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AN INVESTIGATION OF PESTICIDE COMPLAINTS IN MICHIGAN

By

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ABSTRACT

AN INVESTIGATION OF PESTICIDE COMPLAINTS IN MICHIGAN

By

Patrick Patterson

Pesticide usage complaints are generated as a result of the conflict inherent amongst pesticide users and non-users. Basic to this conflict is a perception of dread health effects from involuntary pesticide exposure, that benefits the user, at the expense of the non-users health. This thesis analyzed data collected from pesticide usage complaint-investigations, supplemented with the active ingredient's chemical\physical characteristics. A calculated Henry's Law Constant (K_h) and the pesticides signal word were used as approximations of off-site mobility and acute toxicity. Multiple regression analysis found no significant relationship between the Henry's Law Constant, or the pesticides signal word and the number of complaints per county. However, a significant positive relationship was found between percent of population with a college degree, the population of the county and the number of complaints.

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Many contributed to the completion of this degree. Thanks to Dr. Lynn Harvey for his mentoring. It was through Lynn that I learned the value of research and teaching and how it could change peoples' lives for the better. Thanks also to my late Grandfather, Homer Patterson. His zeal for education and its extension to the citizens of Allegan county made my study at Michigan State University a possibility. It was his encouragement that guided me to seek out Lynn Harvey.

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My parents supported, encouraged and prayed for my progress from the first day of my undergraduate to present. Their generosity is limitless.

Thanks to Teresa, Emily, Alicia and Lauren who endured the long nights and seemingly endless waiting. They supplied the energy to finish this degree while living in a family. Thanks to Teresa especially for all she endured and her courage. Without her persistence this Thesis may never have come to fruition.

Lastly I thank God for the inspiration and grace to endure to the finish.

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INTRODUCTION

The purpose of this investigation is to determine the existence and strength of a hypothetical relationship between a pesticide's[1] volatility and the incidence of complaints filed from its use. It is further meant to provide insight on the effectiveness of the current regulatory structure to moderate the conflict between the user and the non-user.

The steps hypothesized to lead to a complaint are summarized below.

STEP 1. People fear pesticides to the extent that they will complain for fear of their health and property regardless of the actual hazard the pesticide poses.

STEP 2. Because of this fear, many will complain if they can detect that a pesticide application has been made and they are being exposed.

STEP 3. Complainants rely upon their senses to determine exposure to themselves or their property. Evidence of toxic effects will be stronger for those pesticide with higher acute toxicity.

STEP 4. Pesticide movement through the air is the most rapid route for off-target movement of pesticides.

STEP 5. Partitioning to air is determined by the volatility of the pesticide, and the Henry's Law Constant (K_h) is the limiting factor in volatilization

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[1] The word pesticide is used as defined in the Federal Insecticide, Fungicicde, and Rodenticide Act (FIFRA) and includes "(1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desicant:" The term pest is further defined by the act to be (1) any insect, rodent, nematode, fungus, weed, or (2) any other form of terrestrial or aquatic plant or aminal life or virus, bacteria, or other micro-organisms". 7 U.S.C. 136

Therefore, it is expected that pesticides having high acute toxicity or high K_h values will generate more complaints than those with low toxicity or low K_h values.

RESEARCH HYPOTHESES

H_{O1}: There is no statistically significant relationship between the incidence of pesticide complaints and the K_h of the pesticide applied.

H_{O2}: There is no statistically significant relationship between the incidence of pesticide complaints and the signal word of the pesticide applied.

H_{A1}: The relationship between the incidence of pesticide complaints and the K_h of the pesticide applied is statistically significant

H_{A2}: The relationship between the incidence of pesticide complaints and the signal word of the pesticide applied is statistically significant

The statistical tests developed compare two independent and four demographic control variables. The independent variables are:

1.) Henry's Law Constant K_h for the pesticide involved

2.) A measure of toxicity using the lethal dose 50% (LD_{50}).

The demographic control variables are:

1.) Percent of county population with a college degree

2.) Percent farm land in county

3.) Percent of county population with a high school diploma

4.) Median income per county

5.) County's population

This thesis is organized by typical format in five chapters. The first chapter will review the context of and state the problem of investigation. Chapter two will review relevant literature and law. Chapter three will discuss the research methods. Chapter four and five will cover the research findings and conclusions respectively.

Chapter 1

CONTEXT AND STATEMENT OF THE PROBLEM

The American Public is concerned about its health as well as environmental degradation. Despite living longer and enjoying better health than any previous generation, Americans believe they face graver risks than did their parent's generation.[2,3] But research shows they are not concerned about motor vehicle accidents or back injuries. The risks they fear are those from modern technological processes and are perceived to have unknown, dread, catastrophic and uncontrollable morbidity and mortality.[4] Examples of technological risk include: nuclear power, food irradiation, genetic engineering and residual pesticides in food and drinking water. Covello and Mumpower call this fear of technology the fear of the "mysterious". [5] This ground swell of concern has been reborn and seems to be an issue that will be the subject of controversy for many years to come.

Pesticide use is a technology that is consistently grouped with those that are perceived to pose catastrophic risks. These mistrusted technologies consistently receive heavy regulation as society seeks and Congress provides stricter controls on their use.

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2 Louis Harris and Associates, *Risk in a complex Society,* Public opinion survey conducted for Marsh and McLennan, Inc., 1980

3 United State Surgeon General, *Healthy People,* Washington D. C., Government Printing Office, 1979

4 Slovic, Paul, "Perception of Risk," *Science*, Volume 236, 283, April 17, 1987

5 Covello, Vincent T. and Mumpower, Jeryl, "Risk Analysis and Risk Management An Historical Perspective", *Risk Analysis*, Volume 5 (2) 1985.

Those who seek further pesticide regulation fear pesticides are threatening the environment, (flora and fauna) the food supply, drinking water, surface waters, and laborers. On the other side is an increasing body of knowledge that says environmental chemicals, including pesticides, pose little threat to humans at the low doses received by the majority of the population. Many scientists think the debate over the carcinogenicity of low-dose environmental chemicals, detracts from the effective control of known human carcinogens like smoking and aflatoxin.[6,7] The majority of farmers likewise believe the risk is overstated and cannot envision farming without pesticides. Intensive fertilizer use has dramatically increased yields per acre, but high plant density increases the need for pest control. Being "price takers," individual farmers cannot afford the loss in production that changing back to traditional methods would entail.[8,9]

The perception of risk from residual pesticide exposure has increased markedly due to modern analytical techniques and media coverage. The media have been shown to provide a disproportionate coverage of cancer risk from

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[6] The term "known human carcinogen is used as it appears in the National Toxicology Program's *Annual Report on Carcinogens*. Known Human Carcinogens have been shown to cause cancer in humans by the evidence of epidemeology. A few examples include vinyl chloride, coke oven emmissions, and arsenic.

[7] Ames, Bruce et. al., "Ranking Possible Carcinogenic Hazards," *Science*, Volume 236, April 17, 1987

[8] The increase in agricultural productivity is predominantly from an increase in nitrogen use and not reduction in crop loss. (Pimentel, et. al., *Pest Control Cultural and Environmental Aspects*, Westview Press, 1980) Crop loss due to insects has nearly doubled from 7.1 to 13 % from the 1940's to 1974 while loss to weeds has decreased from 13.8% to 8% for the same time period. (Pimentel, David, *Bulletin of the Entomological Society of America*, Volume 22)

[9] "Exposure" as used here means any contact with pesticides. Human exposure to pesticides is by one of the four routes of absorption. The four are ingestion, inhalation, absorption through the skin or mucuous membranes, or percutaneously by means of a cut or injection through the skin at high pressure. Applicators and nearby people are exposed to some dosage of pesticidies each time a pesticide is used. The relevant question is what dose. The same reasoning applies to plants and animals. A pesticide's sublimation and vaporization during and after application and subsequent off-target exposure is assumed to occur, at some dosage., for each application.

environmental chemicals. The coverage provided environmental chemicals does not align with scientific knowledge of their carcinogenic power. However, repeated news coverage of environmental chemical residuals elevates the issue in the public's mind.[10] Adding to the public's concern is the Environmental Protection Agency's (EPA) risk policy, which defines an acceptable risk to be 1 additional cancer in a million. Detection of residuals at lower concentration levels makes the public more aware of the ubiquitous nature of pesticide residuals. Detection limits and media coverage may combine to elevate a chemicals "pariah" status as was the case with Alar.[11] No longer is the public perception, "what I can't see can't hurt me."

This perception of harm is supported by many competent scientists who regard long term health effects from relatively slight exposures as cause for worry.[12] The reasoning cited by those practitioners is lack of good research on the huge numbers of chemicals in society, as well as lack of oncological knowledge that explains how cancer develops. Government errs on the side of caution to the extent that it has become acceptable to regulate the uncertain without scientific evidence of harm. Many scientists now agree that government should act when there is a consensus of opinion amongst scientists. This is a departure from the hallowed grounds of no action without scientific evidence. [13]

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[10] Slovic, 285

[11] Wildavsky, Aaron B., *But Is It True?, A Citizen's Guide to Environmental Health and Safety Issues*, Harvard University Press, Cambridge, MA, 1995.

[12] The degree of uncertainty is manifest in Federal Regulatory Agencies who use "one-hit", and linear models for carcinogenesis assessment. The regulators feel this cautious approach is justified by the lack of information on cancer mechanisms. There is considerable debate over the one-hit model with many reputable scientists considering it an accurate representation in light of the data.

[13] See Wildavsky, *But is it True?* for a thorough discussion of what the author calls the "Precautionary" principle.

If those concerned with low dose environmental chemicals are correct, there is plenty of cause for worry. Human exposure to pesticides through crop residuals and drinking water can be easily documented. "Ground water has been contaminated in 24 states where a total of 57 pesticides have been detected and most likely from agricultural use." [14] An EPA survey released in 1990 found as many as 60,900 rural domestic and 7,600 community wells may contain pesticide residues at levels above current health standards.[15] Four out of the five pesticides found to exceed Safe Drinking Water Act Standards are suspect carcinogens [16,17]

Regardless of the actual risk posed by pesticide residuals, property rights have traditionally served to protect oneself from unwanted pesticide exposure. But ground water, food, and air are not controlled by property rights. Proponents of more regulation say the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and its Michigan equivalent, the Michigan Environmental Pesticide Control Act (MEPCA) lack the power necessary to control these exposures. They say people have the right to not be exposed to pesticides. Although MEPCA closely dictates application behavior through the prescription of the pesticide label, off-target exposure is not illegal if the pesticide was applied according to the label.

Users, applicators and manufacturers directly benefit from pesticide use. They also have the opportunity to know more about the risks of the pesticide in use than non-users. Non-users know less about a pesticide and usually do not directly benefit from its use. Therefore, they resent the application out of fear for their health and property with no perceived benefit.

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[14] Zabik, Matthew, *Environmental Chemodynamics*, Michigan State University, Winter 1991

[15] Environmental Protection Agency, *1990 Survey of Pesticides in Drinking Water Wells*, Washington D.C., U.S. Government Printing Office, 1990

[16] *Federal Register*, U.S. Government Printing Office, Washington D.C. V. 50, p. 1115, 1985

[17] Dibromochloropropane (DBCP) and Ethylenedibromide (EDB) are "Resonably Anticipated to be Carcinogens", *Fourth Annual Report on Carcinogens*, National Toxicology Program, 1985.

PESTICIDE VOLATILITY AND OFF-TARGET MOBILITY

A person or their property, must be exposed to a pesticide to suspect it is causing harm. Many variables related to a particular pesticide application may lead to a complaint. These characteristics combine to evoke a perception of danger in the complainant. Complainants rely upon their senses and empirical judgment of a pesticides' toxicity to arrive at a conclusion of danger from their perceptions. Even those who distrust pesticides and pesticide applicators, must be aware that an application has occurred. The same chemicals used in different applications, for example, solvents in paint, will not evoke the same reaction. The most common detection may be through smell. Another strong indicator is simply observing the application. But the great majority of the public does not know what pesticide is being used, nor do they have expert knowledge to guide an assessment of danger. As a result, pesticides of relatively low toxicity may be perceived as highly toxic and vice versa. Any inaccurate perception of pesticide-application-hazard is a problem. If the public routinely misjudges the risk posed by pesticides, they will seek further protection under the law, which results in higher costs to the user. The user, and hence society, will face additional regulatory compliance cost. On the other hand, people who underrate the risk of pesticide use subject themselves and others to health risks and costs in lost health. Either situation generates conflict between the user and non-user. This is not necessarily enlightening, but poor conflict resolution between the groups often leads to unproductive policy.

A useful definition of the word "hazard" is, the product of the amount of exposure and toxicity of the compound. A combination of these two factors generates a toxic effect. Exposure and toxicity are largely determined by the physical\chemical properties of the pesticide. Different individuals will have varying aversions for the same exposure but in order to complain they must feel they are, or will be, harmed in some way.

Exposure can be predicted using physical\chemical properties of the pesticide, application method, and apparatus used. Exposure is determined by how much of a pesticide is distributed through the air, water and soil. All chemical properties affect exposure either directly or indirectly. Examples of physical\chemical properties include; molecular structure, boiling point, dipole moment, adsorption\desorption, photodegredation, biodegradation, water\lipid solubility, acid dissociation, heat capacity and many others. Many of these in turn are also affected by the weather conditions during application these being; temperature, wind speed and precipitation.

Application apparatus and technique also affect exposure. Some pesticides are applied as a gas or aerosol. This application situation results in potentially large exposures since these tend to be the smallest physical units. The energy applied (pressure) and nozzle size, along with chemical characteristics, determine particle size for liquids. Small particles, droplets, mists and aerosols are more likely to drift since the gravitational pull will be relatively small. Fine solids that are scattered, blown or shot, will also result in more drift. Secondary volatilization (sublimation or vaporization) occurs at a greater rate when the surface area to volume ratios are great, as is the case with particulates. Likewise, increased distance from sprayer to target means decreased target impact. Tree spraying and aerial application are two examples where a pesticide is suspended in the air at relatively high concentrations. Ultra low volume sprayers are an example of the opposite application situation. These low pressure, short-distance-from-target sprayers, leave relatively low concentrations suspended in air. But regardless of application apparatus, technique, or weather, chemical properties are the most fundamental predictor of exposure. Pesticides having low vapor pressures and high molecular weights will be less available for off target transport under all application techniques and conditions. They will settle out of water or air faster than volatile and soluble compounds and in general, be less volatile.

A compound's rate of solubility\dispersion in ubiquitous air and water is the most fundamental determinant of exposure. Henry's Law Constant is a good measure for this use. Essentially, what is needed to be known is how easily will the pesticide be dispersed through air and water.

> *"The Henry's Law Constant is important in several respects. ... the tendency of a chemical to volatilize from water solution to air is largely determined by the K_h a high value favoring volatilization. Chemicals of low K_h may persist in soil, surface, or ground-waters...*
>
> *It is noteworthy that air and water are the ubiquitous, fluid, mobile components of the environment. Many pesticides (and other man-made chemicals) are known to move, as vapor, between the atmosphere and soil, plant, and water surfaces. The direction of this transfer is dictated by the fugacity of each component of the system which in turn is controlled by the K_h. Thus pesticides volatilize from treated soil and plant surfaces and their vapors are transported away, often to distant location by atmospheric movement. Once outside the treated area the vapors may be readsorbed by 'dry deposition.' "Wet deposition also occurs when the atmospheric vapors partition into, and are brought to the soil surface by rain. The processes of wet deposition, dry deposition, and volatilization are all influenced in rate by the K_h."*[18]

The K_h is commonly used in research to indicate air\water partitioning.[19] The constant is calculated using vapor density, molecular weight, water solubility and temperature.

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[18] Suntion, L. R., et. al., *Reviews of Environmental Contamination and Toxicology*, Vol. 103, 2,

[19] Matthew, Zabik, personal interview, January 14, 1991

Henry's Law Constant

$$K_h = \frac{\text{(Vapor Pressure, Pa) (Molecular Weight)}}{\text{(Temperature, K) (Water Solubility g/l) (Gas Constant)}}$$

Units

K_h = Dimensionless Henry's Law Constant

Pa = Pascals

K = Degrees Kelvin

g/l = Grams per liter

The K_h is a good indicator of exposure across all conditions since chemicals move the fastest in air. Those dissolved or miscible in water will not travel as fast in general, but will still vaporize from water. Pesticides sorbed to soil colloids will settle out of air and water and will not remain in solution like gases, aerosols, and soluble compounds. Because they do not diffuse through air and water, soil colloid plumes cover less area than gases, aerosols and soluble compounds.

The first half of a hazard is probability of exposure. The second half is the toxicity of the compound. Once a xenobiotic gains a route of entry, its toxicity determines the effect. Complainants are likely to perceive a pesticide as dangerous because it produces toxic effects in themselves, plants or animals. If a tenant becomes nauseated after his apartment is fogged for cockroaches, he is likely to feel endangered by the pesticide and complain. Likewise, phytotoxicity, or animal toxicity are signs of a pesticide's danger. However, it is difficult to measure toxicity. Actual human toxicities are rarely know since humans are not subjected to chemical bioassays. Other animals are used in bioassays with the results being extrapolated to humans.[20] It is further difficult to measure an individual's

[20] Extrapolation from lower animals to humans involves many difficulties. Outstanding among these is the difference in toxicity due to differences in physiology between species. Many researchers believe toxic effects can vary from white mice to human beings by as much as four orders of magnitude.

perception of toxicity, for example fear of cancer, from anonymous complaints. MEPCA provides protection of anonymity for complainants. This would also be difficult to measure. Furthermore, there are few "known human carcinogens" and considerable debate over the carcinogenic potential of those "suspected," "reasonably anticipated to be" and other taxonomies of cancer. Acute effects as determined by the signal word rating system (Death blindness etc.) is used as a measure of the pesticide's toxicity in this research. Data on complainants fear of cancer and other chronic effects is not available.

☐ SUMMARY

The current conflict over the negative effects of pesticides is highly charged. Research shows that people fear those things which are complex and whose negative consequences are perceived to be "unknown" or "dread".[21] Pesticides are one of these things. This thesis suggests that the citizenry does have a heightened fear of pesticides and are therefore prone to file a complaint regardless of the actual harm. It further asserts that the complainant's exposure is determined by the Henry's Law Constant of the pesticide. Once exposed (either property or bodily) a complainants perception of risk is determined by the acute toxicity of the pesticide.

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[21] Paul, Slovic, *Perception*, 283

CHAPTER 2

REVIEW OF RELEVANT MATERIAL

☐ INTRODUCTION

This review first covers risk perception research and the relevant theory to pesticide complaint applications. Secondly, it reviews the research on pesticide volatility and Henry's Law Constant specifically. The last part of the chapter is a historical review of FIFRA and MEPCA

☐ REVIEW OF RELEVANT RISK PERCEPTION RESEARCH

"Expert" or "Professional Risk Assessors" see risk in terms of negative effects and the probability of occurrence. Their estimates rely heavily upon existing mortality data and on the estimation of added mortality risk. Typically, their results are expressed in terms of additional cancers or expected deaths per million people. Lay people have a much more complex model for risk assessment. Researchers are not certain how to describe, account for, or predict how an individual will react to a given risk. Government and industry experts repeatedly underestimate and are confounded by the public reaction to technological risk. This disparity between public and expert risk perception has serious ramifications for society. Needlessly thwarted technologies result in significant economic costs and decreases in the standard of living. Public reaction to certain events may bankrupt an entire industry. The overheating of the Third Reactor at Three Mile Island is argued to have doomed the U.S. Nuclear industry, even though no one was killed or is expected to be injured.[22] The 1959 Cranberry Scare over aminotriazole cost cranberry farmers an estimated $40 million with the USDA paying another $8 million for compensation.[23] Regardless of the lessons of the past, government and industry are likely to remain at odds with risk averse citizens. Government and industry continue to develop probabilistic estimates of risk while citizen groups will argue they are inaccurate and do not measure "real risk." Current research seems to indicate it is not the risk which is at question, but a substitute for society's more fundamental struggles between ideology and who wins and loses.[24,25] Other theory says it is about risk, but there are significant differences rooted in psychology, culture and individual security.[26] Which of these theories is more useful is unclear. Slovic's Psychometric Paradigm is a better predictor of what technologies will be feared and to what extent. Wildavsky's "Cultural Bias" theory has more predictive power to determine what groups will react to a given risk. Comparing the psychological roots of fear to ideology is analogous to the chicken or the egg argument. Each is determined by and affects the other. Both yield surprising insights into societal perception of risk.

Modern risk assessment grew out of technology as a consequence of technological change. Modern risk assessment is a self-perpetuating phenomenon.[27] Risk analysis developed in the 1970's, when society became less worried about nature and more worried about technological risks. Society became

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22 Roger E. Kasperson, et. al., "The Social Amplification of Risk: A Conceptual Framework," *Risk Analysis*, Volume 8, 1988.

23 Aaron Wildavsky, *But Is It True?*, 11

24 Aaron Wildavsky and Karl Dake, "Theories of Risk Perception: Who Fears What and Why?" *Daedalus, Journal of the American Academy of Arts and Sciences*, Volume 119(4), 1990.

25 Mary Douglas and Aaron Wildavsky, *Risk and Culture*, University of California Press, Berkeley, CA, 1982.

25 Paul Slovic, 285

26 Susan L. Cutter, ed., *Environmental Risks and Hazards*, Prentice Hall, Englewood Cliffs, NJ, 1994, 2

increasingly concerned about new technologies, such as genetic engineering and the proliferation of existing technologies at rapid rates, such as nuclear power and agrochemicals.[28,29,30] The rapid development and proliferation of technology outstripped traditional methods of risk assessment and risk management. Traditional methods used mortality and morbidity data to estimate risks for marginally improved or different technology. Modern technology has developed too fast and proliferated too quickly to allow experience to catch up. "Engineering developments involving new technologies are likely to appear in many places simultaneously and to become deeply integrated into the systems of our society before their impact is evident or measurable."[31] Modern risk assessment has developed in response to the rapid development of technology. It has also developed from modern computer technology and new analytic methods.

> "The development of analytical techniques .... enabled scientists to better identify and measure risks, which in turn led to more governmental involvement in regulating them. As new risks were 'discovered', the regulatory environment shifted; as new analytical techniques were used, policy refinements were made. As the public became more concerned about risks, regulators had to defend programs and were often asked, to determine how safe is safe enough?"[32]

Answering the question, how safe is safe enough was first attempted by Chauncey Starr in his ground breaking article "Social Benefit Versus Technological Risk."[33] Starr's research confirmed the theory of early scholars that

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[28] David Pimentel, et. al., "Pesticides: 'Environmental and Social Costs', in *Pest Control Cultural and Environmental Aspects*, (D. Pimentel and J. J. Perkins, eds.) Westview Press, Boulder, Colorado, 1980.

[29] Paul Slovic, 280

[30] Chauncey Starr, "Social Benefit Versus Technological Risk", *Science*, Volume 165, 1969.

[30] Chauncey Starr, 56

[31] Susan L. Cutter, *Environmental Risks*, 2

[32] Chauncey Starr, 56

individuals, and society as a whole, had ideas about risk that were not based on a pure consideration of the probabilities. Starr's significant findings included:

1. Individuals would voluntarily undertake activities that were a thousand times more risky than those they were involuntarily exposed to.
2. Death from disease seems to be the benchmark of what aggregate individuals consider a "reasonable" voluntary risk.
3. The acceptability of risk seems to be crudely proportional to the third power of the benefits (real or imagined)
4. The social acceptance of risk is directly influenced by public awareness of the benefits of an activity, as determined by advertising, usefulness, and the number of people participating.
5. In a sample application of the above criteria to atomic power plant safety, it appears that an engineering design objective determined by economic criteria would result in a design-target risk level very much lower than the present socially accepted risk for electric power plants.

Starr's findings directly bear on risk perception from pesticide applications. Voluntary\involuntary exposure and acceptability of risk put the applicators and the exposed at odds. Starr's finding of a factor of a thousand between involuntary and voluntary risk exposure virtually guarantees conflict with pesticide application. Applicators, who voluntarily accept exposure, will not be sufficiently sensitive to neighbors and tenants who are involuntarily exposed. Applying his third finding to pesticide application reveals that most complainants would not view their exposure to pesticides as a benefit. If an exposure is not beneficial, it further lowers the acceptability of the risk another 1,000 times, even assuming the complainant would choose to be exposed. In effect, complainants and applicators are a factor of a million apart in their view of the acceptability of the risk posed by the situation. Starr's findings suggest that a complaint should likely be filed for every application that is known of. The public has a "hair trigger" reaction when it comes to pesticide application. The hypothesis of this thesis is that people, at a minimum, have to smell a pesticide to complain. It is in agreement with Starr's findings.

Starr's research framed the theoretical development of risk analysis and was the impetus to further risk research. During the seventies, researchers furthered Starr's early insights. Sociologists showed that social influences moderate, or help to form, an attitude toward risk perception and risk acceptance even if post facto. [34] Douglas and Wildavsky argue cultural biases alter risk perception and an individual's risk taking viewpoint. Cultural bias is better defined by the individuals ideology or "outlook of the world".[35] Personality research found that people develop a higher order set of rules - heuristics - when forced to make decisions where they have little knowledge or experience.[36] Lay people have to rely upon their heuristics when judging risks when they lack understanding and experience. Heuristics are valid in some circumstances but laboratory research has shown that "...understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxieties generated by life's gambles cause uncertainty to be denied, risks to be misjudged and judgments of fact to be held with unwarranted confidence."[37] In other words, exactly the situation most lay people are in when judging technological risk.

THE PSYCHOMETRIC PARADIGM

Researchers have developed a taxonomy of risk perception called the psychometric paradigm which uses psycho physical scaling and multivariate analysis techniques to produce quantitative representations or "cognitive maps" or risk attitudes and perceptions.[38]

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[34] J. F. Short Jr., *American Sociological Review*, Volume 49, 1984

[35] Douglas and Wildavsky, *Risk*,

[36] D. Kahneman, Slovic, P. and Tversky, eds., *Judgement Under Uncertainty: Heuristics and Biases*, New York, NY, Cambridge University Press, 1982.

[37] Kahneman, Slovic, and Tversky, eds., *Judgement*, 332

[38] Slovic, *Perception*. 281

Figure 1
Location of 81 hazards on factors 1 and 2 derived from the relationships among 18 risk characteristics. Adapted from: Paul Slovic, "Perception of Risk," *Science*, Volume 236, 1987

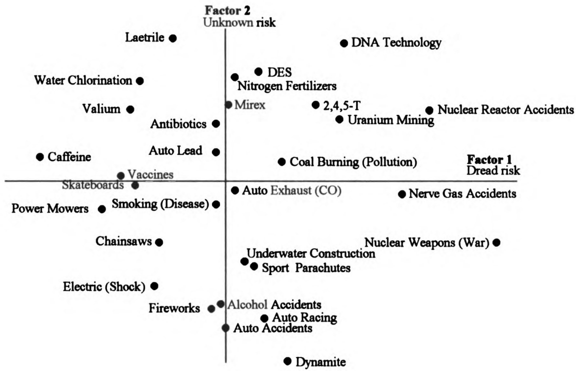

Figure 1 - The Psychometric Paradigm

It has enjoyed widespread acceptance and stands as one of the dominant techniques of risk perception. Slovic is most cited among the psychological researchers referenced in this literature review. Relevant findings from Slovic's psychometric paradigm include the following:

1.) When experts view risk their estimates correlate highly with technical estimates of annual fatalities.
2.) People tend to view current risk levels for most activities unacceptably high
3.) Familiarity, control, catastrophic potential, equity, and level of knowledge influence the relations between perceived risk, perceived benefit, and risk acceptance
4.) The dominant factor is dread risk. The higher the risk on this scale the more likely people are to want it strictly regulated to reduce the current risks.
5.) Dread risk technology accidents can result in dramatic public outcry against the activity and corresponding industry or government responsible. Resulting regulation can be devastating to industries, companies and governments.[39] [40]

Slovic's findings generally support this thesis. Pesticides are on the threshold of the "super dreaded" technologies and also ranked fairly high as presenting unknown risk.[41] These characteristics of risk perception suggest that people would file a complaint with little information about their exposure or its actual harm. They would be likely to "react" to the exposure if they knew that what they were smelling or seeing was a pesticide exposure. This reaction is likely for many of the complaints since little information is available or required for those who may be exposed during applications. Lastly the "ripples" from "signal events" spread through the public and in turn influence their risk perception. Slovic's findings show that accidents with technologies, in the upper right quadrant, have high potential to be a signal event. As mentioned earlier, pesticides are on the threshold in the upper right quadrant with 2,4,5-T even further to the right. Both Slovic and

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[39] Slovic, *Perception*, 284.

[40] Examples of "Signal Events" include Times Beach, Love Canal, Alar in apples, Three Mile Island, Union Carbide Bhopal gas leak, and Exxon Valdez Oil Spill.

Wildavsky cite media reporting to have a major impact on risk perception.[42,43] Risk perception of pesticides can generate a self-sustaining hysteria. An accident occurs, or a report is published concerning pesticides, that can generate tremendous public concern. The public concern feeds media coverage decisions, which generate inaccurate and overstated risks.[44] Overstated and inaccurate reporting are consumed by the public, which confirms their earlier fears and adds to their aversion to pesticide risk.[45,46] Arguably, pesticide signal events occurred within the time frame of this study. Alar's use for apples was canceled in response to a carefully planned media campaign by the Natural Resources Defense Council (NRDC).[47] Dioxin and Agent Orange were frequently reported in the media throughout the time period from 1986 to 1992.[48,49]

Slovic concludes his article by suggesting further research may show risk perception is based in the roots of fear or actually be explained by a lack of trust.

> Whereas psychometric research implied that risk debates are not merely about risk statistics, some sociological and anthropological research implies that some of these debates may not even be about risk. Risk concerns may provide a rationale for actions taken on other grounds or they may be a surrogate for other social or ideological concerns. When this is the case, communication about risk is simply irrelevant to the discussion. Hidden agendas need to be brought to the surface for discussion.[50]

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[42] "Is Cancer News a Health Hazard", *Media Monitor*, Volume 7, No. 8, Nov.\Dec. 1993

[43] Henrion, M. and Fischoff, *American Journal of Physics*, V 302, 1987

[44] "Is Cancer News" *Media*

[45] "Is Cancer News" *Media*

[46] Lichter, S. Robert, and Rothman, Stanley, *Scientific Opinion vs. Media Coverage of Environmental Cancer: A Report on Research in Progress*, Washington, D.C, Center for Media and Public Affairs, Center for Science , Technology, and Media; Studies, Conneticut, University of Connecticut, Roper Center for Public Opinion Research; Northampton, Mass.: Smith College, Center for the Study of Social Change, 1993.

[47] Wildavsky, *But Is It True?*, 202

[48] Michael Gough, *Dioxin, Agent Orange: The Facts*, New York, NY, Plenum, 1986

[49] Peter Schuck, *Agent Orange on Trial*, Cambridge, MA , Harvard University Press, 1986

[50] Slovic, *Perception*, 280

CULTURAL BIAS THEORY

Aaron Wildavsky, of Harvard University, has shown there is a lot of truth to the above statement. In the introduction to this section (Literature Review) it was mentioned that the two branches of research that Wildavsky and Slovic head, are from different paradigms. Wildavsky first asserted that culture influences risk perception in 1982, in the publication of his research with Mary Douglas. Their findings showed that individuals choose what to fear to support their way of life.[51] Wildavsky followed up with this finding in 1990 with publication of his comparisons of risk perception theory with Karl Dake.[52] In this study, the researchers tested the leading risk perception theories including Knowledge, Cultural Biases, Political Orientation, and Personality. The findings supported the cultural biases theory the strongest. However, a review of the negative conclusions is also of value.

Some students of risk perception have attributed the disparities between expert and lay people's risk perception as a result of knowledge. Experts understand the technology, the systems and the regulations and have a better understanding of reality than lay people who do not have the same knowledge. Earlier it was noted that, difficulties in understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxieties of life's gambles cause uncertainty to be denied, risks to be misjudged (sometimes overestimated and sometimes underestimated) and judgments of fact to be held with unwarranted confidence.[53] Inaccurate conclusions based on poor information

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[51] Douglas and Wildavsky, *Risk and Culture*,
[52] Aaron Wildavsky and Karl Dake, "Theories of Risk Perception: Who Fears What and Why," *Daedalus, Journal of the American Academy of Arts and Sciences*, Volume 119(4), 1990
[53] Slovic, *Perception*, 285

may explain the disparity between expert and lay people's comfort with technological risk.

To test the power of the "Knowledge" theory Wildavsky and Dake devised a test using the *Risk Index* of the *Societal Risk Policy Instrument.* Knowledge was measured by the researchers, by a combination of a self-identified score and a score calculated from their alignment with expert estimates of mortality for eight risks.[54] Those whose estimates closely corresponded with experts and who self identified as having a high level of knowledge of technological risks, did not prefer aggressive risk taking by society. They tended to discount the benefits claimed by technological innovation. In other words, they are not, as a group, either risk takers or risk averse. They are statistically neither.

"Political Orientation" theory asserts that party identification is a predictor of risk perception. Findings show that there is some truth to this but not as defined. Correlation scores were low for the Democrats but higher for the Republicans. Wildavsky and Dake cite the relative homogeneity of the parties as indicative of this finding.[55] The Republican party is much more homogeneous with regard to its members and risks. The Democratic Party is heterogeneous relative to the Republicans. But party identification as a whole is not as good a predictor as cultural bias.

Reducing political orientation another step yields ideology.

> "...Preferences among different types of risk taking (or avoiding) correspond to cultural biases - that is, to worldviews or ideologies entailing deeply held values and beliefs defending different patterns of social relations. Social relations are defined in cultural theory as a small number of distinctive patterns of interpersonal relationships - hierarchical, egalitarian, or individualist."[56]

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[54] Wildavsky and Dake, *Daedulus*, 169
[55] Wildavsky and Dake, *Daedulus*, 171
[56] Wildavsky and Dake, *Daedulus*, 167

Three distinct ideologies are defined as follows:[57]

Egalitarian: Believe in equality of wealth and opportunity distribution. They view the earth and natural resources as fragile. They view the cost benefit of technology to be low, with high risks and low benefits. They believe an egalitarian society will help protect the environment from the profit of the few who would exploit it. They do not fear social deviance as much as hiearchists or individualists.

Hierarchy: Prefer defined social roles and contracts, superior\subordinate, chain of command, hierarchical organizations. They fear social deviance because it erodes this set of social relationships. They tend to favor risk if society's experts recommend it. They are concerned about youthful rebellion and unpatriotic behavior.

Individualist: See resources as a cornucopia with plenty for all. They favor opportunity for the individual and so disfavor hierarchy. They feel the individual should be free to use his intellect and talents to maximum advantage and so resist encumbrances (excessive regulation). They trust their institutions to take care of contingencies.

The above worldviews were tested as predictors of risk taking or avoidance from the *Pro-Risk Index* of the *Societal Risk Policy Instrument* of the University of California's Institute of Personality Assessment and Research. As mentioned before, the correlation scores for the above cultural biases were far higher than the other theories of risk perception, i.e., knowledge, political orientation, and personality.

Significant findings include:

1.) The risk perceiver's knowledge and accuracy of mortality knowledge have a minimal relationship to risk perception.
2.) Pro-risk personality types are similar to the personality types of hierarchists.
3.) Those who perceive greater risk to the environment from technology share similar personality types with egalitarians.
4.) Liberals have a strong tendency to be egalitarian and reject hierarchy and individualism
5.) Republicans tend to have individualist and hierarchical ideology and are strongly opposed to egalitarianism.

To simplify the detailed findings of this study, when it comes to technological risk two groups line up against one. Hiearchists and Individualists tend to favor

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[57] Wildavsky and Dake, Daedulus, 168

technological risk taking, egalitarians do not. Hiearchists are rationale forbearing types who trust society's esteemed experts and view the necessity of expert research and opinion to be essential. Actors in the interest wars over technological risk are likely to be individualists. Republicans are likely to be individualists or hiearchists. Democrats are likely to be egalitarians but the association is not as reliable as republican party identification.

"For example, on the question of whether we are seeing only the tip of the iceberg with regard to technological risk , 88.5 percent of the very liberal ...agreed...as did 74 percent of the liberals. Only 25 percent of the very conservative and 36.4 percent of the conservative respondents agreed."[58] Another example Wildavsky and Dake cite is:

> "Environmentalists perceived water clarity to be getting worse, while those in favor of economic growth and property rights simply refused to believe the wealth of documented, and widely diffused, scientific evidence developed by one of the world's leading limnologists demonstrating statistically significant declines in water clarity over the previous 10-15 years. This suggests that in high-conflict situations, perceptions on even relatively straightforward technical issues can be heavily influenced by elites normative positions."[59]

The hypothesis that develops from the findings is: why the distrust? It's a philosophical question, at least if the discussion if narrowed to areas of technological risk. The great technological risks controversies of our day result from distrust. Egalitarians do not trust industry and or government if government is advocating a technological risk.

What do these findings mean for Michigan pesticide application and resulting complaints? We would expect to find egalitarians making up a predominant share of the complainants and individualists making up a great share

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[58] Dietz, Thomas and Rycroft, Robert, The Risk Professional, Russel Sage Foundation, New York, 1987 as cited in Wildavsky and Dake, p. 174

[59] Sabatier, Paul and Hunter, S., *Western Political Quarterly*, Volume 42, 1989

of the commercial applicators. A similar point was made regarding voluntary\involuntary acceptance of risk from the findings of Chauncey Starr. If this theory applies, it casts further doubt on the lowering of conflict between these groups, at least by typical means.

Cultural bias theory also supports the existence of a "tripwire mentality" for a substantial block of the population. Strongly liberal individuals are likely to resist any pesticide exposure regardless of the dose or relative toxicity.

Wildavsky and Dake's findings are not conclusive regarding the variable of college degree found to be the most significant association in this study. Knowledge of the risk and knowledge of mortality data were considered and dismissed but were more specifically defined than college degree.

Questions that remain for risk perception are: (1) what motivates governmental actors and (2) is risk perception the same as a technological cost benefit assessment?

Cultural Bias theory identifies individualists, hiearchists and egalitarians as the three main worldviews. The perception of risk from a given technology, by a strongly self-identified liberal, is predictable. Industrialists and entrepreneurs may also be highly predictable as individualists. What is unclear however is the ideology of a government bureaucrat, politician, or section chief. Are they motivated by service to the constitution, their constituents, or their personal career objectives. The government, especially the federal government, is often the most powerful actor in technological risk decisions.

Wildavsky and Dake, when reporting on their findings for knowledge and education say, "While on the whole those who are more in accord with expert mortality estimates perceive less risk, they are also less optimistic regarding the benefits of technology"[60]. In my opinion, it is not clear whether the authors separate risk perception from acceptable risk. The former implies a ranking of perceived societal risks. Acceptable risk implies that the costs and benefits have been weighed and found to be a positive gain.

The psychometric paradigm may yield better results when developing or revising governmental strategy. Slovic's work better predicts what pesticide issues may be subject to an unexpected reaction. Cultural bias is a better predictor for determining how groups involved in policy issues are likely to act. Both theories are useful. Each researcher cites the other to support their conclusions. The question that still needs to be resolved is between ideology and the roots of fear. Do fears determine ideology or ideology determine fears?

□ PESTICIDE VOLATILITY, MOBILITY AND HENRY'S LAW

Pesticide vaporization and off site transport has always been a problem. In 1945 revaporization and transport of 2,4,-D was shown to cause off target phytotoxicity.[61] Of course 2,4-D is one of the more volatile pesticides. Research focused on these more volatile pesticides. However, continuing research showed that even DDT (The least volatile pesticide in this research database) did volatilize and was transported through the environment.[62,63] Spencer, Farmer and Claith reporting on their findings showed the following:

1.) Pesticides evaporate from soil, water and plant surfaces after application.
2.) Volatilization of surface deposits is controlled by the pesticides vapor pressure.

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[60] Wildavsky and Dake, Daeduls, 171

[61] Staten, G., *Journal of the American Society of Agronomy*, Volume 38 1946

[62] Fred Acree Jr., et al., Codistillation of DDT With Water, Journal of the Agricultural Food Chemist, Volume 11, 1963.

[63] Jury, William A., et. al., "Transport and Transformation of Organic Chemicals in the Soil-Air-Water Ecosystem," *Reviews of Environmental Contamination and Toxicology*, Volume 99

3.) Soil incorporated or pesticide sorbed into plant surfaces will volatize at a different rate little of which little is know.
4.) Pesticides volatilize from wet soils because water competes for adsorption sites with the pesticide on soil, but also mass flow of water and pesticide affect the volatilization of pesticides.

Field trials, conducted in 1978, show up to 90 percent or more volatilization within two or three days under warm and humid conditions. Volatilization was controlled by incorporation and the least volatilization occurred from dry soils.[64] Taylor goes on to note that the state of the science cannot predict rates of volatilization and that calculations to do so would be complex. He suggests that getting to that point would require inclusion of the compounds vapor pressure, water solubility, a measure of adsorption, and soil moisture.[65] "Volatilization rates are greatly influenced by temperature mainly through its effect on vapor pressure. Vapor pressures of most intermediate-molecular-weight organics increase 3 to 4 times for each 10 degree Celsius increase in temperature."[66] By the late seventies, volatilization had been measured extensively for many crops under many different field trial conditions. As previously noted, researchers had also learned that water content, soil adsorption and temperature could effect volatilization dramatically. Documentation of a soil's water content controlling adsorption of pesticides goes back to 1961 and has been confirmed many times since.[67] From soil water-content research also came demonstration of "wicking" of pesticides.[68] This term describes the mass transport of pesticides from wet lower layers to the soil surface when the surface layers are dry. Adsorption forces are strong. Once sorbed into soils or

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[64] Alan W Taylor, "Post-Application Volatilization of Pesticides under Field Conditions," *Journal of the Air Pollution Control Association,* Volume 28, No. 9, 1978

[65] Taylor, *Journal of the Air,* 927

[66] W. F. Spencer, and M. M. Cliath, "Pesticide Volatilization as Related to Water Loss From Soil,"*Journal of Environmental Quality,* Volume 2, 1973

[67] Fang et al. 1961: See Spencer et. al. in *Residue Reviews,* Volume 49, 199, 1973 for a thorough bibliography

[68] G. S. Hartley, , *Pesticidal Formulations Research, Physical and Colloidal Chemical Aspects,* Advanced Chemistry Series, Volume 86, 1969

plant tissues volatilization is dramatically reduced. Vaporization from water, at the soil surface is the dominant route for pesticide volatilization.

Liss and Slater first showed that the "two-film" theory developed from industrial applications could be applied to environmental conditions[69] The two film theory held that partial pressures of solutes in water were at equilibrium in the top layer of the water-surface boundary. Volatilization of solutes is controlled by the Henry's Law Constant of the solute.[70]

With the acceptance of the "two-film" theory in the scientific community, research switched to Henry's Law Constants as predictors of volatilization of pesticides from soil and plant surfaces. "At equilibrium, the distribution of a pesticide between water and air is described by Henry's Law, which is:

$$C_a = K_{aw}C_w$$

where C_a and C_w are the air and water concentration, respectively (mol/m^3) and K_{aw} is the dimensionless air-water partition coefficient or the Henry's constant."[71]

Through the eighties, the mechanisms of volatilization became well established. Henry's law was and still is thought to be the controlling factor within the mechanism.

> "Many pesticides (and other man-made chemicals) are known to move as vapor, between the atmosphere and soil, plant, and water surfaces. The direction of this transfer is dictated by the fugacity of each component of the system, which in turn is controlled by the Henry's Law Constant. Thus, pesticides volatize from treated soil and plant surfaces and their vapors are transported away, often to distant location by atmosphere movement."[72]

Henry's Law (K_h) is now regarded as a "partitioning coefficient." It is described as such because of its value in predicting where a pesticide will partition.

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[69] Liss, P. S.and Slater, P. G., "Flux of Gases Across the Air-Sea Interface,"*Nature*, Volume 247, 1974

[70] J. H Smith, D. Mackay and C.W.K. Ng, "Volatilization of Pesticides From Water," *Residue Reviews*, Volume 85, New York, NY, Springer-Verlag, 1983

[71] J.H. Smith, *Residue Reviews*, 74

[72] Jury, *Reviews of Environmental*

Pesticides with a high K_h will partition to the air and those with a low K_h will partition to water.[73] Those in water will volatize at a slower rate and will be adsorbed by plant tissue, organic matter, and soil surfaces to some extent.

The consensus of leading researchers including Cliath, Spencer, Jury and Zabik is that the K_h is the most fundamental predictor of partitioning and therefore off site travel. Many things affect the volatilization of pesticides, including wind speed, barometric pressure, radiant heat, temperature, wind speed and turbulence, water solubility and others. Vapor pressure is the most predictive and the limiting factor of the latter, excluding temperature. Increased wind speeds are not likely to move a pesticide off site if it is not volatile. (To control for the great differences in vapor pressure due to temperature, K_h was calculated using daily temperature highs for the application area. See chapter four for more information.) The hypothesis of this thesis is that people, at a minimum, have to smell a pesticide to complain. Transportation by air through vapor diffusion or mass transport is the most rapid transport mechanism for all but heavy rainfall conditions. Water transport is likely to result in visual observation of a pesticides presence, specifically animal or plant toxicity. Whether through air or water, some relationship would be expected between the K_h and the number of complaints.

Using K_h to predict partitioning and transport has its problems. The model is not sophisticated enough to account for cosolvent characteristics of emulsifiers, surfactants, time release agents and other additives to pesticide formulations.[74] Furthermore, standard determinations of vapor pressure and water solubility need more research and standardization. Calculation of K_h for 259 cases involving different pesticides could not be completed because of missing vapor pressure

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73 Spencer, W. F., et. al., *Journal of Environmental Quality*, Volume 17, No. 3, 1988

74 Bentson, K., P., *Reviews of Environmental Contamination and Toxicology*, Volume 114, New York, NY, Springer-Verlag, p. 141, 1990

data. Vapor pressure data is missing the most. But availability of water solubility data could also be improved.

□ THE HISTORY OF PESTICIDE REGULATION RELATING TO APPLICATION AND COMPLAINTS

In the 1960's the American Public became increasingly aware of environmental degradation. This heightened awareness led to the passage of legislation in the early seventies to reduce environmental contamination including the Clean Air and Clean Water Acts. Residual insecticides in the environment and their effect on the ecosystem was also soon to be further regulated.

A Presidential Scientific Advisory Committee was formed to study the issue of the negative effects of pesticide use. Among the 1963 report recommendations was: "A broad educational program emphasizing the hazards in the use of pesticides should be undertaken."[75] The Congress did not act on this recommendation specifically, but as a result of other recommendations in the report, FIFRA was amended in 1964. The amendments eliminated protest registrations and required a license number for each pesticide manufactured. However, it did not include provisions for pesticide education and did little to increase the control over pesticide use.

Dichlorodiphenyltrichloroethane (DDT) was a widely used insecticide, and at the time, thought to be safe. It was an appealing chemical because it is selectively toxic to insects and relatively acutely non-toxic to humans. Unfortunately, it was found to concentrate in fat in those animals which ingested food contaminated with it. These levels biomagnified and resulted in toxic effects to wildlife. Chief among these was the reproductive toxicity found in birds, the American Bald Eagle and others.

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[75] United States House of Representatives, *House Report No. 92-511*, September 1971

Out of concern for these detrimental effects, the federal government began exploring the possibility of further regulating pesticides. The debate in congress hinged around the popular issue of what to do about DDT. The debate ceased with the passage of the Federal Environmental Pesticide Control Act. (FEPCA) of 1972. FEPCA restructured the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). FIFRA was, and still is, the basis of pesticide regulation in the United States.

FEPCA originated in the House of Representatives where the House Agriculture Committee did the bulk of the work preparing it. There was much debate over its contents. As today, the environment was a popular issue with the American Public. Environmentalists were calling for widespread pesticide regulation, while manufacturers and users were urging a more cautious approach. Many hearings were held. Respected scientists from both sides made convincing arguments for many different perspectives and regulatory schemes. In the end, the bill gave the EPA new authority to regulate the manufacture and use of pesticides. The registration system was overhauled. The burden of persuasion for safe use now rested with the manufacturer, not the government. Emergency cancellation procedures were developed to allow immediate removal of a pesticide from use. Pesticides were divided into two categories, restricted use and general use. Restricted Use Pesticides (RUPs) could not be used without first being a certified applicator. The certified applicator requirement created a licensing mechanism by which applicators could be prohibited from using RUPs by removal of their certification.

To be certified the applicator was required to pass a test to prove his knowledge was sufficient to "safely and properly use the pesticides they will apply." [76]The test was to be developed by the EPA Administrator. The following paragraph contains the intentions of the House Agriculture Committee regarding certification.

> *"The provisions for certification of applicators comprise new and important authorities for regulating pesticide use. Many restricted use pesticides would be restricted to use by certified pesticide applicators whose misuse of pesticides could result in withdrawal of certification. In the case of commercial applicators, such action would be extremely serious. In the case of private pesticide applicators such action would remove from them the opportunity to obtain and use restricted use pesticides so regulated.*
>
> *Further, the educational process entailed by certification provides an opportunity not only to greatly diminish the possibility of injury to persons but also injury to the environment from both misuse and, more importantly, overuse."*[77]

The Committee intended certification to be both a licensing mechanism and an educational program. Both are important to an effective regulatory program. Licensing and its threat of removal are effective to the extent inspections can be made and misuse is grave. Education is effective for those applicators who wish to prevent negative pesticide effects.

Education is essential for wise pesticide use due to the dangerous nature of pesticides. For example, a common misconception is "more is better". But excessive concentrations above those recommended will only contaminate the environment, leave high residuals in crops and soil, and cost more money. The other extreme is the user who skimps on concentration hoping to save money. This enables the pest to become resistant to the insecticide.[78] These are but two

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[76] United States House of Representatives, *House Report,* 15

[77] United States House of Representatives, *House Report* 22

[78] See Georghiou, G. P. and Mellon, R. B. "Pesticide Resistance in Time and Space," in *Pest Resistance to Pesticides*, 1983

examples. Others include apparatus calibration, worker protection, scouting, evaluation and many more. [79]

Greater chemical and apparatus technology underscores the need for more education. Further example is provided by Bert L. Bohmont,

> *"we now have families of pesticides that are applied at the rate of ounces or grams per acre instead of pounds and gallons as we did for many years in the past. These new, extremely active pesticides require highly accurate placement in order for them to do their job as intended and not endanger other crops or remain as a residue to threaten future crops. We are going to have a challenge in getting private and commercial applicators to understand the vital need for precise calibration of their equipment. In the past we have relied on rather routine training and what I would call 'textbook calibration' wherein the instructor imparts information by showing calibration calculations on the blackboard and perhaps handing out written information on how to calibrate a sprayer. We have found out through experience and practical observations that many applicators either do not properly understand the mathematical calculations required or do not practice them once they have gotten back to their place of work."* [80]

Education corrects common misconceptions and inabilities which enable responsible use; problems not likely to be solved by licensing removal alone.

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[79] "Apparatus calibration" refers to measuring the output of pesticide by the area covered. A common example of an apparatus would be a "broadcast granular applicator" which distributes granular preparations by feeding them onto a spinning disc. Another one would be a sprayer which would be used for liquid formulations.

Worker protection is a controversial topic in pesticide regulation. The controversy arises from workers repeatedly being exposed and suffering various toxic effects. Requiring applicators be minimally educated should help prevent direct worker exposure.

Scouting is thought by most experts to be done poorly by applicators who lack knowledge about the suspected pest. Good scouting is essential for the best combination of pest control, and, environmental harm.

[79] Bert L Bohmont, "Pesticide Applicator Training", paper given at the Thirty-seventh Annual Meeting of the Agricultural Research Institute, Washington, D.C., October 12-14, 1988.

MICHIGAN HISTORY

In Michigan the legislative history was much more subdued. This was due in part to the earlier passage of FEPCA. The fight at the federal level was the litmus test. There would be tighter pesticide control. The states had only to decide details of their enforcement programs if they wished to retain control over enforcement within their state. This was even subject to EPA approval. The law Michigan adopted was written by the National Conference of State Legislators. [81] Former State Senator Richard Allen was party to both sides of the discussion representing a largely agricultural district and sitting on the Senate Committee on Agriculture and Consumer Affairs.

> *"We reacted to federal regulations as to how we had to do it, including certification issues." However, this was not the case within his district. "There was considerable interest in local circles over the provision. There was an extensive discussion and debate at Farm Bureau meetings and CES meetings. There was general support in the agriculture community I came from, grudging support, because of more required information. There was a fair amount of debate about the certification process; could you take these orally and so on. There was a general feeling the education had some value above a licensing scheme. However, I think it was an action we wouldn't have taken without the prodding of Federal Action."*[82]

With the passage of MEPCA, the Michigan Department of Agriculture (MDA) The Pesticide and Plant Pest Management Department (PPPMD) took responsibilities for its administration. One particular provision of the law requires pesticide applicators to be certified to use restricted use pesticides. The State is required to provide the certification exams and the training necessary to pass them.

The structure of FEPCA and MEPCA is intended to provide controlled application of pesticides. It is not intended to control the volume or use of

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[81] Bohmont, "Pesticide".
[82] Former Senator Richard Allen, telephone interview, February 9, 1990.

pesticides. It was written in a day where controlling the overuse of pesticides was a pressing objective. As mentioned, DDT was considered a miracle pesticide. It was very effective against insects and relatively nontoxic to humans at environmental levels but probably overused and used without enough caution.[83,84,85] FIFRA reigned in pesticide use and provided for a mechanism for toxicity testing and product removal. It is not a law that provides useful authority or policy to resolve today's pesticide conflicts.

Current day disputes revolve around the question of what is acceptable risk. Pesticides do appear as residues in the food supply and ground water. They also expose humans as agricultural workers, applicators and as neighbors to applications. The issue of food supply and ground water defy simple solutions, since the guilty party cannot be easily determined. These problems defy easy solution but regulatory schemes exist to control them. Likewise agricultural workers are now protected under the law and some workers by OSHA. But one failure of pesticide regulation is the exposure that results from a legal application to neighbors and tenants from an application. In theory, some exposure is present with every application. The harm resulting from this exposure increases as distance decreases. As mentioned in the first chapter many other variables affect harm, but dosage is the fundamental control. The crux of the issue between users and non-users is fair usage of property. How does pesticide application bear on the right to protect owned property from others impeding on its productive use or enjoyment (trespass). The question is valid for both sides, the user and the neighbor or tenant.

FIFRA and state equivalents lack guidance on fair property use. Relying upon the label as the law results in off-target exposure. Legal pesticide application,

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[83] The LD50 for DDT is estimated to be 500mg\Kg of body weight.

[84] Because of its widespread use and persistence, DDT or its derivative DDE can be found in most all humans at a mean level of 8 ppm in adipose tissue.

[85] R. E. Gosselin, *Clinical Toxicology of Commercial Products*, Section III, 116-119.

therefore, can legitimately harm or irritate the sensibilities of a neighbor or tenant. Peoples' fear of pesticides is well documented in this paper. But FIFRA does little to adjudicate the problem or suggest a reasonable framework to resolve the conflicts.[86] The motivation for peoples' fear is increasingly understood but the question of whether they can be exposed remains the fundamental issue.

This research provides some insight on this conflict through the investigation of complaints. If complaints are a function of toxicity or volatility or both, it leads us to legal solutions based in the application itself. If there is no relationship found between toxicity or volatility and the incidence of complaints, it bolsters the conclusions of Slovic and Wildavsky. Retooling FIFRA to reduce a perceived threat requires a weighing of the interests and is a matter of public choice.

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[86] One notable exception is the Pesticide Application Notification Registry that requires notification of neighbors before a pesticide application. (Regulation 637, Rule 5)

☐ SUMMARY

People fear technological risk because of its perceived dread, unknown and catastrophic effects if an accident occurs.[87] Ideology, or world view, may predict what groups will be present in conflicts over risk.[88] Henry's Law Constants predict air\water partitioning and are the limiting factor in pesticide off-target mobility. Lastly, FIFRA is not helpful in resolving conflicts between users and neighbors where an exposure results from a legal application. These are the most significant issues that arise from review of the literature and existing law. These issues and the impact of the findings of this study will be discussed in chapters four and five, Findings and Conclusions respectively.

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[87] Slovic, *Perception*.
[88] Wildavsky, *Daedalus*.

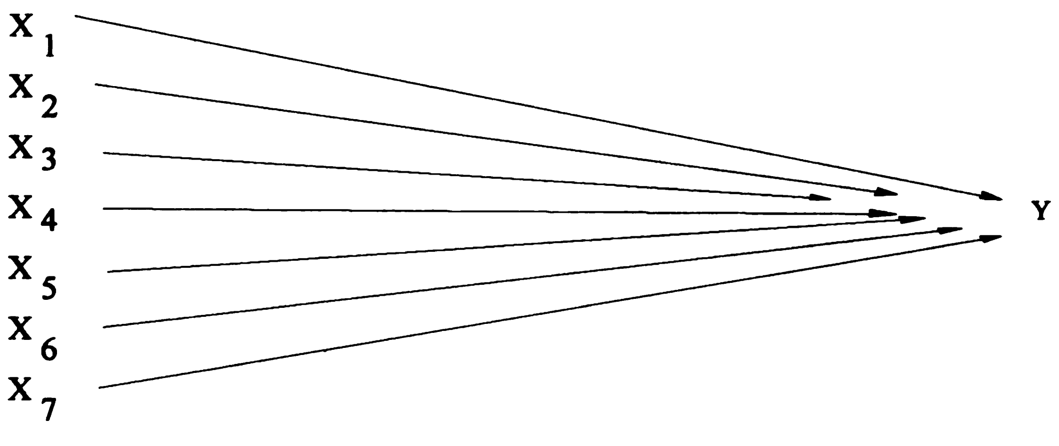
CHAPTER 3

RESEARCH METHODS

□ INTRODUCTION

The cases used for the testing of the research hypotheses are those recorded in the Enforcement Database of the MDA - PPPMD. The data was tested to assess the presence of a correlation between the dependent variable, number of complaints (Y_1) and the independent variables:

X1 K_h of the active ingredient
X2 Level of toxicity signal word the pesticide
X3 Percent of county population with a college degree
X4 Percent farm land in county
X5 Percent of county population with High School Diploma
X6 Median income per county
X7 County's population



□ DESIGN

This population level data is a compilation of investigation reports stemming from complaints. The PPPMD is required to respond to and investigate all pesticide complaints. Field investigators fill out a field report detailing the nature of the compliant, the target crop and many other variables. These reports are entered into two databases. (To see an example filed report see appendix A) The general information database "PESTUSE" is listed first. Each record is comprised of the following fields.

Michigan Department of Agriculture
Pesticide and Plant Pest Management Division
Pestuse Database

Field Name	Description
CASENUM	Unique identification number for the investigation
COUNTY	County where the application occurred
EPADATE	Date EPA report was filed
INVDATE	Date of the investigation
CERT	Certification category of application (Applicator may or may not have been certified)
COMPDATE	Date complaint was made
COMPDESC	Brief description of complaint, ie. drift, unlicensed, misapp (misapplication) vandalism, disposal, fish kill and others
EXPOSED	Type of exposure ie, human, plant, animal, feed and others
CLASS	Agricultural or nonagricultural
SITE	Site of application
APPLDATE	Date of application
TARGET	Pest target, ie. weeds, insects, fungus, rodents, and others
SAMPLE	Number of samples taken
MISUSE	Was the action a misuse of pesticide
SUMMARY	Brief summary of complaint
EFT1	Effect score calculated from degree of negligence and resultant harm
EFT2	Other resultant harm
ACTION	Enforcement action taken by PPPMD
ENFDATE	Date of enforcement action

PESTUSE contains 1240 records dating from 1/8/84 to 1/17/90.[89]

During investigations field agents gather evidence to help support or reject a claim of misuse. Field agents take samples from foliage, soils, water or other media. Samples are then recorded and sent to the lab for analysis. The second database is that used to track the samples. Each sample database record contains the "use investigation number," which matches the record to its sister record in

[89] The dates of the data suggest the database covers six years of compliants. However, in 1984, records were not routinely entered. There are 29 records for 1984 and one record for 1990. In essence, the database, is comprised of data from 1985-1989 for a total of five years. The average number of cases in the "pestuse" database for the 5 complete years is 239.

PESTUSE. Each record contains an additional six fields. The seven fields are listed below.

Michigan Department of Agriculture
Pesticide and Plant Pest Management Division
PESTSAMP Database

FIELD	DESCRIPTION
CASENUM	Unique identification number for the investigation
SAMPLNUM	Unique identification number for sample chain of custody
CHEMNAME1	Name of chemical in sample and indication of positive or negative analysis
TYPE1	Type of pesticide: herbicide, insecticide, fungicide, rodenticide, desiccant, or attractant
CHEMNAME2	Name of second chemical in sample, if any, and indication of positive or negative analysis
TYPE2	Type of pesticide: herbicide, insecticide, fungicide, rodenticide, desiccant, or attractant
CLASS	Indicates whether the first pesticide is a restricted or general use pesticide

PESTSAMP contains 1623 records.

ADDITIONAL DATA SOURCES

The above data tables provided an impressive amount of data on pesticide complaints in the State. However, some key data necessary for hypothesis testing was missing. The research hypothesis states pesticides that partition to the, air as opposed to water, are more likely to result in a complaint. This was postulated due to the fact that the sense of smell is a common means of detecting a pesticide application. Those pesticides which partition to the air diffuse throughout it at a rate determined by their kinetic energy and mixing gradients due to turbulence. The air-partitioned pesticides are also subject to mass movement through the wind. Partitioning to water or air is derived from the Henry's law (K_h) of the active ingredient. K_h has been experimentally derived for few active ingredients, and there is considerable variation among reported results. For this reason, and to account for climatic conditions, the K_h was calculated for each case. The calculated K_h used the high temperature, on the day of the compliant, to be factored into the volatility of the pesticide. Temperature was added to the statistical matrix from National Weather Service data compiled over the range of the investigations.

Henry's law requires a compound's water solubility, vapor pressure and molecular weight, in addition to the temperature and the gas constant. This other data was also collected from secondary sources. The best source for pesticide technical data was the *Pesticide Manual*.[90] All active ingredients from the database were not listed in this source. However, they often could be found under a synonym with the help of a cross reference. The chemical could often be found under its technical name in the .[91] Three valuable cross references were the *Farm Chemicals Handbook*,[92] *Pesticide Index* and the *Merck Index*.[93]

Data on acute toxicity as represented by the "Signal Word" of the active ingredient was obtained from the *Farm Chemical Handbook* first, the *Pesticide Manual* second and the *Merck Index* last.

Demographic data was obtained from the 1990 census database.[94]

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[90] British Crop Protection Council, *The Pesticide Manual, a World Compendium*, London, Crop Protection Publications, 1994.

[91] The Merck Index an Encyclopedia of Drugs, Chemicals and Biologicals, Rahway, NJ Merck and Company.

[92] Richard T. Meister, ed. *Farm Chemicals Handbook*, Willoughby, OH, Meister Publishing Company 1986,87,88,89,90 and 91,

[93] Entomological Society of America, *Pesticide Index*, New York, William J. Wiswesser, 1976.

[94] United States Department of Commerce, Bureau of the Census,*The Census of The United States of America*, Washington, D.C. U.S. Governemnt Printing Office, 1990

☐ DATA CORRECTIONS AND FORMATTING

Pesticide signal words were used as the measure of acute toxicity. They are grouped into four basic categories as defined by FIFRA. FIFRA assigns signal words based upon the compound's LD_{50} in rats, mice or rabbits. The other criteria considered are dermal and eye toxicity. These signal words are approximately equal to the state of research for active ingredients and LD_{50}s. Reported LD_{50}s vary widely between sources. Order of magnitude precision corresponds closer with the research on LD_{50}s. It is difficult to defend LD_{50}s as ratio-level data since many are extrapolated from limited data points in animal studies.

Traditionally, three to four categories are used to group pesticide toxicity. The EPA has followed this practice by requiring "signal words" describing a pesticides acute toxicity on pesticide labels. These measures are developed from standard criteria developed by the American Association of Pesticide Control Officers (AAPCO). The signal word corresponds to the LD_{50} as indicated in the table below. The difficulty in making these measures into values for regression analysis lay in category I, those pesticides assigned the "Danger" signal work. Chemicals in this category, with differing levels of toxicity, are assigned the same signal word". A skull and cross bones and the word "Poison" mark those pesticide labels that are extremely toxic as measured by death. To make these toxic effects distinct, the number four was assigned to those causing death at the indicated doses. The others, listed as "Dangerous" because of another acute effect, besides death, were assigned a value of three.

EPA PESTICIDE SIGNAL WORDS AND STUDY ASSIGNED VALUES		
ORAL LD50 (mg/kg)	SIGNAL WORD	THIS STUDY VALUE
< = 50	Danger *	4
51 - 500	Warning	3
501- 5000	Caution	2
> 5000	Caution	1
* Toxic effect = death through ingestion the Skull and crossbones and the wo		
"Poison" are further required on the label.		

Neither PESTUSE or PESTSAMP contain a classification of a pesticides formulation. This presented a problem for the signal word since the toxicity between some formulations vary significantly enough to change the required signal word. Pesticides that belonged to a class with multiple formulations were assigned an acute toxicity score to most accurately represent the hazard without overstating it. The following process was used to resolve these cases:

1.) Check PESTSAMP to see if pesticide is listed as general or restricted use.
2.) Check ENFORCEMENT in PESTUSE to see if action was taken on account of certification.
3.) Check DESCRIPTION in PESTUSE to see if complaint was described as usage of a restricted use pesticide by an uncertified applicator.
4.) Check PESTSAMP to see if pesticide used was a mix with multiple active ingredients. (Recall that the predominant active ingredient is used as the base for statistical testing for each case.)
5.) Use the Farm Chemicals Handbook to verify all formulations presented were manufactured in the year given by the application date.
6.) If all above fail, assign the lower toxicity score.

PESTICIDE CHEMICAL CHARACTERISTICS

Pesticide chemical characteristics were reported in many different standard units owing to the wide variation in the chemical properties of commercially prepared pesticides. An example of this is vapor pressure. Variation in reported measures for vapor pressure equaled 14 orders of magnitude. Variation reported for water solubility was also high with 10 orders of magnitude. Converting these to units necessary for the unitless K_h calculation required many conversions be calculated. These were done according to standard practice.

Some pesticides were given measures expressed in qualifiable terms. Examples include using the terms "very high" or "negligible" for vapor pressure or "insoluble" or "practically non soluble" for water solubility. Many of the verbal measures represent zero. For this reason, the verbal vapor pressures were reassigned to zero when stated as "negligible", "involatile" or "practically none".

In the Henry's law formula, vapor pressure is factored in the numerator and water solubility in the denominator. Assigning zeros for water solubility would result in a denominator of zero, and undefined values for K_h. To avoid skewing the data, water solubilities stated as zero were assigned the smallest reported solubility in PESTSAMP, that of DDT, 1.2×10^{-6} grams per liter. Verbal statements of high water solubilities were not reported probably due to the ease of measurement of high amounts. When the vapor pressure or the water solubility could not be found the case was deleted.

TEMPERATURE

Temperatures were not available for every Michigan County. Temperatures were taken from National Weather Service (NWS) reporting stations across the state. Counties lacking a reporting station were assigned the temperature from the nearest reporting location. The NWS records a high, and low for each day of the year for each reporting location. There are reporting stations in 79 of Michigan's 83 counties. Assigning values from the closest county meant the longest distance from known reporting station to an assigned county is approximately 30 miles. The high temperature for the day was chosen because it contributes to the greatest kinetic energy for vapor pressure and solubility. Those pesticides vaporizing would be most likely to do so at these temperatures.

□ CONTROL VARIABLES

The research design of this thesis is post-facto. That is, the independent variable is not manipulated. An experimental design would require that people be exposed to pesticides of varying K_h and toxicity while controlling for application technique, income and other demographic variables. This design would present some difficult ethical problems in terms of exposing humans subjects to pesticides. Since this research is post-facto the relationships expressed cannot be said to assess causation. However, this model does employ a multivariate analysis with seven independent variables. Simultaneously testing each variable while controlling for the others, lends more credibility towards determining causation but cannot be said to show causation.

It is possible that other variables outside the research hypothesis (People complain when they smell a chemical odor, or have direct evidence of toxicity) may explain the probability of complaints. It is widely known, for example, that people with higher income and education tend to read more, and be more politically active. Reading more could plausibly account for higher complaints since knowledge of pesticide toxicity and risk come to most people through the popular media. Percent of population having a college degree, percent of population with high school diploma and median county income were added as control variables.

It was mentioned earlier that proximity to the application was an important determinate of likely off-target exposure. Data to support testing of this hypothesis was not available in the PPPMD databases. But an approximation of population density is available to test for the existence of a relationship between it and pesticide complaints. The county's population and percent farm land were added to test for this relationship. In summary, the following demographic data was added to the research database from the 1990 census. It includes:

1.) Percent of county population who have a college degree
2.) Percent of county population with a high school diploma
3.) Median income of the county
4.) County's population
5.) Percent county farm land

The applicator's certification status had to be removed from the analysis. Investigation showed that the PPPMD, although including the variable in the database, did not consistently record it until 1992. According to Sandy Winans, the technician responsible for entering data during the years of the analysis, "applicators were tracked by their name not their certification number".[95] In 1992 a separate column was created to track applicators by their certification number. The field was not uniformly recorded previous to this. Analysis of the data supports this statement. Many entries are simply a listing of the application categories the applicator is certified in. Other entries are application categories apparently for the type of application that was made regardless of the certification of the applicator. Still other severe violations identified as, "dumping chemicals in the roadway," "baby bottle filled with roach spray", "human exposure" and "police matter child poisoning" make no mention of the applicator certification status. The CERT field was not consistently evaluated and does not reflect the certification status of the applicator. There further appears to be no way of correcting this data for the time period, prior to 1992, unless the applicator's certification status could somehow be ascertained from a separate record. For these reasons certification status was deleted from the model.

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[95] Sandy Winans, telephone interview, July 25, 1995

☐ STATISTICAL TECHNIQUES

This research is atypical in trying to formulate a holistic approach to the incidence of pesticide complaints. Concepts from physics and chemistry were applied to predict how humans were exposed to pesticides and if it was the toxicity of the pesticide they were worried about or something else. Because the final variable is human behavior societal characteristics were also measured to safeguard against spurious conclusions explained by demographic variables.

Data was collected on seven different variables all together. Choosing a statistical technique that would utilize this broad range of data was important. Multiple regression analysis allows the analysis of variance between multiple independent variables. "Multiple regression analysis sic. is eminently suited for analyzing the collective and separate effects of two or more independent variables on a dependent variable."[96]

☐ SUMMARY

The data used for the analysis was not seriously lacking nor manipulations necessary that significantly changed the investigation with one exception. Applicator certification status had to be dropped as an independent variable. It was originally included in the prospectus but was inconsistently entered in the database. Unavailability of vapor pressure and water solubility forced the deletion of some cases but this number did not significantly affect the data.

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[96] Elazar J.Pedhazur, *Multiple Regression in Behavioral Research*, p. 6, 1982

CHAPTER 4

FINDINGS

□ INTRODUCTION

Statistical scores are reviewed for each variable as well as the results of the research hypotheses stated in chapter one. The findings for the steps hypothesized to lead to complaints are also reviewed. Lastly, the significance of the findings to theory and policy are discussed. (See summary page 30)

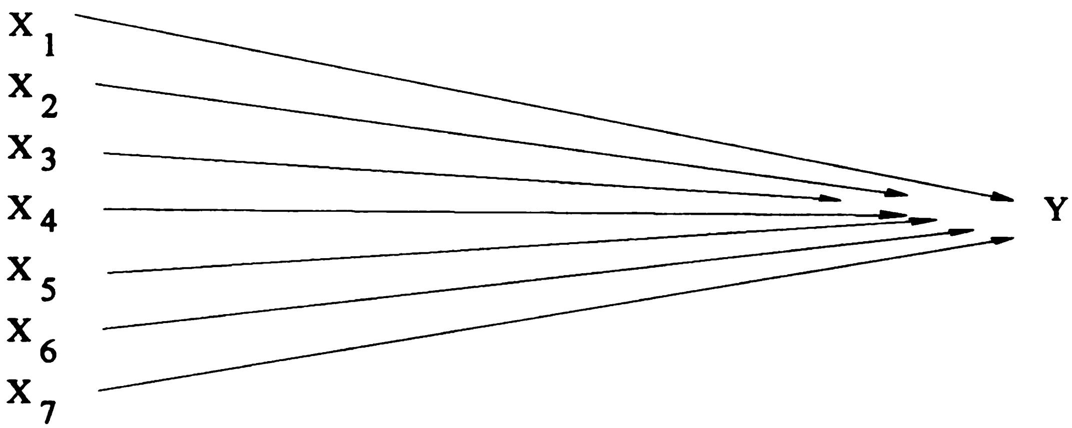
REGRESSION SCORES AND SIGNIFICANCE

Significant regression scores were found between two of the variables, those being percent of population with a college degree and population of the county. No other score was found significant. The null hypotheses must be accepted. There is no statistically significant relationship between the K_h constant of a pesticide's active ingredient or its LD_{50}. and the number of complaints. Regression analysis showed the independent variables explain 59.53% of the variance in the number of complaints per county evident by an R-square of .59533 with $p<.0001$. The R-square is significant.

The regression equation is:

$$Y_1 = -24.01 - .05x_1 + .87X_2 + 1.18X_3 + .06X_4 + .39X_5 + 6.7X_6 + 6.47X_7$$

X1 K_h of the active ingredient
X2 Lethal Dose fifty percent (LD_{50}) of the active ingredient
X3 Percent of county population with a college degree
X4 Percent farm land in county
X5 Percent of county population with High School Diploma
X6 Median income per person per county
X7 County's population



As shown, the only slopes that are significant are percent of county with a college degree (X_3 1.18) and Size of the County's Population (X_7 6.47). Population has the largest impact on number of complaints per county as evidenced by the Standard Slope of .732821 standard deviations. Toxicity and K_h constant have the smallest impact on number of complaints per county. See appendix B for scatter plots and regression lines

CORRELATION SCORES

Correlation scores, were calculated for each combination of variables. See appendix B. Henry's Law Constant is slightly correlated with the other variables of this model. It is only significantly correlated to percent farmland. The coefficient between Henry's law score and percent farmland is - .06 with $p < .04$.

Acute toxicity is also only slightly correlated with the other variables and only significantly correlated with income level. It is negatively correlated at - .05 with $p < .04$. Controlling for the demographic variables still yielded small correlation's which are insignificant.

The demographic control variables correlate strongly as is typical and expected.

☐ STEPS HYPOTHESIZED TO LEAD TO A COMPLAINT

STEP 1. People fear pesticides to the extent that they will complain for fear of their health and property regardless of the actual hazard the pesticide poses.

Findings support the hypothesis that the public fears pesticides to the extent they will complain regardless of the actual hazard. Complainants seem to be risk averse given the findings of no significance for both acute toxicity and volatility.

STEP 2. Because of this fear, many will complain if they can detect a pesticide application has been made and they are being exposed.

People obviously know if a pesticide has been applied. But they are not necessarily basing their complaints based upon exposure if the pesticides volatility and toxicity are both insignificant. They apparently are calling based upon witnessing the application and assuming the application is harmful to them or their property.

STEP 3. Complaints rely upon their senses, to determine exposure to themselves or their property. Evidence of toxic effects will be stronger for those pesticide with higher acute toxicity.

Complainants probably do not rely upon their sense of smell. As mentioned above they see the application. They may hear the application, for structural applications or aerial application but hearing would still need to be confirmed by sight.

Regarding the second part of the statement; again, the toxicity of the pesticide was found to be insignificant as a determinant of complaints.

STEP 4. Pesticide movement through the air is the most rapid route for off-target movement of pesticides.

This assertion cannot be directly answered as the research hypotheses are formulated. Again, the insignificance of Henry's Law Constants does not support this assertion. But sighting of the applicator or application apparatus would be faster than smell as it travels through the air.

STEP 5. Partitioning to air is determined by the volatility of the pesticide, and the Henry's Law Constant (K_h) is the limiting factor in volatilization

This theory has been validated by others. But again it is not upheld in this case by the lack of relationship between Henry's Law Constants and incidence of complaints.

□ THEORETICAL AND POLICY SIGNIFICANCE

PERCEPTION OF PESTICIDE RISK AS A STIMULUS OF COMPLAINTS

The findings support the findings of risk researchers in general. That is, there is something explaining people's reactions besides actual harm. This finding supports Wildavsky and Slovic generally. It could be a persons fear of dread, and unknown effects from the application. It also could be the person's ideology. Specific conclusions decisively supporting either theory cannot be made from this research. But it seems clear that the public is risk averse when it comes to pesticides.

FIFRA USEFULNESS FOR DISPUTE RESOLUTION

Based upon the conclusions from the review of FIFRA, the findings suggest a public choice refinement would best serve to reduce the conflict between complainants and users. This statement is based upon the insignificance of Henry's

Law Constants and acute toxicity. It was said that significant findings related to these two variables would suggest that the conflict could be lessened by changing to more specifically prescribed applications. Given there is no relationship between the incidence of complaints and the K_h and acute toxicity, the conflict results from the more fundamental objection to pesticide use. The fundamental objection could be explained by Slovic or Wildavsky but the explanation by either theory reveals a person not easily swayed by risk assessment arguments. Again, an improvement in FIFRA should be based in a weighing of the interests.

☐ SUMMARY

The findings of this research are unexpected for they reveal a disconnection between the risks of pesticide application and the impetus to complain. The findings suggest complainants do not base their decision to complain on an assessment of harm to themselves or signs of actual toxicity. The finding of significance with percent with a college degree and county population are serendipitous. The findings taken as a whole support a weighing of the interests for FIFRA reform that will reduce the conflict between pesticide users and neighbors to applications.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

☐ INTRODUCTION

This chapter is formatted the same as the past one with a discussion of the research hypotheses, each assertion and significance to theory in order. The discussion of each of the above points is followed by recommendations. The summary discusses the larger issues of application situation, risk perception, and pesticide regulation. It ends with some considerations of the larger issue of chemical use in society.

☐ RESEARCH HYPOTHESES

The results of the statistical model indicate there is no relationship between the K_h of the active ingredient and the incidence of complaints. The null hypothesis must be accepted. The likelihood that a pesticide complaint will result from a volatile pesticide is not significant. This finding is surprising. It seems from intuition that the more volatile pesticides would be generating many more complaints. Perhaps, there are simply too many intervening variables that affect off-target exposure and the K_h is too fundamental a measure. Possible intervening variables could be odor, wind speed, wind direction, inactive ingredients and others. High K_h scores would end up in the air, but odorless or aromatic smells may not trigger a reaction of fear. Many complaints list an odor on their complaint investigations. The direction of the wind and its speed could prevent exposure of neighbors. High winds, with the neighbor on the leeward side, may result in no exposure at all.

Inactive ingredients in the formulation affect volatilization of the active ingredient, but they must not, to the extent they interfere with the absorption or availability of the pesticide. The findings do not hint at what characteristics of pesticides or the application situation would better predict complaints. None of the intervening variables listed above occur with every application.

Determination of the intervening variables could be accomplished with complaint investigations. Investigators would have to respond immediately to a complaint, even getting the details as they drove. Air samples could be taken with total hydrocarbon analyzers and other direct read instruments used to measure the concentration of the pesticide in air. These readings could then be compared with a calculated K_h to determine if any relationship exists between the variables.

PESTICIDES ACUTE TOXICITY

This variable was included in the analysis because it is available and measurable but also because it is a real-time indicator of toxicity. The extremely toxic pesticides will produce instant effects in significant doses. Strong herbicides will curl leaves within a few hours. Nausea, headache, watering and burning of the eyes, nose and throat are all common acute effects from chemical exposure. Explanation of no significance is surprising and suggests that toxicity effects are not present in the great majority of the cases. This is significant for policy since acute effects has been the litmus test to prove harm from chemical exposure to date. Cancer and other chronic effects are pathologically indistinct and too far removed from the exposure to establish causation.[97] Changes in FIFRA, based upon a weighing of the interests, will go towards users if harm cannot be shown.

☐ STEPS HYPOTHESIZED TO LEAD TO A COMPLAINT

STEP 1. People fear pesticides to the extent that they will complain for fear of their health and property regardless of the actual hazard the pesticide poses.

These findings and the theory support this assertion. However, which branch of theory is not clear. It is recommended that further research be conducted to confirm which theory of risk perception is most useful. Slovic's risk perception psychometric-paradigm is well developed and has been replicated several times.[98] It exists as a survey instrument that could easily be applied to pesticide complaints in Michigan. Wildavsky's Worldview theory could also be applied, but would be more difficult. His research used data collected on the national level and seems to require more knowledge in its application. However, survey methods could be developed to test the theory. As discussed in chapter two, Worldview theory may hold the edge in ability to predict who will complain. The reader may recall that the relative strength of Slovic's method is the ability to predict which technologies will be feared. Either theory is useful but for different applications. For example, some biological pesticides are currently used such as Bacillus Thuringiensis for mosquito and black fly control. If other biologicals are licensed that are products of genetic engineering they will likely be feared strongly. Research shows these compounds would also be highly susceptible to signal events similar to Alar. (See

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[97] There are a few distinct carcinogens that are exceptions to this rule. Vinyl Chloride and asbestos cause distinct pathologies even after years have passed since exposure. But niether of these carcinogens are considered to be environmental carcinogens generally. Both result from occupational exposure. (See Wildavsky, *But Is It True,* for a review of research of environmental exposure to asbestos). The current progress of litigation against tobacco companies is of interest but stems more from the relevation they adjusted nicotine levels than an admission that smoking causes lung cancer.

[98] Susan L Cutter,.et al. *Industrial Crisis Quarterly*, Volume 6, 1992.

chapter one for a discussion of signal events.) A public-information emergency-response plan may be wise for such pesticides. Other applications of the theory may be monitoring of a large scale right of way spraying. Slovic's work may predict what pesticides would produce a perception of dread, catastrophe and unknown effects, and hence be feared. Wildavsky's Worldview Theory could predict what party involved, will react in what manner and what PPPMD actions would be successful in reducing the conflict.

STEP 2. Because of this fear, many will complain if they can detect a pesticide application has been made and they are being exposed.

The existence of fear has been discussed. Detection of pesticide application seems to exclude or discount smell and evidence of toxic effects, which leaves observation of the application. This is the next most likely verification a complainant has of application. Complaints apparently see the application as it happens. This seems logical under many circumstances. For example, for herbicide drift, a neighbor may notice toxic effects long after the application. They may only notice it while mowing the lawn or walking the fields and even then not suspect herbicide as the culprit. Often times, the cause of leaf curl, for example, is indistinguishable between herbicide and other phytopathology. A lay person would be unable to make such a distinction and therefore be reliant upon witnessing the application.

The question of how risk was detected and judged dangerous, by the complainant, could be confirmed by the PPPMD also. The investigation response time would have to be lowered, or the information taken when the complaint is called in. But additional information from the complainants could answer this question.

STEP 3. Complaints rely upon their senses, to determine exposure to themselves or their property. Evidence of toxic effects will be stronger for those pesticides with higher acute toxicity.

As mentioned in the discussion of Step 2, this assertion is not as significant as expected. Recommendations are the same as for Step 2 with the exception of adding more detail to the questioning of how an application was detected. For example, the question to determine initial detection may be, "Why do you suspect a pesticide is responsible?" A follow up question may be, "What was your first indication that it was a pesticide?" Discovery of the root of the fear-to-complain will expose the basis of the conflict.

STEP 4. Pesticide movement through the air is the most rapid route for off-target movement of pesticides.

This assertion cannot be fundamentally answered by this research. The expected findings of significance between volatility and acute toxicity would have substantiated this assertion. But in their absence, little more can be said. Further research is not advised until the subtle questions of Steps 2 and 3 are answered above. Research of the flux of pesticides from an application is of value for fundamental research, but a priority in this applied research situation. Researching steps 2 and 3 above may show Worldview is the best predictor and the complaint has nothing to do with the pesticide or its exposure to the complainant.

STEP 5. Partitioning to air is determined by the volatility of the pesticide, and the Henry's Law Constant is the limiting factor in volatilization.

Again, this theory is will documented by other researchers. (See chapter two for more detail) However, this study does not support it. This conclusion is surprising for its lack of significance but especially because the calculated K_h included a measure of heat energy. Daily high temperatures were used to calculate K_h for the active ingredients. The calculated K_h's included a measure of this important variable as it affects vapor pressure and water solubility. Further research is not recommended until the questions of Steps 2 and 3 are resolved for the same reasons.

☐ SERENDIPITOUS FINDINGS

Percent of population with a college degree and county's population were unexpected findings of significance. College degree is interesting in that it implies that the uneducated are more likely to be victimized if harm occurs. In other words, the educated can look out for themselves and understand how to mobilize the PPPMD on their behalf. Further research, taken to explore the magnitude of the effect of college degree on complaints, showed the effect is not obvious, at least to simple frequency analysis.

COUNTY	PERCENT WITH COLLEGE DEGREE[99]	NUMBER OF COMPLAINTS[100]	PERCENT OF TOTAL
Ingham	29.2	38	3
Kent	20.7	110	9
Oakland	30.2	97	8
Washtenaw	41.9	81	7

However, it is worth further research. One notable point from PESTUSE is that no complaints were reported within the four years of this study for Crawford, Kalkaska, Keweenaw and Luce counties, All have very low percentages of the population with a college degree.[101] Whether these numbers are in line with the number of applications that occur in these counties cannot be said without further

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[99] United States Department of Commerce, Bureau of the Census,*The Census of The United States of America,* Washington, D.C. U.S. Governemnt Printing Office, 1990

[100] Pesticide Usage Database, Michigan Department of Agriculture, Pesticide and Plant Pest Management Division 1982-1989

[101] Source: Pestuse

research. One way of answering that question, is to compare the Restricted Use Pesticide (RUPs) sales logs from authorized dealers for counties across the state.

Another serendipitous finding was found in the relationship between population of the county and complaints. It seems obvious that the size of the population would directly correlate with the number of applications performed and hence the number of complaints. This would seem especially true for the non-agricultural applications such as "wood destroying" and "turf." Investigations labeled as "NA" (Non-Agricultural) by the PPPMD, comprise 68 percent of all complaints.[102] (Non-agricultural application arises from urban populations.) However, the finding of no significance of percent-county-farm-land disputes a direct correlation of population with incidence of complaints. If the non-agricultural complaints were simply a matter of population we would expect Wayne, Oakland and Macomb counties to account for 42 percent of the complaints.[103] Furthermore, it would be expected that percent farm land would have a negative and significant relationship with the incidence of complaints. The three counties together account for 24 percent of complaints despite making up 42 percent of the State's population. So it seems the conclusion of positive significant correlation with population only cannot be made.

Reconsidering the findings of the control variables - college degree and population significant - percent farm land and median income insignificant - supports the supposition that county population and college degreed are surrogates for suburbs. Suburbs have lots of people and lots of lawns. PPPMD reports, for the most recent fiscal year consider the application category "Turf" to represent 80 out of 292 complaints, 27 percent. The next significant category is

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[102] MDA, PPPMD, Pesticide Usage

[103] *U.S. Census of the Population, 1990*

"Private" with 48 of 292, 16 percent.[104] Considering these findings together debunks the popular perception that the conflict is between farmers and the rest of society. It seems the bulk of the complaints are between suburbanites or their hired parties. The resultant policy question for the PPPMD is the distribution of resources. Are resources for pesticide complaints effectively distributed to serve this suburban citizen that comprises the bulk of complaint investigations.

□ THEORETICAL AND POLICY SIGNIFICANCE

PESTICIDE REGULATION

Accepting that pesticide complaints are primarily a suburban phenomenon begs the question: Is PPPMD protecting the environment or refereeing disputes between suburban neighbors of different ideologies? Regulating the two activities requires different expertise and authority.

Certainly, there is intensive use of pesticides in agriculture. Protecting the environment from pesticide misuse was the original intent of FIFRA. The more recent concern over controlling pesticide residuals is also consistent with agricultural regulation. These functions protect the environment and food supply respectively. But control of suburban application through complaint investigation does not serve so well to protect the environment. It is not a function of protecting the food supply since suburban gardens do not make up a significant percentage of purchased food. It is more a matter of public safety and property rights. Local property rights are significantly determined by zoning and use laws and may be instrumental to the evolution of rules to reduce pesticide conflict.

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[104] Julie Stachecki and Brian Rowe, "Michigan Department of Agriculture - 1995 Pesticide Compliance Activities," *Pesticide Notes*, Michigan State University, November - December 1995.

The PPPMD, as an advocate of the public interest, can influence public opinion through its education efforts. This finding, combined with the considerable research on risk perception, suggests that education targeting the public may be effective to reduce complaints and fear of pesticides. At the least, PPPMD should investigate further this hypothesis by enhancing its current data collection. Helping to defray this distrust or intolerance is a legitimate role of the PPPMD. Education programs targeted at the relatively well educated populations that complain may yield fruitful resulting safe and effective use and more efficient use of PPPMD's resources. Such efforts could be targeted at supplying leadership to developing agreements for pesticide use within neighborhood associations. Investigating fewer complaints may free upon enforcement resources for case where harm has actually occurred or more Use Investigations. Another worthy alternative may be teaching the relatively uneducated (those without college degrees) to complain when a careless applicator has violated their rights and risked their health. Recall that four counties filed no complaints in four years.

APPLICATOR AND EQUIPMENT APPEARANCE AND RISK PERCEPTION

The finding that people who are better educated are more likely to complain, regardless of the real danger posed by the pesticide, suggest the application method is also irrelevant. But investigation of this assumption may yield significant insight into the conflict. Does the complainant have to see the application taking place and if so what impact does this have? Does high volume tree spraying generate more complaints than granular yard applications?

Assume Worldview is correct and determines who will complain. An applicator is considered dangerous as soon as they pull up to the site. The person of liberal ideology is poised to call in a complaint. Arguably the only intervening variable is the appearance of the applicator and the apparatus. Does the appearance of the applicator and his equipment affect the risk perception of the complainer? Does the perceived intelligence and knowledge of the applicator weigh into the decision? If an applicator is perceived to be bright and articulate and interacts with curious people well, does this reduce complaints? Combining the existing information with a follow-up of commercial applicators is recommended. Do firms with regular training programs generate less complaints? If the applicator is perceived to be competent does this reduce the chance of a complaint? If Worldview theory is correct the decision to file a complaint is more prejudicial than reasoned. A judgment of appearance seems to be more consistent with the situation described than a reasoned decision based on risk assessment.

The applicator's certification status may be an indicator of an applicator's skills and thereby influence risk perception. As previously mentioned in the discussion on methods, applicator certification was deleted from the analysis. The variable was originally included in the analysis to test the effect it had on the number of complaints. It remains an important test to make. It is a major part of the lack of information that can be called the "Application Situation" The application situation includes all those variables related to how a pesticide is delivered to the intended target: the applicator, and the apparatus used, the physical\chemical characteristics of the pesticide, weather conditions, proximity to neighbors and others.

□ SUMMARY

This study has identified three areas that affect the incidence of pesticide usage complaints. The first is the pesticide and the application situation. The second is how risk is perceived by complainants. The last area is the law that defines the rights and responsibilities of the parties to the conflict.

APPLICATION SITUATION

If there is further value in determining the physical\chemical characteristics that affect the incidence of complaints, hypotheses will have to be made from analysis of more field data. Much field data recorded during investigation is available. The best hypotheses will be generated from a combination of review of existing complaint investigation documents, specifically - completed Complaint Investigation Forms - and more rigorous initial investigations with faster response times. The current maximum response time of 24 hours is too long to detect relationships with some pesticides or windy situations. Experimental research will have to collect data within an hour.

RISK PERCEPTION

Risk perception seems to be germane to pesticide complaints and should be investigated further. Its relationship with education is of distinct interest. Significant contributions to risk perception theory could be made by better explaining the relationship between the two major branches of risk perception and education. Perhaps, the first choice should be the impact of education on the consumption of risk information and its usage according to ones ideology. This is a finer point to be found from the research on risk assessment suggested in discussion of Step 1. Another fertile question is the relationship of education to ideology and activism. Wildavsky has shown that liberals tend to be individually risk taking and socially risk averse. Conversely, Individualists and Hiearchists, tend to be the opposite for environmental issues. How does education interplay with ideology to explain complaints? What is the added relevance of the insignificance of median income?

PESTICIDE REGULATION

Another good opportunity for research would be to investigate the hypothesis that suburban areas generate the bulk of complaints. Relevant questions include, determining the nature of the conflict and what is at issue. Does suburban pesticide use threaten the environment? Are suburban volumes of pesticide usage significant compared with agriculture? If volumes applied are not a risk to the environment, are they a concern for public health? If volumes are low and there is little risk to the environment or public health are pesticide complaints simply a matter of people living too close together for outdoor pesticide usage?

Resolving the above question is where FIFRA and MEPCA fail. The technology of measurement, public concern and increased pesticide usage has outgrown the basic structure of this law. FIFRA is 26 years old this year.

The findings from this research and others suggest changes in the pesticide laws should go one of two ways, based upon risk perception. If scientifically substantiated harm can be shown to be responsible for complaints, then the application situation must be controlled tighter. If it has nothing to do with harm, then it is a matter of public choice as to who wins or loses with pesticides, but the choice should be defined more clearly. Issues of harm, compensation, off-target exposure and residuals should be addressed. What concentration constitutes "no drift?" Can a neighbor prohibit an application given the existence of off-target exposure? Is off-target exposure a "taking" under the law, and if so, how can it be compensated?

CHEMICAL USE IN SOCIETY

These are the recommendations to further research <u>some</u> of the conflict involved with chemical use in our society. As noted in the opening paragraph of this thesis, society is convinced it faces graver risks than past generations despite steadily living longer and enjoying better health. Is the conflict over pesticide usage a symptom of this larger phenomenon?

Progress can surely be made to improve the quality and span of human life. The wisdom is in the selection of the improvement. Pursuing zero-risk exposure and neglecting significant risk costs all of us dearly. There are still plenty of risks that routinely take huge tolls. Smoking, motor vehicles, alcohol abuse and natural disasters are but a few. Many of these risks get overlooked because they are voluntary. But overlooking voluntary risks and concentrating on lesser involuntary risks is the height of self-deception. Hopefully, this current round of societal worry will produce risk reductions that improve the quality of life for the most people, and not just rules that take away worry and accomplish nothing else.

APPENDICES A - I

APPENDIX A

COMPLAINT INVESTIGATION FORM

P1-192 (10-90)

MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE AND PLANT PEST MANAGEMENT DIVISION

White - Lansing
Canary - Regional Supervisor
Pink - Conclusion
Goldenrod - Investigator

REQUEST FOR INVESTIGATION

(In accordance with Act 380, P.A. 1965, as amended)

NAME OF OWNER (ESTABLISHMENT)			Telephone ( )	INVESTIGATION NO.
ADDRESS			ESTABLISHMENT TYPE	TYPE OF INVESTIGATION (Program)
CITY	STATE	ZIP CODE	COUNTY	RECEIVED BY
ESTABLISHMENT LICENSED ☐ YES ☐ NO			IF YES, LICENSE NUMBER	DATE/TIME RECEIVED
COMPLAINANT (Person Reproting Incident)			Telephone ( )	DATE/TIME OF OCCURRENCE
ADDRESS			REVEAL IDENTITY ☐ YES ☐ NO	ASSIGNED TO
CITY			STATE ZIP CODE	DATE/TIME ASSIGNED
				REASSIGNED TO
				DATE REASSIGNED
				DATE INVESTIGATION COMPLETED

DESCRIPTION OF THE INCIDENT (Who, What, Where, When, etc.)

OTHER AGENCIES OR INDIVIDUAL INVOLVED (Affiliation and Telephone Number)

1. ______ 3. ______
2. 4.

INVESTIGATION

SEAL NUMBER OF SAMPLES

MATERIAL SEIZED OR OTHER ACTION TAKEN:

DESCRIPTION: NOTICE NO.

DISPOSITION OF MATERIALS:

PRELIMINARY: FINAL

FOR LANSING OFFICE USE:

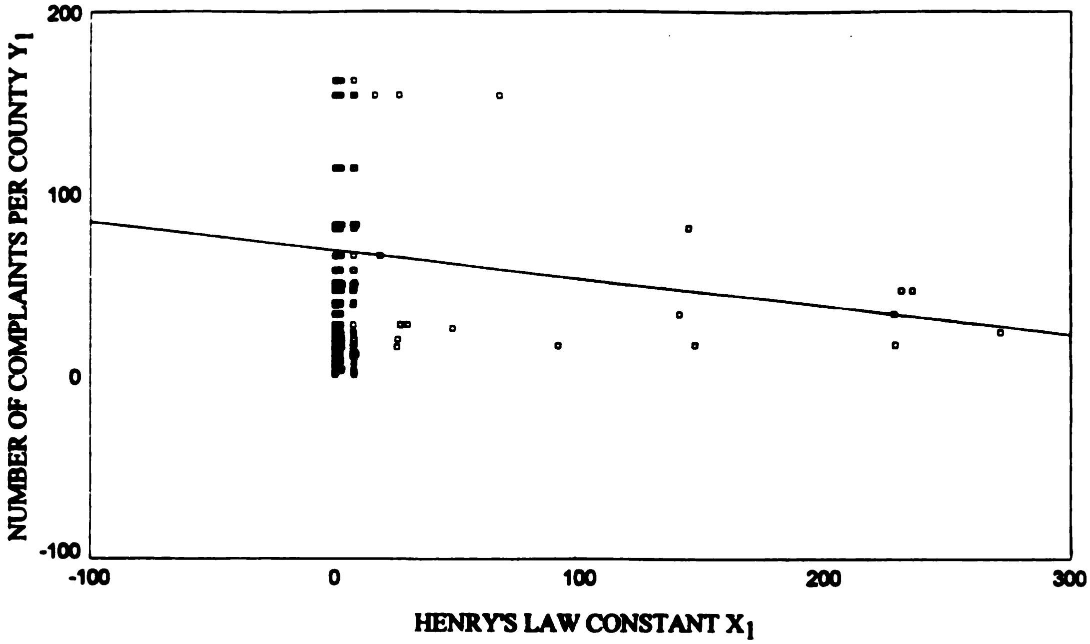
DISPOSITION OF CASE

OTHER DIVISIONS/OFFICES INFORMED

☐ EXECUTIVE OFFICE ☐ PRESS & PUBLIC AFFAIRS ☐ ANIMAL INDUSTRY ☐ OTHER ______

APPENDIX B

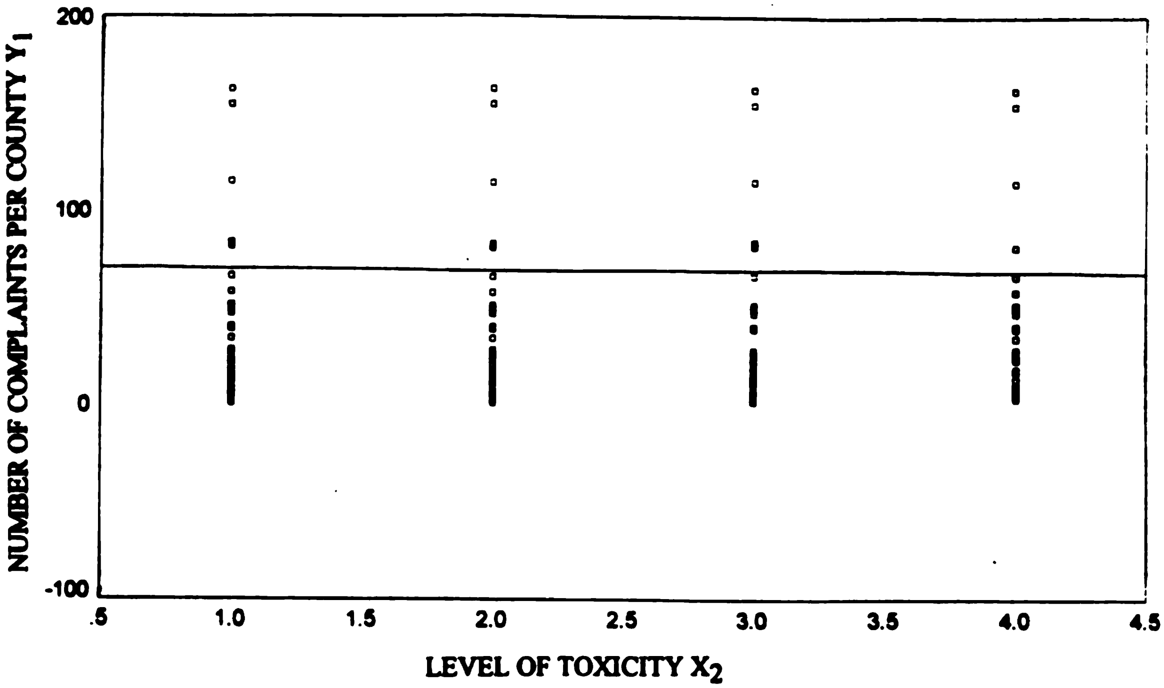
HENRY'S LAW SCATTERPLOT AND DESCRIPTIVE STATISTICS



Mean	**3.353**	**Standard Error Mean**	**.543**
Standard Deviation	**18.646**	**Variance**	**347.658**
Range	**271.368**	**Minimum**	**.000**
Maximum	**271.36**	**Sum**	**3949.669**
Valid observations	**1178.0**	**Missing observations**	**445.0**

APPENDIX C

LEVEL OF TOXICITY (RANKING OF PESTICIDE SIGNAL WORD) SCATTERPLOT AND DESCRIPTIVE STATISTICS

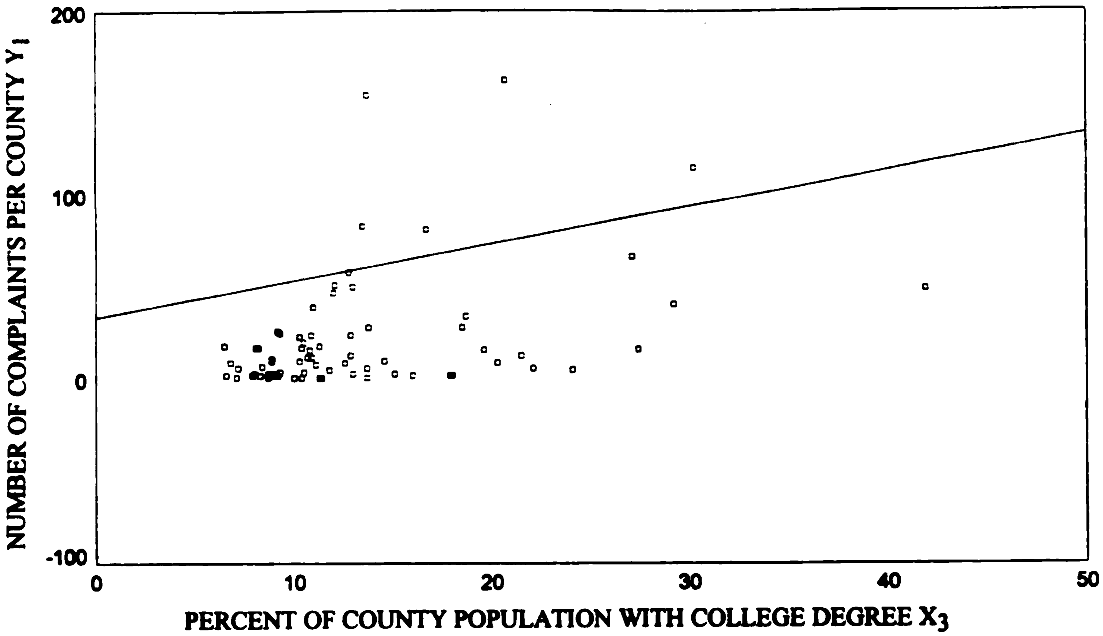


Mean	1.936	Standard Error Mean	.025
Standard Deviation	.884	Variance	.781
Range	3.00	Minimum	1.00
Maximum	4.00	Sum	2377.00
Valid Observations	1228	Missing Observations	395

Note: Toxicity is measured by the pesticides signal word. Signal words are: Caution, Danger, Poison, and the Skull and Crossbones. These words are dummy coded with values one through four. (See chapter three for a discussion of their assignment. Dummy variables are ordinal level and not continuous. Data points are aligned with each and the regression line is flat.

APPENDIX D

PERCENT OF POPULATION WITH A COLLEGE DEGREE SCATTERPLOT AND DESCRIPTIVE STATISTICS

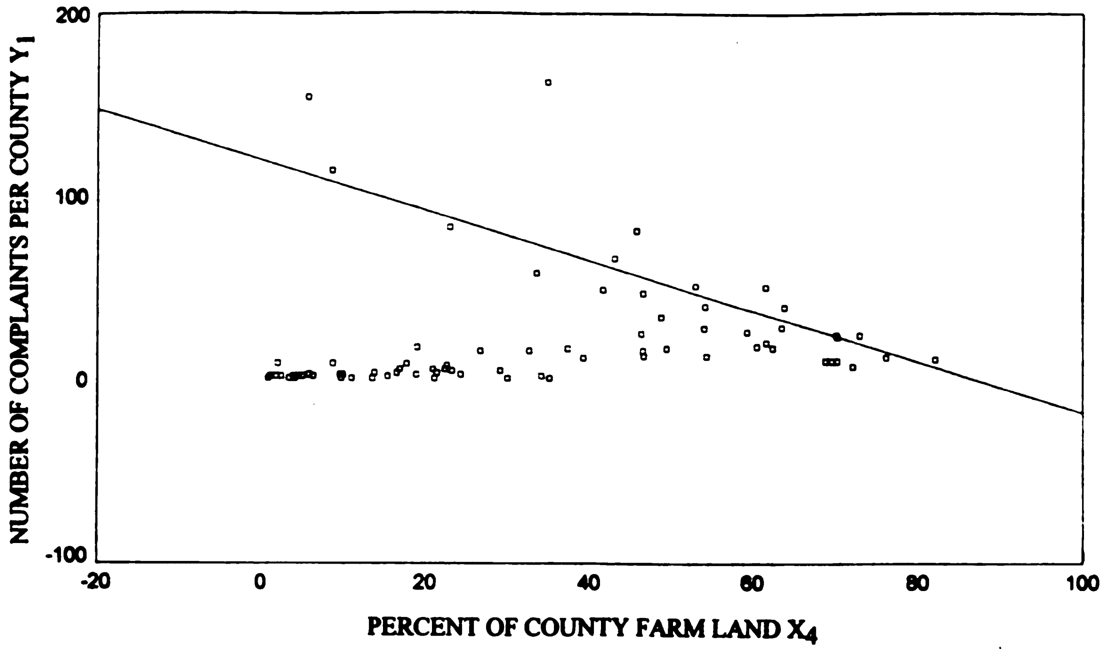


Mean	16.919	Standard Error Mean	.196
Standard Deviation	7.872	Variance	61.961
Range	35.400	Minimum	.000
Maximum	271.368	Sum	27425.500
Valid Observations	1621	Missing Observations	2

Note: Apparent outliers are valid and represent the following counties from left to right: Wayne, Oakland and Washtenaw.

APPENDIX E

PERCENT OF COUNTY FARM LAND SCATTERPLOT AND DESCRIPTIVE STATISTICS

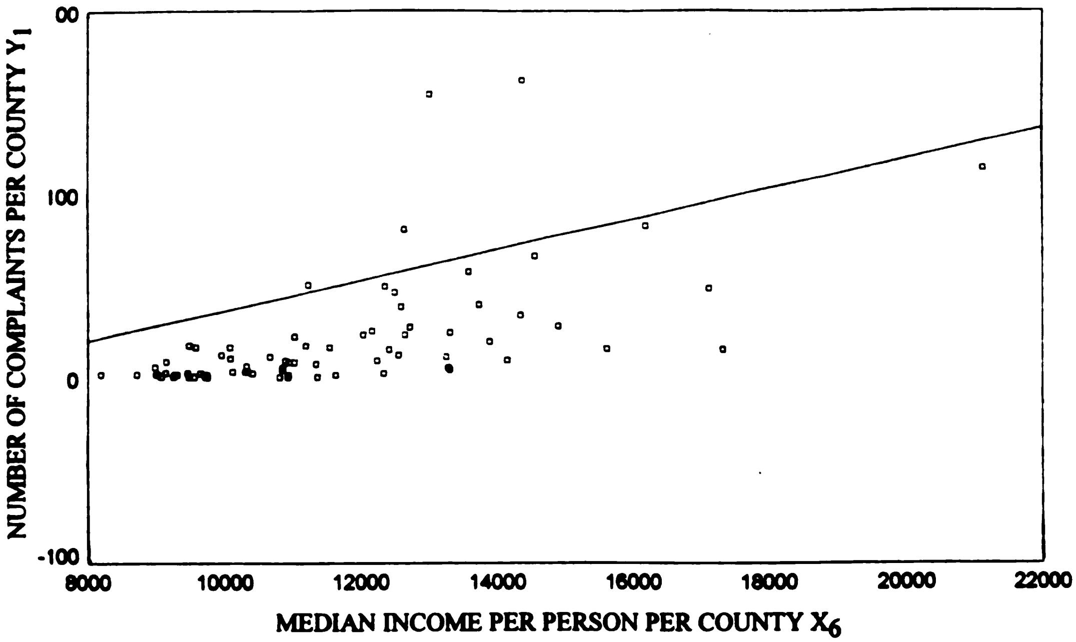


Mean	38.237	Standard Error Mean	.517
Standard Deviation	20.817	Variance	433.327
Range	81.200	Minimum	.80
Maximum	41.90	Sum	61981.800

Valid Observations	1621	Missing Observations	2

APPENDIX F

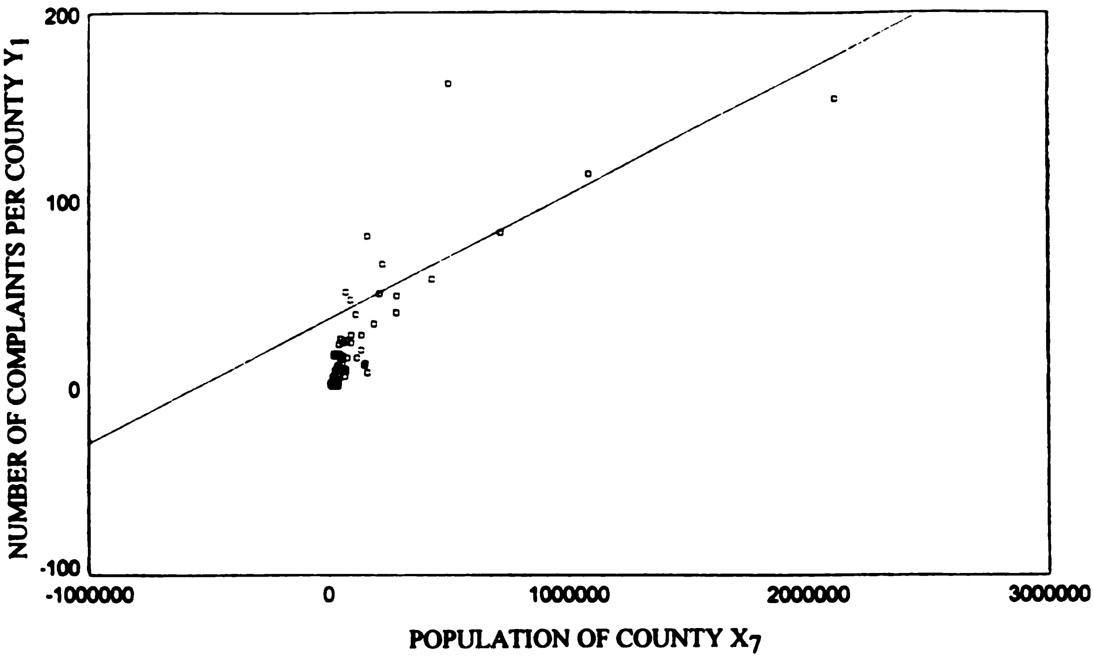
MEDIAN COUNTY INCOME PER PERSON DESCRIPTIVE STATISTICS AND SCATTERPLOTS



Mean	13639.060	Standard Error Mean	68.217
Standard Deviation	2746.517	Variance	7543356.753
Range	12930.	Minimum	8195.00
Maximum	21125.	Sum	22108916.
Valid Observations	1621.	Missing Observations	2

APPENDIX G

POPULATION SIZE PER COUNTY DESCRIPTIVE STATISTIC AND SCATTERPLOTS



Mean	457054.605	Standard Error Mean	15158.974
Standard Deviation	610325.211	Variance	372496863231.
Range	2103845.	Minimum	7842.
Maximum	211687.	Sum	740885515.
Valid Observations	1621	Missing Observations	2

Note: Apparent outliers are valid and represent the following counties from left to right: Kent, Macomb, Oakland and Wayne.

APPENDIX H

CORRELATION COEFFICIENTS

	PERCENT COLLEGE	PERCENT FARM	HENRY'S SCORE	% HIGH SCHOOL	MEDIAN INCOME	NUMBER OF COMPLAINTS
PERCENT COLLEGE	1.0000 (1621)	-0.2158 (1621) P=.000	-0.0400 (1176) P=.171	0.8245 (1621) P=.000	0.7300 (1621) P=.000	0.2935 (1620) P=.000
PERCENT FARM	-0.2158 (1621) P=.000	1.0000 (1621)	0.0641 (1176) P=.028	0.0403 (1621) P=.105	-0.3633 (1621) P=.000	-0.5355 (1620) P=.000
HENRY'S SCORE	-0.0400 (1176) P=.171	0.0641 (1176) P=.028	1.0000 (1178)	-0.0175 (1176) P=.549	-0.0391 (1176) P=.181	-0.0534 (1175) P=.067
% HIGH SCHOOL	0.8245 (1621) P=.000	0.0403 (1621) P=.105	-0.0175 (1176) P=.549	1.0000 (1621)	0.7098 (1621) P=.000	0.0605 (1620) P=.015
MEDIAN INCOME	0.7300 (1621) P=.000	-0.3633 (1621) P=.000	-0.0391 (1176) P=.181	0.7098 (1621) P=.000	1.0000 (1621)	0.4248 (1620) P=.000
NUMBER OF COMPLAINTS	0.2935 (1620) P=.000	-0.5355 (1620) P=.000	-0.0534 (1175) P=.067	0.0605 (1620) P=.015	0.4248 (1620) P=.000	1.0000 (1620)
POPULATION	0.1289 (1621) P=.000	-0.6940 (1621) P=.000	-0.0488 (1176) P=.094	-0.1681 (1621) P=.000	0.3419 (1621) P=.000	0.7552 (1620) P=.000
TOXICITY	-0.0038 (1226) P=.893	0.0251 (1226) P=.380	-0.0239 (1085) P=.431	-0.0158 (1226) P=.580	-0.0587 (1226) P=.040	-0.0077 (1225) P=.789

APPENDIX I

PARTIAL CORRELATION COEFFICIENTS

	HENRY'S SCORE	TOXICITY	NUMBER OF COMPLAINTS
HENRY'S SCORE	1.0000 (0000)	-0.0235 (1076) P=.441	-0.0241 (1076) P=.429
TOXICITY	-0.0235 (1076) P=.441	1.0000 (0000)	0.0218 (1076) P=.475
NUMBER OF COMPLAINTS	-0.0241 (1076) P=.429	0.0218 (1076) P=.475	1.0000 (0000)

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