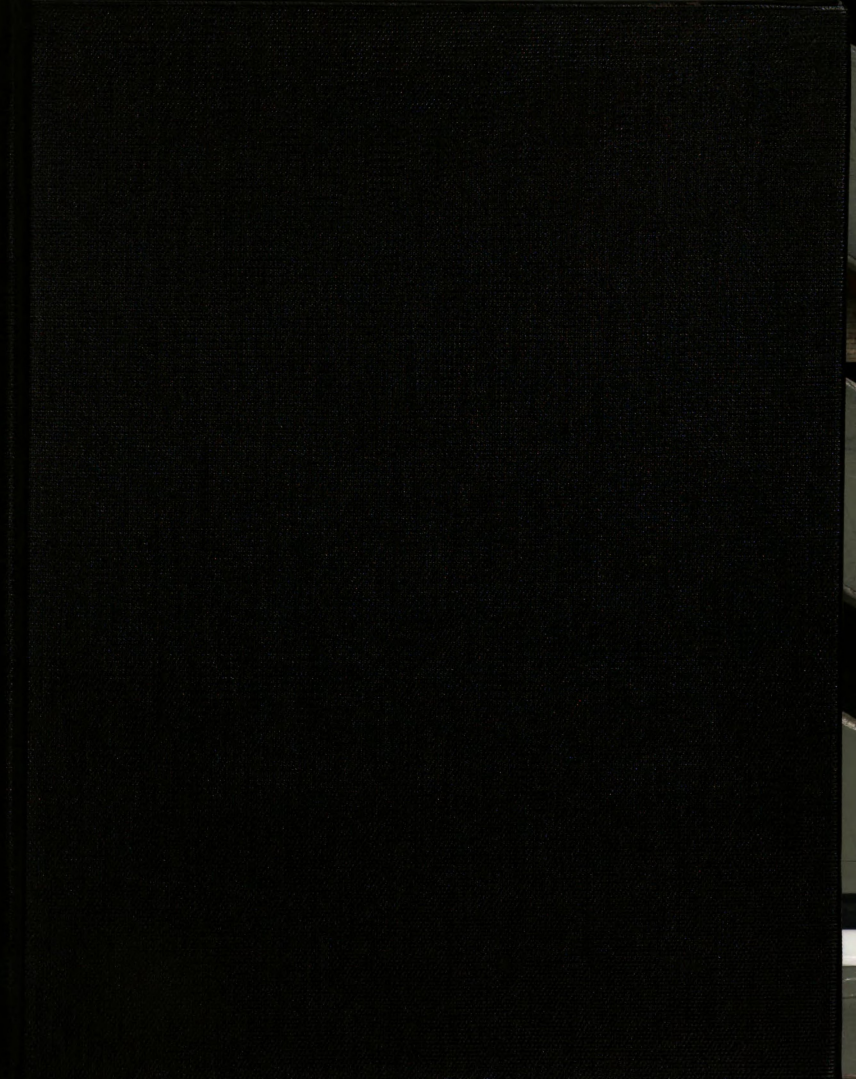






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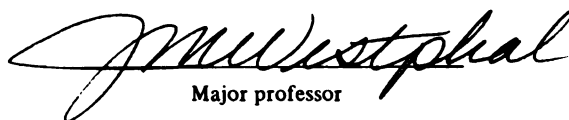
An Examination of a Distance Decay Function
Relating Air Quality to
Power Plant Location

presented by

Christopher Paul Brown

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Masters degree in Geography



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**An Examination of a Distance Decay Function
Relating Air Quality to
Power Plant Location**

By

Christopher Paul Brown

A Thesis

**Submitted to
Michigan State University
in partial fulfillment of**

MASTER OF ARTS

Department of Geography

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ABSTRACT

An Examination of a Distance Decay Function

Relating Air Quality to

Power Plant Location

by

Christopher Paul Brown

Fossil Fuel Combustion (FFC) plays a pre-eminent role in meeting domestic U.S. energy needs; in doing so, it generates a wide range of negative externalities, with significant effects on the structure of urban environments and residents who live in urban areas.

This research uses a survey technique to examine the existence of a distance decay function regarding how urban residents perceive the negative externalities resulting from a large FFC power plant in the Lansing, Michigan area. The results indicate that a distance decay function does act on perceptions of these externalities and that certain socioeconomic variables --i.e., level of education, level of support for environmental legislation, and level of expressed health concern also significantly influence the relationship between distance to a FFC facility and perceived negative externalities.

**To my mother and father,
who gave me the talents necessary to
pursue a graduate degree.**

ACKNOWLEDGEMENTS

I wish to thank Dr. Joanne Westphal for her continued support, guidance, and patience in the preparation of this thesis, as well as my graduate career. Thanks are also due the other members of my research committee, Dr. Bruce Pigozzi, and Dr. Tom Edens, for their time and effort in this project.

An endeavor such as this would not have been possible without the financial support of the Geography Department; my sincere gratitude goes to Dr. Gary Manson and Dr. Judy Olson, for their extraordinary help in this area.

Several other people have provided invaluable assistance in this project. Ellen White and Charlie Radar went out of their way in assisting me in the trials of preparing graphic materials. Mike Lipsey provided me with the computer skills needed to undertake this effort, as well as others, in my graduate career. The support staff of the Geography Department, particularly, Marilyn Bria and Carolyn Brookins-Williams, provided the necessary office support that often goes overlooked.

I would also like to thank Cynthia Wheatley and Eleanor Love of the Lansing Planning Department, who assisted me in selecting and mapping the study area. Lastly, I wish to thank the people living in Lansing who participated in the survey used in this research, particularly the presidents of the neighborhood associations involved; without them, this project would never have been completed.

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Chapter I. Introduction:

The present means of meeting domestic U.S. energy needs generate many different negative externalities, which are physically distributed over, and therefore affect urban areas in a variety of ways. Individuals in these areas will perceive these externalities and may react to them by altering their location in relation to each other and the externalities in question. Through this process, the very structure of the urban areas will reflect the effects of these externalities on the individuals involved.

While it is beyond the scope of this research to directly monitor the physical effects that various negative externalities have on environmental quality or the direct effect that they have on the human condition, it is possible to study the perceptions that people have concerning the value of air quality within the structural context of an urban area. In fact, mounting population pressures and competing interests that affect the quality of life of urban residents argue for this type of research.

Therefore, this thesis examines the effects of fossil fuel combustion (FFC) facilities on peoples' perceptions of environmental quality, with a focus on the spatial dynamics of these effects. The general organization of the thesis is as follows.

The balance of Chapter One introduces the role that FFC has had in meeting domestic energy needs and the results of this energy source on the human and natural environment. Further discussion then moves to the interactions between these externalities and human populations in a spatial context. With this societal relevance in place, the literature dealing with past research into these interactions is reviewed. Chapter Two presents a formal statement of the research

problem and hypotheses. Chapter Three provides a description of methods and the statistical analysis that were part of the research effort. Lastly, the manuscript closes with a presentation of the results as they relate to the formal statement of the research problem and a discussion of the associated societal and theoretical implications.

The Role and General Effects of FFC:

FFC plays a pre-eminent role in meeting domestic energy needs. According to the Energy Information Administration's Monthly Energy Review (1990), FFC accounts for approximately 90% of domestic energy use. In fulfilling this role, FFC generates a myriad of negative externalities with varied, significant effects on both the human and natural environment.

Specifically, FFC is a major source of air pollution, generating a wide range of pollutants including particulates, carbon dioxide, and sulfur oxides. An examination of pollutants presented by Miller (1980), indicated that "stationary fuel combustion (primarily at fossil fuel power plants) emerges as the most dangerous source" of air pollution, well ahead of both general industry and transportation (Table 1).

The Effects of FFC on Human Health:

Over the past twenty years, a substantial amount of research has established cause and effect relationships between air pollution generated by FFC and subsequent human mortality rates. Lave and Seskin (1970, 1977) were among the first researchers to examine the negative relationships between various air

pollutants and human health (Figure 1). In a 1970 article published in Science, they conducted an extensive review of the literature and found that air pollution had statistically significant effects (regression results were reported at the .05 level) on mortality rates associated with bronchitis, lung cancer, nonrespiratory cancers, and cardiovascular disease. Lave and Seskin (1970) concluded that "there is an important association between air pollution and various mortality and morbidity rates".

Table 1. Relative importance of sources of domestic air pollution (CEQ, 1975).

<u>Source</u>	<u>Annual Emissions</u>		<u>Relative Health Effect</u>	
	% of total	Rank	% of total	Rank
Stationary Fuel Combustion	16.9	2	43.0	1
Industry	15.3	3	25.7	2
Transportation	54.5	1	22.2	3
Agricultural Burning	7.3	4	4.4	4
Solid waste Disposal	4.2	5	3.0	5
Miscellaneous	1.8	6	1.7	6
Total	100.0		100.0	

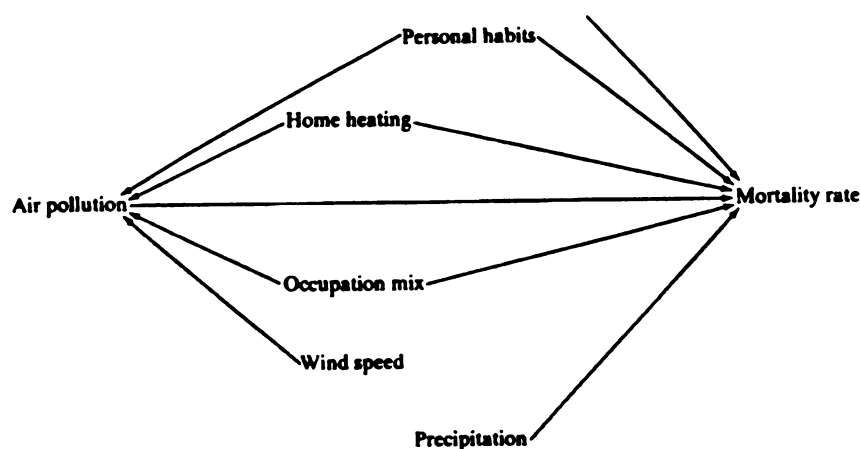


Figure 1. Path analysis of the air pollution - mortality model (Lave and Seskin, 1977).

Further research by Lave and Seskin (1977) began to address the issue of quantitative improvements in human health that resulted from lowering ambient levels of certain air pollutants. They estimated that a 58% decrease in suspended particulates and an 88% decrease in sulfur oxides would bring about a 7% decrease of air pollution induced mortality. In addition, their work reviewed the general relationship between air pollution and human health in light of the nine criteria that Hill (1965) developed to determine causality between environmental influences and diseases. This review, when coupled with the association discussed above, supports an argument for a causal link between air pollution and negative effects on human health.

The prominence of suspended particulates and sulfur oxides in these causal relationships is evidenced in research by Lynn (1976), in which the relative impacts of certain pollutants on human health are examined. The occurrence of "killer" smogs in the mid-twentieth centuries in Donora, Pennsylvania (1948) and London, England (1952) highlighted the severe impact that these pollutants can have on human health. Further research into these effects revealed that suspended particulates and sulfur dioxides present the two greatest threats to human health of any of the airborne pollutants (Table 2); only the combination of these two pollutants can pose a greater threat.

Research presented by Lynn (1976), was one of the first attempts to develop a predictive model that examined the relationship between certain pollutant concentrations and the mortality rates of people in various age groups (Table 3). This work further established the pre-eminent impact of suspended particulates and sulfur dioxides on human health.

Table 2. Relative significance of major domestic air pollutants (Lynn, 1976).

<u>Pollutant</u>	<u>Emissions</u>		<u>Standard</u>	<u>Relative Emissions</u>
	10 ⁶ T/yr.	% of total	µg/m ³	% of total
Sulfur oxides	33.9	12.7	80	34.4
Particulates	26.1	9.8	75	28.2
Carbon Monoxide	148.6	55.8	10,000	1.2
Hydrocarbons	34.9	13.1	160	17.7
Oxides of Nitrogen	22.8	8.6	100	18.5
Totals	266.3	100.0		100.0

Table 3. Predictive equations relating mortality to sulfur oxide and particulate pollution (Hodgson, 1970, as cited in Lynn, 1976).

<u>Age</u>	<u>Formula</u>
All ages	R-H deaths = 150.5 + 7.7(COH) + 20.7(SO ₂) + 0.7(temp)
over 65	R-H deaths = 101.8 + 5.3(COH) + 18.9(SO ₂) + 0.5(temp)
45 to 65	R-H deaths = 40.8 + 1.9(COH) + 0.9(SO ₂) + 0.2(temp)
under 45	R-H deaths = 8.0 + 0.5(COH) + 0.9(SO ₂) + 0.03(temp)

R-H deaths	= daily mortality from respiratory and heart disease
COH	= daily mean particulate pollution in coefficient of haze units
SO ₂	= daily average SO ₂ concentration in parts per million
temp	= departure of daily mean temperature from 65° in degrees F

The Effects of FFC on the Natural Environment:

It is an established fact that FFC is causing an increase in the concentration of carbon dioxide (CO₂) in the atmosphere. In one of the earliest studies into this phenomenon, researchers found that CO₂ concentrations have risen approximately 18% from the late 1800's to the 1970's as a result of FFC and limestone kilning (Keeling, et al, 1973). Further research into CO₂ levels in this century has revealed an increase in atmospheric CO₂ concentrations of approximately 3.5% in the

period from 1959 to 1971; the results also confirmed the long term trend mentioned above (Keeling, et al, 1976a and 1976b).

Although the effects of CO₂ on the natural environment are not as clearly established as the effects of particulates and sulfur dioxides on human health, there is nonetheless a large body of literature that suggests that increasing levels of CO₂ can have harmful effects on global and regional environments via climate change. Kellogg and Schware (1981) did an extensive review of a variety of climate models based on a wide range of assumptions concerning the complex oceanic and atmospheric interactions between CO₂ levels and the global energy balance. The vast majority of the models indicate that increasing levels of CO₂ and projected energy use patterns (generating a doubling of CO₂ concentration) will result in an increase of global temperatures ranging from 1.5 to 4.5 degrees Celsius over the next century. The potential end results of this warming include disruption of food production due to shifting regional climate zones and pest populations, poleward spread of tropical disease via increasing vector habitat, and extensive flooding of coastal areas due to rising sea levels (Kellogg, et al, 1981). While the certainty of these results varies with the accuracy of the global temperature change predictions, the impacts that they may have on the human and natural environment argue for research into the underlying processes.

Interactions Between Externalities and Human Populations:

As cited in the literature, FFC plays a pre-eminent role in meeting domestic energy needs and also generates negative externalities that have significant effects on both human and natural environments. These externalities interact differentially across the various populations of existing urban areas;

therefore, the actual end results of FFC on society is difficult to measure. One can measure, however, the perceived effects of FFC on urban populations.

The current issue of where to site certain facilities (i.e., landfills, hazardous waste facilities, power plants, nuclear facilities, etc.) that generate negative externalities highlights the importance of spatial and locational variables in the interactions between these facilities and people. The very processes by which humans interact with their physical environment across space to yield the structure of our urban areas are mirrored by the manner in which negative externalities are perceived by people. Just as people may wish to locate in proximity to a market or other amenity to reduce travel time, they may also perceive a facility that generates negative externalities (e.g., a factory) differently according to the proximity of this facility. Papageorgiou (1978) sees spatial externalities being transmitted to the urban form by a process of diffusion as people perceive these effects and interact with each other over space. He goes so far to suggest that urban form is the product of "two interacting surfaces unfolding over the landscape - a population surface and an externality surface", with the result being a dynamic distribution of population across space (Papageorgiou 1978).

The role that space and distance have in relating environmental interactions with people underlies a considerable portion of the field of geography. For example, over the years, geographers have demonstrated that a *general* distance decay function exists, such that certain types of interactions diminish as one moves farther away from the source of these interactions (Figure 2). This distance decay function is explained by the notion of concrete space generating "friction"; the phenomenon of increasing transport costs of goods and services as one moves away from urban centers is one example of this concept (Foust and de Souza, 1978).

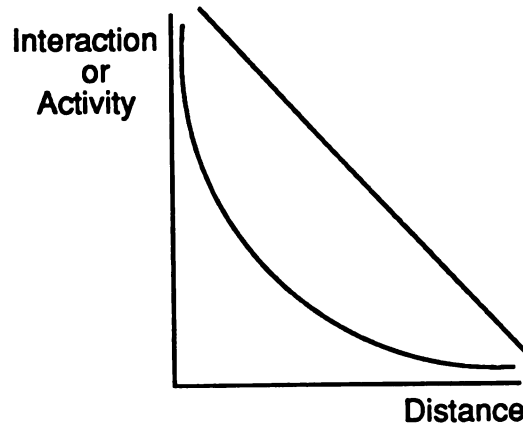


Figure 2. General distance decay function.

The specific issue of how space and distance affect the perception of facilities that generate negative externalities has been documented in the past. In research dealing with perceptions of community mental health facilities, Dear, et al (1980) introduced the concept of a "spatial externality field" (SEF), which describes the explicit manner in which distance to a given facility affects the perception of the facility. According to this concept, the SEF has three dimensions: *intensity*, *extent*, and *rate of distance decay*, as indicated in Figure 3. The *intensity* of the SEF is a measure of the total impact of the externality; specifically, it can equate to the total loss in property value due to the activity in question. The *extent* of the SEF is the actual spatial dimension of the field, which is in turn determined by the *rate of distance decay*. (This is the rate at which the perception of the negative externality associated with the facility in question diminishes over distance). Hence, this concept very closely parallels the traditional view held by geographers regarding the effect of distance on given interactions.

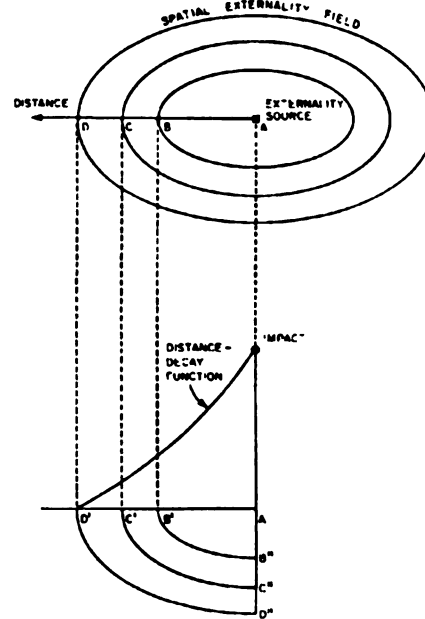


Figure 3. Spatial Externality Field, and its components (Dear et al, 1980).

Societal Implications of the SEF Concept and Locally Unwanted Land Uses (LULU's)

Dear and Taylor (1982) note that when externalities exist with demonstrable consequences, the presence of these externalities (and by extension, the facility that generates them) is a source for conflict. Davis (1984-1985) reviewed the literature regarding procedures for the siting of hazardous waste facilities; he found that policy formulations that required adequate siting decisions often were seriously impeded by institutional barriers. Davis went so far as to suggest that political obstacles resulting from public perception of such locally unwanted land uses (LULU's) may be the most serious barriers to reaching adequate siting decisions. Davis (1984-1985) described this situation as one of "concentrated costs and dispersed benefits" – i.e., the provision of the site in

question yields a collective good for a group of people dispersed spatially, while those living in immediate proximity to the site receive the vast majority of the costs (Figure 4).

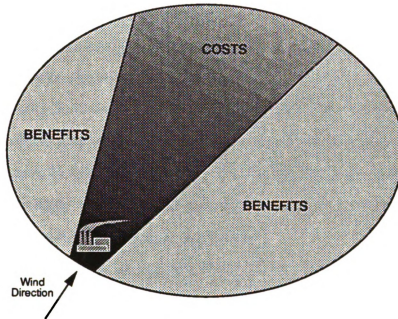


Figure 4. Concentrated costs and dispersed benefits associated with facilities that generate negative externalities (Getz and Walter, 1980).

It is clear that the manner in which people perceive these facilities, via the externalities that they generate, has tremendous impact on the degree to which they are accepted by society. Therefore, it is important to establish how people perceive these facilities, and what implications these perceptions have for siting a LULU in a given area.

Review of Other Pertinent Literature:

With a basis for the societal relevance of this work in place, a more formal review of the literature reveals an extensive amount of research dealing with a

variety of facilities that generate negative externalities. One of the earlier pieces of research was a study by Odland and Balzer (1978) that examined the localized processes that determined the spatial distribution of condemned housing. They derived a predictive model, lagged across space, that predicted the occurrence of new housing condemnations based on the current spatial distribution of existing condemnations. Statistical analysis found that within a hexagonal cell of 400 meters, the interaction between existing and new condemnations was maximized. Accordingly, the Odland and Balzer (1978) study provided empirical evidence of the spillover effects surrounding the negative externality of being proximal to a condemned house. In light of the effect of these buildings on the quality of life in urban areas, this study was also an early attempt to examine the quality of life dimension of perceptions of negative externalities.

A concept of a "zone of interaction" surrounding negative externalities was the basis for a set of policy prescriptions developed by a joint task force of the Nuclear Regulatory Commission and the Environmental Protection Agency (NRC/EPA, 1978). As detailed in Figure 5 and Table 4, the NRC established two zones surrounding a nuclear power plant, the plume exposure pathway (extending from 0 to 10 miles from the plant) and the ingestion pathway (extending from 10 to 50 miles from the plant). The rationale for these zones was the view that effects from even the most serious accident, a "class 9 accident" (i.e. a core meltdown), would dramatically decline at a distance of 10 miles from the plant. Past this distance, the risk to humans was felt to exist only through the ingestion of food and drink products effected by fallout, not through direct exposure.

Table 4. Size and rational of Emergency Planning Zones (USNRC\EPA, 1978).

<u>Emergency Planning Zone</u>	<u>Critical Organ and Exposure Pathway</u>	<u>EPZ Radius</u>
Plume Exposure Pathway	Whole body (external) Thyroid (inhalation) Other organs (inhalation)	approximately 10 miles
Ingestion Pathway	Thyroid, whole body, bone marrow (ingestion)	approximately 50 miles

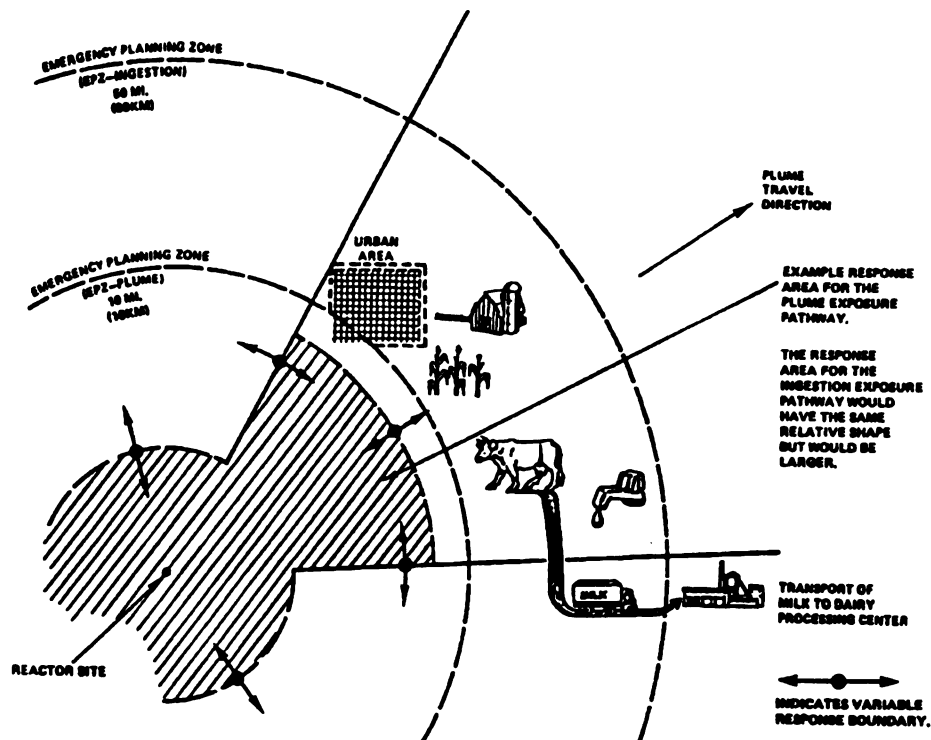


Figure 5. Emergency Planning Zones (NRC, 1980).

These zones in turn were the basis for further policy prescriptions involving information dissemination within certain distances of nuclear plants. According to the NRC's Public Information Planning Objectives (NRC/FEMA, 1980),

information about radiation, sheltering, and evacuation must be made available to "the permanent and transient adult population within about 10 miles of the site". This recommendation is clearly based on the results of the above mentioned NRC/EPA study. These two pieces of NRC policy are evidence that federal policy formulation bodies acknowledged the existence of a distance decay function that acts on the SEF's surrounding large scale nuclear facilities.

The accident that occurred at the Three Mile Island (TMI) nuclear power plant on March 29, 1978 and the ensuing crisis that followed offered researchers an excellent opportunity to study another facet of negative externalities surrounding nuclear plants. The policy that the NRC developed to handle emergencies like this was based on the following assumptions (Ziegler and Johnson, 1989; Johnson and Ziegler, 1983).

- 1) Adequate information would be available upon which public authorities would base their emergency notifications.
- 2) This information would result in zones of prescribed activity based on the two emergency zones described above.
- 3) People living within these zones would obey the official directives of evacuating, sheltering, or continuing normal activities.

Actual behavior of people living in the vicinity of TMI ran counter to the third assumption; namely, many more people evacuated than were instructed to do so. According to the official notifications, approximately 3500 people should have evacuated; in actuality, it has been estimated as many as 200,000 people living

within 25 miles of the plant evacuated (Johnson and Ziegler, 1986). This instance of extreme human behavior has been termed the "evacuation shadow" phenomenon (Ziegler, Brunn, and Johnson, 1981), and it was found to extend 25 miles from the plant (Johnson and Ziegler, 1983). The areal extent of this shadow and the sheer number of people involved are excellent evidence of the dramatic spatial dimension that can accompany human perceptions of facilities that generate negative externalities.

Further work by this team of researchers explored the exact nature of the spatial dimension of the evacuation shadow, as well as the effect that socioeconomic factors had on this phenomenon. All of the studies found distance to the plant to be the most significant variable in determining not only whether people evacuated, but when they evacuated and how long they stayed away. As opposed to people living farther away from the plant, people living closer to the plant:

- 1) were much more likely to evacuate (Flynn, 1979) (Figure 6);
- 2) evacuated earlier and stayed away longer (Ziegler, Brunn, and Johnson, 1981);
- 3) were more likely to view TMI as a very serious threat during the emergency period (Flynn, 1979);
- 4) were more likely to have experienced a significant or severe episode of stress during the emergency (Flynn, 1979); and
- 5) were more likely to have experienced disruption of normal household activity (Flynn, 1979).

Clearly, peoples' intentions and feelings, as well as their actions, reveal a distance decay function regarding their perceptions of the externalities associated with the accident at TMI.

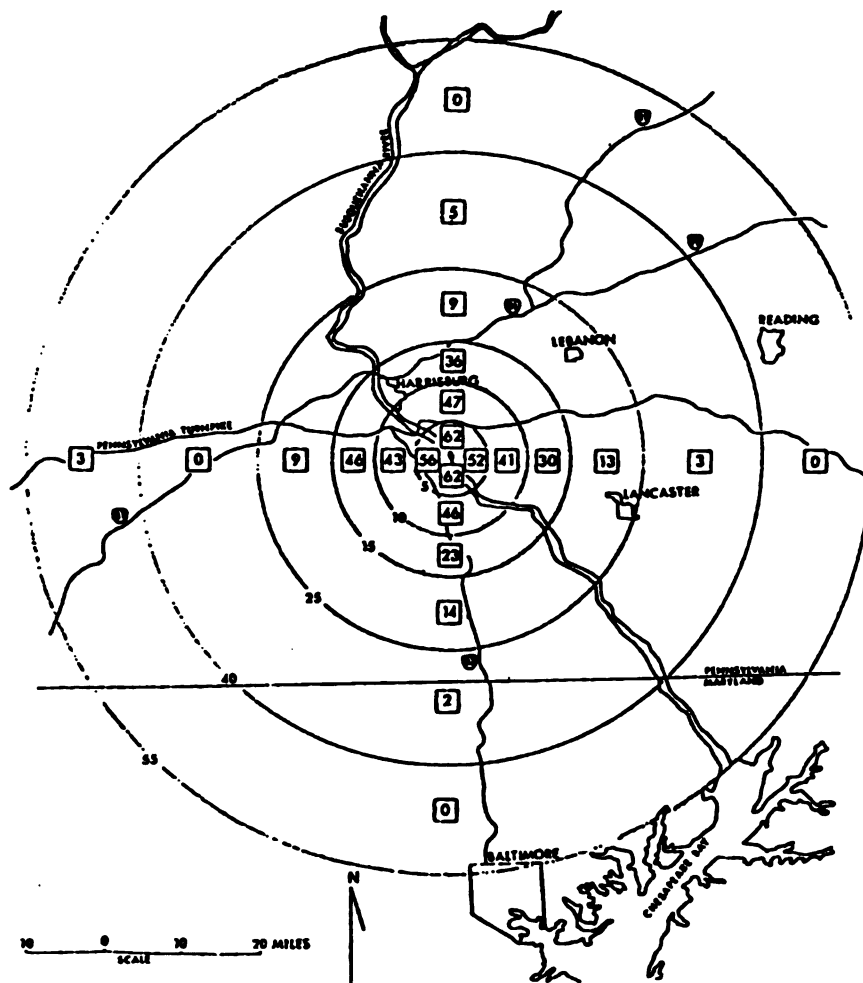


Figure 6. Distribution of origin of evacuees during the TMI accident, percentage of residents evacuating indicated in boxes (Flynn, 1979).

Direction of peoples' evacuation destination relative to the plant was another facet of the spatial dynamics of their evacuation behavior. As Figure 7 reveals, there is a strong directional bias that favored sites to the northwest of the

plant at TMI (Ziegler, et al, 1981). The authors hypothesized that this was due to a combination of people desiring to be upwind from the plant and in the mountains, an area felt to possess a sense of safety amidst the chaos and danger of the area near the plant. In examining the location of peoples' residence prior to the accident, one should note that there does not seem to be a directional bias present (i.e. the same percentage of people living downwind versus upwind from the plant evacuated) (Flynn, 1979). This author suggests that peoples' perceptions of the dangers associated with the accident were so severe that direction to the plant was far surpassed by distance to the plant as the primary motivator to evacuate. Irrespective of direction to the plant, anyone living proximate to the plant perceived a risk and acted accordingly.

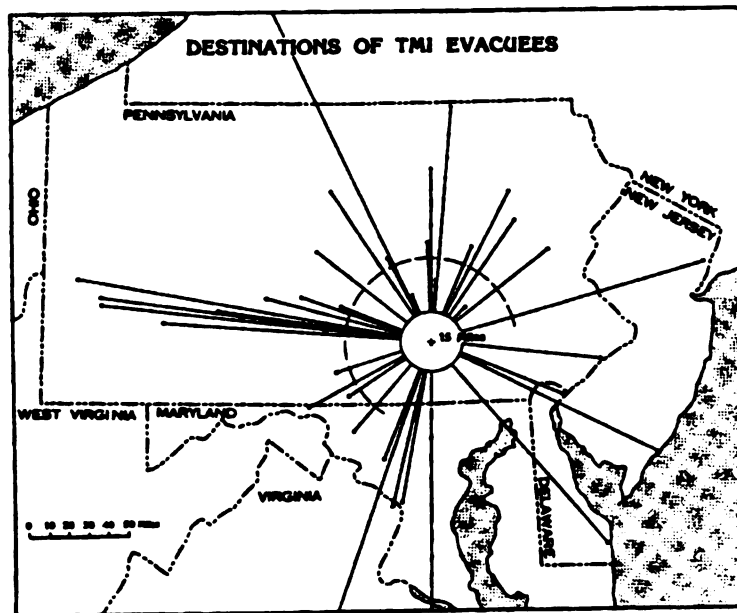


Figure 7. Destinations of TMI evacuees (Ziegler et al, 1981).

Socioeconomic variables associated with the population around the plant also were examined by the above mentioned researchers, and several variables

were found to have a significant effect on evacuation behavior and the perceptions of the people living in the vicinity of the plant. The following groups of people were most likely to evacuate (Johnson and Ziegler, 1986):

- 1) families with a head of household under 35 years of age and having children;
- 2) families with a head of household having more than 12 years of education;
- 3) families with a head of household having a higher *a priori* opposition to nuclear energy; and/or
- 4) families with a head of household having a higher *apriori* perception of the risk of a nuclear accident.

Whereas all of the above follow from logic and therefore are not surprising, Johnson and Ziegler (1986) did not find any significant relationship between married families with a pregnant woman in the household and tendency to evacuate; one would have expected this relationship to follow from item number one above.

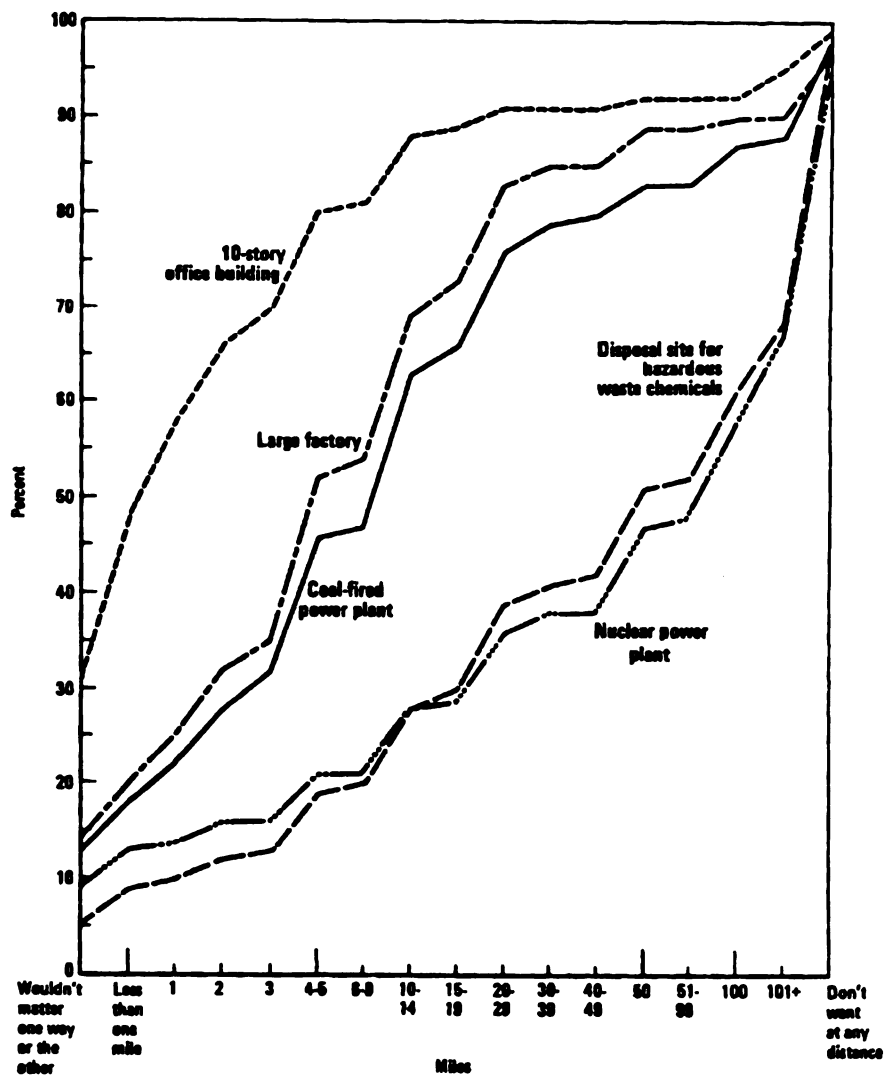
Related to the above research was another set of studies that examined peoples' intentions to evacuate given the hypothetical scenario of a TMI class accident occurring at the Shoreham nuclear power plant on Long Island, New York (Johnson and Ziegler, 1983, 1984, 1989; Johnson, 1985). For the most part, this body of literature supports the findings of the TMI research, with distance and direction to the facility, place in life cycle, education, and *a priori* views of nuclear energy and its associated risks having similar effects on peoples' intention to evacuate. Of particular interest, however, is a study by Johnson and Ziegler (1983)

that found people living nearer to a plant are actually more likely to underreact and not evacuate in the event of a protective advisory. This result hints at the possibility that either there is some type of hypothetical bias to the instrument or people close to the plant had become acclimated to the effects of the plant. Both of these possibilities will be addressed later in this manuscript.

Clearly, the literature dealing with peoples' perceptions of the TMI and Shoreham nuclear plants reveals a distance decay function that acts upon the SEF's associated with these plants. This relationship is also influenced by various socioeconomic factors including peoples' age, place in lifecycle, education, and *a priori* perceptions of an energy source and its attendant risks.

In 1980, as part of a general public opinion poll regarding the environment, the Council on Environmental Quality (CEQ) queried people regarding their views about living proximate to certain land use facilities (CEQ, 1980). The results of this portion of the survey are depicted in Figure 8; this graph relates the cumulative percentage of those surveyed to the distance at which they would be willing to accept these facilities. Examination of this diagram indicates several items of interest regarding the spatial dimension of peoples' perceptions to these facilities:

- 1) peoples' perceptions of these facilities vary across type, as indicated by the distinct curves for each of the facilities;
- 2) acceptance of these facilities increases as the distance to them increases, as indicated by the positive slopes of the curves; and
- 3) the rate of change of peoples' acceptance itself varies across facilities, as revealed by the different shapes of the curves.



These results not only support the existence of a distance decay function regarding peoples' perceptions of facilities that generate negative externalities, but the results also provide empirical evidence that this function performs differently when perceptions of different facilities are involved.

This basic concept was expanded upon by Furuseth (1989), who examined community acceptance of a hazardous waste facility (HWF) located near a residential neighborhood of Charlotte, N.C.. Distance to the facility was the most significant factor in explaining acceptance of it, accounting for 54% of the variance. Of several socioeconomic variables queried, only level of education was found to have a significant effect on acceptance of the facility. While not verified statistically, Furuseth (1989) contended that the tenure of this facility and its benign appearance were responsible for the high level of community acceptance. As indicated in Figure 9, these factors may have effected the acceptance curve of this facility; from the figure, one can see that the curve for the facility lay somewhere between the acceptance curves of other HWF's and those of coal fired power plants and large factories. The author closes with the contention that optimal siting decisions require policy makers to be aware of how the public perceives these facilities, and what factors influence these perceptions.

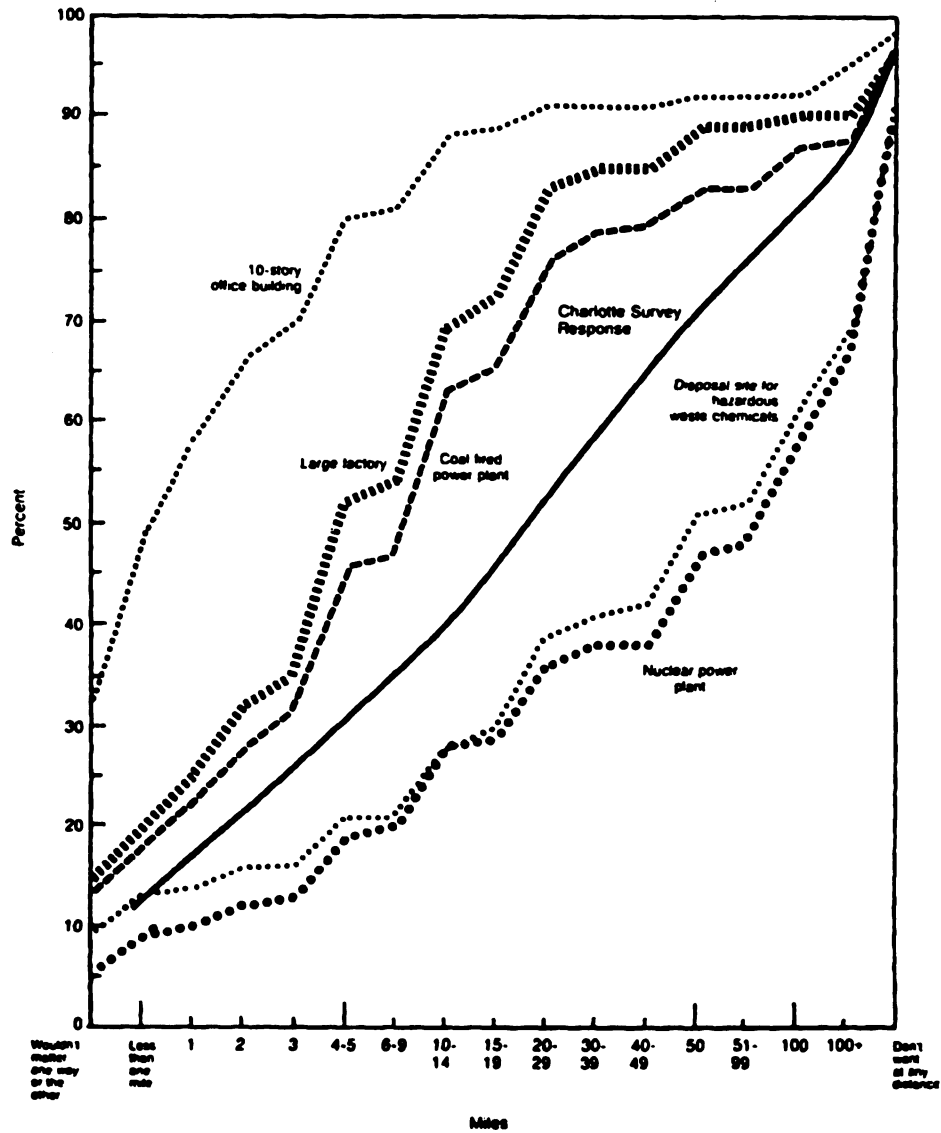


Figure 9. Distance decay functions of facilities generating negative externalities (Furuseth, 1989).

Summary:

Certain large scale energy conversion and industrial facilities generate a wide range of negative externalities, which in turn have a pronounced effect on the human and natural environment, and the resultant quality of life for urban residents. FFC facilities are one such type of facility instrumental in satisfying domestic energy needs, and they have their own set of externalities and impacts. Nonetheless, certain parallels can be drawn between FFC facilities and other facilities that generate negative externalities. The perception of these externalities by the public can significantly influence the acceptance of these facilities, as well as the ability to site future facilities.

A review of the literature supports the concept of a distance decay function acting on the SEF's of these facilities, such that the degree to which people perceive the negative externalities declines as the distance to the facilities increases. This distance decay function is one facet of the interaction of the population surface and the externality surface that has been hypothesized to determine the structure of the urban form (Papageorgiou, 1978). Congestion and both stationary and mobile sources of pollution have been shown to influence the degree of dispersal and concentration of populations within urban areas (Papageorgiou, 1978). In addition, the manner in which this interaction occurs over space may also determine the degree of acceptance of certain facilities (Furuseth, 1989).

The above review of the literature and resulting discussion have attempted to link the issue of peoples' perceptions of facilities that generate negative externalities to both a theoretical relevance in regards to classic distance decay relationships, and the related societal significance that these perceptions can have

on acceptance and siting of these facilities in contemporary society. With this linkage established, the discussion will now turn to the problem statement and formal statement of hypotheses.

Chapter II. Problem Statement-Hypotheses:

Although the research cited supports the existence of a distance decay function regarding peoples' perceptions of the externalities that certain land uses generate, the literature is not without exception on the direction of this relationship. As noted earlier, Johnson and Ziegler (1983) found that people living in close proximity to a nuclear power plant actually would have underreacted to an evacuation advisory; this situation brings up the possibility that they may have acclimated to the risks and negative externalities that the plant presented. One might argue, therefore, that the relationship between distance to a facility and the perception of the attendant negative externalities may be a positive one.

With the exception of the CEQ (1980) research that compared peoples' perceptions of a variety of types of facilities, little research has been done regarding how peoples' perceptions of FFC facilities is effected by distance to these facilities. Several factors at present make this issue a matter of renewed importance.

First, legislation regarding clean air is pending in several legislative bodies at the federal, state, and regional level. Second, numerous municipalities are wrestling with siting issues concerning where to site waste to energy conversion facilities (solid waste incinerators). Presently, municipalities in and around Lansing, Michigan are involved with pending legislation and permits concerning a proposed incinerator, while the corporation that is operating a large, existing facility in the Detroit, Michigan area is wrestling with the denial of a permit from the Michigan Air Pollution Control Commission to continue operations. Therefore, an incentive exists to study the perceptions of individuals that live adjacent to these types of facilities; as FFC facilities are both directly involved in

the legislation and have similar effects as waste to energy conversion facilities, research into the perceptions specific to these facilities is warranted.

Problem Statement:

This research will examine the relationship between distance to a FFC facility and the perception that people living downwind from the facility have concerning the negative externalities that the plant is generating. Specifically, what is the relationship between the distance at which people live from a point source of air pollution (namely, a FFC power plant) and the perceived evaluation of air quality at the location of their residence? Two possibilities for this relationship exist.

- 1) Is the relationship a positive one, indicating some sort of assimilation process, whereby the value that people hold for air quality increases as the distance to the plant increases?
- 2) Is the relationship a negative one, corresponding to a classic distance decay function, whereby the value that people hold for air quality declines as the distance to the plant increases?

Formal Statement of Hypotheses:

A two-tailed research hypothesis is proposed corresponding to the two facets of the problem statement mentioned; a null hypothesis is included, which

incorporates the possibility that no relationship exists between distance to a FFC facility and peoples' perceived evaluation of air quality.

Research Hypothesis, H_1A : Evaluation of air quality at sites downwind from a FFC will be negatively related to distance to this facility. Evaluation of air quality will be at a maximum very close to the facility and will decrease as the distance to the facility increases (Figure 10a).

Research Hypothesis, H_1B : Evaluation of air quality at sites downwind from a FFC will be positively related to distance to this facility. Evaluation of air quality will be at a minimum very close to the facility and will increase as the distance to the facility increases (Figure 10b).

Null Hypothesis, H_0 : Evaluation of air quality at sites downwind from a FFC will have no relation with distance to this facility. Evaluation of air quality will be either constant across distance to the facility, or it will be distributed randomly in relation to distance to the facility (Figures 11a and 11b).

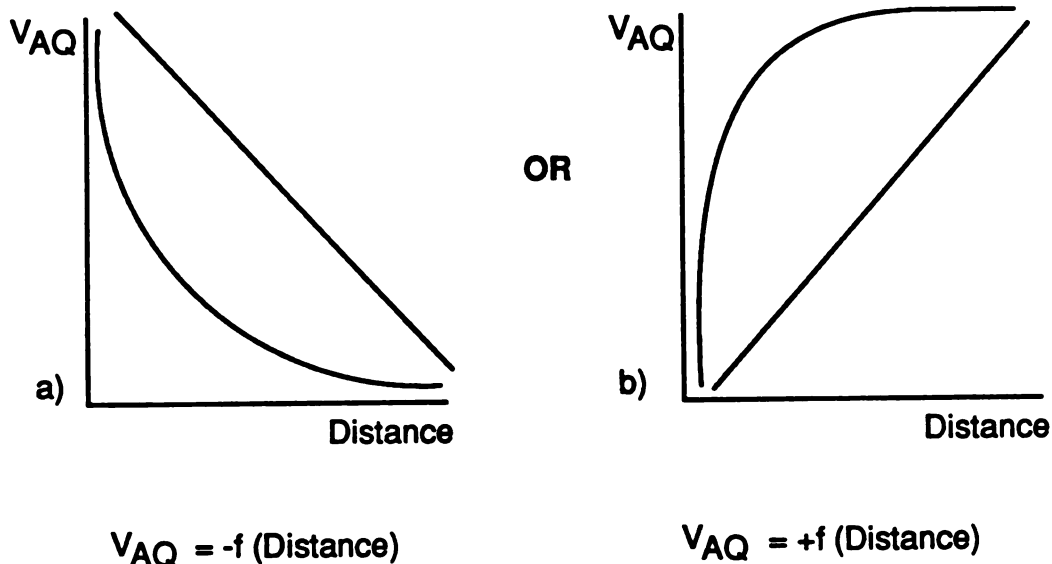


Figure 10. Research hypothesis.

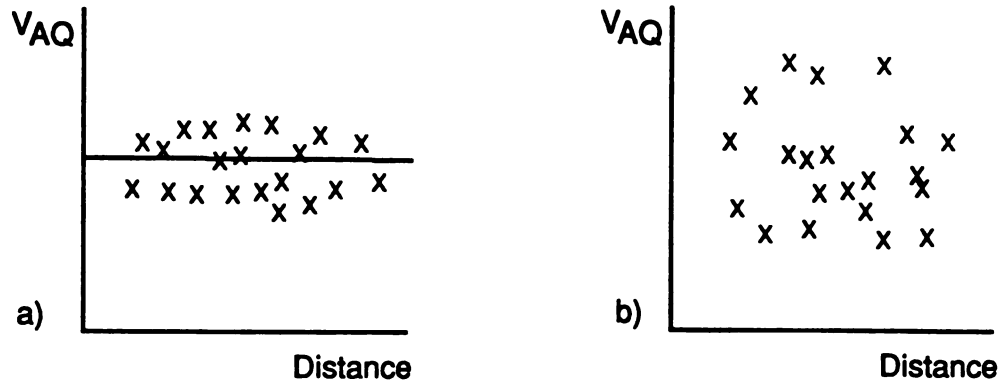


Figure 11. Null hypothesis.

Justification of the Hypotheses:

Research hypothesis H_{1A} is supported by the literature cited in this manuscript, including:

- 1) the work by Odland and Balzer (1978) that examined housing condemnations;
- 2) the study by the CEQ (1980) that examined public acceptance of certain land use facilities;
- 3) the research by Dear, et al (1980; 1982) that examined community acceptance of mental health care facilities;
- 4) the work by the team of Johnson and Ziegler (1984; 1986; 1989) that examined evacuation behavior around nuclear power plants; and
- 5) the study by Furuseth (1989) that examined community acceptance of HWF's.

This hypothesis also follows from the generally accepted principle that a good in scarcity (such as clean air near a FFC facility) will be valued highly at this location; as the distance to the facility increases, the effect of the facility on air quality will decrease, relieving the scarcity of clean air, and causing the valuation of air quality to decline.

Research hypothesis H_{1B} originated from two pieces of literature that suggested an assimilation effect when individuals are proximal to a facility that generates negative externalities. As previously mentioned, Johnson and Ziegler (1983) found that people living proximate to a nuclear facility were more likely to underreact to an evacuation advisory than those who live at a greater distance from a plant. While the possibility of some sort of hypothetical bias of the instrument cannot be discounted, this finding points to the possibility of an assimilation effect existing for those people living proximal to the plant.

In a similar vein, a study by Vleeming (1985) examined the possibility of people living near a nuclear plant becoming acclimated to the risks associated with the plant. During the early 1980's, protest behavior concerning the Zeeland, Netherlands plant increased markedly, and Vleeming (1985) hypothesized that the protesters were actually "outsiders" or people that lived at a greater distance from the plant. In addition to this somewhat political premise, the hypothesis concerning an assimilation effect also had, as an underlying basis, Festinger's Theory of Cognitive Dissonance (1957).

According to this theory, individuals strive for a sense of internal consistency; when an external source of dissonance or inconsistency arises, an individual will undertake various options to relieve the dissonance. These include:

- 1) physically removing the source of dissonance or relocating him/herself from the dissonant environment,
- 2) changing the nature of the source of dissonance to eliminate the inconsistency, or
- 3) changing their belief system to eliminate the inconsistency.

In the case of the Zeeland nuclear plant, these three options translated to the following possible actions:

- 1) individuals relocating their residence far enough away from the plant to eliminate it from their practical environment,
- 2) individuals protesting to shut the plant down, thereby changing its nature enough to eliminate the dissonance,
- 3) individuals changing their belief that the plant poses a risk, via some process of rationalizing or becoming acclimated to the risks, or
- 4) a combination of the above three actions.

While the results of Vlemming's (1985) study did not verify the existence of a "dissonance" driving an assimilation effect, the underlying premises to this possibility seem rather logical. Many people who have lived adjacent to a prominent source of noise (i.e., an airport or rail facility) can attest to the phenomenon of "not even hearing the noise after a while".

These two studies point to the real possibility that people living proximal to facilities that generate negative externalities may become assimilated to them. Regarding the specific questions of this study, this translates to the possibility that people living proximal to FFC facilities may become acclimated to the effects of

these plants on air quality. This in turn drives the second research hypothesis, H_1B as follows. People living in very close proximity to a plant will be very acclimated to the effects and therefore, will not value the absence of these effects (i.e., clean air) very highly. As the distance to a FFC facility increases, this assimilation will diminish and the evaluation of air quality will rise accordingly.

In addition to the assimilation concept, another factor may be contributing to the possibility that perceived evaluation of air quality is positively related to distance of a FFC facility. It is a commonly known fact that areas either downwind or highly proximal to facilities generating negative externalities tend to be areas with lower incomes and/or lower valued housing stock. The existence of a positive relationship between perceived evaluation of air quality and distance may argue for the existence of a "bid rent function for pollution" (Pigozzi, 1990).

As distance from a FFC facility increases, incomes increase and people may be willing and able to spend this income on higher quality housing stock, with cleaner air. People living farther away from FFC facilities may actually have been able and willing to "bid" to live at this location. This concept, as suggested by Pigozzi (1990) could be viewed as the inverse of the established concept of a bid rent function, as originated by von Thunen and cited by Losch (1954). While not to be empirically tested, this concept was used to formulate the second research hypothesis.

The null hypothesis is proposed strictly as an alternative to the two research hypotheses to fit the traditional hypothesis testing framework. It is anticipated that the null hypothesis will not be borne out by the data. The effects of FFC facilities and the increasing public awareness of the entire issue of negative externalities of various facilities argue that distance to FFC facilities will have some effect on peoples' perceptions of these externalities. Further conjecture is

posited as to the direction of this relationship; while the possibility of an assimilation effect has theoretical merit, it is anticipated that the negative relationship between distance to FFC facilities and the perception of the evaluation of air quality will be born out by the data. It is suggested that any assimilation effect will be overridden by the dynamics underlying the phenomenon of a distance decay function. With the formal statement of the research problem and hypotheses in place, discussion now turns to the methods used in the design and implementation of the research.

Chapter III. Methods:

Evaluation of Environmental Quality:

In order to address the research problem and test the above mentioned hypotheses, a method was needed to assess the value that people have for air quality. Environmental economists have wrestled with the problem of assigning economic values to the nonmarket good of environmental quality for years, with varying degrees of success. A brief review of these methods will be presented after Randall, et al (1974) in order to develop justification for the method that this author chose for this research. Then, a more formal description of the means that were used in this research will be undertaken.

Three general classes of methods have been developed to ascribe economic value to the class of nonmarket goods that comprise environmental quality. These are direct cost techniques, revealed demand techniques, and contingent valuation (CV) techniques.

The direct cost techniques simply attempt to aggregate the total costs that a loss or degradation of environmental quality would entail. Randall, et al (1974) presented a marginal value of damage avoided by abatement (MVDA) curve; this curve estimated the value that given levels of abatement of water pollution would yield. Failure to include all relevant costs and difficulty in obtaining certain types of information may lead to problems with this technique.

Lave and Seskin (1970, 1977) also explored this general technique with their attempts to find the economic value that abatement-generated improvements to human health would provide. While their research demonstrated considerable utility for this method in approximating the optimal level of pollution abatement

for both stationary and mobile sources, two major shortcomings were evident. First, this method failed to capture the aesthetic and quality of life aspects of the damages of air pollution. A second, related problem was the same problem that Kneese and Bower (1972) encountered – i.e., the inability to include all of the relevant costs of the abatement in the analysis; this problem resulted in the total value of the abatement being underestimated. The authors conclude "the relevant measure is what people would be willing to pay (WTP) to reduce mortality and morbidity" (Lave and Seskin, 1970). This comment suggests the concept of attempting to internalize these costs in some sort of market mechanism.

The revealed demand technique seeks a suitable proxy for the value of environmental quality. Much of the work in this area has used property values as a surrogate for differing levels of air quality in urban areas. One study presented by Nourse (1967) examined differences in property values and levels of sulfur trioxide in St. Louis via a regression framework; the results indicated a strong, positive relationship between the two variables. Another study by Nourse (1967) examined this question in the same geographic area; while these results were promising, they were not statistically significant at the .05 level. He closed with a note of caution regarding using this technique in other areas without modification, due to the confounding influences of differences in housing stock, income distributions, and individual preferences of housing characteristics.

Wieand (1973) reviewed this research more critically and found two major problems with this type of analysis. First, he suggested that the use of total expenditures on housing as a proxy for the *value* of housing does not include all relevant factors. Accordingly, the regression equation is not completely specified. This fact leads to another problem with the analysis. While the premises underlying the technique seem to be valid, Wieand proposes the technique lacks

necessary statistical rigor due to the fact that the coefficients are not statistically significant at the .05 level.

The third technique used in the past to estimate the economic value of differing levels of environmental quality is the contingent valuation (CV) technique. This method is based on the idea mentioned briefly in the close of the discussion of Lave and Seskin's work (1970), that of internalizing the costs of environmental damage in a market-like mechanism.

The CV method is based on the concept of bidding games that query people about:

- 1) how much they would be willing to pay (WTP) to receive or retain a given level of environmental quality, or
- 2) how much money they would need to receive to accept a given level of environmental degradation (their willingness to accept or WTA).

The literature proposes that this method yields a hypothetical market that serves as a viable surrogate to an actual market, but the hypothetical market that results is not without its possible problems.

Several biases may result from the creation of the hypothetical market that CV seeks to establish (Schulze, et al, 1981). These include:

- 1) strategic bias - the result of the subject giving false bids in order to further a personal view in a strategic manner;
- 2) information bias - the result of the information given in the CV scenario differing significantly from that which would exist in actuality;

- 3) instrument bias - the result of a bias being introduced via either the payment vehicle or the starting point of the bidding game;
- 4) hypothetical bias - the result of the CV scenario not being believable enough to the respondent to elicit a valid bid; and/or
- 5) sampling, non-respondent, or interviewer biases - biases common to this and all other survey research.

In addition, research by Knetsch and Sinden (1983) challenged the notion of WTA being approximately equal to WTP and called into question which of these measures was best to use in this type of research.

Further review of the literature concerning CV addresses the majority of these concerns. Thayer (1981) examined the issues of information, starting point, and hypothetical biases via a survey instrument that queried people regarding the value they held for preserving the aesthetic quality of areas in the Sante Fe National Forest in New Mexico. His results indicated that "in cases in which the commodity is well-defined and the questionnaire requires routine behavior, starting point bias does not exist" (Thayer, 1981). Via a comparison of the bidding game results with those of a site substitution exercise, he also was able to discount the possibility of information and hypothetical biases. Thayer (1981) closes with the comment that "the survey procedure can provide accurate estimates of the individual and aggregate welfare losses associated with environmental degradation".

The issue of strategic bias being introduced into CV scenarios was explored in a study done by Brookshire, et al (1976) that examined peoples' evaluation of aesthetic qualities being impacted by the Kaiparowits power plant near Lake Powell in the southwestern United States. The results of this research indicate

strategic bias was not a significant problem, as evidenced by a low percentage of either zero bids or extremely high bids. In addition, Brookshire, et al's (1976) research examined the question of whether WTA and WTP provide equal measures of the welfare loss associated with environmental degradation; the results support the theoretical notion that these measures are roughly equivalent.

A study by Coursey, et al, (1984) expanded on this last issue, specifically exploring which of the two measures, WTP or WTA, was a more accurate predictor of actual values. Their results indicate that:

- 1) WTA and WTP do not differ significantly; and
- 2) hypothetical measures of value obtained by WTP (similar to those obtained via a CV scenario) may be more accurate predictors of actual values than WTA.

In light of these findings, this author concluded that the CV technique is the most accurate means of estimating the value of a nonmarket good like air quality. Based on this view, this author chose the CV method as the means by which to gauge the value that people hold for the quality of air in areas downwind from a FFC facility. With this determination having been reached, discussion now turns to the development of the survey instrument used in this research.

Survey Development:

Given the above, a survey was developed that sought to capture the maximum willingness to pay (WTP) of a respondent to effect an improvement in air quality at sites downwind from a large FFC facility in the Lansing, Michigan

area. WTP was chosen as the measure to use based on the above arguments by Brookshire, et al (1976) and Coursey, et al (1984) concerning the ability of this measure to most accurately approximate the actual value of this good. In addition, the survey was developed according to certain principles and guidelines, as outlined below.

The first principle focus's on the *general* question of the validity of surveys. The Theory of Reasoned Action (Ajzen and Fishbein, 1980) states that a person's behavior is determined by the interaction of their *a priori* attitude with other peoples' subjective norm; this in turn forms their intention to act in the future, as depicted in Figure 12. Both this research and a study by Bowman and Fishbein (1978) examining public reaction to energy proposals, concluded that peoples' intention to act is an immediate determinant of their action. While the relationship does not argue for a perfect ability to predict behavior, it does describe a regularity that can be used in the development of survey instruments that seek to determine peoples' future actions.

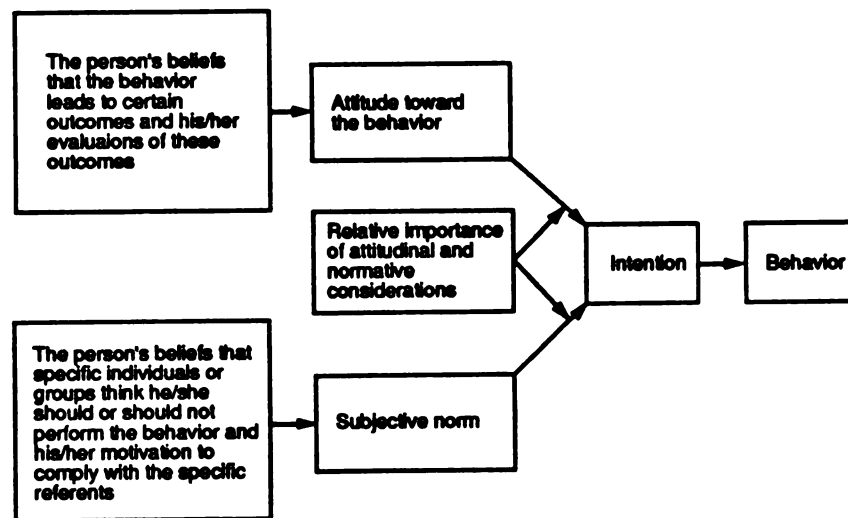


Figure 12. Theory of Reasoned Action (Ajzen and Fishbein, 1980).

With the question of general survey validity in place, a survey was developed according to guidelines initially proposed by Crespi (1971) and used extensively by Randall, et al (1974). In order to obtain expressions of intent that are valid predictors of actual actions, the survey instrument must convey certain information.

- 1) The situation portrayed in the survey must be highly institutionalized or routine.
- 2) The situation portrayed in the survey must be likely.
- 3) The situation portrayed in the survey must require a low level of abstraction to visualize (i.e., it must be a concrete situation).
- 4) The behavior that is queried must be a specific one (i.e. in order to determine if a person would pay a pollution abatement tax, the questions in the survey must focus on that particular tax, not the general issue of taxation).

The first three of these conditions assures that the situation portrayed is believable and reduces the likelihood that a hypothetical bias may be introduced; the last condition assures that the instrument is obtaining data that is valid in the sense of providing responses about the specific action being examined.

The last general concern to be addressed in the design of the survey instrument is the "free rider" phenomenon, which arises when an individual believes that he/she may be able to receive the benefits of a publicly provided good without paying for it. Individuals who may receive the benefits of public services without paying their share of the tax burden are one example of this phenomenon. While previous research into the existence of this phenomenon

suggests that perhaps only economists freeride (Marwell and Ames, 1981), this author made explicit efforts to insure that this potential problem did not surface in the administration of the survey.

Survey Structure:

The survey instrument was composed of several parts, the first of these being a script (Figure 16 in the Appendix) that the interviewer used to guide the interviews in a consistent manner, thereby avoiding any interviewer or sampling bias.

Introduction of the Survey:

The script began with a very general introduction that:

- 1) introduced the general purpose of the survey, that of querying peoples' views of power plants and air pollution;
- 2) informed them of the hypothetical nature of the survey;
- 3) disclaimed any involvement of the power company in the research;
- 4) assured them that their responses would be treated with the strictest of confidentiality; and
- 5) advised them of the need to sign a consent form (Figure 17 in the Appendix), which stated that their participation in the survey was completely voluntary.

Survey Explanation:

After dealing with the consent form, the script moved onto the more detailed explanation of the survey. The wording of this portion of the survey was written with a concerted effort on behalf of the researcher to provide the subjects with enough information to participate without biasing their responses. Specifically, the explanation portion of the survey was designed to address the following concerns.

- 1) It identified the plant by mentioning a popular set of nicknames and presenting the subjects with both an 8 X 10 color print of the plant and a map of the Lansing area that indicated the location of the plant (Figures 18 and 19 in the Appendix).
- 2) It presented them with an unbiased list of the advantages and disadvantages of the plant.
- 3) It advised the subjects that they would be asked some questions about how they valued certain trade-offs that resulted from these advantages and disadvantages. This provided a lead in to the actual bidding portion of the survey.

Bidding Exercise:

In order to solicit the bids from the subjects, they were asked how much they would be willing to pay (WTP) in order to eliminate all of the previously mentioned problems of the plant. Two aspects of this solicitation of the bids are of particular note. First, the payment vehicle chosen to solicit the bids was an

increase in their monthly utility bills, which was believed to be a very believable and realistic payment vehicle. Second, mention was made that under the hypothetical scenario, all people in the area would be paying the increased rates, not just the individual being interviewed. It was believed that this adequately addressed the possibility of a free rider phenomenon existing.

Once the subjects were advised of the rules of the bidding game, the bids were solicited in an iterative manner, using a method employed in previous studies (Randall, et al, 1974; Brookshire, et al, 1976; Thayer, 1981). The choice of the iterative method also was based on the finding that it resulted in an approximation of WTP that most closely approached WTA (Coursey, et al, 1984). A one dollar per month rate increase was chosen as the starting point since this seemed to be the lowest reasonable amount to suggest as a rate increase. The subjects were asked if they would be willing to pay this increased rate if all of the possible problems associated with the plant could be eliminated. From this point, the bid was increased until the subject gave a "no" response. The bid that elicited the last "yes" response became the bid of record, and this was recorded on the subject response form (Figure 20 in the Appendix). All subsequent responses and data were also recorded on this form.

Subjects were then queried as to which of the possible concerns of the plant mentioned previously were included in their decision process, and these were ranked from most to least important on the form. Subjects then were asked if their bid would differ if the plant in the scenario was a waste to energy conversion facility; this question was posed to determine if people perceived the negative externalities of this type of facility any differently than traditional FFC facilities. The last part of the bidding exercise queried any individuals who gave zero bids as

to the reason for their bid. This was done to determine if the zero bid was either a protest bid or a bid exhibiting strategic behavior.

Socioeconomic Data:

The survey then solicited socioeconomic data from the subjects for two reasons. First, this would facilitate comparison with previous research into the spatial and nonspatial nature of facilities that generate negative externalities (the vast majority of this research gathered this type of data). Second, as discussed previously, Papageorgiou (1978) and Dear, et al, (1980, 1982) proposed that the interaction of the externality surface and the population surface determined the societal relevance of the externality, perhaps even to the point of determining the urban structure itself. Gathering this data would therefore allow this researcher to explore these interactions at length.

Specifically, the following types of data were solicited from the subjects:

- 1) tenure at their current and previous addresses;
- 2) number of children, adults and senior citizens in their household;
- 3) marital status of the subject;
- 4) level of education that the subject had attained;
- 5) occupation of the subject;
- 6) age of the subject; and
- 7) approximate family income, and whether it was a single or dual income.

These variables were chosen on the basis of previous research, as well as intuitive notions of this author, as to how different groups of individuals would

perceive the negative externalities that result from being proximal to a FFC facility. The following outcomes were expected as a result of the research (*ceteris paribus*, or other things being equal):

- 1) People living at their residence for longer periods of time would be more acclimated to the effects and would therefore perceive the negative externalities to a lesser degree, resulting in lower bids.
- 2) Married people, those with more children, or seniors in the household would be more sensitive to health concerns, and therefore, would generate higher bids.
- 3) People having attained a higher education would be more aware of the effects associated with the plant and therefore would generate higher bids.
- 4) People with occupations in the industrial sector would be more acclimated to similar effects in their workplace, and therefore, would generate lower bids.
- 5) People with jobs outside the industrial sector would have an opposite situation and generate higher bids.
- 6) Higher income families would be more sensitive to the effects of the FFC facility and therefore, would generate higher bids.

While the basis' for these expectations are not in the form of formal hypotheses, they were still of interest to the author; therefore, data were gathered in order to determine if the expectations would be born out in the analyses.

Environmental Awareness and Support Queries:

The last type of data that was gathered in the interview concerned the subjects' level of awareness of legislation designed to protect the environment and the support of the respondents for such legislation. The literature indicates that this effect may exist, and this author also had an interest regarding the effect these variables have on the distance decay function. While these concepts may seem to be born out of common sense, mention is made of them, and the literature dealing with them, in order to justify the awareness and support questions included in the survey.

Van der Plight (1984) examined the factors that influence the acceptance of nuclear energy facilities and found that *a priori* views of this energy source affected the degree to which people would accept the siting of a facility in close proximity to their residence. This has been termed the NIMBY (Not In My Back Yard) syndrome, a common description of this perceptual phenomenon (Furuseth, 1989).

Levenson (1974) examined the effect of *a priori* membership in anti-pollution organizations on individuals' perceptions of pollution. Anti-pollution organization members in general felt that pollution was a greater problem and had more negative consequences. In addition, they were more active in their expression of these views.

Sundstrum, et al, (1977) examined the factors that contributed to acceptance of a proposed nuclear power plant and found that two dimensions acted on this acceptability, an economic dimension and a hazards/disruption dimension. As one would expect, individuals scoring high on the economic

dimension were more prone to favor the plant, whereas those high on the hazards/disruption dimension opposed the plant.

The above mentioned research and this author's intuitive interest in these issues drove the formulation of the portion of the survey that dealt with the Statement of Purpose of the National Environmental Policy Act (NEPA), as depicted in Figure 21 in the Appendix. In addition, this measure allowed this researcher to standardize responses within a population of respondents. This item includes a paraphrased version of the formal statement of purpose of this law (Public Law 91-190, 1970) as follows. This law seeks:

- 1) to encourage harmony between humans and the environment,
- 2) to prevent or eliminate damage to the environment, and
- 3) to enrich the understanding of the environment.

After this statement are two questions that query the subjects about their *a priori* awareness of this law and their support for the intent of this law. A concerted effort was made to focus the subjects' attention on the specific issues of, being aware of, and in support of, the intent of this law. Perhaps more importantly, care was taken to avoid confounding their response with any feelings on the general issue of taxation, or how the funding for this law was to be obtained. This author felt this manner of structuring the question conformed to the guidelines that Crespi (1972) and Brookshire, et al (1974) proposed for valid questionnaire design.

An additional aspect of this item worth noting is the use of a linear response scale with the instructions to have the subjects place a mark on the scale to indicate their response. This method yielded a variable that was truly

interval/ratio in nature, and one that could be treated with greater statistical rigor than traditional Likert scale questions.

Enumerator Recorded Data:

The last page of the subject response form allowed the interviewer to record the sex of the subject, the type of housing unit, the time of day and day of the week that the interview was performed, and whether or not the subject had signed the consent form. The first two variables were gathered to determine if there was an effect of the subject's sex or type of housing unit on the relationship between distance to the FFC facility and perception of attendant negative externalities. The time of day and day of the week variables were gathered to check for a temporal bias to the data, and the consent form item allowed verification that this procedure had been followed, if the need to provide verification arose at a later date.

Selection of the Research Area:

Several criteria were included in the process of selecting the study area where the survey was to administered. The FFC facility used as the focus of the survey and the surrounding area had to satisfy the following criteria.

- 1) The FFC facility involved had to generate a large enough output of pollutants to generate externalities of a nature to be perceived by the people living at different proximities to it.

- 2) The FFC facility had to be physically large enough to facilitate identification by the subjects in the study.
- 3) The FFC facility had to be located in an area that had an adequate number of people living downwind of it to supply the required subject population.

The Air Quality Division of the Michigan Department of Natural Resources was contacted to determine which site or sites fulfilled these criteria. Six possible plants were found to exist in the Lansing Tri-county area, and these are listed in Table 5 and depicted on the map in Figure 13. Inspection of the spatial distribution of these plants and their corresponding output figures revealed that the Board of Water and Light's Eckert Station Plant suited the site selection criteria the best. It generated the largest pollutant output of the six sources, was the most visible, was the most identifiable (even being known to Lansing residents by the nicknames of "Winkin', Blinkin', and Nod" and the Three Sisters"), and had the requisite number of people living proximate to it to generate an adequate survey sample size.

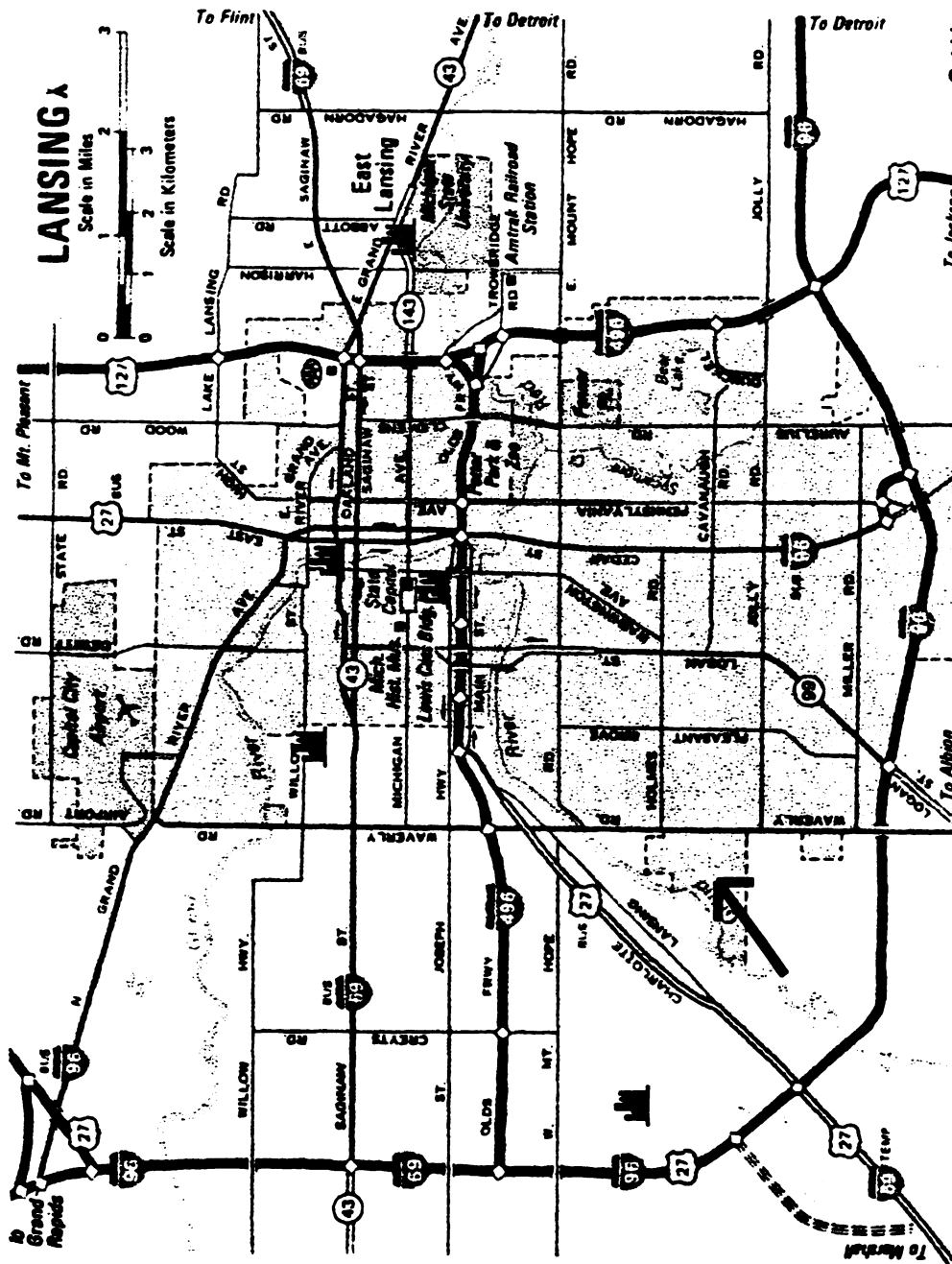


Figure 13. Map of 5 potential power plants to serve as focus of study area.

Table 5. Six largest plants in the Lansing area reviewed as possible focus sites for sampling areas (Air Quality Division, MDNR, 1989).

<u>Facility</u>	<u>Emissions Total</u>	<u>Fuel burned</u>	<u>Power output</u>	<u>Abatement mix</u>
BWL Eckert Station Plant	12,176 T (SO ₂) 207 T (Part)	764,465 T Coal 319 MGal. Oil	18.4 x 10 ¹² BTU	13, 3
BWL Erickson Station Plant	7078 T (SO ₂) 151 T (Part)	437,289 T Coal	10.5 x 10 ¹² BTU	13
MSU Power Plant	2,455 T (SO ₂) Unknown (Part)	165,965 T Coal 54,682 x 103 ft ³ NG	data not available	10, 13, 3
BOC Power Plant	1069 T (SO ₂) 210 (Part)	63, 783 T Coal 7,508 x 103 ft ³ NG	data not available	10, 13, 3
BWL Ottawa Station Plant	323 T (SO ₂) Unknown (Part)	20,620 T Coal 57 MGal. Oil	.5 x 10 ¹² BTU	13
Owen Glass Co. Production Plant	Unknown (SO ₂) 87 T (Part)	525,000 x 103 ft ³ NG	data not available	10, 2

Explanation of Notation:

Units of Measure:
T = Metric Tons
MGal = Million Gallons

Pollution Abatement Codes:

2 = Single Cyclone
3 = Multicyclone
10 = Baghouse or Fabric Filter
13 = Electrostatic Precipitator

Pretest of the Survey Instrument:

With the selection of the target FFC facility and the development of the survey instrument established, a pretest was administered to several people living in the sampling area. At the suggestion of Cynthia Wheatley and Eleanor Love of the Lansing Planning Department, the presidents of the Cherry Hill, Green Oaks, and East Side Neighborhood Associations were contacted to act as pretest subjects. These individuals and their spouses provided valuable insight into administering the survey instrument in their respective neighborhoods.

Two initial instruments were tested that were similar to the final instrument with the exception of the specific nature of the scenario presented. Both presented a hypothetical, newly proposed power plant to be placed at various locations. The subjects were then queried how much they would be willing to pay (WTP) to either move the plant to a location farther away from their residence (pretest survey #1), or to prevent the plant from being built at all (pretest survey #2). Several problems were evident with these scenarios, which included:

- 1) a difficulty in getting the subjects to understand the rules of the bidding game;
- 2) a basic problem of credibility regarding the need for a new plant;
- 3) a failure by the subjects to understand exactly what they were being asked to pay to avoid or prevent; and
- 4) an equity problem dealing with simply pushing the plant and its attendant problems into "someone else's backyard".

Based on the comments of the people who participated in the pretest, the instrument was changed to the form that was administered in the final gathering of the data.

Sampling Strategy and Implementation:

Similar to the strategy used by Furuseth (1989), a stratified, random sampling strategy was used, with a random sub-sample being taken in each of four zones, stratified by distance to the Eckert Station Plant (Figure 14). The distances of the four zones from the plant were as follows:

- | | |
|--|---|
| 1) $1\frac{1}{4}$ to $1\frac{1}{2}$ mile | 3) $1\frac{1}{4}$ to $1\frac{1}{2}$ miles |
| 2) $1\frac{1}{2}$ to $3\frac{3}{4}$ mile | 4) $1\frac{1}{2}$ to 2 miles |

The rationale for this type of a sample at these distances was similar to that used by Dear, et al (1980) and reflected a trade-off between three factors.

- 1) The zones must be large enough and of such a nature to generate enough people for a reliable sample.
- 2) Previous research by Dear, et al (1980) and Furuseth (1989) indicated that the SEF may be fairly compact spatially, reflecting the fact that a FFC site is not perceived to be as noxious as a nuclear plant.
- 3) The number of subjects in the sample and the spatial extent of the sampling must be such that a single interviewer could perform the interviews in a reasonable period of time.

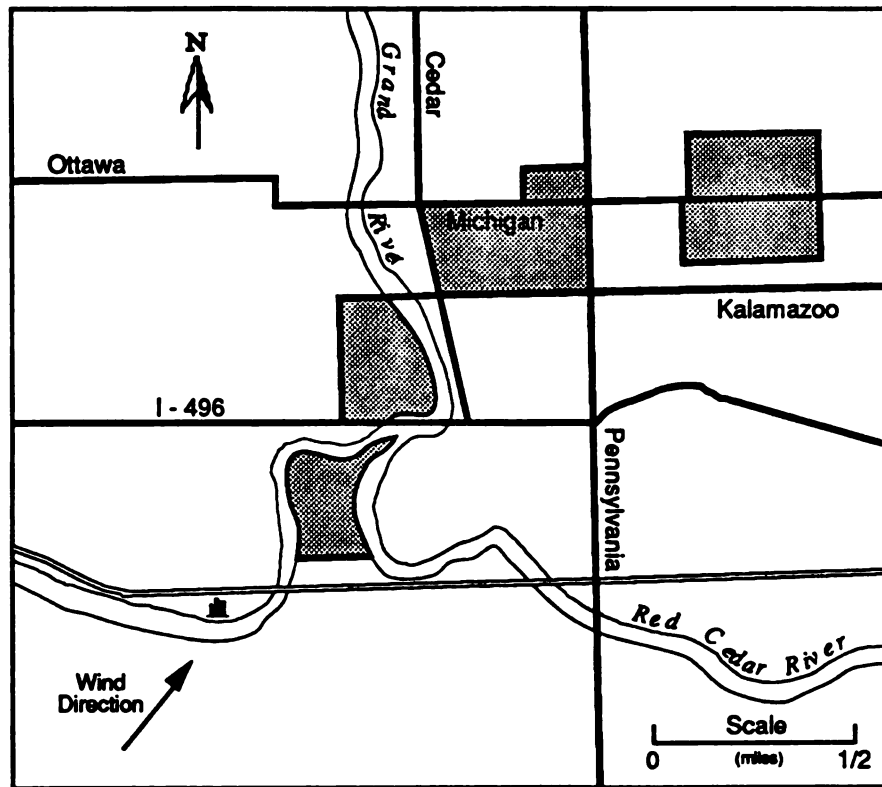


Figure 14. Sampling areas relative to the power plant location.

Based on this set of spatially stratified zones, a sub-sample size (n_i) of thirty people in each zone was chosen, yielding a total sample size (N) of 120 people in all. This represented about fifteen percent of the approximate 800 households in the four zones, and compares quite favorably with sample sizes in previous research.

With this scheme established, 800 cover letters (Figure 22 in the Appendix) were hand-delivered to the prospective subject households in the four areas. The purpose of this activity was threefold.

- 1) This would notify all potential subject households of the fact that interviews would be commencing in the near future, increasing the likelihood that they would elect to participate.
- 2) This allowed this author to operate more efficiently and safely in these neighborhoods.
- 3) This also would allow any condemned or vacant dwellings to be noted so these could be taken out of the total pool of possible subject residences.

With the strategy established, the cover letters distributed, and any vacant or condemned dwellings removed from the pool of prospective subjects, the selection of the subject households was done in a random manner as detailed below.

- 1) All prospective subject households within each zone were given a discrete number.
- 2) A random number generator was used to produce fifty prospective households within each zone; this assured a valid sample size of at least thirty subjects, given that some people would be unwilling to participate or would not be at home.
- 3) These fifty prospective subject residence locations were then transferred to 1 to 100 scale assessor's maps, which were used in the field to locate and keep track of the subject residences.

The implementation of the actual survey work in the field took place during the two week period from March 26, 1990 to April 10, 1990. Following the

randomization scheme outlined above, 116 usable personal interviews were administered, with the data being recorded on the subject response forms.

Data Analysis:

Once the data were gathered, some preliminary coding was performed, and the data were entered into a Compaq 386 micro computer and analyzed in SYSTAT (The System for Statistics, Version 3.0, 1986).

Since the data were to be analyzed in a multiple regression framework, the first step in the analysis was to do a set of diagnostic statistical runs to determine how closely the data conformed to the assumptions underlying the General Linear Model (GLM) (Poole and O'Farrell, 1971). Some of the diagnostics were done before the regression runs occurred, while others were performed in an interactive manner. These initial analyses included:

- 1) a review of plots of the variables to determine if the variables themselves were normally distributed;
- 2) a review of correlation matrices to determine if multicollinearity was present;
- 3) a review of the KS Lilliefors statistic to determine the degree of normality and homoscedasticity that was present among both the variables and the residuals or error term;
- 4) a review of the tolerance statistics that accompanied the simple and multiple regression runs involving the dependent variable of the bid that subjects gave for improving air quality (BID) and the main independent variable of distance from the subjects residence to the

- FFC facility (DIS);
- 5) a review of the plots of the residual term to determine normality of the residuals;
 - 6) a review of plots of the residuals versus DIS to determine the homoscedasticity of the error term in relation to the independent variable; and
 - 7) an examination of the leverage values resulting from the regression runs mentioned above in item number four to determine if there were any undue leverage values resulting from these runs.

As mentioned above, some of these diagnostics were run *a priori*, while others were run interactively, in an ongoing manner with the subsequent simple and multiple regression runs.

Once all of these analyses were performed, they were reviewed in detail to determine which of several potential structures being considered to relate distance to the bid variable yielded the best behavior among the residuals and other pertinent statistics. It should be noted that a basic philosophy was adhered to in this stage of the analysis. While the literature (Shaw and Wheeler, 1985; Clark and Hosking, 1986) was consulted in detail to help determine the structure being considered, thought was also given to the underlying processes that were hypothesized to be acting on the relationship between distance and the subjects' bid. This author was after a balance between a structure that behaved well statistically and had a reasonable degree of theoretical basis to it.

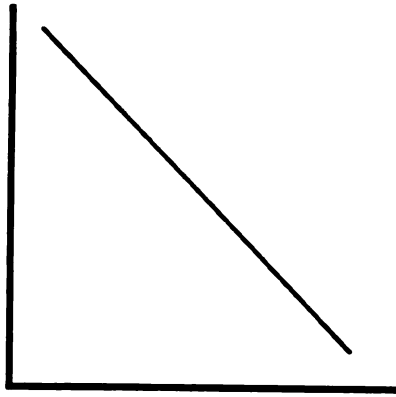
The various structures explored included a simple linear form, various power curves, exponential curves, higher order polynomials, and certain log

transformations of these curves. The more promising of these are portrayed in Figure 15. The log transformations were explored for two reasons.

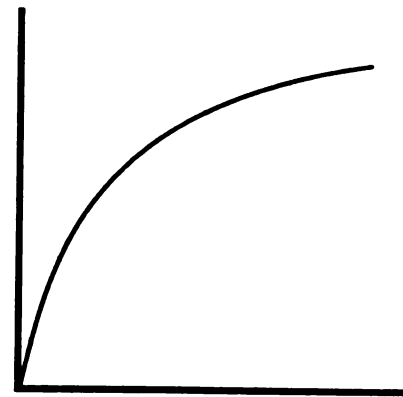
- 1) The log structure had a certain amount of theoretical basis to it concerning how the variables being considered may interact together.
- 2) The log transformation allowed the regressions to be run in the linear form that satisfied the "inherently linear" nonlinear condition of the GLM (Pindyck and Rubinfeld, 1981).

Again, the intent at this stage of the analysis was to determine a structure that achieved a balance between theoretical soundness and adequate behavior of the diagnostics.

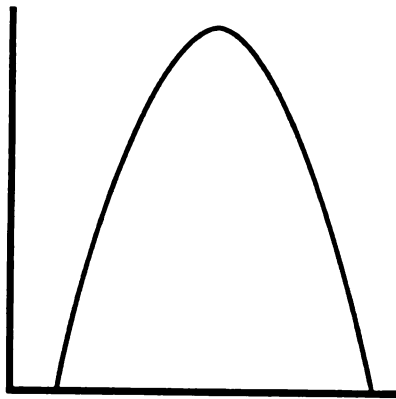
Once this structure was determined, an extensive series of runs was performed that searched for the other bivariate and multivariate relationships that existed among the variables. The author followed previous research (Dear et al, 1980 and 1982; CEQ, 1980; Levensen, 1974; and Sundstrum, 1977) to guide the search for these relationships. With this description of the analysis used and the justification for it in place, discussion will now turn to a formal review of the results.



a) $y=a-bx$



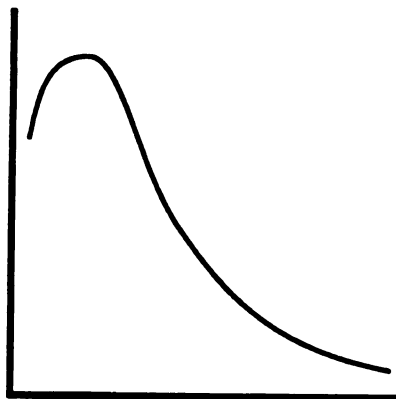
b) $y=ax^b$



c) $y=a+bx+cx^2$



d) $y=ae^{-bx^2}$



e) $y=ae^{bx}-cx^2$



f) $y=ae^{-bx}$

Figure 15. Various regression structures explored.

Chapter IV. Results and Discussion:

Results:

The Main Research Question:

The best fitting structure for the regression that related the subjects bid for improving air quality (BID) to the distance at which they were located from the FFC facility (DIS) was the log transformation of the first order negative exponential as detailed below. (The transformation is listed first, with the raw form of the relationship following; an asterisk indicates significant coefficients at an alpha level of .05).

$$\text{LOGBID} = 2.583^* - .357^* (\text{DIS}) \quad \text{Equation 1A}$$

$$\text{BID} = 13.237 e^{-.357 (\text{DIS})} \quad \text{Equation 1B}$$

Examination of the tolerance values, KS Lilliefors statistics, residuals, and leverage values indicate that this structural form is relatively well behaved. The relationship is in the direction that was anticipated, and the coefficients are both significant at an alpha level of .05. Collinearity of the variables is not a problem, and neither the KS statistic nor the plots of the residuals indicate a significant departure from the normality assumption of the GLM. Lastly, the leverage values do not exhibit any extreme behavior.

Related Research Questions :

Papageorgiou's (1978) suggestion that urban form results from an interaction of a population surface and an externality surface drove the exploration of these related research questions. Specifically, variables that were found to effect perceptions of externalities in previous research were examined; in addition, this author's intuitive views exerted a certain amount of influence at this stage of the analysis.

It should be noted that the log transformation was retained as the basic structure for these and all other subsequent explorations into the relationships between the BID variable and related variables. While the underlying rational for this structure, as regards non-distance variables, is not as strong as for the distance variable, it did yield relationships that had the greatest statistical significance. As mentioned previously, this analysis was performed with the concept of a balance between theoretical soundness and statistical validity in mind.

Several bivariate relationships were found to exist between the BID variable and the socioeconomic variables -- i.e., SUPPORT (the subjects expression of support for the NEPA legislation, HEALTH (the ranking of health concerns as a consideration in their bid), and SCHOOL (the level of education that the subject had completed). The variables and the coefficients of these relevant regression equations (numbers 2, 3, and 4) are detailed in Table 6, along with the R squared statistics and an indication of significance at the .05 level.

All of the coefficients are significant at the .05 level, with the exception of the intercept in equation 4, and the relationships are all in the expected direction. Examination of the diagnostic statistics mentioned above indicates that all of these

Figure 6. Coefficients, t values, R squared values and indication of significance for the regression equations reported in the text.

<u>Equation #</u>	<u>Variable Name</u>	<u>Coefficient</u>	<u>T value</u>	<u>R Squared Values</u>	<u>Significant at .05 level</u>
1A	Constant	+2.583	+12.121	.039	Yes
	DIS	-.357	-2.078		Yes
2	Constant	+1.375	+4.968	.088	Yes
	SUPPORT	+.008	+3.188		Yes
3	Constant	+1.490	+4.307	.039	Yes
	HEALTH	+.766	+2.075		Yes
4	Constant	+.748	+1.561	.080	No
	SCHOOL	+.105	+3.047		Yes
5	Constant	+1.859	+4.973	.086	Yes
	DIS	-.396	-2.341		Yes
	HEALTH	+.850	+2.338		Yes
6	Constant	+1.081	+2.231	.134	Yes
	DIS	-.426	-2.578		Yes
	SCHOOL	+.116	+3.417		Yes
7	Constant	+1.803	+5.408	.129	Yes
	DIS	-.357	-2.215		Yes
	SUPPORT	+.008	+3.143		Yes
8	Constant	+2.392	+9.876	.062	Yes
	DIS	-.431	-2.442		Yes
	INCOME	+.125	+1.620		No
9	Constant	+.780	+1.562	.186	No
	DIS	-.414	-2.619		Yes
	SCHOOL	+.090	+2.689		Yes
	SUPPORT	+.006	+2.610		Yes
10	Constant	+.826	+1.442/+ .467	.189	No
	DIS	-.413	-2.580		Yes
	SCHOOL	+.093	+2.726		Yes
	SUPPORT	+.006	+2.443		Yes

relationships behave relatively well, with no major problems in the distribution of the error term, no collinearity among the variables themselves, and reasonable leverage values.

Several multivariate relationships were found to exist among the data, whereby certain socioeconomic variables acted in conjunction with the DIS variable in effecting the subjects bid (BID). The first of these regressions (numbers 5, 6, and 7), as indicated in Table 6, are relatively strong relationships; again, significance of the coefficients is indicated in the table.

All of these coefficients and the overall relationships are significant at the .05 level, and the relationships are in the direction that was anticipated. Examination of the diagnostic statistics indicates again that these relationships behave with no major problems with regards to distribution of the residuals, no collinearity among the variables, and no extreme behavior of the leverage values.

Three other multivariate relationships (numbers 8, 9, and 10) were found that were not quite as strong as the above mentioned ones, but still deserve mention. Most of these coefficients are significant at the .05 level with the exception of the income coefficient in equation 8, and the intercepts in the last two equations.

The last two equations relate the effect that level of education (SCHOOL) , and support for the NEPA legislation (SUPPORT) had on the relationship between DIS and BID, but there is a minor difference in the coefficients. The last equation contains a binary choice variable that indicates whether a person in the subject's family had a serious breathing ailment. This variable acts as an intercept dummy variable that generates coefficients with different values than those in Equation 9. Hence, the presence or absence of a person having a breathing

ailment effects the overall relationship among these variables, but the resulting intercepts are not significant at the .05 level.

In addition to the lack of statistical significance in these latter relationships, there are some problems with the behavior of the residual term (specifically, evidence of heteroscedasticity in the distribution of this term) as well as leverage values considerably higher than the level deemed safe by Wrigley (1983). While these problems and the marginal level of significance suggest these results are not as strong as those previously reported, they hint at some underlying processes that are of considerable interest. Therefore, mention is made of them now, with further discussion following in the latter portion of this manuscript.

A last group of regressions that is not even formally reported in the tables or equations will be briefly discussed before moving to the discussion of the results. In an attempt to examine whether family structure or tenure of residence had any effect on the BID variable, regressions examining these variables were run both via the LOG transformation and the linear form, with no significant results.

The variable for tenure that examined how long residents had lived at their present residence yielded a zero coefficient that was not significant. Perhaps even more interesting, the coefficients obtained for number of children or seniors in the household, while not statistically significant at the .05 level, were actually opposite to the direction anticipated. This suggests that these variables may be masking a negative income effect, whereby households with more children, or seniors on limited incomes, may not have had the financial resources to provide a higher bid. Comments noted in the field support this possibility, although this facet of the regressions was not tested statistically.

The last set of results to be presented concern the difference of the mean BID among various subgroups of the sample population. This portion of the data

set either did not reveal significant results in the above discussed regressions, or was not suited to treatment in this manner. Accordingly, the mean BID's for these variables were examined via the T test to determine if they were statistically different from each other.

The following subgroups were examined in this manner:

- 1) the bids that people gave to improve air quality effected by a FFC facility, as opposed to a hypothetical waste to energy incinerator;
- 2) the bids given by male as opposed to female respondents;
- 3) the bids of individuals involved in factory or industrial occupations versus occupations outside of the industrial sector;
- 4) the bids of individuals living in single family detached homes versus apartment dwellers,, and
- 5) the bids of married versus single individuals.

As indicated in Table 7, the only set of mean bids that were statistically different were those of bids related to FFC facilities versus those related to waste to energy incinerators. While the other pairs of mean bids exhibited minor differences in values, these differences were not significant at the .05 level.

With this review of the statistical results in place, attention will now turn to a more extensive discussion of these results and the relevance they have to the various research questions posed in the statement of the problem and the hypotheses.

Table 7. T test results comparing mean bids for certain sub-groups.

<u>Variable Pair</u>	<u>Mean value</u>	<u>T value</u>	<u>Significant at .05 level</u>
Bid for FFC facility	\$12.76	4.733	Yes
Bid for waste to energy incinerator	\$14.67		
Bid by males	\$12.60	.729	No
Bid by females	\$14.71		
Bid by industrial occupation workers	\$11.00	.451	no
Bid by non-industrial occupation workers	\$12.95		
Bid by single-family dwelling occupants	\$11.69	.796	no
Bid by multi-family dwelling occupants	\$13.88		
Bid by married individuals	\$13.86	.115	no
Bid by single individuals	\$13.48		

Discussion:**The Main Research Question :**

As formally noted in the statement of problem and research hypotheses, the main research question deals with the relationship between the distance at which people live from a FFC facility that generated negative externalities (DIS) and their perceived valuation of air quality (BID). As noted in Equation 1, the log transformation of the first order negative exponential was found to be the best fitting structure that relates (DIS) to (BID) and indicates that there is a negative relationship between these variables.

This result supports research hypothesis H_1A , and reveals a distance decay function acting on the perception that individuals living downwind from this FFC facility have regarding the negative externalities being generated. These findings are consistent with the majority of research reviewed previously, including that of

Furuseth (1989), Van der Plight (1984), Dear, et al (1980, 1982), and the wealth of work done concerning evacuation behavior surrounding nuclear power plants done by Johnson, et al (1983, 1984, 1985, 1986, 1989) and the USNRC (1978, 1980).

The valuation that people hold for improvements in air quality effected by the plant is higher near the facility and then decreases via the form specified in equation 1 as the distance to the source increases. Those individuals living nearest to the FFC facility perceive the negative externalities to the greatest degree, and this perception lessens as the distance to the facility increases. Evidently, any assimilation effect that may exist as a result of people becoming acclimated to the effects of the plant is superseded by the distance decay function.

Related Questions :

In addition to the bivariate relationship between DIS and BID, several other relationships were found to be statistically significant at the .05 level. As noted in the previous section, SUPPORT, HEALTH, and SCHOOL all affected the BID variable as hypothesized.

The level of support that an individual had for national environmental legislation (SUPPORT) was positively related to the evaluation the individual had for improvements in air quality. As was anticipated, this support translated into a higher evaluation for this improvement; this is consistent with previous findings by Van der Plight (1984) and Levenson (1974) regarding *a priori* views of facilities that generate negative externalities and peoples' perceptions associated with the externalities.

An individual's ranking of health concerns also had the anticipated effect on the BID variable. People who expressed a greater concern for the health

related effects of the externalities associated with the plant apparently were more sensitive to these effects, and this translated into higher bids.

Lastly, an individual's level of education was also positively related to their bids. As anticipated, these individuals tended to be more aware of both the direct effects of the plant as well as the implications to the human condition; this was revealed in their bids.

When these variables were examined to determine how they acted in conjunction with the distance variable, similar results were found. As detailed in equations 5, 6, and 7, these variables were all significant at the .05 level, and the relationships found were in the direction expected. The coefficient of DIS remained negative, as anticipated, whereas the coefficients of SCHOOL, SUPPORT, and HEALTH all remained positive, as hypothesized.

When several of these ancillary variables were included with the DIS variable, the statistical validity of the resulting regressions began to erode. As mentioned previously, Equations 8, 9, and 10 moved towards the margins of significance, although the direction of the relationships was still as expected.

Perhaps the most interesting of these latter regressions were Equations 9 and 10, which contained the binary choice variable that dealt with the presence or absence of a serious breathing ailment in the respondent's family. While the lack of statistical validity makes drawing any major conclusions inappropriate, it is interesting to note that the presence of a serious breathing ailment in the household has some effect on the resulting regression.

The last group of findings to be discussed is the results of the T tests that examined the existence of any differences in the mean bids among certain sub-groups. As previously indicated, the only statistically significant result of these tests was the examination of the differences of the mean bids resulting from perceptions

of a FFC facility as opposed to the perception of a waste to energy incinerator. As indicated in Table 7, the difference of these two mean bids is statistically significant at the .05 level. Clearly, people in this study perceive the resulting negative externalities of these facilities differently.

The other T test results do not indicate any differences that are statistically significant. As indicated in Table 7, while these mean bids do differ slightly, the differences are not significant; in fact, the bids for individuals living in single family dwellings was actually lower than for individuals living in multi-family dwellings, which was the opposite of what was anticipated. Sex of the respondent, marital status, and job type all failed to generate any significantly different bids.

Chapter V. Summary and Conclusions:

Summary of the Research:

FFC facilities play a pre-eminent role in meeting U.S. domestic energy needs and generate a variety of negative externalities that have significant effects on the natural and human environment. The manner in which these externalities interact with the population surface of urban areas may actually define the structure of these urban areas (Papageorgiou, 1978). Human perceptions of these processes are a natural result of these interactions and can have a major influence on the acceptance of existing facilities as well as the ability to site future facilities (Davis, 1984-1985; Furuseth, 1989). Accordingly, research into peoples' perceptions of these facilities and how these perceptions vary across space is warranted.

This research used a survey instrument to implement the contingent valuation technique to capture peoples' evaluation of air quality (via a series of bids for this non-market good) at various sites downwind from a major FFC facility in the Lansing, Michigan area. The main research question that was posed concerned the nature of the relationship between the distance at which people lived from the facility in question and the bid that the subjects gave for their evaluation of air quality affected by the plant.

A two-tailed research hypothesis describing a positive and negative relationship between these variables was tested in a regression framework. In addition, several other bivariate and multivariate relationships involving several variables that described certain facets of the population surface of the study area also were tested in this manner.

The results indicate that a distance decay function exists between the distance at which people live from a FFC facility and the value they place on air quality; log-linear regression showed the first order negative exponential was the best fitting structure. In addition, individuals' level of support for national environmental legislation, their ranking of health concerns, and their level of education completed had the expected positive effect on the bid variable. These variables exerted an effect on the bid variable in a bivariate set of relationships as well as in a multivariate set of relationships whereby they acted in conjunction with the distance variable.

Certain sub-groups of the subject population were examined to determine if there were any differences in their mean bids for the proposed improvements of air quality. While there were minor differences in these mean bids, none of the differences were significant at the .05 level. However, the bids that individuals gave to mitigate the effects of an *existing FFC facility* as opposed to a *hypothetical waste to energy facility* did differ significantly, and this finding indicates that people perceive the negative externalities of these facilities quite differently.

Overall Significance of the Study:

As outlined in the introduction of this manuscript, the manner by which people perceive negative externalities that result from certain energy facilities has both theoretical and societal relevance. Determination of the spatial dimension of peoples' perceptions of these facilities adds to the existing literature concerning this issue; in this study, this researcher specifically addressed the question of how the externality surface resulting from these facilities interacts with the population surface of urban areas to help determine their structure and form.

The distance decay function that this study has found to exist supports the majority of research in this field, and reflects the fact that the effect of distance to a given interaction or activity does indeed have a dampening effect on the perception of this interaction or activity. The other relationships that were found to exist among the variables examined, lend further insight into the manner in which the "people" facet of urban areas influences the end result of the externalities resulting from FFC facilities.

This distance decay relationship can be expanded by rotating the curve indicated in equation 1 around the vertical axis; this generates a cone or horn, with the power plant at the center of the cone. The volume of this horn represents the financial value of eliminating the negative effects of the plant to the people living proximate to the facility. As such, it represents the welfare value of such an improvement, and this value can have utility in the resolution of the issue of whether to compensate the individuals living proximate to the facility or attempt to mitigate the effects of the facility.

Given that people living proximate to such a facility have access to valid information, have the freedom to act upon this information, and are given a choice as to whether to voluntarily accept the effects of the negative externalities, the ethical issue of compensation versus mitigation invites discussion. Arguments in favor of both of these options can be made, and these arguments involve the different social discount rates that certain individuals have regarding the trade-offs that exist between retention of environmental quality and economic gain or loss. Another facet of this question is the tradeoff between efficiency in a Pareto optimal sense versus a sense of social welfare or equity.

As is so often the case in issues of social welfare, the real question is "who decides?"; specifically, who decides whether the above mentioned welfare value is

utilized to mitigate the environmental disruption or to compensate those who bear the most direct effects of it? Do policy making bodies of a popularly elected government make this decision (for the good of those involved) or is it best left up to the people involved to make the decision directly? Who decides whether these resources are used to approximate Pareto optimality in resource utilization, or to attempt to address the social equity issue?

These very questions were posed to this author in the final phase of this research; summarizing this discussion may help answer the above questions, while probably posing or leaving open other related issues. Given the assumptions of people having access to valid information and the freedom to choose, this author argues that, for the most part, those receiving the direct effects of the above mentioned externalities should have a considerable voice in deciding the mitigation versus compensation issue.

Two significant caveats to this view deserve attention. The above set of assumptions implied that those parties receiving the majority of the effects have the ability and freedom to evaluate the trade-offs involved and to make a decision; this implies a sense of maturity of thought and the power to render this decision. What of those individuals who do not have this decision making power, specifically children or other people in a family in a subordinate position? If one expands this discussion to facilities that may generate more pervasive and damaging externalities than FFC facilities (i.e., nuclear weapons facilities and toxic or nuclear waste disposal sites), this issue takes on even greater importance.

This author suggests that some form of social protection may need to be exercised on behalf of these individuals, particularly in cases of facilities generating more damaging externalities. The facility involved in this study operates within the set of laws that regulates air pollution; yet, questions are raised by certain special

interest groups as to the efficacy of these laws. If this analysis and discussion is extended to facilities that either do not operate within relevant laws, or involve issues where valid laws are yet to be concretely established, the argument for policy makers to exert a sense of social responsibility takes on greater relevance. Although this most recent discussion has departed from the specific results of the research, this author believes the issues raised in this area are some of the most important facets of how certain negative externalities interact with the human dimension of our urban built environment.

As Davis (1984-1985) and Furuseth (1989) stated in previous research, the perceptions that individuals have for these types of facilities may be both a necessary and sufficient condition for the acceptance of existing facilities, as well as the ability to site future ones. While the results of this research may not have direct utility in the planning and policy processes involved with siting and managing these facilities, this author concurs with the view that Furuseth stated in the close of his research on hazardous waste facilities (Furuseth, 1989). Optimal siting and management decisions will require that policy makers and researchers interested in resource management issues be well aware of how individuals living in proximity to these facilities perceive them. As this research has answered some of the questions relating to this perception, this author feels that the effort was warranted and has added to our knowledge base in this important problem area.

Recommendations for Future Research:

As is so often the case with a research effort of this nature, even the suggestions of an experienced research committee and the pretesting of the survey instrument left some facets of the research question unexplored. While the results

reported in this manuscript were significant at the levels cited, the low R squared values found indicate that there may be other variables involved in the relationships studied that were not included in the analysis.

Specifically, the effect of income on the regressions examined may warrant further research. The questionnaire used did query the respondents in a general manner, via ranges, about their income, but the coarse resolution of the data generated may have limited its usefulness. (The intent of this technique of using ranges was to defuse any resistance that the subjects may have had regarding this question.) Income was found to have the expected positive relationship, with higher income individuals generating higher bids, but the relationship lacked statistical significance. Comments by a considerable number of respondents also suggested that there may have been an unexplored income effect acting on their bids.

Two possibilities for further exploration of this effect come to mind. First, determining subjects' existing utility bills would allow determination of what percentage increase over their existing expenses their bid represented. Second, determining the respondents' precise income levels (i.e., asking for a specific figure as opposed to ranges) would probably provide a more useful index of their financial resources. These two enhancements to the survey instrument may help uncover any hidden income effect(s).

Another idea for future research would be that of a cross-sectional study examining perceptions of both an existing FFC facility and an existing waste to energy incinerator. The findings of this research indicated people perceived an existing FFC facility differently than a hypothetical facility; it would be interesting to see if this difference in perception would be born out in a cross-sectional study that compared two existing facilities.

Related to this issue is the possibility of a trans-frontier effect acting on the perceptions of facilities generating negative externalities that move across a political border. It has been suggested that the large waste to energy facility that operates in the greater Detroit, Michigan area is most likely exporting its externalities to our Canadian neighbors in the Windsor, Ontario area. This seems a promising study area in which the differential effects of Canadian versus United States citizenship and the effect of externalities from "Someone Else's Backyard" could be explored.

Glossary

Terms and Abbreviations:

Distance decay function (DDF) - the relationship that describes how the effect or perception of a given interaction or activity declines as the distance to the given activity or interaction increases.

Fossil Fuel Combustion (FFC) - the burning of fossil fuels (coal, natural gas, and petroleum) in order to meet domestic energy needs.

LULU's - locally unwanted land uses; the group of land uses that generate negative effects that are usually unwanted by the residents of a given locality.

NIMBY's - Not In My Back Yard; the usual manner by which people in local areas react to the above mentioned land uses (LULU's).

Negative externality - a negative or bad effect of a given activity that tends to occur outside of the normal market mechanism that is responsible for delivering the given activity. An example is the pollution resulting from industrial activities that is not mitigated; the costs of dealing with this pollution that is not included in market delivery mechanisms is an extension of this initial externality.

Spatial externality field (SEF) - the concept that describes how negative externalities are distributed spatially over a given geographic region. This consists of three components:

- 1) the intensity - the total impact of the externality,
- 2) the extent - the actual spatial dimension of the impact of the externality, and
- 3) the rate of distance decay - the rate at which the perception or impact of the externality diminishes over distance.

WTA (Willingness to Accept) - the amount of money that must be paid to people to voluntarily accept the effects of negative externalities.

WTP (Willingness to Pay) - the amount of money that people will pay to avoid receiving negative externalities.

Explanation of Variable Names:

BID - the amount of money that respondents were willing to pay to eliminate the possible effects of the FFC plant in the study.

DIS - the actual distance from the FFC facility to the respondents house.

HEALTH - the respondents ranking of health concerns as a concern that effected their bid.

INCOME - the income classification that captured the respondent's income level.

SCHOOL - the highest year of schooling that the respondent completed.

SUPPORT - the degree to which respondents supported the statement of purpose of the NEPA statement.

APPENDIX

APPENDIX

1

ScriptI. Introduction:

As part of my master's research at Michigan State, I am studying how people feel about power plants and pollution. The current issue of where to site certain energy facilities makes this a matter of some importance to us as consumers, but please understand that many of my questions will be based on imaginary events. I do not work for the power company and have no knowledge of their plans. I will be talking to you about the Eckert Station power plant, and then asking you some questions about the plant and some questions about yourself. Please rest assured that all your answers will be kept strictly confidential.

Do you have any general questions about the survey that I am conducting today? If not, we can now move to the consent form and then on to the questions in the survey.

II. Consent Form:

This is a consent form that I need to have you read and sign before we get into the survey itself. (Hand the form to the person being interviewed.) Can you take a brief moment to read and sign it? This is on a separate sheet from my notes and will be stored separately as required by federal regulations.

Thank you.

III. Survey Explanation:

The Eckert Station power plant is the largest plant in the Lansing area and also produces the most pollution of any plant. You may know it by one of its nicknames, "The Three Sisters" or "Winkin', Blinkin', and Nod". Here is a photograph of the plant and a map showing where it is located in the Lansing area. (Show the map and photo to the person being interviewed.) Are you familiar with this plant?.... Good.

While it uses modern means to reduce this pollution to levels within the law, it still produces alot of pollution. Possible negative effects from this pollution include:

- * health risks,
- * higher noise levels,
- * negative effects on property values,
- * more dirt on our homes and cars, and
- * visual or aesthetic problems with the plant appearance itself; how it actually looks.

Figure 16. The script used to guide the interviews.

On the positive side, Lansing enjoys the lowest utility rates of any northern city, and the Eckert plant is a very important part of the power generating capability of the Board of Water and Light. Put simply, the operation of the plant has both plus's and minus's.

I am interested in how you feel about the trade-offs that result from these plus's and minus's. I will be asking you some questions to find out how you value the different costs and benefits that are mentioned above. Do you have any questions so far?.... Good.

Suppose that we could eliminate all of the possible negative effects of the Eckert Station plant; in exchange for this, higher utility rates would result. Please bear in mind that this increase in costs would occur through higher monthly utility bills and would apply to everyone in your area, not just you (there will be no free riders).

Figure 16 (cont'd).

CONSENT FORM

1. I have freely agreed to take part in a scientific study being conducted by Christopher Brown, a graduate student in the Geography Department at Michigan State University, working under the guidance of Dr. Joanne Westphal. I will be taking a survey that asks me questions about power plants, pollution, and some information about myself.
2. The survey has been explained to me, and I understand the explanation that has been given and what my role in the survey will be.
3. I understand that I am free to discontinue participating in the survey at any time. I understand that the expected length of the survey will be about 20 minutes.
4. I understand that the results of my participation in the survey will be kept in strict confidence, as will those of all other people participating. In other words, all participants will remain anonymous in the reporting of results. Within these restrictions, results of the study will be made available to me at my request.
5. I understand that, at my request, I can receive additional explanation of the study after my participation is completed.

Signed: _____

Date: _____

Figure 17. The consent form.



Figure 18. 6 x 8 inch reduction of the original 8 x 10 inch color print of the Eckert Station Plant.

Figure 19. Reduction of the original map used to aid the respondents in identifying the plant.

Subject's ResponsesI. Bidding Responses:

A) How much would you be willing to pay to bring this about?
Would you be willing to pay:

1\$ more per month? _____	10\$ more per month? _____
2\$ more per month? _____	15\$ more per month? _____
3\$ more per month? _____	20\$ more per month? _____
4\$ more per month? _____	25\$ more per month? _____
5\$ more per month? _____	30\$ more per month? _____

Continue until a "no" response is given. If this is between 5\$ increments, bid down from the no response until you receive a yes response; this is the bid to record _____

B) Which of the following concerns associated with the plant were reasons that influenced your decision to pay the higher rates? Of those mentioned, can you rank them from most to least important?

Health concerns	_____ rank _____
Impact on property values	_____ rank _____
Noise pollution	_____ rank _____
Dirt getting on houses and cars	_____ rank _____
Aesthetic or visual impact of the plant	_____ rank _____
Other	_____ rank _____

Are there any other reasons that influenced your decision? _____

C) If the power plant involved in the survey was to be an incinerator that burned solid waste in order to produce electricity, would the amount you would be willing to pay be different? If so, what would the new dollar amount be? _____

Figure 20. Subject response form.

II. Treatment of Zero Bids: (Query only if zero bids were received).

What was the reason that you were unwilling to pay a higher utility bill to eliminate the negative effects of pollution associated with the plant?

a) Did you feel that eliminating the negative effects of the plant was truly not worth paying more on your utility bill? _____

b: Did you feel that it was unfair for those that receive the damages of pollution to pay money to avoid such damage? _____

c) Other _____

III. Personal Data:

If you don't mind, I would now like to ask you some questions about yourself. Again, please be assured that the responses to these questions also will be kept strictly confidential. Your responses will not be associated with your name or address.

A) How long have you lived at your present address? _____

Prior to this, where did you live, and for how long?

Location _____ How Long _____

B) How many members are there in your household?

Number of children _____

Number of adults _____

Any senior citizens? _____

C) Are you married or single? _____

D) What is the approximate grade in school that you have completed? (Circle the response that corresponds to their answer.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
								(High School)				(College)		(Grad school)		

E) What is your occupation? _____

Figure 20 (cont'd).

F) What is your approximate age? _____

G) Do you or any of your family members have a serious problem with breathing (asthma, emphysema, or bronchitis)? _____ If yes, which ailments? _____

H) This is the statement of purpose for the National Environmental Protection Act that caused the EPA to be formed (Hand the NEPA form to the subject.); I'd like for us to read it together. Two questions follow this statement; please place a dot on the accompanying scale at the place that best describes your answer to the questions. (Read with the respondent from their form).

This law establishes a national policy for the environment and provides for the establishment of a Council on Environmental Quality. Specifically, this law:

- * encourages productive and enjoyable harmony between humans and their environment,
- * promotes efforts which will prevent or eliminate damage to the environment, and
- * enriches the understanding of the natural resource systems important to the Nation.

Can you place a dot on the accompanying scale at the place that best describes your answer to the questions.

Thank You. Just 2 more questions.

H) What is your approximate family income?

Less than \$10,000 _____
 \$10,000 - \$20,000 _____
 \$20,000 - \$30,000 _____
 \$30,000 - \$40,000 _____
 \$40,000 and over _____

Is this a dual income or a single income? _____

IV. Conclusion:

Thank you for your time and patience in taking this survey. I really appreciate your cooperation; the information that you gave me will help me in completing my research at Michigan State.

Figure 20 (cont'd).

A) Sex of the subject:

B) Type of housing unit:

C) Time of day \ Day of week:

D) Consent form signed? _____

Figure 20 (cont'd).

Statement of Purpose, National Environmental Protection Act
NEPA

This law establishes a national policy for the environment and provides for the establishment of a Council on Environmental Quality. Specifically, this law:

- * encourages productive and enjoyable harmony between humans and their environment,
- * promotes efforts which will prevent or eliminate damage to the environment, and
- * enriches the understanding of the natural resource systems important to the nation.

Place a dot on the line that follows the question at the place that best indicates your response.

How aware were you that such a law existed before reading this statement?

Very unaware

Very aware



How supportive are you of the use of government funds to carry out the intent of this law?

Very unsupportive

Very supportive



Figure 21. NEPA question form.

MICHIGAN STATE UNIVERSITY

DEPARTMENT OF GEOGRAPHY
315 NATURAL SCIENCE

EAST LANSING • MICHIGAN • 48824-1115

March 21, 1990

Dear Lansing Resident,

As part of my masters degree in geography at Michigan State University, I am studying how people feel about power plants and pollution. To gather the information that I need in this study, I will be giving short personal interviews of the residents that live near the Board of Water and Light facility located at Eckert Station. I will be doing these interviews over the next few weeks. Although the study does deal with the Eckert Station, it does not reflect any actions, views, or plans of the Board of Water and Light.

All of the information that I gather will be treated in the strictest confidence. Your responses will not be associated with either your name or your address.

I would appreciate it very much if you could give me about 20 minutes of your time when I call on you in the coming weeks. Participation is totally voluntary, of course. I plan to be making my calls on weekday afternoons and evenings and on weekend days between the hours of 10:00 am and 5:00 pm. I hope these hours will be the most convenient for you. Should I arrive at an inconvenient time, please feel free to ask that I return later.

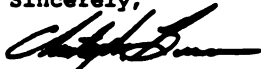
If you wish to confirm that this request is legitimate, please feel free to contact the following people in the Geography Department at Michigan State University.

Dr. Judy Olson, Chairperson
Department of Geography, MSU
315 Natural Science Building
East Lansing, Mi. 48824
(517) 355-4651

Dr. Joanne Westphal, Assoc. Professor
Department of Geography, MSU
108 UPLA Building
East Lansing, Mi. 48824
(517) 353-7880

Thank you for your cooperation in this matter.

Sincerely,



Christopher Brown
Graduate Student
Department of Geography
Michigan State University

Figure 22. Coverletter.

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