of industries near the boundary of two townships, Pennsville and Carneys Point. The DuPont Chambers Works, the largest facility in the county, stretches across this boundary. Based on air photographs and land use maps, it was determined that the largest portion of industrial activity occurs in Pennsville, while the company’s landfill is located in Carneys Point. Pollutants were divided by their media, with emissions from the air and water attributed to Pennsville, and emissions to the land attributed to Carneys
Point. Once again, this division of pollutants by political units is far from ideal, which increases the importance of analyzing the statistics in conjunction with the maps (which show the actual point source of the pollutants) while bearing in mind attributes of the physical environment, such as prevailing winds and stream flow, that affect the dispersion of pollutants.

Two alternative techniques for assigning pollutants to geographic space could have been used, but were rejected for this study. The first technique is to assign radiating circles around facilities in order to explore environmental inequities based on distance from site. There are a number of limitations to this approach, because circles are often drawn arbitrarily and do not reflect quantity or toxicity of chemicals at the site. (Chakraborty and Armstrong 2001:120). The other technique is a geographic plume analysis, which uses a dispersion model in conjunction with data in a GIS to pinpoint areas of risk (2001:120). This method is extremely data intensive and particularly complicated when large numbers of different chemicals are involved. It is better suited to a more specific study of one or two chemicals and their corresponding risks to a surrounding area, and not for an aggregated study such as this.

Finally, the correlation study is skewed by the disproportionately high level of pollutants in one of the townships. A second set of values will represent emission levels by using surrogates, or “dummy variables,” so the correlation study can be performed more effectively (Easton and McColl 2000). Numbers from 0 to 4 are assigned to townships based on their pollution level, with 4 being a very high level of pollutants and 0 being no pollutants. The surrogate emissions variable will be the primary variable used to measure emissions, but correlations for actual emissions will also be provided.
Contaminated Sites

The second database used to measure pollution in Salem County is the Known Contaminated Sites in New Jersey report, produced by the NJDEP under the Site Remediation Program (SRP) (NJDEP 2001a). In this study, it serves as a measurement of smaller sources of pollution.

The report defines a contaminated site as "[a site] where contamination of soil and/or ground water is confirmed at levels far greater than the applicable cleanup criteria or standards" (NJDEP 2001a). Sites are classified as sites with on-site contamination (which are in the majority for Salem County), unknown sources of contamination, or as closed cases with restrictions, with remedial action being taken at sites that are not closed cases. Actions to prevent human exposure are taken at any site that poses an immediate threat to human health (NJDEP 2001a).

In 2001 there are 124 contaminated sites in the county that encompass a wide variety of uses (both active and abandoned) and a varying degree of contamination, which require anything from "simple 'cut and scrape' removals to highly complex remedial activities" (NJDEP 2001a). Sites are listed by county and are divided further into townships, with each site listed by name and address. This study divided the list of sites into the following categories for further analysis: industrial facilities, landfills, gas stations, other commercial businesses, private residences, private properties, and other miscellaneous uses.

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2 Originally it was hoped that the sites could be pinpointed to a specific location rather than aggregating them at the township level, but this was impossible for two reasons. First, the addresses were often incomplete, containing only a street but no number. Second, the Census Bureau only geo-coded urban parts of the county and not rural areas, so many of the sites could not be matched to the street grid.
The site listing is intended to be a ‘pointer system,’ so that interested parties can contact the appropriate bureau to obtain more information about the site (NJDEP 2001a). This is the major limitation of this data source. The extent of contamination and the chemicals associated with it are not provided. For further information concerning a site, the interested party must call the bureau that is currently handling that site. There are at least ten bureaus (not including sub-bureaus) that are in different stages of action in Salem County. There is no centralized source of data, making it difficult to obtain additional information. Information regarding the extent and types of contaminants was not obtained for this study.

**Mortality Data**

Mortality rates are used as the indicator of health in this study. While epidemiologists generally prefer to examine patterns of morbidity or incidence of disease, because the primary interest is uncovering factors that contribute to the occurrence of disease, adequate data for incidence does not exist (Pickle 2000:241). In contrast, mortality data has been collected for many years in several countries of the world and at several scales within each country. Mortality certification and reporting has been conducted by every US state since 1933 (2000:241). The availability and coverage of the data, medical certification, and the adoption of common standards for compiling the data are all major advantages of using mortality data (Lopez 1992:37-8). The issue of duplicate registrations, which is a problem with data in cancer registries and other registries of disease incidence, is extremely unlikely to occur in a mortality database (Swerdlow 1992:57).
The *New Jersey Vital Events Public Use Data Files*, provided by the State of New Jersey Department of Health and Senior Services (NJDHSS 2001), was used to obtain mortality data from 1994 to 1998. This study will examine mortality rates at the township level in Salem County for all five years that are available, and the average mortality rates for each township over the course of five years will be used in the mapping and statistical analysis. Aggregating the data over five years present some limitations, such as hiding temporal trends over time, but will be adopted because it increases the stability and significance of the data due to addition of cases (Monmonier 1996: 159). Small area studies can produce a fair degree of variability from place to place that may reflect random variation, variation that is usually not present in larger studies because larger numbers tend to be self-compensating (Lopez 1992:49) Large, sparsely populated areas with few cases tend to have considerable random variation (Elliot et al 2000:8).

Aggregated data over a five-year period will be used to limit the effects of random variation, which is an issue due to Salem County’s low population and low population density (which results in low numbers of cases).

The data is stored by year in one large ASCII text file, that contains all deaths that occurred in New Jersey during that year. A line of code up to 154 characters long represents each case. Each character or, in many instances, strings of characters, represents different information for that given case. A codebook is available to decipher what columns contain what information and what each character or string of characters

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3 While ASCII text files seem archaic, they are commonly used by archivists to preserve data because the format is simple and can be accessed by any computer. Because of their simplicity, records from twenty years ago can still be accessed on most computers, and it is likely that data stored in this format now will be accessible far into the future. While word processors or other programs are more sophisticated and easy to use in the present, they will become obsolete more quickly and thus become inaccessible in the future (James 2001).
represents. Certain information, such as the persons name and social security number, are omitted because of confidentiality. An example of a portion of a string of code that contains information that will be used in this study (pertinent characters are in bold) is displayed below, followed by the information that each character(s) provide (Letters are added for the convenience of the reader).

```
31 1730 1740 10 72 34 12 1820 94 2 2 2
A B C D E F G H I J K L M N
```

state (A), county and municipality of occurrence (B), county and municipality of residence (C), place of death (D), age units (E), age (F), state of birth (G), race (H), Hispanic origin (I), cause of death (J), year of death (K), marital status (L), veteran status (M), gender (N)

The county and municipality of residence were used to assign cases to the proper township. A test to see whether municipality of occurrence was a better indicator was performed for one of the years. Mortalities were overwhelmingly high in townships with hospitals and low everywhere else, and introduced the problem of non-resident deaths within the county. County of residence was the more accurate choice by far.

Age was used to determine life expectancy and to separate the number of deaths that occurred below the age of 65. There were two problems associated with age in this study. First, an initial test of the data using only one year determined that a higher number of mortalities occurred within townships that had nursing homes. Nursing homes essentially clustered persons that tended to be older and in poorer health than the rest of
the population, in specific townships. Separate mortality rates for persons under 65 were calculated to overcome this limitation. Persons under 65 are presumably less likely to live in nursing homes than people over 65. In addition, a high rate of death among persons under 65 might be indicative of environmental exposure, since it is below the average and median age of death. Finally, Salem County’s mortality rate for persons under 65 is higher than the New Jersey average.

The second problem with age is the result of a technical flaw. Age units were listed as only two digits, which can lead to confusion between deaths of individuals below ten years of age and deaths of individuals over ninety-nine years of age, i.e. an age listed as 02 could be two or one hundred and two. This would significantly affect the calculation of life expectancy and mortality under 65. To avoid this error, the stated age units string (a surrogate number that refers to age category) was checked for all persons less than twenty years of age.

The state of birth string was used to determine migration as a factor of mortality. Different environments expose people to different substances and situations that may increase or decrease their risk of contracting a disease (Braus 1996). The place of birth was used to determine if a township’s high or low mortality might be a factor of residents who brought their conditions from another place. A limitation of place of birth is that it does not indicate how long a person lived in another place. Due to the introductory nature of this study, place of birth was aggregated into three categories: born in the region (New

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4 Initially, the place of death string (which specifies whether a person died in their homes, a hospital, a nursing home, or somewhere else) was going to be used to account for the deaths that occurred in nursing homes. It was quickly discovered that persons were listed as dying in nursing homes in townships that did not have nursing homes. This could be due to persons relocating to a nursing home in one township while maintaining their documented place of residence in their original township.
Jersey, Pennsylvania, or Delaware), outside the region (any other state or country), and
unknown place of birth.

Surrogate numbers that are defined in the codebook represents race and gender in
the database. Race and gender are basic measures required for any epidemiological
analysis (Swerdlow 1992:54), because diseases and mortality can vary significantly by
race and gender (Philp 1995:22-24). Race of the mortality cases is also central to the
issue of environmental justice. The percentage of African American mortality in a
township will be compared to the percentage of African American residents in that
township and to the presence of pollutants, in order to determine if there is an imbalance
between white and black mortality in certain townships, and whether or not this
imbalance is associated with pollution. Other categories of race, Asian / Pacific Islanders,
and Native Americans, occurred so infrequently (due to the small number of these groups
living in the county) that they will not be examined. Hispanics, who comprise a much
smaller percentage of the county population when compared to the state average, will
also unfortunately be excluded due to coding issues. The most frequent coding for the
Hispanic string was "unknown," making it impossible to study this group.

The last string that will be used is comprised of four digits that indicate the cause
of death. These numbers are the International Classification of Diseases (ICD) codes,
which are standardized codes used worldwide to indicate the underlying cause of death
(Lawson and Williams 2001: 47-8). This study used the ninth revision of the codes,
which can be properly applied to this database. The codes are classified into seventeen
categories of disease, with further subdivisions within each category. The first three digits of the code indicate the disease and specific sites, when applicable, where the
disease occurred and caused death. The last digit of the code provides a more specific site or cause of the disease. The codes will be used in this study to examine general mortality trends in the county. Cancer, known medically as Neoplasms, is categorized under group two and will be analyzed in more detail than the other groups. Injuries and Poisonings fall under group seventeen and include deaths due to human action, such as car accidents, falls, poisonings (such as drug overdoses), homicides, and suicides, among other causes. Since it is unlikely that causes of death due to human actions are the result of environmental exposure, and because most deaths under 65 occur under this category, mortality rates for persons under 65 were adjusted to exclude this category.

The strings of characters were not delineated in the text file, so a considerable amount of data processing was involved. First, cases that pertained to Salem County were selected from the database by isolating the county of residence string. In many instances for each year, the last digit of the cause of death string was missing (because it was not provided by the doctor), and a dash "-" was listed in the database as a placeholder. When the Salem County cases were exported to a spreadsheet program, such as Excel or S-Plus, the spreadsheet moved the dash to the front of the string and created a negative number, creating an error. The spreadsheet also did not view the character strings as unique bits of information, but as large numbers that it classified into a few large fields. This made it impossible to sort the cases by certain categories, such as age, because this string of characters was hidden within one large "number." It was impossible to delineate much of the information by a fixed width, because certain cases had extra digits (such as information regarding death from an accident) which made simple delineation of digits into categories impossible.

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6 In medical terminology, "site" refers to a part or system of the body that is targeted by a disease.
Due to these limitations, the cases from Salem County were exported to a separate text file. Deleting the dash and adding a zero to the end of that string resolved the "negative number" error. Certain pertinent fields were delineated by hand by inserting commas in-between the columns that were pertinent to the study. The edited text file was then exported to a spreadsheet program, where the cases could be sorted properly by township and cause of death.

Some of the primary limitations of the mortality database are actually problems posed by other data that are used in conjunction with the mortality data. Mortality rates are calculated for each township by dividing the number of mortalities for a year by the 2000 population for the township, and multiplying that number by 1000 to get a rate per thousand residents. The limitation is that the population from 1994 to 1998 is not the same as it is in 2000, which adds inaccuracy. Population estimates for each township are available for each year, but since these are merely estimates, they also carry a degree of inaccuracy. Since the estimates vary only slightly between 1994 and 2000, because the county's population change is not very robust, the 2000 census data was used for calculating all rates.

Socio-economic confounding poses another limitation. Researchers who are examining disease patterns often find clusters of higher rates of disease because poverty is high and income is low in a particular area, often in areas adjacent to industrial sites (Jolley, Jarman, and Elliot 1992:115-16). People of lower income tend to have worse access to healthcare, a poorer diet, and increased rates of substance abuse, among other factors, which can lead to poor health and higher rates of disease and mortality (Meade and Earickson 2000: 218-20). Possible exposure to environmental pollutants is one of
many factors that can attribute to poor health. In this study in particular, one township, the City of Salem, has very high rates of mortality and poverty and very low income, but has very low levels of emissions. Its poor health could be attributed to lifestyle and economic decay as well as environmental exposure.

Another important confounding socio-economic variable is occupation. A high rate of mortality in a township with TRI emissions could be the result of occupational exposure to toxins, and not the result of environmental exposure (i.e. nearby residents who are exposed to toxins released into the air or water), since workers receive higher exposure than residents and could live in townships adjacent to the TRI emitting facilities. While it can be assumed that some workers live near their place of work, it cannot be assumed that the majority of all workers do, as one third of Salem County’s labour force resides outside the county (NJDL 1990).

Finally, there are limitations and sources of error within the database itself that are dependent on the doctor and/or medical examiner’s analysis. In many instances, the last digit in the ICD code was not provided, because it is unknown or the investigation was not thorough, which results in a loss of specificity and the unintended consequence (which is partially the fault of the encoder) of data errors when the database is exported into a spreadsheet package. Diagnostic accuracy is important in the determination of the cause of death (Lopez 1992:38). Mis-diagnosis, an increasing trend not to perform autopsies, the forced practice of choosing only one underlying cause of death, diagnostic 'fads', medical training, cultural norms, and the certifying physicians knowledge of the deceased history of illness are all factors that can lead to inaccuracy (Lopez 1992: 39,47-49). Despite these limitations, the data quality of mortality diagnoses is very high, and
steadily increasing (Pickle 2000:242). Inaccuracies also extend beyond the cause of death to other important pieces of information, the failure to code whether a person was Hispanic or not in this data set is a prime example.

Due to the vast amount of data contained in the database, not all of the strings and variables are being considered because of time constraints and other uncertainties. For example, each case also has a listing for industry and occupation, which would be useful in determining if certain mortalities may be related to exposures at work, but there is no specification of whether it was the deceased’s last place of employment or the place he or she was employed longest, the length of employment is not specified, and outdated SIC codes (that indicate occupation and industry) are used. The data file is also limited by certain information it lacks, particularly whether a person was a smoker or non-smoker. This lack of information prevents an examination of diseases of the respiratory and circulatory systems, which is significant considering that high levels of pollution can lead to respiratory problems, and even heart attacks (Falkenburg 2001).

**Conclusion**

This chapter has discussed methods and processes used for analysis and provided important background information regarding the source, format, and contents of the primary databases. The purpose of using the databases and their benefits were discussed. Limitations of the data were stated, and when possible, some of the limits were overcome and the methods used to overcome them were described. It is important to note that as far as is known, this is the first study that examines the associations between these four databases in the way that it does.
Chapter 3
INDUSTRY AND POLLUTION

Introduction to Salem County

This chapter reviews the industrial and environmental history and geography of Salem County. Each facility listed in the TRI will be discussed in reference to its history, activity, role in the economy, and pollutants that it produces. The chapter will conclude with an examination of the types of pollutants being emitted, and a discussion of the known health effects associated with these pollutants.

Salem County is located in the southwest corner of New Jersey, bordered by Gloucester County to the north and by Cumberland County to the east and south. The Delaware River separates Salem from the State of Delaware, and specifically New Castle County, to the west. Wilmington, Delaware lies across the river to the west and is the focal point of economic activity in the immediate region. The City of Philadelphia lies to the northwest.

Salem County encompasses an area of 338 square miles (543.8 sq km) (Census 2000a) and is composed of fifteen townships of varying size and character. For the purposes of this study, the townships were divided into three distinct regions (Figure 3.1). The northwestern region is the Industrial Corridor, comprised of the townships of Oldmans, Penns Grove, Carneys Point, and Pennsville. It is the most urbanized, industrialized, and heavily populated region. The southwestern region is the Marginal Coastal Plain, composed of Lower Alloways Creek, Elsinboro, Mannington, and the City of Salem, which is the capital of the county. This region is comprised of low-lying
marshland that is sparsely inhabited. The City of Salem is somewhat out of place in this region due to its high population and urban character, but does not belong within the Industrial Corridor. Industry and development are fairly contiguous in the IC, while the City of Salem is separated from the suburban areas of Pennsville by tracts of marshland. Finally, the centre point of the county, in terms of its industrial economy, is within the Industrial Corridor, while Salem is the older industrial centre point that has been marginalized. The final region to the east is the Farm Belt, which consists of the remaining townships of Quinton, Alloway, Pilesgrove, Woodstown, Upper Pittsgrove, Elmer, and Pittsgrove. Compared to the other regions, these are medium sized areas in terms of population, where farming is the main occupation. Woodstown and Elmer, the smallest of the fifteen townships, are small towns that cater to the surrounding farming townships. Pittsgrove is becoming an exception in this region, as its population is the second highest of all the townships, due to the completion of a new state highway which has increased suburbanizing pressures.

The land is relatively flat and between sea level and one hundred feet (30 meters) above sea level. Most areas in the county have been cleared for agriculture or residential/industrial use. The low lying, marshy nature of the land bordering the Delaware River makes this area, and areas along the Delaware’s tributaries, prone to flooding. Salem County is an ideal place for agriculture, because the southwestern portion of the outer coastal plain (which covers all of the county) has much better soil than other parts of the outer plain (Stansfield 1998:283). The climate of Salem County is typical of mid-latitude continental climates, but due to regional conditions, the county and the state are considerably wetter than most of the United States (Stansfield 1998:24-
29). Prevailing winds are from the southwest, except in winter, when west to northwest winds dominate (NJ State Climatologist 2001). The county’s physical geography is important because it influences the dispersion of pollution. The soil and marshy nature of the coast implies that persistent toxins can remain for sometime, and seep through the soil into aquifers. The low-lying, flood-prone landscape and rainy conditions can move pollutants through the soil and water more quickly and possibly spread contamination, while wind patterns move air pollutants throughout the region.

**Industrial History**

Salem remained an agricultural and rural county until the end of the nineteenth century. The turning point in the county’s history was the construction of a gunpowder factory by the Wilmington based DuPont Company in 1893 (Cunningham 1994:189). The demand that the factory created for workers, both within the factory and in support industries such as construction and transportation, transformed the county and promoted population growth. The northwestern portion of the county became more urbanized, and the economic focus shifted from agriculture to industry, while the economic centre of the county moved away from the City of Salem.

The population slowly increased after the factory was built (Figure 3.2), but jumped between 1910 and 1920, as the DuPont gunpowder plant expanded production and increased sales during World War I (Sickler 1937:365). DuPont began manufacturing dyes in 1917 and tetraethyl lead, a gasoline additive used to reduce the

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1 Average rainfall in the county is 43.7 inches a year (1110 mm) and the average temperature is 54 degrees F (12.5 C), with a high average of 76 degrees F (24.5 C) in July and a low average of 31 degrees F (-0.5 C) in January, as measured from Woodstown, in the centre of the county (World Climate 2000).

2 The plant had contracts with both the Allied and Central Powers, until the U.S. entered the war in late 1917. In the postwar period, the company violated the Versailles treaty by selling ammunition to Germany (Colby 1984: 190, 335-36).
Figure 3.2 Salem County History and Events

- DuPont builds gunpowder plant (1893)
- DuPont builds dye works (1917)
- Delaware Memorial Bridge Opens (1951)
- Mannington Mills opens (1911)
- Deepwater Generating Plant built (1929)
- Chemical revolution begins (post 1945)
- Secondary chemical plants open (mid to late 1960s)
- DuPont employment mid 1950s - 6,800
- Nuclear plants built late 1970s
- Only population loss in the 20th century (1990 - 2000)
- De-industrialization era begins (post 1970)
- DuPont employment Year 2000 - 1,400
knocking sound in internal combustion engines, in the early 1920s, prompting an increase in the facility's size. DuPont was instrumental in building homes for workers and for modernizing the township, supplying paved roads and streetcars. (Cunningham 1994:190-91).

Population growth accelerated again after 1930. The Atlantic City Electric Company finished building a generating plant in 1929, providing the county with an abundant supply of electricity (Sickler 1937:370). The increasing use of the automobile and the paving of roads made Salem County a more accessible place. Accessibility was enhanced further, following the construction of the New Jersey Turnpike, Interstate 295, and the Delaware Memorial Bridge (linking New Castle County, DE and Salem County) in the 1950s and 1960s. DuPont's expansion into a variety of consumer goods kept the local economy stable through the Great Depression, and the Second World War boosted production. The postwar period emerged as the beginning of the chemical age, as thousands of new chemical products began flooding the world's market (Fagin and Lavelle 1999:1-2). Salem's other industries, glass manufacturing, textiles, canning, and floor coverings, also grew during the post-war period, while the presence of DuPont fostered the growth of other related industries in the chemical sector by the late 1960s and early 1970s.

Despite the growth of new chemical industries, Salem County was severely affected by a stagnant economy during the 1970s, as the United States began the process of de-industrialization (Bluestone and Harrison 1982: 25-48) and the shift to a more service oriented economy. Much of the county's industry eroded, as a number of canning

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3 Fumes from the production of TEL often caused dementia and delirious effects in workers at the plant, and was responsible for a number of deaths between 1923 and 1925. Workers and residents nicknamed the plant "The House of Butterflies." (Colby 1984: 246).
and textile plants closed. DuPont cut its workforce, moved its dye production out of the county by the late 1970s, and was hurt by new environmental regulations that began phasing out leaded gasoline. The rise of the cancer issue previously mentioned, as well as a number of accidents at the plant, dampened the region. The continuing process of suburbanization led to a continuation of slow population growth, despite economic hardship, between 1960 and 1980. Growth stagnated between 1980 and 1990, and for the only time during the twentieth century, Salem County lost population between 1990 and 2000. Most population growth between 1990 and 2000 (Figure 3.3) occurred in the larger townships in the northern tier of the Farm Belt. Economically depressed Salem City suffered the greatest decline, losing one thousand residents.

Penns Grove and Salem suffered worst during the transition from industrial to service based economies that began in the late 1960s and early 1970s. Penns Grove experienced rapid growth after the DuPont Company initially arrived, and its population jumped from two thousand to ten thousand residents between 1910 and 1920 (Sickler 1937:365). Workforce reductions at the plant, which began in the 1970s, had an immediate negative impact on the city. Penns Grove also suffered from the loss of its other manufacturing businesses; the closure of a textile factory in 1994 with a loss of 125 jobs is one example (NIDL 1998). The City of Salem suffered similar problems, such as the closure of a large cannery owned by the Heinz Company in the 1970s (Salem County Board of Freeholders 2001). The city was also at a geographic disadvantage, due to its distance from the new focus of economic activity near the DuPont plant and I-295. Like

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4 An explosion in 1974 killed three workers, and an explosion in 1978 occurred one week after the plant was honoured with the New Jersey Governor’s Safety Award (Colby 1984: 801).
5 Only twenty-percent of the United States’ 3,141 counties lost population between 1990 and 2000, and Salem County was one of them (Schmitt 2001).
Population and Population Change

Population

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1090-1860</td>
<td>2770-4890</td>
</tr>
<tr>
<td>5850-8900</td>
<td>13,200</td>
</tr>
</tbody>
</table>

Percent Population Change 1990 - 2000

Percent Change

<table>
<thead>
<tr>
<th>Change Range</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.3 - 21.7</td>
<td>5.3 - 8.9</td>
</tr>
<tr>
<td>-1.8 - -8.8</td>
<td>-9.7 - -17.2</td>
</tr>
</tbody>
</table>

Figure 3.3
Population and Population Change
Population data provided by US Census Bureau
Basemap data provided by ESRI
many large cities, Salem and Penns Grove suffered from suburbanization processes that accelerated during the post WWII period. Both communities are implementing strategies to improve their situation and participate in a federal program to rejuvenate local economies, while Salem is launching an urban renewal/historic preservation program to attract tourists while improving the quality of life for residents (Wiggins 2001).

Pennsville lost population between 1990 and 2000, percentage wise its loss was average compared to the rest of the townships. Due to its accessibility and larger population, the township has performed better economically because it has been able to attract a number of service industries. A new shopping centre, anchored by a Wal-Mart and a supermarket, opened in 1993 and an additional supermarket was enlarged and re-opened in 1997. Trade employment grew by 5.1 % between 1992 and 1997, with most of this activity concentrated in Pennsville (NJD L 1998). Trade in the county was boosted overall in 1994, when the state declared the county as “a competitive business zone” and allowed it to reduce its sales tax from the State’s six percent rate to three percent (Aregood 1995:10,14).

Salem County has a higher percentage of employment in manufacturing and utilities compared to the state. For economic activities listed in the 1997 Economic Census for Salem County6, manufacturing accounted for fifty-two percent of all sales, receipts, or shipments, sixty percent of payroll, and thirty-eight percent of paid employees (US Census 1997a). Ten out of the forty-eight manufacturing establishments in the county are chemical manufacturers (US Census 1997b). The fourteen active facilities that report to the TRI employ about 2900 workers (Figure 3.4). Half of these

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6 Mining, utilities, construction, transportation and warehousing, information, finance and insurance, and management of companies and enterprises are all activities not available at the county level.
Figure 3.4
TRI Reporting Facilities and Employment
Employment data extracted from the NJDEP Community Right to Know Program and from individual company websites. Base map data provided by ESRI.
workers are employed by the DuPont Chambers Works, and roughly seventy-five percent of all workers are employed by the two largest companies, DuPont and Mannington Mills.

Despite the prevalence of manufacturing, industry has continued to suffer, particularly during the economic downtown of the post millennium. At its peak in the 1950s, the DuPont Chambers Works employed 6800 workers (Hobson 1958:24), compared to about 1400 employees today. The downsizing is the likely result of increased mechanization, the closure of the gunpowder and dye works in the 1970s, the transfer of certain processes to other plants, and the subcontracting of various services. The company cited lower sales and higher energy costs as major factors of the recent downturn. The company’s profits were down by fifty percent from the previous year in July of 2001 (Agulnick 2001ab). The Chambers Works cut 160 jobs in July of 2000 and 48 more in April of 2001 (Anonymous 2000:7; Roncace 2001). Other industries in the county are also under stress. Conectiv, the primary utility in Delaware and Southern New Jersey, sold off its interests in the Pedricktown Cogeneration plant (Shoer 2001a) and is selling the large Deepwater Generating facility (Yingling 2001). The Polyone Company announced that it was closing eleven of its thirty-four nationwide plants by 2003, but did not specify which (Witsil 2001).

Although industry is declining, it continues to be a major force in the county’s economy, and community. Most of the plants contribute funds to support local charities and social institutions, which further ingrains their presence in the county. A recent example was a fundraising drive where Chambers Works employees donated 2,500 books to the United Way of Salem County (Wilson 2001).
The Geography of Pollution

The county’s ten chemical companies have reported releases to the TRI sometime between 1987 and 1999 (Table 3.1). In addition to these ten, three power utilities and one other manufacturing facility have reported releases. While all of these facilities are currently active, some have not reported releases in 1999 or other years presumably because they did not meet the minimum reporting requirements. Two additional chemical firms, Exxon and Xerxes, reported releases in the county between 1987 and 1999, but are no longer in business.

Five facilities reported releases in Oldmans; four are active and three reported to the TRI in 1999. The chemical facilities have been in Oldmans since the late 1960s, but under various ownership. Polyone, Oxy Vinyl, and B.F. Goodrich are closely related in terms of corporate ownership. The plants produce substances used in the manufacture of PVC plastics that are generally classified as resins, elastomers, and plastics. The plants are concentrated in the northern part of the sparsely populated township, near the village of Pedricktown. A small power utility is also located in the township. Carneys Point and Penns Grove lie to the south, and contain two and one active facility respectively, each constructed in a different decade. The Budd Chemical Company specializes in urea-formaldehyde resins, while Mac Specialty Coatings produces paints, enamels, and varnishes for automobiles. The Carneys Point Generating plant, run by Pennsylvania Gas and Electric, entered operation in 1994 and was the first coal powered generating plant built in New Jersey in twenty-five years (Business Wire 1999:1278). It utilizes new “clean coal” technology which pollutes far less than traditional coal plants. This type of facility is an example of power generation advocated by many environmental liberals,
Table 3.1 Characteristics of Facilities in Salem that Report to the TRI

<table>
<thead>
<tr>
<th>Township</th>
<th>Name</th>
<th>Type</th>
<th>Established</th>
<th>Employment</th>
<th>Headquarters</th>
<th>Reported in 1999</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canneys Point</td>
<td>Canneys Point Generating</td>
<td>Utility</td>
<td>1994</td>
<td>60</td>
<td>Regional</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Canneys Point</td>
<td>Budd Chemical Company</td>
<td>Chemical</td>
<td>1966</td>
<td>30</td>
<td>Local</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Elmer</td>
<td>United Resins</td>
<td>Chemical</td>
<td>Unknown</td>
<td>14</td>
<td>Local</td>
<td>No</td>
<td>Active</td>
</tr>
<tr>
<td>Mannington</td>
<td>Mannington Mills</td>
<td>Other</td>
<td>1911</td>
<td>800</td>
<td>Regional</td>
<td>No</td>
<td>Active</td>
</tr>
<tr>
<td>Oldmans</td>
<td>B.F. Goodrich</td>
<td>Chemical</td>
<td>Late 1960s</td>
<td>42</td>
<td>National</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Oldmans</td>
<td>Exxon Chemical Company</td>
<td>Chemical</td>
<td>Unknown</td>
<td>X</td>
<td>National</td>
<td>No</td>
<td>Inactive</td>
</tr>
<tr>
<td>Oldmans</td>
<td>Oxy Vinyls</td>
<td>Chemical</td>
<td>Late 1960s</td>
<td>41</td>
<td>National</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Oldmans</td>
<td>Polyone Corporation (Formerly Geon)</td>
<td>Chemical</td>
<td>Late 1960s</td>
<td>110</td>
<td>National</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Oldmans</td>
<td>Pedricktown Cogeneration</td>
<td>Utility</td>
<td>1992</td>
<td>24</td>
<td>Regional</td>
<td>No</td>
<td>Active</td>
</tr>
<tr>
<td>Penns Grove</td>
<td>Mac Specialty Coatings</td>
<td>Chemical</td>
<td>1979</td>
<td>47</td>
<td>International</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Penns Grove</td>
<td>Xerxes Corporation</td>
<td>Chemical</td>
<td>Unknown</td>
<td>X</td>
<td>National</td>
<td>No</td>
<td>Inactive</td>
</tr>
<tr>
<td>Pennsville</td>
<td>Deepwater Generating</td>
<td>Utility</td>
<td>1929</td>
<td>48</td>
<td>Regional</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Pennsville</td>
<td>DuPont Chambers Works</td>
<td>Chemical</td>
<td>1893/1917</td>
<td>1400</td>
<td>Local</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Pennsville</td>
<td>DuPont Dow Elastomers</td>
<td>Chemical</td>
<td>Unknown</td>
<td>100</td>
<td>Local</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Pennsville</td>
<td>Ganes Chemicals</td>
<td>Chemical</td>
<td>1972</td>
<td>160</td>
<td>International</td>
<td>Yes</td>
<td>Active</td>
</tr>
<tr>
<td>Salem</td>
<td>Aluchem</td>
<td>Chemical</td>
<td>1981</td>
<td>12</td>
<td>National</td>
<td>No</td>
<td>Active</td>
</tr>
</tbody>
</table>

Township is the primary township where the plants operations are physically located.

Location of the company's headquarters is defined as local (in Salem County or New Castle County, DE), regional (in New Jersey, Pennsylvania or Delaware), national (anyplace else in the United States) and international (outside the United States).

Sources: Information regarding type of facility and reporting years was extracted from the EPA TRI Explorer, 2001. Information on employment was gathered from the NJDEP New Jersey CRTK Public Access System – Facility List, and from individual company websites. Year established and headquarters were gathered from individual company websites and local news and history sources.
and has received numerous accolades. An additional chemical facility, the Xerxes Corporation, manufactured fibreglass in Penns Grove but the company closed the plant in the early 1990s.

Pennsville has four active facilities, the most important of which is the large DuPont Chambers Works. The seven hundred acre complex employs 1400 workers and contains a number of divisions that produce a variety of products, including plastics, resins, elastomers, surface and finishing agents and oils, and industrial organic chemicals. A 1967 visitors guide to the plant still aptly describes its functions:

“While Chambers Works is encircled by a single fence, it is really a community of manufacturing plants. Each produces its own list of products, but the interdependence of chemicals is such that the entire plant is crossed and re-crossed by complex bonds of relationships. A chemical made in one area becomes an ingredient for another area, and the product of the second area may return to the first to assist in the production of still another” (DuPont 1967:4).

The complex has a number of other tenants, including Union Carbide and the DuPont Dow Elastomers Partnership, which registers to the TRI independently of the Chambers Works. The facility is also home to DuPont Environmental Treatment, the world’s largest commercial and industrial wastewater treatment facility. The facility processes wastes from DuPont and its tenants, and accepts a variety of hazardous wastes from various facilities across the country. The facility’s water treatment plant treats wastes and recycles them or discharges them into the Delaware River; otherwise the waste can be incinerated or dumped into the company’s landfill, or shipped to a different location for additional treatment or disposal (DuPont 1999b).
The other two facilities in Pennsville are the Deepwater Generating Station, a large power utility that uses natural gas, fuel oil, and coal, and the Ganes Chemical Company. Unlike the other facilities in Pennsville and Carneys Point, Ganes is located in the southern half of Pennsville, distant from the major cluster of industry and south of the major concentration of residents. Ganes specializes in medicinal chemicals and botanical products. The other major facility in the county is Mannington Mills, located just within the city limits of Salem. The company produces linoleum and vinyl floor coverings and is the second largest employer and second oldest company in the county. The City of Salem has one other small chemical company, as does the City of Elmer (located in the eastern part of the county), that both tended to be under the minimum thresholds for reporting.

The DuPont Chambers Works had the most releases in 1999, accounting for eighty-three percent of the county’s total emissions (Table 3.2), with over three million pounds of releases. Eighty-three percent of DuPont’s emissions were released into the Delaware River, eleven percent was emitted into the air and the remaining four percent was dumped into the plants on site landfill. In contrast, the majority of all other releases in the county were emitted into the air. The Deepwater Generating plant emitted eleven percent of the county’s releases, while the remaining eight facilities released the other six percent of emissions. Emissions were concentrated in the northern part of Pennsville and the southern part of Carneys Point (Figure 3.5).

Aggregate emissions for 1987 to 1999 reflect DuPont’s dominance in pollutants (Table 3.3). The plant released close to forty-two million pounds of emissions during this period, ninety-one percent of the total emissions reported to the TRI. The B.F. Goodrich Company ranked second for total releases, the majority of which were released in 1987.
### Table 3.2 TRI Emissions in Salem County 1999

<table>
<thead>
<tr>
<th>Facility</th>
<th>Township</th>
<th>Emissions (lbs)</th>
<th>% Total Emissions</th>
<th>Primary Media</th>
<th>Number of Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>DuPont Chambers Works*</td>
<td>Pennsville</td>
<td>2,893,559</td>
<td>79</td>
<td>Water,Air</td>
<td>72</td>
</tr>
<tr>
<td>Deepwater Generating</td>
<td>Pennsville</td>
<td>387,856</td>
<td>11</td>
<td>Air</td>
<td>3</td>
</tr>
<tr>
<td>Budd Chemical</td>
<td>Carneys Point</td>
<td>147,298</td>
<td>4</td>
<td>Land</td>
<td>2</td>
</tr>
<tr>
<td>Carneys Point Generating</td>
<td>Carneys Point</td>
<td>59,191</td>
<td>2</td>
<td>Air</td>
<td>3</td>
</tr>
<tr>
<td>Ganes Chemicals</td>
<td>Pennsville</td>
<td>47,550</td>
<td>1</td>
<td>Air</td>
<td>6</td>
</tr>
<tr>
<td>Polyone</td>
<td>Oldmans</td>
<td>19879</td>
<td>½</td>
<td>Air</td>
<td>3</td>
</tr>
<tr>
<td>Oxy Vinyls</td>
<td>Oldmans</td>
<td>7089</td>
<td>&lt; ½</td>
<td>Air</td>
<td>2</td>
</tr>
<tr>
<td>Mac Specialty Coatings</td>
<td>Penns Grove</td>
<td>2000</td>
<td>&lt; ½</td>
<td>Air</td>
<td>4</td>
</tr>
<tr>
<td>B.F. Goodrich</td>
<td>Oldmans</td>
<td>397</td>
<td>&lt; ½</td>
<td>Air</td>
<td>8</td>
</tr>
<tr>
<td>DDE Chambers</td>
<td>Pennsville</td>
<td>23</td>
<td>&lt; ½</td>
<td>Air</td>
<td>2</td>
</tr>
</tbody>
</table>

*Emissions from the DuPont facility were divided into two parts, with emissions to the land being allotted to Carneys Point and emissions to the air and water allotted to Pennsville. In total, DuPont emissions were 3,040,857 lbs, accounting for 83% of the total emissions from Salem County in 1999.

Source: Data extracted from EPA *TRI Explorer*, 2001.
Figure 3.5
TRI Emissions
Emissions data extracted from the EPA TRI Explorer
Basemap data provided by ESRI
Table 3.3 TRI Emissions in Salem County 1987 - 1999

<table>
<thead>
<tr>
<th>Facility</th>
<th>Township</th>
<th>Years Reported</th>
<th>Emissions (lbs)</th>
<th>% Total</th>
<th>Primary Media</th>
<th>Facility Inactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>DuPont Chambers Works*</td>
<td>Pennsville</td>
<td>1987-99</td>
<td>39,023,253</td>
<td>85</td>
<td>Water, Air</td>
<td></td>
</tr>
<tr>
<td>B.F. Goodrich</td>
<td>Oldmans</td>
<td>1987-99</td>
<td>2,697,918</td>
<td>6</td>
<td>Land</td>
<td></td>
</tr>
<tr>
<td>Ganes Chemicals</td>
<td>Pennsville</td>
<td>1987-99</td>
<td>1,453,683</td>
<td>3</td>
<td>Water, Air</td>
<td></td>
</tr>
<tr>
<td>Deepwater Generating</td>
<td>Pennsville</td>
<td>1998-99</td>
<td>977,867</td>
<td>2</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Xerxes Corporation</td>
<td>Penns Grove</td>
<td>1987-89</td>
<td>282,000</td>
<td>½</td>
<td>Air</td>
<td>X</td>
</tr>
<tr>
<td>Budd Chemical</td>
<td>Carneys Point</td>
<td>1987-99</td>
<td>266,247</td>
<td>½</td>
<td>Air, Land</td>
<td></td>
</tr>
<tr>
<td>Polyone (Geon)</td>
<td>Oldmans</td>
<td>1993-99</td>
<td>231,589</td>
<td>½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Carneys Point</td>
<td>Carneys Point</td>
<td>1998-99</td>
<td>132,072</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Mannington Mills</td>
<td>Mannington</td>
<td>1987-98</td>
<td>103,227</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Exxon Chemical</td>
<td>Oldmans</td>
<td>1987-91</td>
<td>36,968</td>
<td>&lt; ¼</td>
<td>Air</td>
<td>X</td>
</tr>
<tr>
<td>Pedricktown</td>
<td>Oldmans</td>
<td>1998</td>
<td>19,250</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Cogeneration</td>
<td>Penns Grove</td>
<td>1991-99</td>
<td>15,621</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Mac Specialty Coatings</td>
<td>Pennsville</td>
<td>1996-99</td>
<td>7,089</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>DDE Chambers</td>
<td>Salem</td>
<td>1987</td>
<td>1,664</td>
<td>&lt; ¼</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Aluchem</td>
<td>Elmer</td>
<td>1989</td>
<td>500</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>United Resins</td>
<td>Elmer</td>
<td>1987</td>
<td>250</td>
<td>&lt; ½</td>
<td>Air</td>
<td></td>
</tr>
</tbody>
</table>

Total DuPont Chambers Works emissions were 41,721,171 lbs, or 91% of the total emissions from Salem County between 1987 and 1999.

The rankings are not truly representative of the total actual emissions in the county, due to the exclusion of power plants in the TRI up to 1998. The Deepwater plant released over 872,000 pounds in just two years, in all likelihood it would be ranked as the number two polluter if its total emissions from 1987 had been recorded. Likewise, the Carneys Point Generating Plant, in operation since 1994, would also be higher on the list if actual releases were reported. If they had been reported, the concentration of pollutants in northern Pennsville and southern Carneys Point would be intensified. Aggregate releases for the total reporting years reflect a more geographically dispersed release of pollutants, due to the larger amount of releases in Oldmans in the late 1980s, and smaller releases spread throughout the Industrial Corridor. It important to bear in mind the actual dispersion of pollutants. Since prevailing winds tend to be from the southwest, Carneys Point, Penns Grove, and Oldmans may be exposed to more of the air pollutants from Pennsville than the majority of Pennsville itself. Conversely, since water flows to the south, Pennsville is more exposed to the county’s water pollutants than areas to the north.

There is a highly complex relationship between chemical production and pollution; higher chemical production does not necessarily equate with higher chemical releases, nor is discharge reduction simply a function of better efficiency, as industry often claims (Smith and Gottlieb 1995:218). Pollution releases are a function of various chemical processes, sales and the business cycle in general, the increase of off site treatment, the introduction and elimination of specific facilities, limitations of the TRI data, and changes in TRI requirements which increases the number of chemicals and industries under regulation. 1987 and 1988 are considered to be unreliable years, because of low participation in reporting releases (only two thirds of all facilities required to
report actually did so) and because six major chemicals on the regulation list in 1987 were dropped in 1988 (Gottlieb et. al. 1995:132). More chemicals were added to the regulatory list in 1991 and 1995, and more industries were required to report beginning in 1998.

The trends for individual facilities will be examined first, in order to have a better understanding of the overall trend. The B.F. Goodrich Company had the largest amount of emissions in the northern part of the Industrial Corridor. The company released over one million pounds of pollutants in 1987, the majority of which was discharged into the Delaware River and its tributaries. Its emissions fell by over ninety percent in 1988, and between 1993 and 1999 its emissions average 470 pounds a year, all released into the air. The company sold off most of its facilities to the Geon Company (which later became Polyone) (OxyVinyls 2001). Emissions in the northern half of the county were practically zero between 1991 and 1992 (Figure 3.6) as the Xerxes and Exxon plants went out of business. Emissions increased after Geon began operations, and decreased in 1998 and 1999, as three different companies formed mergers to create Polyone and Oxy Vinyls, the latter of which came into operation in 1999. Mac Specialty Coatings maintained constant emissions of 2000 lbs a year between 1994 and 1999.

Major companies in the southern half of the county reported higher emissions than companies in the north. The Ganes Company accounted for the majority of emissions in this region until 1992, followed by a precipitous drop in 1993. Fluctuations in the Budd Chemical Company’s emissions between 1993 and 1997 may reflect turbulent changes in management during that time (Bercute 1997). These issues were resolved in 1996, and emissions increased dramatically in 1998 and 1999. Emissions at
TRI Emissions Trends for Various Facilities

TRI Emissions for Northern Facilities 1987 - 1999

- Xerox Corp
- Polyone
- Mac Specialty Coatings
- Oxy Vinyls

B.F. Goodrich reported emissions from 1987 to 1999 but was excluded from the graph because high emissions in 1987 and low emissions for all other years skewed the distribution.

TRI Emissions for Southern Facilities 1987 - 1999

- Ganes Chemical
- Budd Chemical
- Mannington Mills

Aluchem and United Resins were excluded from the graph because of low emissions and few reporting years.

TRI Emissions for Utilities 1998 - 1999

- Pedricktown Cogeneration 1998
- Carneys Point Generating 1999
- Deepwater Generating 1999

Power utilities were not required to report to the TRI until 1998. Pedricktown Cogeneration reported no emissions in 1999.

Figure 3.6
TRI Emissions Trends for Various Facilities
TRI data extracted from the EPA's Envirofacts Warehouse - TRI Data
Mannington Mills steadily declined since 1993 and dropped to zero in 1999, as the company has increased the transfer of chemicals to off-site recycling programs. The three major power facilities have only logged emissions since 1998; all three utilities had decreased emissions between 1998 and 1999. The large amount of emissions from the Deepwater plant relative to the Carneys Point plant is a reflection of Deepwater’s use of older, dirtier, and less efficient technology.

The DuPont Company experienced a number of fluctuations in its releases since 1987 (Figure 3.7), and given the fact that it is the primary source of emissions in the county, total releases in the county reflect DuPont trends. Releases increased dramatically between 1988 and 1989, possibly due to more reliable reporting to the TRI. Interestingly, as emissions to the water fell, as in 1991 and 1994, emissions to the air subsequently increased, possibly reflecting a change in disposal or other waste management methods. Emissions to the land have generally declined, possibly due to decreasing landfill space (NJDEP 2000), and emissions to the air have also decreased. Emissions to the water have increased substantially since 1995, except for the decrease for the latest reporting year. Some of this increase may be due to the increase in chemicals under TRI regulation in 1995, but it is doubtful that this factor explains the total increase. DuPont’s claim that they have “reduced toxics” (D’Amico 1999: S5) is questionable. The graphs clearly do not show a consistent reduction in overall pollutants. The county’s overall releases largely reflect DuPont’s trends, except for the increase in air toxins in 1998 and 1999, due to the inclusion of power utilities.

While DuPont is by far the largest employer and largest source of emissions, this relationship between emissions and employment does not extend to the other plants. For
Figure 3.7
TRI Emissions by Media for DuPont and Salem County 1987 - 1999

TRI data extracted from the EPA's Envirofacts Warehouse - TRI Data
example, Mannington Mills accounts for less than a half of one percent of the county’s total aggregate emissions, and actually had zero emissions in 1999, but is the second largest employer with eight hundred workers. In contrast, the Budd Chemical Company employs only thirty workers, but had aggregate emissions that were twice as high as Mannington Mills and was responsible for two percent of the county’s total emissions in 1999. This imbalance is even more marked when examining the power utilities, which are major sources of emissions but minor sources of employment. Even though these facilities provide much needed employment, most of them produce high levels of pollution relative to the number of persons they employ.

**Chemical Profile**

Eighty different chemicals were released into the environment in 1999; this paper will focus on the top twenty releases in more detail. This imposes some limitations, as the amount of a chemical does not necessarily relate to its toxicity, but due to the introductory nature of this study and time constraints, the top twenty releases will be sufficient as they represent ninety-seven percent of the total releases in the county. Table 3.4 lists the top twenty releases, their amount, media, source, and percent total that each release comprises. Table 3.5 is a generalized chart that attempts to illustrate how toxic the chemicals are in relation to each other, based on criteria used by the Environmental Defence Fund. Because chemicals have different effects based on their media and route of exposure, it is difficult to provide a uniform standard of toxicity. The EDF rankings attempt to provide a uniform standard based on a variety of toxicological studies of a chemicals effect on human health and on ecosystems. The number of studies conducted on a chemical differs, and thus poses a limitation. The hazard ranking provides a fraction
in order to illustrate the number of studies that have been conducted, and a decimal number that will help to indicate a chemical's toxicity relative to another. Finally, a chemical's toxicity will vary by time of exposure, emissions trends, and a variety of other factors, such as weather and dispersion patterns. Table 3.6 is the health profile of the top twenty chemicals, based on current scientific knowledge and information sheets provided by the US EPA, OSHA, and other US federal agencies. It lists the parts or systems of the body that the chemicals affect or target. These charts portray the types of chemicals released into the environment and their known effects under specific conditions, but these conditions do not necessarily reflect the effects of environmental exposure on nearby residents.

Nitrate compounds are the number one pollutant released in Salem County, representing over half of the total emissions released. DuPont is the only source of the compounds, which are all discharged into the Delaware River. Nitrates are used in various chemical processes, and are typically utilized as food preservatives and fertilizers. The compounds are harmful if ingested because they deplete the blood of oxygen, but pose no direct threat to humans when removed from drinking water through treatment. Residents who rely on private wells, which are common in rural areas like Salem County, are at higher risk. A study of wells in South Jersey found that six percent of the wells tested contained nitrate at levels that exceeded federal drinking water standards (Murphy 1998:3). Ecosystems are at higher risk, because nitrates are a primary cause of eutrophication, which depletes the amount of oxygen in bodies of water and stresses aquatic organisms. One study showed that shoreline plants that usually grow in

---

7 The study did not definitively state the sources of the contamination. In addition to production from industry, a major source of nitrate are agricultural fertilizers due to run-off.
Table 3.4 Top Twenty Chemical Releases by Volume 1999

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Total Emissions (lbs)</th>
<th>Air %</th>
<th>Water %</th>
<th>Land %</th>
<th>Manufacturer %</th>
<th>% Total Releases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Nitrate Compounds</td>
<td>1,979,603</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>Dupont 100</td>
<td>54</td>
</tr>
<tr>
<td>2 Hydrochloric Acid</td>
<td>442,462</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>Deepwater 86,</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Carneys Point 13,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dupont 1, DDE &lt; 1</td>
<td></td>
</tr>
<tr>
<td>3 Sodium Nitrite</td>
<td>261,879</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>Dupont 100</td>
<td>7</td>
</tr>
<tr>
<td>4 Ammonia</td>
<td>243,491</td>
<td>6</td>
<td>94</td>
<td>0</td>
<td>Dupont 99,</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Carneys Point 1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oxy Vinyls &lt; 1</td>
<td></td>
</tr>
<tr>
<td>5 Dichlorodifluoromethane</td>
<td>138,800</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>Dup 100</td>
<td>4</td>
</tr>
<tr>
<td>6 Methanol</td>
<td>103,119</td>
<td>100</td>
<td>&lt; 1</td>
<td>0</td>
<td>Budd 45, Ganes 31,</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dupont 24</td>
<td></td>
</tr>
<tr>
<td>7 Copper Compounds</td>
<td>40,327</td>
<td>0</td>
<td>11</td>
<td>89</td>
<td>Dupont 100</td>
<td>1</td>
</tr>
<tr>
<td>8 Formaldehyde</td>
<td>39,601</td>
<td>100</td>
<td>&lt; 1</td>
<td>0</td>
<td>Budd 95, Dupont 5</td>
<td>1</td>
</tr>
<tr>
<td>9 Chloromethane</td>
<td>35,577</td>
<td>99</td>
<td>1</td>
<td>0</td>
<td>Dupont 100</td>
<td>1</td>
</tr>
<tr>
<td>10 Dichlorotetrafluoroethane</td>
<td>35,021</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>Dupont 100</td>
<td>1</td>
</tr>
<tr>
<td>11 Zinc Compounds</td>
<td>33,184</td>
<td>0</td>
<td>37</td>
<td>63</td>
<td>Dupont 100</td>
<td>1</td>
</tr>
<tr>
<td>12 1,3-Phenylenediamine</td>
<td>32,757</td>
<td>3</td>
<td>1</td>
<td>96</td>
<td>Dupont 100</td>
<td>1</td>
</tr>
<tr>
<td>13 Nickel Compounds</td>
<td>27,230</td>
<td>0</td>
<td>54</td>
<td>46</td>
<td>Dupont 100</td>
<td>1</td>
</tr>
<tr>
<td>14 Vinyl Chloride</td>
<td>25,902</td>
<td>100</td>
<td>&lt; 1</td>
<td>0</td>
<td>Polyone 76, Oxy</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vinlys 24</td>
<td></td>
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<tr>
<td>15 2,4-Dinitrophenol</td>
<td>23,287</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>Dupont 100</td>
<td>½</td>
</tr>
<tr>
<td>16 Freon 113</td>
<td>16,366</td>
<td>100</td>
<td>&lt; 1</td>
<td>0</td>
<td>Dupont 100</td>
<td>&lt; ½</td>
</tr>
<tr>
<td>17 Chromium Compounds</td>
<td>14,620</td>
<td>0</td>
<td>9</td>
<td>91</td>
<td>Dupont 100</td>
<td>&lt; ½</td>
</tr>
<tr>
<td>18 2-Chloro-1,1,1,2-</td>
<td>13,539</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>Dupont 100</td>
<td>&lt; ½</td>
</tr>
<tr>
<td>Tetrafluoroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Toluene</td>
<td>10,785</td>
<td>90</td>
<td>2</td>
<td>8</td>
<td>Ganes 79, Dupont</td>
<td>&lt; ½</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17, Mac Specialty</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>5</td>
<td></td>
</tr>
<tr>
<td>20 Cyclohexane</td>
<td>10,129</td>
<td>94</td>
<td>6</td>
<td>0</td>
<td>Dupont 100</td>
<td>&lt; ½</td>
</tr>
<tr>
<td>Total</td>
<td>3,527,679</td>
<td>25</td>
<td>72</td>
<td>3</td>
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<td>97</td>
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</table>

Source: Data extracted from the EPA TRI Explorer, 2001.
<table>
<thead>
<tr>
<th>Chemical</th>
<th>Hazard Rank</th>
<th>Human Health</th>
<th>Ozone Depleter</th>
<th>Aquatic Life</th>
<th>Terrestrial Ecosystems</th>
<th>Aquatic Ecosystems</th>
<th>Atmospheric Persistence</th>
<th>Table 3.5 Health Profile for Top Twenty Chemicals Released 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclohexane</td>
<td>20</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Toluene</td>
<td>19</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2-Chloro-1,1,2-Trichloroethane</td>
<td>18</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Chlorinated Compounds</td>
<td>17</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Freon 113</td>
<td>16</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2,4-Dichlorophenoxyacetic Acid</td>
<td>15</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Atrazine</td>
<td>14</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nickel Compounds</td>
<td>13</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>12</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Zinc Compounds</td>
<td>11</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dichloroethene</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Chlorophenols</td>
<td>9</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>8</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Copper Compounds</td>
<td>7</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Methanol</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>5</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ammonia</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sodium Nitrite</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hydrochloric Acid</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nitric Compounds</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: The table shows the hazard rankings and health profiles for various chemicals, including their impact on human health, ozone depletion, aquatic life, and terrestrial ecosystems.
Table 3.6 Sites Targeted by Top Twenty Chemicals Released 1999

<table>
<thead>
<tr>
<th></th>
<th>Recognized</th>
<th>Suspected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nitrate Compounds</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Hydrochloric Acid</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Sodium Nitrite</td>
<td>X X X X</td>
</tr>
<tr>
<td>4</td>
<td>Ammonia</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Dichlorodifluoromethane</td>
<td>X X</td>
</tr>
<tr>
<td>6</td>
<td>Methanol</td>
<td>X X X</td>
</tr>
<tr>
<td>7</td>
<td>Copper Compounds</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Formaldehyde</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Chloromethane</td>
<td>X X X X</td>
</tr>
<tr>
<td>10</td>
<td>Dichlorotetrafluoroethane</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>Zinc Compounds</td>
<td>X</td>
</tr>
<tr>
<td>12</td>
<td>1,3-Phenylenediamine</td>
<td>X X X</td>
</tr>
<tr>
<td>13</td>
<td>Nickel Compounds</td>
<td>X</td>
</tr>
<tr>
<td>14</td>
<td>Vinyl Chloride</td>
<td>X X X X</td>
</tr>
<tr>
<td>15</td>
<td>2,4-Dinitrophenol</td>
<td>X X</td>
</tr>
<tr>
<td>16</td>
<td>Freon 113</td>
<td>X</td>
</tr>
<tr>
<td>17</td>
<td>Chromium Compounds</td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>2-Chloro-1,1,1,2-Tetrafluoroethane</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Toluene</td>
<td>X X X X X X X X X X</td>
</tr>
<tr>
<td>20</td>
<td>Cyclohexane</td>
<td>X</td>
</tr>
</tbody>
</table>

Car – Carcinogenic  
Card - Cardiovascular  
Dev – Developmental  
Gas – Gastrointestinal  
Imm – Immunological  
Kid – Kidneys  
Neu – Neurological  
Rep – Reproductive  
Res – Respiratory  
Skin – Skin  

brackish conditions extend farther upstream in the Delaware than they did earlier in the 20th century, while plants common to freshwater conditions have not been found as far downstream as they were in the past (Schuyler et al. 1993: 263-66).

Hydrochloric acid, which is used as a solvent, anti-corrosive agent, a cleaning agent, and as an additive to high-octane fuel, is the second largest pollutant, comprising twelve percent of total releases. The primary source was the Deepwater Generating Plant, which accounted for eighty-six percent of the amount released; the total amount was released to the air. The acid is rated as one of the ten most harmful chemicals to ecosystems and human health. It is primarily an irritant to the skin and respiratory system.

Five of the twenty chemicals are carcinogenic: Formaldehyde, nickel compounds, and vinyl chloride are recognized carcinogens as well as chemicals that are ranked in the top ten percent of most harmful chemicals to the ecosystem and human health, while chloromethane and toluene are suspected carcinogens as well as recognized developmental toxins. All five chemicals target more parts or systems of the body than the other fifteen. Despite the dominance of the DuPont Company in emissions, three of these chemicals are primarily emitted into the air by smaller facilities. Formaldehyde (ranked eighth) is emitted by the Budd plant in Carneys Point, vinyl chloride (ranked fourteenth) is produced by Polyone and Oxy Vinlys, and toluene (ranked nineteenth) is released primarily by Ganes, and to a lesser degree by DuPont and Mac Specialty Coatings. DuPont released all of the nickel compounds (ranked thirteenth), which were disposed of in the Delaware River and the landfill, as well as all of the chloromethane (ranked ninth). This is extremely significant because it implies that although certain areas
of the county (Oldmans) have lower levels of emissions than other areas (Pennsville), areas with lower emissions may be at higher risk due to the presence of more toxic chemicals (and as mentioned previously, all areas north of Pennsville will be exposed to its’ atmospherically released pollutants due to wind direction).

Out of the top twenty chemicals released in the county, nine are in the top ten percent of most harmful chemicals to the ecosystem (according to the EDF), and six are in the top ten percent of most harmful chemicals to human health. Four chemicals, which tend to be more benign to humans, deplete the ozone layer. The top three targeted organs or systems are the respiratory system (fourteen chemicals), neurological system (twelve), and the skin (eleven).

**Contaminated Sites**

Contaminated sites in Salem County are more evenly distributed than TRI emissions, since every township has at least one site, but there is still a clear geographic pattern of clustering (Figure 3.8). The overwhelming number of contaminated sites is in the Industrial Corridor, with the highest numbers in Penns Grove and Pennsville with twenty sites each, followed by Oldmans, with eighteen sites, while Carneys Point and Salem fall in the second interval.

The largest number of sites are classified as industrial, with the highest number in the IC except for Carneys Point, because Salem has five sites to its two (Table 3.7). A few of the contaminated industrial sites are listed in the TRI, including Deepwater Generating and DuPont in Pennsville, B.F. Goodrich in Oldmans, and the abandoned Xerxes plant in Penns Grove. Each one of these sites raises a number of different concerns. In Penns Grove, the state must negotiate with a company that is no longer in
A Contaminated site is defined as "a site where contamination of soil and/or ground water is confirmed at levels far greater than applicable cleanup criteria or standards" (NJDEP 2001).

Contaminated Sites data provided by NJDEP
Basemap data provided by ESRI
Table 3.7 Contaminated Sites Classification by Type 2001

<table>
<thead>
<tr>
<th>Township</th>
<th>Commercial</th>
<th>Gas Station</th>
<th>Industrial</th>
<th>Landfill</th>
<th>Residential</th>
<th>Property</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>Penns Grove</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td></td>
<td>20</td>
</tr>
<tr>
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<td>6</td>
<td>8</td>
<td>1</td>
<td>3</td>
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<td>4</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Carneys Point</td>
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<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>6</td>
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<td>3</td>
<td>5</td>
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<td></td>
<td>12</td>
</tr>
<tr>
<td>Cameys Point</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Salem</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Pilesgrove</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
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<tr>
<td>Elmer</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>5</td>
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<tr>
<td>Pittsgrove</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Upper Pittsgrove</td>
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<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Woodstown</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Mannington</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Alloway</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Lower Alloways Creek</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Quinton</td>
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<td>2</td>
<td></td>
<td></td>
<td></td>
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<td>2</td>
</tr>
<tr>
<td>Elsinboro</td>
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<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>24</strong></td>
<td><strong>35</strong></td>
<td><strong>12</strong></td>
<td><strong>17</strong></td>
<td><strong>11</strong></td>
<td><strong>13</strong></td>
<td><strong>124</strong></td>
</tr>
</tbody>
</table>

Of the 124 Contaminated Sites:

115 have on-site sources of contamination
3 have unknown sources of contamination
6 are closed cases with restrictions

Source: NJDEP Site Remediation Program *Known Contaminated Sites in New Jersey, 2001*. Classification scheme was created for this study.
the county. Contamination at the DuPont plant ranges from chemical contamination from the plants processes to radioactive contamination remaining from the Manhattan Project. Four areas within the plant, including a building and a parking lot, have elevated levels of uranium that are above acceptable US Dept of Energy guidelines (USACE 2000). The local newspaper reported that youths were trespassing at an abandoned petro-chemical plant in Oldmans (Shoer 2001b), raising the issue of injury and contamination. The industrial contaminated sites also include NL Industries, the county’s only Superfund site. The abandoned lead battery recycling and smelting plant is still undergoing clean-up and a recent report claims that the site poses no apparent hazard to public health (NJDHSS and CEHS 1998).

Gas Stations are the second most common contaminated site, which tend to be located in more populated areas. Contamination usually occurs when old, underground gasoline storage tanks begin to leak. A status report available for a gas station in Pennsville showed that volatile organic compounds (VOCs) and petroleum hydrocarbons had contaminated nearby soil and groundwater, but did not extend beyond the property (NJDEP 1999). New Jersey has a number of leaking gas stations (Bates 2001), and since gasoline contains many carcinogenic chemicals, the leaking of storage tanks is a major issue. A number of gas stations in New Jersey complained that oil companies were pressuring them economically, resulting in reduced profits, (Gottschalk 1994:11) and since leaking tanks are expensive to clean up and replace, many owners are forced out of business.

The number of residential properties with contaminated sites in Penns Grove is particularly worrying, the issue is even more pressing considering that this is the second
smallest but most densely populated township and it is ranked first (tied with Pennsville) with twenty contaminated sites. Old, underground fuel oil tanks are a possible source of residential contamination. The remaining types of sites are evenly distributed throughout the county.

**Water Quality**

A survey of community water systems, defined as systems that serve the same people year round, shows that water treatment is usually effective in eliminating toxins from public water systems. According to water safety records (EPA 2001d), there were ten health violations in Salem County between 1993 and 2000, four of which were for coliform. The remaining six violations occurred in Salem City’s water system between 1994 and 1996. The system was over the limits for Trihalomethanes (THMs), which are created as by-products of the chlorination process (Upton and Graber 1993:527).

There are some limitations to these water safety records. First, water treatment techniques primarily reflect older concerns of infectious diseases (which are still valid concerns) rather than more present concerns of increasing carcinogenic toxins (Meade and Earickson 2000: 199-200). So even though the water supply may meet safety specifications, these specifications may be outdated in some cases and may no longer adequately protect public health.

A second limitation of these water safety records is the failure to account for private wells, which are common in rural areas like Salem County. Studies have shown elevated nitrate levels in six percent of 792 wells surveyed in South Jersey (Murphy 1998:3) and high concentrations of mercury in twelve percent of 2239 wells surveyed in South Jersey (Murphy and Muessig 1995:4). In the latter study, eleven percent of fifty-
two wells surveyed in the county had levels higher than the MCL of 2 ug/L. Salem County had the third highest median level of mercury out of the seven counties studied (tied for second place with Camden County), and had the well with highest value out of all wells in the study, 42 ug/L.

Surface water is very polluted by agricultural and industrial sources. According to the EDF, thirty-two percent of surface waters have beneficial uses that are impaired or threatened, and both watersheds in the county have very serious water quality problems (EDF 2001). A 1998 survey of the Cohansey-Maurice watershed in Salem and Cumberland counties listed one hundred locations where water was impaired, with the primary problem listed as “biology moderately impaired.” There were a few serious problems, including elevated levels of chromium in a creek in Oldmans, ammonia and fecal coliform in the Salem River, and mercury in fish tissue in Memorial Lake just outside of Woodstown (EPA 1998). There is not a similar report for the Delaware River/Bay watershed, but it is likely that it is far more contaminated than the Cohansey Maurice by industrial point sources to the north and agricultural sources in the south.

**Other Pollution Sources**

In addition to toxic emissions and contaminated sites within the county, there are other types and sources of pollutants that should be briefly mentioned. Salem County is ranked in the fiftieth percentile for traditional criteria air pollutants\(^8\), with the exception of volatile organic compounds, in which it is one of the most polluted counties in the

---

\(^8\) Criteria air pollutants include sulphur oxides, carbon oxides, nitrogen oxides, ozone, volatile organic compounds, lead, and particulate matter. These were the first pollutants regulated in the United States under the Clean Air Act of 1970. Despite some overlap between the two groups, criteria air pollutants are considered as separate from TRI air toxins and are regulated by a different bureau and stored in a separate database. They are not a primary consideration in this study, because their levels in Salem County are average compared to the rest of the country.
entire U.S. The geographic pattern of criteria emissions mirrors that of toxic emissions, with the exception of one DuPont facility in the middle of Alloway township, which is a high emitter of VOCs (US EPA 1999b).

The county is also home to three nuclear power plants, which are the other major employers in the county with approximately two thousand workers. The plants are clustered together in sparsely populated Lower Alloways Creek. Salem 1 and Salem 2 were built in 1976 and 1981 respectively and use older technology that utilizes water directly from the Delaware River to cool the reactor (as opposed to a cooling tower). These two plants have been a subject of controversy and the sole target of environmental activism in the county, because the older technology kills many fish while allowing radioactive chemicals into the water, and because both plants had safety and structural problems in the past and were closed during the mid 1990s (Kaskey 2001ab). One study documented a rise in cancer mortality in the past two decades in persons over 65 who have lived downwind from the plants (Gould and Steinglass 2001). The plants have countered criticism by launching a marine-estuary enhancement program and recently had their water discharge permit renewed. The third plant, the Hope Creek Generating Station, was built in 1986 using newer technology. All three plants are owned by PSEG, the company that owns the Carneys Point Generating Plant. Although the plants are registered under the TRI, they have reported no emissions because they are regulated by a different federal agency, the Nuclear Regulatory Commission. Two of the three contaminated sites in Lower Alloways Creek are at the nuclear plants.

Finally, there are emissions from non-point sources and outside sources. Mobile sources, such as automobiles, contribute to pollution, and there may be elevated pollution
levels from the interstate systems that run through the northern Industrial Corridor. There are also emissions from sources outside of Salem County. The entire Philadelphia metro area lies north of Salem County and contributes significant levels of pollutants to the Delaware River, which then flows past Salem County. While water pollutants enter from points north, air pollutants tend to blow in from the southwest, immediately from Delaware. There is a heavy concentration of manufacturing around Wilmington, including a number of DuPont plants such as the Edge Moor facility, which lies across the river from Penns Grove. There is also a concentration of chemical plants in Delaware City, southwest of Lower Alloways Creek. A recent explosion of a sulphuric acid tank at one of the Delaware City refineries released a large pollution plume that was carried across the river and over Salem County (Montgomery 2001). Although this accident was an extreme event, it illustrates that Salem County is affected by trans-boundary pollution.

**Conclusion**

In summary, the chemical and utility industries are firmly rooted in the county, to the point where the local economy is extremely dependent on them. The DuPont Chambers Works employed the most workers and had the highest level of emissions by far. Emissions levels in the county have fluctuated over time, but the amount of aggregate emissions was not significantly lower in 1999 compared to 1987. Emissions are concentrated in the Industrial Corridor, with smaller levels in Salem and Elmer. Contaminated sites are also concentrated in the IC, but exist in lower numbers in every township. Wind and water direction alter townships’ levels of exposure to emissions, while porous soil and susceptibility to flooding might increase the risk of exposure. Five of the top twenty chemicals produced are carcinogenic, and many are known to be
harmful to human health and ecosystems, but the known effects of these chemicals do not necessarily apply to actual exposure within the county. Finally, the toxicity of the chemicals that are released can be more health threatening than the chemicals that are released in greatest volume.

The next chapter examines the associations between pollution in Salem County and health, as determined by an examination of mortality data. Variables that could indicate an uneven distribution of pollution and health effects in the county are also examined to determine if environmental disparity is an issue.
Chapter 4

HEALTH AND ENVIRONMENTAL DISPARITY

Introduction

This chapter examines the associations between mortality, pollutants, and socio-economic indicators within Salem County at the township level. An introductory discussion of mortality in New Jersey places Salem County within the broader context of the state. This is followed by an examination of mortality within Salem County and a geographical and statistical comparison of pollution sources, mortality, and cancer mortality. After these associations are examined, other factors that could influence the distribution of mortality relative to pollution sources are examined. Some of these factors, race, income, and poverty, will be given more detailed attention because they tie into the theme of environmental justice. The chapter concludes by tying all of the findings into a matrix that provides an overall picture of the associations between pollution, health, and environmental disparity in Salem County.

Mortality in New Jersey Versus Salem County

In 1998, 71,140 New Jersey residents died, of which 686 were residents of Salem County (NJDHSS 1998a). Although the number of deaths in Salem County comprised less than one percent of the state total, and it is ranked twenty-first out of the state’s twenty-one counties for total deaths, it has one of the highest crude death rates in New Jersey, ranking third (Table 4.1). New Jersey’s rate is 876.6 deaths per 100,000 residents, while Salem County’s rate is 1058.4 per 100,000. This apparent distribution of crude death rates throughout the state can be partly attributed to high numbers of elderly, retired
Table 4.1 New Jersey Mortality by County of Residence 1998

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Deaths</th>
<th>County</th>
<th>Crude Rate</th>
<th>County</th>
<th>Age-Adjusted Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bergen</td>
<td>7328</td>
<td>Cape May</td>
<td>1368.4</td>
<td>Essex</td>
<td>552.5</td>
</tr>
<tr>
<td>Essex</td>
<td>6947</td>
<td>Ocean</td>
<td>1322.9</td>
<td>Salem</td>
<td>539.7</td>
</tr>
<tr>
<td>Ocean</td>
<td>6480</td>
<td>Salem</td>
<td>1058.4</td>
<td>Cumberland</td>
<td>537.8</td>
</tr>
<tr>
<td>Middlesex</td>
<td>5551</td>
<td>Cumberland</td>
<td>1024.6</td>
<td>Atlantic</td>
<td>527.2</td>
</tr>
<tr>
<td>Monmouth</td>
<td>4971</td>
<td>Atlantic</td>
<td>1018.7</td>
<td>Camden</td>
<td>499.4</td>
</tr>
<tr>
<td>Union</td>
<td>4757</td>
<td>Union</td>
<td>950.2</td>
<td>Cape May</td>
<td>497.0</td>
</tr>
<tr>
<td>Hudson</td>
<td>4746</td>
<td>Essex</td>
<td>925.9</td>
<td>Hudson</td>
<td>495.1</td>
</tr>
<tr>
<td>Camden</td>
<td>4542</td>
<td>Camden</td>
<td>899.0</td>
<td>Mercer</td>
<td>473.6</td>
</tr>
<tr>
<td>Passaic</td>
<td>4072</td>
<td>Mercer</td>
<td>890.5</td>
<td>Gloucester</td>
<td>471.6</td>
</tr>
<tr>
<td>Burlington</td>
<td>3334</td>
<td>Warren</td>
<td>859.0</td>
<td>Passaic</td>
<td>458.9</td>
</tr>
<tr>
<td>Morris</td>
<td>3165</td>
<td>Bergen</td>
<td>853.6</td>
<td>Sussex</td>
<td>455.2</td>
</tr>
<tr>
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<td>Hudson</td>
<td>851.8</td>
<td>Union</td>
<td>439.8</td>
</tr>
<tr>
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<td>2425</td>
<td>Passaic</td>
<td>838.3</td>
<td>Ocean</td>
<td>439.5</td>
</tr>
<tr>
<td>Gloucester</td>
<td>1980</td>
<td>Monmouth</td>
<td>823.8</td>
<td>Warren</td>
<td>430.7</td>
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<td>Somerset</td>
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<td>Gloucester</td>
<td>798.7</td>
<td>Burlington</td>
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<td>1438</td>
<td>Burlington</td>
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<td>Middlesex</td>
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<td>Monmouth</td>
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<td>Morris</td>
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<td>354.2</td>
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<td>Warren</td>
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<td>665.6</td>
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<td>Hunterdon</td>
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<td>Bergen</td>
<td>344.5</td>
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<td>Other</td>
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<td>Other</td>
<td>NA</td>
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<tr>
<td>Unknown</td>
<td>62</td>
<td>Unknown</td>
<td>NA</td>
<td>Unknown</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>71,140</td>
<td>Average</td>
<td>876.6</td>
<td>Average</td>
<td>441.8</td>
</tr>
</tbody>
</table>

Crude rates are per 100,000 estimated county population

Age-Adjusted rates are per 100,000 based on 1940 standard population

residents, which would explain why the shore counties of Cape May and Ocean rank first and second (Figure 4.1).

When the death rate is adjusted for age, Salem County has the second highest death rate, with 539.7 deaths per 100,000 residents, versus the state average of 441.9. The concentration of high rates is reduced in the shore counties of Cape May and Ocean, but a clear geographical pattern of high mortality rates in southern New Jersey persists. This could be due to different life style patterns, different immigration patterns, lower rates of income, the presence of specific pollutants, or a combination of all of the above. Given the lower population levels of the south, the higher rates could also be indicative of statistical variation for this particular year, but a survey of mortality rates between 1994 and 1998 demonstrates a consistent pattern (Table 4.2). The same counties are in the top five for crude and age adjusted rates every year, with few exceptions. Essex, an urban county containing the City of Newark, is continuously in first place for age-adjusted rates for every year. Salem is continuously in the top five for crude rates, except for 1996, and age adjusted rates, except for 1997. Its second place status in 1998 is the highest it has been during the five-year period.

The two leading causes of death in the United States, New Jersey, and Salem County in 1998 were heart disease and cancer\(^1\), but in each case the rate in the county was higher than that of the state (NJDHSS 1998bc). Of the seven leading causes of death, Salem County had a higher rate than the state for five out of seven causes, and had a higher rate for the top four causes (Table 4.3). The rate of mortality for the age groups 25-44 years, 45-64 years, and 65+ years were also higher than the state’s rate.

\(^1\) New Jersey has the fifteenth highest cancer mortality rate out of the fifty states and Washington DC (CDC 2001).
New Jersey Mortality Rates 1998

Crude Death Rate 1998

Age-Adjusted Death Rate 1998

Rate per 100,000
580 - 690
770 - 900
920 - 1060
1320 - 1370

Crude rates are computed by 100,000 estimated county population.
Age-adjusted rates are computed per 100,000 based on the 1940 standard population.

Figure 4.1 New Jersey Mortality Rates 1998
Mortality data provided by NJDHSS
Basemap data provided by ESRI
Table 4.2 Top Five New Jersey Counties for Mortality Rates, 1994-1998

<table>
<thead>
<tr>
<th>Crude Death Rate</th>
<th>Rank</th>
<th>Age-Adjusted Death Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean</td>
<td>1</td>
<td>Essex</td>
</tr>
<tr>
<td>Cape May</td>
<td>2</td>
<td>Cumberland</td>
</tr>
<tr>
<td>Salem</td>
<td>3</td>
<td>Atlantic</td>
</tr>
<tr>
<td>Atlantic</td>
<td>4</td>
<td>Hudson</td>
</tr>
<tr>
<td>Cumberland</td>
<td>5</td>
<td>Salem</td>
</tr>
<tr>
<td>Ocean</td>
<td>1</td>
<td>Essex</td>
</tr>
<tr>
<td>Cape May</td>
<td>2</td>
<td>Cumberland</td>
</tr>
<tr>
<td>Salem</td>
<td>3</td>
<td>Salem</td>
</tr>
<tr>
<td>Atlantic</td>
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<td>Hudson</td>
</tr>
<tr>
<td>Essex</td>
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<td>Atlantic</td>
</tr>
<tr>
<td>Ocean</td>
<td>1</td>
<td>Essex</td>
</tr>
<tr>
<td>Cape May</td>
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<td>Camden</td>
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<td>Salem</td>
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<td>Atlantic</td>
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<td>Gloucester</td>
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<tr>
<td>Cape May</td>
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</tr>
<tr>
<td>Ocean</td>
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<td>Salem</td>
</tr>
<tr>
<td>Salem</td>
<td>3</td>
<td>Cumberland</td>
</tr>
<tr>
<td>Cumberland</td>
<td>4</td>
<td>Atlantic</td>
</tr>
<tr>
<td>Atlantic</td>
<td>5</td>
<td>Camden</td>
</tr>
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</table>

Table 4.3 1998 Mortality in New Jersey Versus Salem County

<table>
<thead>
<tr>
<th>Indicator</th>
<th>County Deaths</th>
<th>State Deaths</th>
<th>County Rate</th>
<th>State Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Deaths</td>
<td>687</td>
<td>71,140</td>
<td>539.7</td>
<td>441.8</td>
</tr>
<tr>
<td><strong>Age Group</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Under 1 year</td>
<td>8</td>
<td>728</td>
<td>---</td>
<td>6.4</td>
</tr>
<tr>
<td>0-14 years</td>
<td>17</td>
<td>1028</td>
<td>---</td>
<td>61.1</td>
</tr>
<tr>
<td>15-24 years</td>
<td>10</td>
<td>611</td>
<td>---</td>
<td>62.0</td>
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<tr>
<td>25-44 years</td>
<td>30</td>
<td>3702</td>
<td>161.9</td>
<td>144.7</td>
</tr>
<tr>
<td>45-64 years</td>
<td>113</td>
<td>10,777</td>
<td>789.4</td>
<td>602.8</td>
</tr>
<tr>
<td>65+ years</td>
<td>516</td>
<td>54,943</td>
<td>5093.3</td>
<td>4968.6</td>
</tr>
<tr>
<td><strong>Leading Causes of Death (State)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart Disease</td>
<td>229</td>
<td>23,045</td>
<td>150.9</td>
<td>119.1</td>
</tr>
<tr>
<td>Cancer</td>
<td>166</td>
<td>17,691</td>
<td>142.0</td>
<td>123.5</td>
</tr>
<tr>
<td>Stroke</td>
<td>41</td>
<td>4088</td>
<td>23.4</td>
<td>20.8</td>
</tr>
<tr>
<td>COPD*</td>
<td>31</td>
<td>2699</td>
<td>18.7</td>
<td>15.1</td>
</tr>
<tr>
<td>Pneumonia/Influenza</td>
<td>21</td>
<td>2402</td>
<td>10.8</td>
<td>10.8</td>
</tr>
<tr>
<td>Diabetes</td>
<td>19</td>
<td>2325</td>
<td>---</td>
<td>15.2</td>
</tr>
<tr>
<td>Unintentional Injuries</td>
<td>23</td>
<td>2008</td>
<td>36.8</td>
<td>21.4</td>
</tr>
</tbody>
</table>

* Chronic Obstructive Pulmonary Diseases

Age-adjusted rates are per 100,000 population based on the 1940 standard population.

This data suggests that a regional pattern of mortality does exist and that Salem is part of a broader trend, but the county clearly stands out as having higher mortality rates in general, and higher rates for leading causes of death and mortality rates within age groups in particular, when compared to New Jersey's rates. High mortality rates are not the function of lower population levels that increase statistical variation, otherwise the sparsely populated counties in the northwest would presumably have high rates as well, but they actually have some of the lowest rates. Since Salem County has one of the highest emissions rates for toxins and one of the highest mortality rates, it is possible that there could be some association between pollutants and mortality. An examination of Salem County at the township level will help to make a clearer determination.

**Mortality in Salem County**

The International Classification of Diseases was used to categorize mortality in Salem County (Table 4.4). Heart disease (Group 7) was the leading cause of death in Salem County over the five-year period from 1994 to 1998 (Table 4.5), followed by neoplasms (Group 2), respiratory disease (Group 8), injury and poisoning (Group 17), endocrine, nutritional and metabolic diseases and immunity disorders (Group 3), and digestive diseases (Group 9). Mortality rates have fallen slightly since 1995, but this may be the function of using 2000 population figures over the entire five years. Dividing the number of deaths in the earlier years by a population level that is lower than it was in the year of mortality produces slightly higher mortality rates. Overall, mortality and cancer mortality rates have remained fairly constant.

Mortality, and subsequently, mortality rates, are not evenly distributed throughout the county and are not necessarily a function of population levels (Table 4.6). For
Table 4.4 International Classification of Diseases - ICD-9-CM

1. Infectious and parasitic diseases (001-139)
2. Neoplasms (140-239)
3. Endocrine, nutritional, and metabolic diseases and immunity disorders (240-279)
4. Diseases of the blood and blood-forming organs (280-289)
5. Mental disorders (290-319)
6. Diseases of the nervous system and sense organs (320-389)
7. Diseases of the circulatory system (390-459)
8. Diseases of the respiratory system (460-519)
9. Diseases of the digestive system (520-579)
10. Diseases of the genitourinary system (580-629)
11. Complications of pregnancy, childbirth, and the puerperium (630-676)
12. Diseases of the skin and subcutaneous tissue (680-709)
13. Diseases of the musculoskeletal system and connective tissue (710-739)
14. Congenital anomalies (740-759)
15. Certain conditions originating in the perinatal period (760-779)
16. Symptoms, signs, and ill-defined conditions (780-799)
17. Injury and Poisoning (800-999)

Source: Duke University Medical School, 2001.
Table 4.5 Mortality in Salem County by Cause of Death 1994-1998

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>14 - Congenital Anomalies</td>
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<td>2</td>
<td>11</td>
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<td>3</td>
<td>1</td>
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<td><strong>Total</strong></td>
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<td><strong>716</strong></td>
<td><strong>697</strong></td>
<td><strong>689</strong></td>
<td><strong>686</strong></td>
<td><strong>3499</strong></td>
<td><strong>699.8</strong></td>
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Mortality Rate 11.1 11.1 10.8 10.7 10.7 10.9

Cancer Mortality Rate 2.7 2.8 2.7 2.4 2.6 2.6

Mortality and cancer mortality rates are per 1000 persons based on 2000 census.

Table 4.6 Mortality Rates by Township

<table>
<thead>
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<td>Quinton</td>
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<td>1.08</td>
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<td>Filesgrove</td>
<td>6.22</td>
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<td>Lower Alloways</td>
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<td>0.97</td>
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<tr>
<td>Creek</td>
<td>6.70</td>
<td>0.97</td>
<td>62</td>
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<td>1851</td>
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</table>

Both mortality rates are based on the average number of deaths over the five-year period 1994 to 1998 and on the 2000 census. Adjusted mortality rates for persons under 65 are based on the population that is under 65, and were adjusted to remove injury and poisoning (ICD group 17) as a cause of death.

example, Pittsgrove has about 1300 more residents than Carneys Point, but over the course of five years, Carneys Point had over 200 more deaths than Pittsgrove and a mortality rate that is twice as high. Geographically, high mortality rates are clustered in the small urban areas of Salem, Woodstown, and Elmer, with the second highest concentration in the Industrial Corridor (with the exception of Oldmans). Further investigation revealed that five townships with nursing homes and hospitals had higher mortality rates than townships that did not have these facilities. Salem and Elmer are also home to the county’s two hospitals. Nursing homes and hospitals tend to cluster sick and elderly residents in one geographical area, thus increasing the rate of mortality. The effects of this clustering are more apparent in Salem, Elmer, and Woodstown due to their small size and population, and less apparent in areas such as Pittsgrove and Carneys Point, which are larger areas with larger populations that tend to dampen the effects of the clustering.

Mortality rates were calculated for residents under the age of 65 to overcome this dilemma, since persons under this age tend to be healthier and most likely would not live in a nursing home. Mortality rates for persons in Salem County aged 25 to 44 years and 45 to 64 years are also higher than the corresponding state averages. Additionally, the rates were adjusted to remove Group 17; the codes for deaths resulting from accident and injury, since the intent is to see whether or not pollution is associated with mortality, and in most instances Group 17 would not apply to this study. The result is the adjusted mortality rate for persons under the age of 65.

The geographical pattern changes slightly when examining this rate (Figure 4.2). Salem and Elmer remain as the townships with the highest rates of mortality with 4.06
Mortality rates are averages calculated for each township for the five year period 1994 to 1998. Rates are based on the 2000 census.

Adjusted Mortality Rate for Persons Under 65

Mortality rates for persons under 65 are averages calculated for the five year period 1994 to 1998. Rates are adjusted by removing ICD Group 17, Poisoning and Injury, and are based on the under 65 population according to the 2000 census.
and 3.47 deaths per 1000 residents respectively. The next interval contains all of the townships in the Industrial Corridor, plus most of the townships bordering the IC, with a few exceptions. The presence of the hospitals in Salem City and Elmer could continue to be the reason for high mortality rates there, as persons with severe illness may live near hospitals for safety and convenience. Salem City’s high rates could also be a function of a number of other socio-economic issues that are not as pressing in other townships, such as high poverty rates and higher rates of infectious disease compared to other townships, indicating a less healthy environment. Pollution is also a factor, even though the township has lower TRI emissions than the Industrial Corridor, it has higher levels than the rest of the county, and ranks fifth for number of contaminated sites. Penns Grove suffers some of the same health and socio-economic problems to a lesser degree, while pollution in that township is far greater. High population density is another factor, since health issues, environmental problems, and people are clustered in a small space. Urban areas in the United States tend to be less healthy than non-urban areas (Fitzpatrick and LaGory 2000: 6-9) and this may be reflected in urban areas in Salem County to a small degree. Even though parts of Salem County are urban, these areas are hardly comparable to large cities given their small size and low levels of population.

Statistically, there was little correlation between overall mortality and environmental contamination, since the location of healthcare facilities was a greater determinant of mortality rates. The correlation between pollution and health was greater when examining the adjusted mortality rates for persons under 65. The raw aggregate pollution values showed practically no correlation, since the overwhelming level of emissions in Pennsville skews the relationship. This is the case in almost every instance
where aggregate pollution values were correlated with another variable. There were moderate associations between the number of facilities and mortality under 65 \((r = .42)\), and surrogate emissions\(^2\) and mortality under 65 \((r = .49)\). The correlation for mortality under 65 and contaminated sites was slightly weaker, with a coefficient of .37.

Townships with high emissions levels tend to have slightly higher mortality rates (Figure 4.3). Salem and Elmer are the main outliers, since their mortality rates are high and their emissions levels are lower than the Industrial Corridor. Woodstown, Alloway, and Elsinboro have rates almost as high as the IC townships, but have no emissions. The association is statistically significant at a 93% level of confidence.

For contaminated sites, the Industrial Corridor townships are clustered near the top of the line of best fit due to their higher number of sites, and slightly higher mortality rates. Alloway and Woodstown have mortality rates that are only slightly lower, but they have less contaminated sites. Elmer and Salem are the main outliers, since their rates are proportionately higher than their number of sites. The association would be much stronger with the exception of these two townships. The association is not very significant, with only 83% confidence.

There is a moderate association between mortality for persons under 65 and the presence of pollutants, and this association would be stronger except that the two townships of Elmer and Salem had a large impact on the relationship, because they have higher mortality rates than the Industrial Corridor but have lower levels of pollution. Since Woodstown and Alloway’s mortality rates were nearly as high as some of the IC townships and their pollution levels were low, they also weaken the association.

\(^2\) As explained in chapter two, surrogate values were created for emissions levels for the purpose of the statistical study, because raw aggregate emissions were inappropriate for this task. Townships were ranked from 0 to 4, with 0 being no emissions and 4 being the highest level of emissions.
Figure 4.3 Plots for Mortality and Pollution

$r = .49$
Conf = 93%

$r = .37$
Conf = 83%

Contaminated Sites

Mortality Rate for Persons Under 65

Surrogate Emissions
Cancer Mortality in Salem County

There is a great deal of literature and scientific study that has established a connection between cancer and pollutants, as discussed in chapter one. Much of this literature focuses on occupational exposure, while fewer studies link cancer and environmental exposure. An imbalance within the county between estimated cancer mortality, calculated using a multiplier from the American Cancer Society to estimate local cancer statistics, and actual cancer mortalities, does exist and was introduced in chapter one. There are a high number of surplus cancer mortalities (actual cancer mortality higher than estimated mortality) in Carneys Point, Pennsville, and Salem City (Figure 4.4). It is significant that excess cases are clustered here, as Pennsville and Carneys Point are the focal points for industry and TRI emissions, and Salem City suffers from pollution and other health issues. All three townships also have high numbers of contaminated sites.

Statistically, there is a strong correlation between the difference between estimated and actual cancer cases and the presence of pollutants, with a coefficient of .68 for surrogate emissions with 96% significance and a coefficient of .56 for contaminated sites with 97% significance (Figure 4.5). Salem City is an outlier given its moderate emissions and number of sites and high surplus cases, while Oldmans is an outlier given its high emissions and number of sites and slight dearth of cancer mortalities, meaning the actual mortalities are slightly lower than the estimate. Despite these outliers, there is a clear geographical pattern and moderate to strong correlations, with a significance level of 99% for emissions and cases and 97% for sites and cases.

---

Difference Between Actual and Estimated Cancer Mortality

Estimated cancer mortality was calculated using a multiplier from the American Cancer Society for estimating local cancer statistics. Actual cancer mortality was calculated by averaging cancer mortality for each township for the five year period 1994 - 1998. The difference is the actual number of cancer mortalities greater than or less than the expected number of deaths. For this figure, the natural breaks method was used to establish intervals but was adjusted so all cancer mortality deaths fell into one interval.

Figure 4.4
Difference Between Actual and Estimated Cancer Mortality
Mortality derived from the NJDHSS New Jersey Vital Events Public Data Files
Base map data provided by ESRI
Figure 4.5 Plots for Pollution and Cancer Mortality

Cancer Mortality Rate for Persons Under 65

Difference Between Estimated and Actual

Cancer Mortality Rate for Persons Under 65

Surrogate Emissions

Surrogate Emissions

Cancer Mortality Rate

Difference Between Estimated and Actual

Correlation Coefficient: r = 0.45
Confidence: 91%

Correlation Coefficient: r = 0.56
Confidence: 97%

Correlation Coefficient: r = 0.57
Confidence: 96%

Correlation Coefficient: r = 0.68
Confidence: 96%
By repeating the methods used to examine overall mortality, the pattern for cancer mortality rates is similar. Salem, Woodstown, and Elmer have the highest five-year averaged rates (Figure 4.6). Salem’s rate is the highest, with almost four deaths per thousand residents, Woodstown is second with 3.57 and Elmer is third with 3.47 (Table 4.7). Once again, Carneys Point is ranked fourth, in the top of the second tier, but here the similarity between mortality and cancer rates ends. The Industrial Corridor is divided amongst the four intervals; Pennsville is ranked with Carneys Point but also Elsinboro and Alloway. Penns Grove is in the centre of the list, and Oldmans is towards the bottom.

The pattern of cancer mortality clustering in Salem, Woodstown, and Elmer may be due to the presence of healthcare facilities and retirement homes, as was the case for overall mortality. The average cancer rate for persons under 65 was examined and a different pattern emerges. Elmer and Salem remain at the top of the rankings and Woodstown does not, but surprisingly, Alloway has the highest cancer mortality rate for persons under 65, with 1.15 deaths per 1000 residents. Salem and Elmer have the next highest rates with 1.06 and 1.01 deaths per 1000 residents, while Oldmans ranks fourth, with 1.00 deaths per 1000 residents. Pennsville, Carneys Point, and Woodstown are ranked in the second interval. The persistence of Salem and Elmer in the top cancer rankings may be explained by the same factors that place both townships in the top mortality rankings, mainly Salem’s depressed status and socio-economic factors, and the presence of hospitals in both townships. Possible reasons for Alloway’s ranking as the top township for cancer for persons under 65 are less certain. It does not contain healthcare facilities and from a socio-economic stand point it is average compared to the other townships for poverty and income, and the majority of the population is white. In
Cancer Mortality Rates

Cancer mortality rates are averages calculated for each township for the five year period 1994 to 1998. Cancer is categorized as ICD Group 2, codes 140-239. Rates are based on the 2000 census.

Cancer Mortality Rate for Persons Under 65

Cancer mortality rates for persons under 65 are averages calculated for the five year period 1994 to 1998. Cancer is categorized as ICD group 2, codes 140-239. Rates are based on the under 65 population according to the 2000 census.

Figure 4.6 Cancer Mortality Rates
Rates are derived from the NJDHSS New Jersey Vital Events Public Data Files
Basemap data provided by ESRI
Table 4.7 Cancer Mortality Rates by Township

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<td>16</td>
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<tr>
<td>Salem</td>
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<td>31</td>
<td></td>
</tr>
<tr>
<td>Elmer</td>
<td>1.01</td>
<td>24</td>
<td>7</td>
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<tr>
<td>Oldmans</td>
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<td></td>
</tr>
<tr>
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<td>.74</td>
<td>64</td>
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</tr>
<tr>
<td>Pittsgrove</td>
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<td>Pilesgrove</td>
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<td>Elsinboro</td>
<td>.37</td>
<td>17</td>
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<td>Upper Pittsgrove</td>
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<td>28</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Lower Alloways</td>
<td>.32</td>
<td>18</td>
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</table>

Both cancer mortality rates are based on the average number of deaths over the five-year period 1994 to 1998 and on the 2000 census. Cancer mortality rates for persons under 65 are based on the population that is under 65.

terms of pollution, it registered no TRI emissions and only has three contaminated sites, one of the lowest levels in the county. There are two other pollution issues that this study’s data does not take into effect. First, a DuPont facility in Alloway emits high levels of Volatile Organic Compounds (VOCs), which are not registered with the TRI but are registered under the EPA’s AIRS database for criteria air pollutants (US EPA 1999b). Second, Alloway has the only active municipal landfill in the county. It is speculation that these two sources of pollution could be the source of higher cancer rates in the township; socio-economic factors will be examined in more detail in the following section.

Statistically, there are very weak associations between overall cancer mortality and the presence of pollutants, but similar to the mortality data, the cancer mortality rate for persons under 65 is more significant than the total cancer rates. In fact, the association between cancer for persons under 65 and pollution is stronger than the associations between mortality and pollution. The two correlations for TRI emitting facilities, surrogate emissions levels, and cancer mortality for persons under 65 are .57 (Refer back to Figure 4.5). Alloway and Elmer are the main outliers, due to their high rates and low emissions levels, while Woodstown is an outlier to a lesser degree. Six other townships with no emissions and low rates are clustered to the left of the graph, below the line of best fit. The association is significant at a 97% confidence level. The association between cancer mortality and contaminated sites is slightly weaker, with a coefficient of .45 and a confidence level of 91%. Once again, Alloway and Elmer are the main outliers, with Woodstown a minor outlier.
Mortality in Salem County – Summary

A statistical and geographical examination has shown that there is a moderate association between high levels of pollutants and high levels of mortality for persons under 65 and cancer mortality for persons under 65, and given the large enumeration districts used in this study (large districts can often dilute results due to aggregation), these findings are noteworthy. The correlations between pollution and cancer mortality were stronger and more statistically significant than the correlations between pollution and overall mortality. This is presumably because the overall mortality rates for persons under 65, even after removing ICD Group 17 injury and poisonings, still contain causes of death that cannot be attributed to pollution, such as diabetes, mental illness, and AIDS. The links between cancer and toxic pollutants are more established, making cancer mortality rates a better measurement of the effects of toxic pollutants.

Amongst the pollution variables, correlations and significance levels between surrogate emissions and the health variables were stronger than the correlations for contaminated sites and the health variables, while the strength of the associations between number of facilities and health fell in between the two. The amount of TRI emissions was more important than the number of contaminated sites, possibly due to emissions patterns and the extent of exposure. Even though contaminated sites are spread throughout the county, TRI emissions are concentrated in the most populated areas, and wind and water (water to a lesser degree) disperse emissions over a wider area. In contrast, contaminated sites are highly localized and affect a smaller population. The uncertainty regarding the types of contaminants at the sites and the extent of the contamination make a firm determination difficult. Interestingly, these different sources
of pollution are strongly related (Figure 4.7). The correlation between contaminated sites and TRI facilities is .90 with 99% confidence, and the relationship between sites and surrogate TRI emissions is .92 with 99% confidence. Therefore, a township with high TRI emissions also has high numbers of contaminated sites, and as discussed in chapter three, some of these sites are directly related to industry.

Geographically, mortality and cancer mortality rates for persons under 65 were concentrated in Salem, Elmer, and the townships in the Industrial Corridor. All of these townships had high emissions and number of contaminated sites, except for Elmer, which had low emissions and an average number of sites. Even though heavily polluted townships had the highest mortality and cancer mortality rates for persons under 65, their rates were not proportional to the amount of emissions or number of sites. For instance, Oldmans and Salem had higher cancer mortality rates than Pennsville or Carneys Point, which had higher levels of emissions. This suggests that types of pollutants, deposition patterns, and socio-economic factors are also influencing mortality rates.

Some alternative factors for high mortality rates have been discussed, such as the presence of hospitals in Salem and Elmer. The presence of noxious industry not listed in the databases used in the study may be a factor for high cancer mortality rates for persons under 65 in Alloway, which has no TRI facilities and few contaminated sites, but this is uncertain. There are a number of factors other than pollution that might explain high mortality rates in certain townships, and some of these factors are examined in the next section.
Figure 4.7 Plots for Pollution and Population

Contaminated Sites

1. $r = .92$, Conf. = 99%
2. $r = .57$, Conf. = 97%
3. $r = .90$, Conf. = 99%
4. $r = .59$, Conf. = 98%
Mortality and Confounding Factors

In order to make a firmer determination regarding the relationship between pollution and health, it is necessary to examine some of the other factors that affect health and mortality. This section will discuss the influence of density, migration, age, and gender on mortality. Race and socio-economic status are also factors that influence health, but they will be explored in the following section on Environmental Justice.

It has been determined in previous sections that the most populated townships contain the highest number of facilities, highest levels of emissions, and highest number of contaminated sites. Statistically, the association between surrogate emissions and population is .59, while the association between population and contaminated sites is .57, both with high levels of significance. The association is weakened by Pittsgrove, which has many residents, no emissions, and few sites, and Oldmans, which has high emissions, many sites, but few residents. This association is relevant because it demonstrates that the majority of the population lives in areas with high exposure to pollutants. Interestingly, there is a moderate inverse relationship between population change and emissions levels, with a coefficient of -.36, indicating that areas of high pollution were losing a greater percentage of residents than areas with no pollution, but this relationship had a significance level of only 74%.

Of greater importance is population density. High densities cluster people, high levels of pollutants, and disease into a small area. Based on the previous section, areas with high densities, like Elmer, Woodstown, Salem, and the townships in the Industrial Corridor (except Oldmans) also tended to have high mortality rates. Statistically, the associations between cancer mortality and density are weak, with a moderate association
with a coefficient of .46 for mortality for persons under 65 and density. When density is compared to emissions levels, the relationship is weak with a coefficient of .27, but the relationship between contaminated sites and density is stronger, with a coefficient of .48 at a 93% level of confidence. In summation, density could influence mortality rates, and densely populated areas are more likely to have higher numbers of contaminated sites.

Migration influences health because people can bring diseases with them as they move, or the causes that led to the development of cancer in a person could have been initiated in another place. This study controlled for migration at the outset by selecting Salem County as the case study, because population levels are static and migration is low. This study attempted to account for migration at the township level by examining the state of birth for the deceased, to determine if high numbers of persons born outside the region could be responsible for higher mortality rates. Of the total number of persons who died in the county between 1994 and 1998, seventy percent were born in the region (New Jersey, Pennsylvania, and Delaware), twenty-one percent were born outside the region, and eight percent had state of birth listed as unknown. Unfortunately, a study of place of birth at the township level proved inconclusive, because the most polluted townships also had the highest percentages of residents whose place of birth was unknown. Given the fact that at least seventy percent of the deceased were born in the region and that population growth has been stagnant for several decades, migration is probably not a major influence on mortality rates in Salem County.

The most basic factor to account for is age, and this study controlled for age by examining the mortality and cancer mortality rates for persons under 65. The percentages of young and elderly are similar to New Jersey’s average, and the percentage of residents
under 65 varies between townships from eleven percent to twenty-one percent, with the majority falling below sixteen percent. Due to low population levels, the effects of nursing homes and hospitals clustering sick and elderly residents in certain townships created noticeably higher mortality rates. This is confirmed by higher life expectancies in Woodstown and Elmer. The average age of death for residents who died between 1994 and 1998 varied from 68 to 78 between townships, but there were only weak relationships between the average age of death and pollution levels, suggesting life expectancy could not be correlated with pollution levels. Other multiple factors besides pollution are more important in determining overall life expectancy.

Gender is an issue, because women live longer than men and are susceptible to different diseases at different rates then men. The percentage of women to men is fifty-two to forty-eight for the entire county, and is roughly equal in every township, with the percentage of female residents ranging from forty-eight to fifty-four percent. The average percentage of female versus male deaths between 1994 and 1998 was equal, fifty percent for each, and most of the townships reflected this even division. Cancer death rates were roughly equal for both genders, but rates for mortality and cancer mortality for persons under 65 were higher for men. It is uncertain why this is the case, except that certain occupations where men constitute a majority of employment may make them more susceptible to exposure/disease, or the numbers simply reflect that more women live past the age of 65 than men. Correlations for all female mortality rates demonstrated no meaningful relationships.

In summary, density was the only other major factor that could account for high mortality rates, with some moderate statistical correlations and a clear geographic pattern.
Townships with high pollution tended to be densely populated and tended to have high mortality and cancer mortality rates for persons under 65, while more rural townships with low or no pollution had lower mortality rates. Migration and the clustering of age groups have been controlled for at the outset and are not major factors. Low life expectancy and female mortality could not be correlated with pollution levels.

**Environmental Justice and Race**

Race is a central issue in this study, because there are systematic biases in mortality and life expectancy according to race, but also because it is one of the major variables used to determine environmental disparity. As discussed in chapter one, a review of environmental justice literature demonstrated that environmental disparities occurred more often by race than by income (Goldman 1994:7-8). The African American population is compared to the presence of pollution to determine if they shoulder a disproportionate amount of pollution, and the African American population is compared to African American mortality to determine if an imbalance in health exists. An examination of mortality rates, cancer mortality rates, and rates for persons under 65 was not attempted, because the number overall number of mortalities was too small to be statistically meaningful.

African Americans account for fifteen percent of Salem County’s population and accounted for, on average, fifteen percent of all deaths in Salem County between 1994 and 1998, so the percentage of deaths corresponds to the population percentage. The townships with the largest percentages of African Americans are Salem, Penns Grove, Mannington, Carneys Point, and Quinton, where blacks comprise between thirteen and fifty-seven percent of the population (Figure 4.8). Salem City is the only township where
African American Population and Mortality

African American Population 2000

African American Mortality Percentage

Figure 4.8
African American Population and Mortality
Population data provided by US Census Bureau
Mortality data derived from NJDHSS
New Jersey Vital Events Public Data Files
Basemap data provided by ESRI

African American mortality percentage is an average percentage calculated for the five year period 1994 to 1998.
African Americans represent the majority of the population. Three of the five townships, Salem, Penns Grove, and Carneys Point, have TRI facilities and large numbers of contaminated sites, while two, Mannington and Quinton, do not. Sixty-nine percent of all African Americans in the county live in Salem, Penns Grove, and Carneys Point, while only eight percent live in Mannington and Quinton.

The percentage of black mortality is similar to the population percentage in each township, with the highest percentages in Salem, Penns Grove, and Mannington. Even though Salem and Penns Grove fall in the top intervals for population and mortality, the percentage of African American mortality is noticeably lower than their percentage of the population (Table 4.8), which indicates that a disproportionate number of white residents are dying in these townships. The percentage of black mortality in Carney's Point is roughly equal to the population percentage, but black mortality percentages in the low pollution townships of Mannington and Quinton were higher than the population percentages. Other townships that have disproportionate amounts of African American mortality are Woodstown and Oldmans. Age may be a factor in some of this inequity, since unadjusted mortality is being examined. This could account for higher black mortality percentages in Woodstown and Mannington, which both had high life expectancies.

Statistically, the relationships between the percentage of black residents and the and TRI emissions and the percentage of black mortality and TRI emissions are both weak. The strongest association is between contaminated sites and the percentage of black residents, with a coefficient of .36 and a confidence level of only 81% (Figure 4.9). All of the statistical relationships between pollution, mortality, and African American
Table 4.8 African American Mortality by Township

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<td>0.6</td>
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<td>8</td>
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<td>0.6</td>
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</table>

Figure 4.9 Plots for Pollution and Other Variables

- Plot 1: Population Percent Change vs. Surrogate Emissions with $r = -0.36$, Conf = 74%
- Plot 2: Incidence of Poverty 1990 vs. Contaminated Sites with $r = 0.48$, Conf = 94%
- Plot 3: Population Density vs. Contaminated Sites with $r = -0.36$, Conf = 81%
- Plot 4: African American Population Percentage vs. Contaminated Sites
residents are weak because Pennsville is a major outlier. Pennsville has the highest level of emissions by far and a large number of contaminated sites, but ninety-nine percent of the population is white.

Based on observations of race, it is difficult to completely confirm or deny the existence of environmental justice in Salem County as an issue. One could argue that it is an issue, because the three townships with the largest African American communities, comprising sixty-nine percent of the county’s total black population, have high levels of emissions and contaminated sites. One could argue against environmental disparity as an issue, because Pennsville has the highest levels of pollution and has practically no black residents, and statistically, the evidence to determine that environmental disparity exists is weak. While pollution may be high in certain townships with large black communities, whites actually comprise a disproportionate amount of mortalities relative to their population within these same townships. A study conducted at a finer level of enumeration, such as census tracts or block groups, would be necessary to make a stronger determination.

**Environmental Justice and Class**

Poverty and median income are measures of socio-economic status, which are important in considerations of health (poorer people tend to be in poorer health) and environmental justice. Even though race appears as a determinant of environmental justice more often than class, class is still an important issue that has appeared in many studies of environmental disparity, as discussed in chapter one. Studies have shown that health levels decline relative to income (Dunn 2001), and that the value of homes decreases relative to the proximity of noxious land use (Farber 1998: 6-8).
Based on estimates for 1997, Salem County’s median household income was $42,378 (US), which is about $5,500 less than the median income for the State of New Jersey (US Census 2000a). The 1997 estimates were not available at the township level, so data from the 1990 census was used (Figure 4.10). Most townships had median incomes between $30,000 and $39,000 (US), with three exceptions. Pilesgrove was at the high end of the scale with an income of $46,000, while Penns Grove and Salem City were at the low end of the scale, with incomes of $17,000 and $21,000 respectively. As discussed in chapter three, these townships were hit hardest by de-industrialization that began during the 1970s. These townships also have the largest African American populations in the county. Statistical correlations between pollution levels and poverty demonstrated weak associations. While Salem and Penns Grove are heavily polluted and have low incomes, other heavily polluted townships, like Pennsville and Oldmans, fall in the mid-range for median income.

Incidence of poverty, based on the 1997 estimates, was ten and a half percent in Salem County compared to nine percent for all of New Jersey (US Census 2000a). Once again, these estimates were not available at the township level, so data from the 1990 Census was used. The City of Salem and Penns Grove are separated from the other townships by a wide rift, with poverty rates of thirty-two percent and twenty-seven percent respectively. A comparison of poverty to pollution levels demonstrated weak relationships between TRI facilities and emissions, but the relationship between poverty and contaminated sites was moderate, with a coefficient of .49 and significance at a 94% level of confidence (Refer back to Figure 4.9). Penns Grove’s high number of sites and high poverty, plus the clustering of townships outside the Industrial Corridor to the lower
Median Income and Poverty

Median Income 1990

Income (1990 US Dollars)
- 17,100 - 21,430
- 30,400 - 35,400
- 36,470 - 39,120
- 46,370

TRI Emissions

Over Ten Contaminated Sites

Incidence of Poverty 1990

Percentage of Population in Poverty
- 4
- 5 - 6
- 7 - 8
- 27 - 32

TRI Emissions

Over Ten Contaminated Sites

Figure 4.10
Median Income and Poverty
Income and poverty data provided by US Census Bureau
Basemap data provided by ESRI
left of the graph, were responsible for the strength of the relationship. The Industrial Corridor townships of Oldmans and Carneys Point, despite their separation from Salem and Penns Grove’s poverty rates by a wide margin, still had poverty rates that were higher than several of the other townships, which also strengthened the relationship. Townships with high poverty tend to have high numbers of contaminated sites.

Overall, the link between low income and high poverty and the presence of pollutants is weak, with the exception of the moderate association between contaminated sites and poverty. The lack of any strong relationships is indicative of the class distribution within Salem County. With the exception of Salem and Penns Grove at one end of the spectrum and Pilesgrove at the other end, the other twelve townships fall within the midrange. While median income in the county is lower than the state’s median income, the gulf is even wider when examining per capita income. In 1999, Salem County had a per capita income of $25,162 (US), about $7,000 less than New Jersey’s income (US Census 2000a). Low per capita income, a dependence on manufacturing employment, a dearth of managerial and professional occupations compared to the state (Stansfield 1998: 221,226), and median income that is rather uniform across most of the county suggests that most of Salem County is comprised of working class people, with a few pockets of poverty and even fewer pockets of wealth. Therefore, a class-based study of environmental justice may not applicable here.

Poverty and income, as well as race, can act as variables that confound epidemiological studies, because they concentrate poor health in certain areas. Salem, with high rates of poverty and low rates of income, had high rates for mortality for persons under 65 and cancer mortality for persons under 65, and although Penns Grove
also had high mortality rates, it never had the highest mortality rates and was surpassed by other townships that were not impoverished. Statistical comparisons of income, poverty, and African American population show strong relationships between the variables. A comparison of these variables to health indicators demonstrates moderate relationships between mortality for persons under 65, but weak relationships for cancer mortality for persons under 65, which is the more important health indicator regarding pollutants. Income, poverty, and race are closely related and do influence mortality rates within Salem County, but given the wide gulf that separates Salem City and Penns Grove from the rest of the county, these two townships are more influenced by these factors than the rest of the townships.

**Summary and Conclusions**

Table 4.9 is a summary of the statistical correlations between pollution and the other variables made in this study, with the accompanying confidence levels for relationships that were charted. Based on the statistical calculations, there is a moderate association between pollution and mortality for persons under 65 and a stronger association between pollution and cancer mortality for persons under 65. Surrogate emissions levels are more strongly correlated with mortality variables than number of TRI facilities and contaminated sites. The pollution variables are all strongly correlated to one another. The association between population and pollution is strong, but correlations between pollution and other socio-economic variables are generally weak with a few notable exceptions.

Table 4.10 is a matrix containing the primary variables being studied (mortality) and factors that influence health. Townships were given an X if they ranked in the top six
### Table 4.9 Statistical Correlations

<table>
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<tr>
<th>Variable</th>
<th>Aggregate Emissions</th>
<th>Surrogate Emissions</th>
<th>Facilities</th>
<th>Contaminated Sites</th>
</tr>
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<tr>
<td>Mortality Rate</td>
<td>0</td>
<td>.27</td>
<td>.18</td>
<td>.16</td>
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<tr>
<td>Mortality Rate Under 65</td>
<td>.07</td>
<td>.49 (93%)</td>
<td>.42</td>
<td>.37 (83%)</td>
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<tr>
<td>Cancer Mortality Rate</td>
<td>.09</td>
<td>.28</td>
<td>.16</td>
<td>.15</td>
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<tr>
<td>Cancer Mortality Rate Under 65</td>
<td>.26</td>
<td>.57 (97%)</td>
<td>.57</td>
<td>.45 (91%)</td>
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<tr>
<td>Difference Between Estimated and Actual Cancer Mortality Cases</td>
<td>.54</td>
<td>.68 (99%)</td>
<td>.52</td>
<td>.56 (97%)</td>
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<td>Aggregate Emissions</td>
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<td>.52</td>
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<td>Surrogate Emissions</td>
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<td>X</td>
<td>.96</td>
<td>.92 (99%)</td>
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<td>Facilities</td>
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<td>.96</td>
<td>X</td>
<td>.90 (99%)</td>
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<td>Population %</td>
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<td>Poverty %</td>
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<td>.34</td>
<td>.26</td>
<td>.49 (94%)</td>
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Table 4.10 Matrix of Primary Variables

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Note: Depending on local break points within the data, Townships in bold had TRI emissions sometime between 1987 and 1999. Townships marked with an X are ranked among the top six Townships for each particular variable. In some instances, more or less than six Townships were ranked.
for the highest value for each variable. In some cases, more or less than six values were used, depending on logical break points within the data. Townships with TRI emissions or high numbers of contaminated sites were printed in bold. The majority of townships with high pollution levels also had the highest rates for mortality for persons under 65 and cancer mortality for persons under 65, had high population levels and densities, tended to be in the industrial corridor, and lost population between 1990 and 2000. The majority were not impoverished, some had high African American populations while other did not.

The majority of townships with no TRI emissions and low numbers of contaminated sites also had lower rates of mortality and cancer mortality for persons under 65. These townships tended to have low population levels and densities, no low levels of income or high levels of poverty; two had large African American communities, and all experienced only slight population loss or population growth. All townships were in either the Farm Belt or the Marginal Coastal Plain.

With a few exceptions, particularly the relatively high cancer rates in Alloway, a trend exists. The matrix makes this evident, because it does not place a value on pollutants or sites. Almost all townships with TRI emissions or over ten contaminated sites share common traits, while low pollution townships do not share these traits. While all polluted townships do have higher levels of mortality, the relationship is not proportional, meaning that mortality does not increase as pollution increases. For example, Salem and Elmer have higher cancer mortality rates for persons under 65 than Oldmans or Carneys Point, but have far less TRI emissions and contaminated sites. The lack of a proportional relationship suggests that other factors affect each township in
different ways (poverty, emissions patterns and trends, chemical toxicity, settlement patterns within the township, etc.) which alters the rate of mortality.

Elmer and Oldmans are good examples of how these different factors may affect mortality. Elmer's dense population may reflect the high mortality in persons under 65, because even though the number of contaminated sites is not that large, these sites are concentrated in one small area with many people. The hospital also influences the rate, since terminally ill persons may wish to live in close proximity to the hospital. Even though the TRI emissions in the township are low, with only one facility reporting to the TRI in 1987 and registering only 250 pounds of releases, the facility still continues to operate. It continues to release emissions, but these emissions are not reported, because the levels are too low. But in a densely populated area, these emissions could have a stronger effect than they would on less densely settled areas. Oldmans is an example of a township that has high mortality rates, but is not densely populated. Here, the level of contamination is higher than Elmer in terms of volume, toxicity, and number of sites. Contaminant levels are so high that they could overcome the fact that Oldmans is not densely settled, which can cause mortality rates to be high even though density is low.

The effects of multiple factors extends to the case of higher than estimated cancer mortality, as Oldmans did not have surplus cancer mortality compared to the nation, despite its higher rates for cancer mortality for persons under 65 relative to the other townships. With the exception of Oldmans, surplus mortality cancer rates come closer than any other variable to being proportional to pollution levels, and the statistical association between them is stronger than any of the other pollution and mortality comparisons. Pennsville and Carneys Point, the two townships with the most consistently
high emissions levels, have two of the highest incidences of excess cancer deaths and are separated from other townships by a wide margin. The City of Salem is the only exception, as high poverty rates, low income, a large African American population, and the presence of a hospital, as well as pollution, contribute to high rates of mortality in all categories. These confounding factors affect Salem, and Penns Grove to a lesser degree, whereas they affect other townships to a far lesser degree.

The associations between pollution and health are far more evident than the existence of environmental disparity in Salem County. This is not to say that environmental justice does not exist as a general phenomena, it just is not evident in this study, possibly due to the large enumeration districts that were used. A case can be made that environmental justice exists by race, based on the presence of TRI facilities in townships where the majority of Salem County’s African-American residents live, but ultimately the determination is unclear, because this case can be refuted. The existence of environmental disparity between classes is not evident, with the exception of a moderate correlation between contaminated sites and poverty. The overall population of Salem County is mainly working class, so an examination of pollutants between townships and class revealed little, since most of the townships are working class.

Despite the lack of a clear answer regarding environmental justice and pollutants, the results of this study are certainly no less significant. The data, based on the parameters of this study, demonstrates that pollution and health are associated, and that pollutants and associated health effects seemed to be distributed rather evenly amongst the residents of the townships that had high levels of pollution.
Chapter 5

CONCLUSION

Introduction

Salem County is not an ugly place with pollution visibly spewing everywhere, and it was not the intention of this paper to portray it as such. Its motto, “The Garden Spot of the Garden State,” is apt, given the rural nature of the county and the fact that half of its land is actively farmed (Salem County Freeholders 2001). The county has a number of buildings dating from the eighteenth and nineteenth century (Lanier 1998: xv), while Main Street in Salem City conjures up images of the typical North American small town from years past. Country roads wind through farms and coastal nature preserves. A pleasant drive on Route 40 brings the traveler through Woodstown, with its beautiful Victorian buildings, past the Cowtown Rodeo and an old dairy and ice cream shop, and through Elmer, with its classic diner and little league field. It is a picturesque place populated by people who are proud of their community.

Salem County also has its problems like all places do, and these have been discussed in this paper. Levels of pollution are relatively disproportionate to the county’s size and population, which make Salem’s environmental issues more extreme than other places. The vast industrial complexes in southern Carneys Point and northern Pennsville are impossible to ignore as you enter the county from the Delaware Memorial Bridge, while elements of decay appear while traveling north of the bridge. The fact that

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pollution cannot always be seen rising from stacks\(^1\), and that much of the plants are obscured from view behind hedges and fences, does not mean that pollution does not exist and does not have an impact. The evidence provided and the associations uncovered by this study indicate pollution exists and has an impact, whether visible or not. This chapter outlines and ties together the main findings of this study and provides recommendations for further study. The chapter concludes with suggestions that can be taken at the local and national level to address the problem of pollution and health.

**Main Findings**

This study has operated within the broad, holistic discipline of geography, under the sub-discipline of medical geography or epidemiology, in order to find connections between pollution, health, and environmental justice by conducting a scoping study of several issues and variables from four primary databases, which are publicly available. GIS and statistics were used to conduct the analysis, and information was collected from several types of sources. The findings of this study can be classified into five main points.

First, the chemical industry and power utilities are firmly embedded in Salem County’s economy and society. These industries are a primary source of employment and revenue. A number of the industries, particularly the DuPont Company, were responsible for the increase in population in the county and its modernization over the course of the twentieth century. Following the onset of de-industrialization in the 1970s, the county became more reliant on these industries, as other traditional industries, like textile manufacturing, began shutting down. Despite their central role in the economy, most of the chemical industries and power utilities have begun to disinvest in the region. Some of

\(^1\) Local residents suspected, and a former plant manager admitted, that during the 1960s the DuPont Chambers Works released air pollutants primarily at night, masking the true extent of emissions (Phelan and Pozen 1973: 45).
the disinvestment in the chemical industry occurred in the early nineties, with the closing of Exxon Chemical and the Xerxes plant, but a new wave has struck during the economic downturn of the new millennium, through job cuts, buyouts, and with possible plant closings in the future.

As some of the benefits of these industries are disappearing, their disadvantages remain, specifically high levels of pollution. The second major finding of this study is that Salem County is heavily polluted, compared to the state and the country. In some cases, many facilities employ very few workers relative to the amount of pollution they produce, but the DuPont company was by far the largest employer and polluter.

Emissions trends in the county have fluctuated over time, but the level of emissions in 1999 was roughly the same as it was in 1987. This is partly due to changes in the number of chemicals and industries that the TRI regulates, but was also a function of changes in chemical processes at the plants and a changing economy. The county’s surface water is impaired by pollutants from agricultural run-off and from industry, which discharges the majority of its emissions to the Delaware River. A number of different contaminated sites present a localized threat to soil and groundwater, while the TRI emissions, concentrated in the Industrial Corridor, are carried over a broader area by wind and water. Nitrate compounds were the number one group of chemicals released by TRI reporting facilities, contributing to the eutrophication of the Delaware River. The top twenty chemicals released by TRI reporting facilities in 1999 included three recognized carcinogens (formaldehyde, nickel compounds, and vinyl chloride) and two suspected carcinogens (chloromethane and chromium compounds). According to Environmental Defence Fund Rankings, the top twenty chemicals released in Salem County included nine that are
ranked in the top ten percent of most harmful chemicals to ecosystems, six that are ranked in the top ten percent of most harmful chemicals to human health, and four that are known to deplete the ozone layer.

The third, and most important, finding of this project is that there is an association between pollution and mortality. The majority of Salem County’s residents live in the most polluted areas of the county. Pollution was moderately correlated to mortality for persons under 65, with an evident pattern of higher mortality rates in townships with emissions sources. The correlation between cancer mortality for persons under 65 and levels of emissions was even stronger at a high level of significance. The level of TRI emissions was more closely associated with higher mortality rates than the number of facilities or the number of contaminated sites. In addition, the number of estimated cancer mortality cases, based on the U.S. average, was often much lower than the actual number of cancer mortality cases in the county. Townships with the highest excess of cancer mortality cases also had the highest level of emissions, and there was a strong correlation between excess cancer deaths and pollutants. The weight of evidence, which includes statistical associations and geographic patterns, knowledge regarding the types of chemicals emitted and their health effects, a history of pollution related health issues, and an imbalance in mortality rates compared to the rest of the state, suggests that there is a definite relationship between the presence of pollutants and higher mortality rates, and particularly between pollutants and higher cancer mortality rates.

Fourth, a number of potentially confounding factors were not major issues in influencing mortality rates. Migration, age distribution, and gender were either effectively controlled for or were not major factors in influencing health. Population
density likely had some effect on mortality rates. Poverty, low income, and a large African American population could have added some bias to mortality rates in The City of Salem and Penns Grove. Given the large gaps between the levels of the variables in these townships versus the rest of the townships, it is likely that they were not major influences in the other townships.

Fifth, the existence of environmental justice in the county as an issue is debatable. The majority of African Americans do live in townships that have TRI reporting facilities and emissions, but statistically there were was only one moderate correlation between African American population and contaminated sites, and the most polluted township was ninety nine percent white. There was not an imbalance between the percentage of mortality that was African American and the percentage of the population that was African American in polluted townships. There was one moderate correlation between high incidence of poverty and contaminated sites, but there were no strong associations between socio-economic status and presence of pollutants, probably due to the fact that most residents of Salem County are working class, with only a few pockets of poverty and fewer pockets of wealth. Environmental justice might be more evident at a different scale. From one perspective, smaller enumeration districts may be more adequate for identifying areas of environmental disparity. From another perspective, environmental disparity may exist between Salem County and the rest of New Jersey, or the rest of the region, given the imbalances that exist between population, emissions, and mortality rates at this scale. This viewpoint will be discussed more thoroughly in the next section, which provides suggestions for addressing the issues of pollution and health in Salem County.
Local Action

Salem County’s chemical and utility industries provide employment, generate additional business, create useful products and needed services, and contribute to the local community through their donations to charity and social services. They also create pollution that poses hazards to health and barriers to further growth. Local citizens pay for water treatment services that remove harmful pollutants generated by industry, municipal landfills have received industry waste, and all New Jersey residents have paid for cleaning up industrial pollution through tax dollars spent on environmental agencies. In all likelihood, non-residents consume most of the electricity produced in the county\(^2\) while residents receive the externalities of pollution. The number of Salem County residents employed by the industries is uncertain, but according to statistics listing county of work by place of residence, one third of all workers in Salem County lived outside the county in 1990 (NJDL 1990), thus these workers have the benefit of Salem County’s jobs without the pollution externalities associated with living there. Businesses large and small also contribute to pollution through the presence of contaminated sites. According to a status report for publicly funded clean-up sites, one service station listed in Pennsville was de-contaminated at a cost of $145,000 (NJDEP 1999).

There are three steps that can be executed at the local level to improve health and reduce pollution. First, there must be clear access to information. Industries, particularly smaller businesses with limited resources, must have clear and concise information concerning environmental regulations. A survey of ten small firms in Delaware and New Jersey revealed that only four had the technical competence or resources necessary to

\(^2\) The three conventional plants produce a combined total of 615 MW, while the nuclear plants produce 3300 MW, for a total of 3915 MW.
comply with certain state environmental regulations (Schaller, McNulty, and Chinander 1998: 186). New Jersey has numerous environmental agencies with seemingly overlapping responsibilities, which can make following regulations difficult. By clarifying and consolidating regulations and objectives, there is a greater probability that companies will be able to follow the law more effectively.

Residents must not only have access to information regarding pollution, health, and their rights as citizens, but they must be aware that this is an issue and that the information exists, through education and public meetings. The county does have a department of health which “investigates citizen complaints and provides public information and citizen education services in all matters concerning environmental health” (SCDH 2000). The department receives complaints, launches investigations, and levies fines against violators. Arming the department with more resources could aid awareness and the spread of information. Residents and workers may already be familiar with their situation, based on a statement of the Director of the Salem Cancer Society back in 1977:

“Cancer is very real down here, it touches a lot of lives… but you can’t find one of them [workers] to [complain]. You accept things. You have to. If it weren’t for DuPont in Salem County this whole place would just fold up and jump in the river” (Philadelphia Bulletin 1977, cited in Colby 1984: 754).

Given the over-dependence on the chemical industry and power utilities in the county and the industry’s clout, it is difficult for residents and workers to protect their health and reduce pollution without risking economic suicide. Realistically, citizens or the government cannot simply order industry to stop polluting. The second step the county must take is to diversify the economy and attract cleaner businesses in order to
become less dependent on the utilities and chemical industry. Once this is achieved, citizens and government would have a greater and more confident voice in their own affairs. The county government is working to attract development in other industries, and the construction of new office parks and light industrial parks may be a step in the right direction (Shoer 2001c). Attracting new industries may require weighing some environmental costs versus environmental benefits. For instance, Salem County is a leading site for a potential cooperative-built ethanol plant (Shoer 2001de). By building the plant, the county would be adding yet another chemical into its air, which is undesirable. On the positive side, ethanol is relatively less toxic than most other chemicals, and is a gasoline additive that reduces pollution. The plant would be a co-op owned by farmers, not by an outside firm or large multi-national, and would guarantee a market for grains, which strengthens Salem County's traditional agricultural base while reducing economic reliance on the chemical and utility sectors.

The chemical and utility sectors are currently reducing their role in the local economy by cutting workforces and selling plants, as discussed in chapter three. Residents and government officials must realize that the companies operate not for their benefit, but for profit, and if a company is not profitable it may cut its workforce, its spending in the local economy, it may cut corners in terms of safety and the environment (in the case of the Motiva accident in Delaware City), or close its facility. Based on the company's decision, the community could not only be left without employment and business, it may be left with unwanted contamination that becomes its responsibility to clean up, as is the case with the Xerxes plant in Penns Grove and numerous sites in Oldmans. While the companies that abandoned the sites are responsible for some of the
clean up, tax dollars cover any costs that remain. Citizens and government should take
the initiative in attracting new and cleaner businesses, rather than compromising the
health and safety of workers and residents for a company that may eventually abandon
them.

Corporations should also be held more accountable for their actions, and should
obey existing regulations. The DuPont Chambers Works failed to file on-time reports for
to the TRI for a number of compounds between 1994 and 1996, but because the company
voluntarily disclosed to the EPA that the filings were late, the company was only fined
$91,570 (US) (US EPA 1999c). Rather then punishing the company for breaking the law,
the EPA merely gave the company incentive to repeat such practices by not imposing
stricter penalties.

There are many instances where the actions of corporations in Salem County are
highly questionable. For instance, the DuPont Company donates funds and participates in
a county-wide program to promote science education in schools (SCSD 2001). At the
same time, it continues to dump lead compounds, neurological toxins that are particularly
harmful to children, into the Delaware River. In another example, the company claims
that it is focused on sustainable growth and reducing greenhouse gas emissions (DuPont
1999b), while the Chambers Works in Salem County has announced a goal of zero waste
and zero emissions (Island Press 1998). Despite these claims, the company has argued
and continues to argue against environmental regulation. The company’s arguments
against limiting the sulphur content of fuel oil for industrial use (in order to allow the
Chambers Works Plant to emit more pollutants than plants in the northern part of New

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3 Out of all chemicals released in 1999, lead compounds ranked twenty-seventh. The DuPont Company
released 6,768 lbs into the Delaware River (EPA 2001).
Jersey) in the late 1960s failed (Phelan and Pozen 1973:45-46), but recent industry lobbying has been more successful. The Safety, Health, and Environment Affairs Manager at the DuPont Chambers Works complained that permit fees in neighbouring Delaware were often lower than fees in New Jersey and the company wanted “an even playing field in New Jersey, if not a competitive advantage” (Fairley 1995:S14). The state complied with such requests by easing the permitting process and lowering fees (Fairley 1995:S13, Tierney 2000:12). These are merely two examples of highly contradictory actions regarding corporate environmental policies. Citizens and government officials should be wary of corporate contributions and statements, for while some actions may be sincere, others may be public relations campaigns (D'amico 1999: S5, Mullin 1997:S25) or efforts that further ingrain the company into the community, making arguments against corporate environmental practices difficult.

The third step is not a remedy, but a pre-emptive measure. The county should fight any attempt to add additional noxious land use within its boundaries. For example, the US Army Corps of Engineers is attempting to execute a controversial plan to dredge the Delaware River so that modern ships with deeper berths, particularly oil tankers, can continue to sail up the Delaware to ports in the tri-state area. The plan is controversial because the river is not being dredged enough to make a substantial difference in depth, and shipping companies have not commented on whether or not they approve the plan and would actually take advantage of the deeper channel. The most controversial aspect of the plan is the millions of tons of dredged soil, contaminated by industrial toxins released over a century, that would be generated. Salem County has been sited as a possible dumping ground for some of the waste; local officials have vigorously
condemned the plan (Hajna 2001, Gurney 2001). Such environmental decisions are not always so obvious. For example, would another high efficiency coal plant, like the Carneys Point Generating Facility, be desirable if it meant that a less efficient and higher polluting facility, like the Deepwater Generating Plant, would be replaced? Ultimately, this decision should be made by residents and government officials in conjunction with the company, and should not be dictated by one party to the rest. Finally, such a preemptive decision should not be regarded as selfish NIMBYism. Citizens should have a voice in such matters since their health and quality of life will be impacted, and since Salem County's citizens already suffer disproportionately from pollution.

**National Action and Beyond**

The problem with refusing noxious land use is that the problem of siting a facility or dumping waste does not disappear, it may not be Salem County's problem, but it becomes the problem of a different jurisdiction. Much of DuPont's dye operations that were discontinued in the county in the 1970s were transferred to Puerto Rico, where labour was cheaper and environmental regulations were less stringent (Phelan and Pozen 1973: 46). The environmental justice paradigm can shift to an international scope, with wealthier industrialized nations exporting polluting industries and wastes to poorer developing nations (Bullard and Johnson 2000: 572-73). In some instances, noxious industry can move between industrialized countries. The Ganes Corporation decided to shift some operations from its plant in Carlstadt, Germany, to expanded facilities and offices in Pennsville, Salem County. The company made the shift because the plant in Carlstadt is older, bounded by a residential area, and is regulated under more stringent German laws (D'amico 1999: S5).
Two steps should be taken at the national level, with international agreement, in order to prevent such actions. The first step regards how chemicals are regulated. Many national governments, including international agencies like the European Union and the United Nations, supported by some in the scientific community, have adopted the Precautionary Principle as a guiding principle in policy making (Jordan and O’Riordan 1999:16). The Precautionary Principle has four components:

“(1) Preventative action should be taken in advance of scientific proof of causality; (2) the proponent of an activity, rather than the public, should bear the burden of proof of safety; (3) a reasonable range of alternatives, including a no-action alternative (for new activities) should be considered when there may be evidence of harm caused by an activity; and (4) for decision making to be precautionary it must be open, informed, and democratic and must include potentially affected parties” (Raffensperger and Tickner 1999: 8-9).

Essentially, the Precautionary Principle is the opposite approach to how chemicals are currently regulated in the United States. The principle states that if the effects of a chemical on human health are uncertain, than that chemical should not be introduced until it is proved to be harmless, rather than the current system, which states that if the effects of a chemical on human health are uncertain, it can be introduced and can remain on the market until it is proved to be unsafe. The principle would shift environmental and health decision making in the United States from regulation and control to prevention (1999:2), which would protect citizens, rather than waiting until it is too late, while saving tax payers large sums of money. The obstacles to implementing the principle are great, given the chemicals industry’s lobbying clout, it’s research that claims that their chemicals are safe, and the industry’s insistence that the economy would severely suffer
if such a policy was introduced. The DuPont Company has a history of opposition to such a policy and its production of tetra-ethyl lead is becoming a classic case study of precautionary action not taken, despite substantial evidence that TEL was harmful to human health (Montague 1999: 294-308; Gottlieb, Smith, and Roque 1995: 170-79).

The Precautionary Principle is also useful for illuminating the limitations of science and risk assessment (which was initially designed for mechanical problems, like bridge construction) in predicting uncertain and highly variable events such as interactions between multiple chemicals in multiple media and their affects on human health and ecosystems (Raffensperger and Tickner 1999: 2-3). The laws of science, which the United States (as well as several other nations) has applied to chemical policy and regulation, require ninety-five percent confidence before concluding that an environmental factor has an effect on human or ecosystem health, otherwise it is rejected as having no effect. Tests that are too weak or data that is too variable, unpredictable, or simply unavailable can incorrectly lead policy makers to assume that the study showed no effects, when in reality the processes are so complicated that strict mechanical tests are inadequate for making firm conclusions (Weis 1996: 160-161). “Policy decisions, unlike science, are not probabilistic, but are usually discrete choices among specific alternatives” (1996:160). Policy should not rely strictly on mechanical scientific techniques which often complex, expensive, and easily exploited, but should rely on the weight of the evidence. This study was not always able to provide strong correlations with ninety-five percent confidence, but was able to provide strong evidence that there was a relationship between health and pollutants, based on an empirical analysis and a

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4 Sweden has adopted the Precautionary Principle for chemical policy, and thus far there is no substantial evidence that the county’s economy has suffered as a result (Wahlstrom 1999:59-60).
review of literature and analysis of facts that touched many disciplines, including geography, medicine, economics, sociology, chemistry, biology, history, philosophy, statistics, and environmental science. Complex problems require holistic approaches rather than narrow methods, and uncertainty should not be interpreted as meaning "not harmful."

A second step that should be taken, which the Precautionary Principle implies, is the substitution of toxic substances with safer alternatives. There has been some progress on the supply side of manufacture, with companies instituting more environmentally friendly practices and substances in the production of goods (Richards, Allenby, and Frosch 1994: 1-19). The government could ban certain chemicals from manufacture or could require manufacturers to use certain processes, but such supply side regulation is expensive and controversial. A more effective method may be the search for alternatives at the demand side of the equation. The chemical industry creates toxic pollution while developing and marketing toxic products (Smith and Gottlieb 1995: 211). While the industry can resist government intervention and environmental activism, it cannot resist the general will of consumers. If consumers demand non-toxic alternatives, then industry would be forced to comply, and the production of hazardous pollutants and products would decrease. The problem with this approach is that it cannot be legislated, but is based on the personal choices of billions of consumers who may not have the time, money, or information to make the best choices. Awareness can be initiated through education, and the government can make policies to require that consumer goods have proper warning labels regarding their chemical content; a law that was successfully launched in California (Gottlieb et. al. 1995: 192).
**Recommendations for Future Study**

There are many facets of this study that can be explored in more detail but were not, due to time constraints and data availability. Data from the 1990 census should be updated when all of the 2000 census data is released. Specific information regarding the type of chemicals and extent of contamination at each contaminated site could be collected in order to obtain a clearer picture of chemical exposures and their relationship to health. The mortality data base can be examined in greater detail, by analyzing other categories / causes of death to see if there are any other pertinent patterns, and by examining the occupations of the deceased to determine the degree to which occupational exposure was a cause of death. An examination of cancer mortality could be expanded to incidence of cancer. All data presented can also be examined in bordering townships outside the county, to determine whether or not a wider geographical pattern exists. More sophisticated statistical methods could be employed to quantify the degree to which certain variables confound the relationship between health and pollution.

Beyond these adjustments, more intensive research could be undertaken at a more detailed enumeration level, such as census tracts or block groups, which would provide more specificity and would be useful in definitively determining whether or not environmental injustice exists. While the mortality database only provides township of residence, the actual death certificates could provide more detailed information, such as a precise address. Alternative methods could be devised to measure TRI emissions more effectively. Morbidity data can be examined and would be a good indicator between health and pollution, since pollution and corresponding sickness can occur more immediately and directly than terminal illnesses with long latency periods.
Finally, one could move beyond this type of study. A survey of Salem County’s residents would add insight, since it is difficult to determine the opinions and feelings of the residents based on a collection of literature and an analysis of databases. Based on the information collected from the local news media, there were community activists fighting against the nuclear power plants, environmentalists who collected information on the county’s watersheds, and communities that launched drives to pick up litter in their neighbourhoods and collect hazardous garbage, like used paint, but there was no fundamental community activism in regard to large scale chemical pollution. A survey would be useful for not only discovering the opinions of residents regarding these issues to initiate policy, but could also aid an epidemiological analysis by inquiring about an individual or family’s history in the county in order to build detailed case studies of individual families.

**Closing Remarks**

Opportunities for further research always exist and can provide more useful information, but should not be regarded as an excuse to do nothing while waiting for further evidence to appear. Based on the weight of evidence presented in this study, an association between mortality for persons under 65, and more particularly, cancer mortality for persons under 65, was established. Environmental disparity in Salem County is a debatable issue; it could be resolved by examining finer enumeration districts. Despite the limits imposed by using townships as the enumeration districts, an association between mortality and pollutants was still established, which makes the findings noteworthy.
Given the unequal distribution of pollutants compared to the State of New Jersey as a whole, and other counties in particular, a case for environmental justice could be made at this scale. While the industries in Salem County were responsible for the county’s modernization and growth, they are also responsible for it’s environmental problems, and as this study has demonstrated, some of it’s health problems. The residents who migrated to the county in the early part of the century knowingly moved near the industrial plants, but they did not possess the information concerning the health effects associated with these pollutants. The health effects of pollution did not become a real issue until the 1960s, with the publishing of Rachel Carson’s *Silent Spring*, and did not become a publicized, political issue until the 1970s and 1980s, at which point the county was heavily dependent on these industries for economic survival. Environmental disparity is certainly a real issue in Salem County, as its citizens are the recipients of large quantities of toxic pollutants relative to the rest of the state, and the region.
REFERENCES


Montgomery, J. 2001. Motiva Knew Tank was Faulty, Repairs were Urged; Role in Blaze Uncertain. Wilmington News Journal. July 25.


