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THE INFLUENCE OF SOCIAL-LEARNING FACTORS ON FARM OPERATORS' PERCEPTIONS OF AGRICULTURAL-CHEMICAL RISK IN THE OHIO DARBY CREEK HYDROLOGIC UNIT

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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****

The Ohio State University

1995

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Agricultural Economics and Rural Sociology Graduate Program
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# TABLE OF CONTENTS

**ACKNOWLEDGMENTS** ........................................................................................................ ii  
**VITA** ................................................................................................................................ iii  
**LIST OF TABLES** ................................................................................................................ vii  

**CHAPTER**  

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. INTRODUCTION AND LITERATURE REVIEW</td>
<td>1</td>
</tr>
<tr>
<td>The Problem</td>
<td>1</td>
</tr>
<tr>
<td>The Environment, Agriculture and the Public</td>
<td>7</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td>11</td>
</tr>
<tr>
<td>Communicating About Risk</td>
<td>20</td>
</tr>
<tr>
<td>Contribution of This Study</td>
<td>23</td>
</tr>
<tr>
<td>Chapter Endnotes</td>
<td>30</td>
</tr>
<tr>
<td>II. THEORY</td>
<td>32</td>
</tr>
<tr>
<td>Introduction</td>
<td>32</td>
</tr>
<tr>
<td>Theoretical Approaches to Risk Assessment</td>
<td>35</td>
</tr>
<tr>
<td>Social Learning Theory</td>
<td>41</td>
</tr>
<tr>
<td>Social Learning Theory and the Evaluation of Agrichemical Risk</td>
<td>44</td>
</tr>
<tr>
<td>Research Hypotheses</td>
<td>55</td>
</tr>
<tr>
<td>Model Specification</td>
<td>57</td>
</tr>
<tr>
<td>Chapter Endnotes</td>
<td>58</td>
</tr>
<tr>
<td>III. METHODOLOGY</td>
<td>60</td>
</tr>
<tr>
<td>Description of Study Area and Population</td>
<td>60</td>
</tr>
<tr>
<td>Sample Selection</td>
<td>61</td>
</tr>
<tr>
<td>Operationalization of Variables</td>
<td>62</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>67</td>
</tr>
<tr>
<td>Chapter Endnotes</td>
<td>69</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Attitudes Toward Ground Water Pollution Within the Darby Creek Watershed (N=245), Presented in Percentages</td>
<td>72</td>
</tr>
<tr>
<td>2. Perceived Health Threat from Agricultural Fertilizer Contamination of Ground Water in County of Residence Among Primary Farm Operators (N=245), Presented in Percentages</td>
<td>73</td>
</tr>
<tr>
<td>3. Perceived Health Threat from Agricultural Pesticide Contamination of Ground Water in County of Residence Among Primary Farm Operators (N=245), Presented in Percentages</td>
<td>74</td>
</tr>
<tr>
<td>4. Incidence of Farmer Participation in Educational Programs to Reduce Fertilizer Application Rates while Maintaining Production Levels (N=245), Presented in Percentages</td>
<td>74</td>
</tr>
<tr>
<td>5. Farmer Attitudes Toward Participating in Educational Programs to Reduce Pesticide Application Rates while Maintaining Production Levels (N=245), Presented in Percentages</td>
<td>75</td>
</tr>
<tr>
<td>6. Years of Formal Education Completed by Primary Farm Operator (N=245), Presented in Percentages</td>
<td>76</td>
</tr>
<tr>
<td>7. Sources of Information about Soil and Water Conservation Used by the Primary Farm Operator in 1993 (N=245)</td>
<td>77</td>
</tr>
<tr>
<td>8. Perceived Level of Risk from Agrichemical Usage (N=245), Presented in Percentages</td>
<td>79</td>
</tr>
<tr>
<td>9. Bivariate Correlation Coefficients of Level of Risk from Agrichemical Usage and Independent Variables (N=245)</td>
<td>81</td>
</tr>
<tr>
<td>10. Regression Findings for Perceived Risk From Farm Chemicals (N=245), Standardized Regression Coefficients</td>
<td>82</td>
</tr>
<tr>
<td>11. Independent and Dependent Variables Appearing on Survey Instrument</td>
<td>103</td>
</tr>
<tr>
<td>12. Characteristics of Darby Creek Watershed Respondents (N=245)</td>
<td>106</td>
</tr>
<tr>
<td>13. Correlation Matrix of Dependent and Independent Variables, Darby Creek Data (N=245)</td>
<td>108</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION AND LITERATURE REVIEW

The Problem

Agriculture in the United States (U.S.) has been hailed as one of modern science’s greatest triumphs. As the world’s largest exporter of agricultural products and largest donor of foreign food aid (USDA, 1994), the U.S. agricultural system is unrivaled in its capacity to furnish food and fiber for a growing world population. Agricultural techniques originating in U.S. agriculture have not only been copied in farming systems throughout the world, but have also been adapted by scientists in other disciplines.

However, not all of modern agriculture’s contributions have been welcomed. A multidisciplinary scientific literature developed over several decades has documented some of the negative environmental byproducts of large-scale agriculture. One of the most publicized issues has centered on the problem of nonpoint source pollution and its effect on water quality. At issue are U.S. Environmental Protection Agency (EPA) and other government-agency statistics that suggest agriculture is a significant, if not the leading, source of water pollution in the U.S. (National Research Council, 1989). As evidence has developed on some of the harmful consequences of agricultural production, it has increasingly been disseminated through the popular media, which has stimulated public dialogue and scrutiny of agricultural practices and policy. Recent examples include nationally syndicated reports warning consumers that high levels of farm pesticides were present in drinking-water samples taken in the Midwest.
Although states vary greatly in their dependence on surface water and ground water supplies (Pye et al., 1983), all have a profound interest in protecting these natural reserves. Because U.S. citizens use an average of 75 gallons of water a day (Burby et al., 1983), it is easy to understand why the threat of unsafe water has long been viewed as an unacceptable risk for most persons. Recent research suggests that consumers have become increasingly alarmed about the current state of environmental affairs since the late 1960s (Stern & Oskamp, 1987; Train, 1978). Approximately 77 percent of the respondents in a 1992 Roper poll indicated that water pollution was one of the most significant contemporary environmental problems, and nearly 80 percent believed that current water pollution regulations were not sufficiently stringent (Adler et al., 1993). Recent national studies suggest that increasing numbers of consumers also believe that agricultural activities are posing some of the most serious threats to environmental quality and safety.  

Surface water quality traditionally has attracted a great deal of attention from the news media. Unlike ground water, surface water is a highly visible resource valued not only for its utility as a source of drinking water, but also for the benefits it provides through recreation and aesthetic beauty of lakes, streams and estuaries. While the noneconomic value of natural resources has proven difficult to assess (Pitt & Zube, 1987; Schnaiberg, 1980), natural resources scientists have estimated that costs associated with surface-water pollution amount to billions of dollars annually. Such costs are reflected in contaminated drinking water, dredging of reservoirs and waterways, threats to fish and wildlife habitat, and lost recreational opportunities. Easter et al. (1983) report that foregone revenues resulting from lost recreational activities due to water pollution by themselves amount to more than $5 billion a year. Surface water quality is particularly important for recreational activities that involve direct contact with water, such as swimming and water skiing. The National Research Council (1989) has estimated that agriculture’s yearly contribution to surface-water damages may range as high as $16 billion a year.
While consumers are generally more familiar with surface sources of water through recreation and other uses, they are increasingly dependent on ground water usage, which quadrupled between 1945 and 1980 (Gordon, 1984). Ground water accessed through public reserves or private wells is the primary source of drinking water for more than 100 million Americans and provides about 97 percent of all rural drinking water (National Research Council, 1989).

Because contamination of underground aquifers occurs below the earth’s surface from diffuse sources, its actual extent is largely unknown. Unfortunately, it is particularly difficult to detect (Dao, 1987; Easter et al., 1983). Degradation generally occurs over long periods, so that contamination may be extensive by the time it is discovered (Gordon, 1984). Researchers also have found that springs, seeps, and other natural discharges of an aquifer can reintroduce contaminants to bodies of surface water. Control also is complicated by the slow movement of contaminants in underground aquifers, which may amount to as little as a fraction of an inch a day (Pye et al., 1983). At this rate, contaminants can remain undiscovered in aquifers for decades (National Research Council, 1989).

Another complicating factor in controlling ground and surface water contamination is the sheer volume of chemicals used in agriculture, business and industry. Pye and Kelley (1984) estimated about 10 years ago that 30,000 chemicals were in use and an additional 1,000 were being added yearly. Mrak (1978) reports that more than 700 different chemicals have been detected in drinking water across the country. The 23,000 pesticide products registered for use today contain more than 700 active ingredients (Guerrero, 1992). Unfortunately, very little is known about the long-term effects of most of these materials or, indeed, their extent of contamination in wells, aquifers and surface water supplies (Francko et al., 1983; Kotas, 1987). However, the potential for environmental degradation is so broad that experts speak realistically in terms of minimizing surface and ground water
contamination as opposed to totally eliminating it (Pye et al., 1983). Further, scientists
know very little about the synergistic effects or interactions among multiple contaminants in
drinking water.

Depending on the sources one uses, the problem of ground and surface water
contamination may range from negligible to extremely serious. For instance, Burby and his
colleagues (1983) write that 423 organic chemicals have been detected in freshwater, and
325 of these chemicals have been found in treated water. Agricultural chemicals are
frequently highlighted as a severe threat to public safety (Regenstein, 1993). Total annual
pesticide use amounts to more than 1 billion pounds (Guerrero, 1992), and agricultural
uses account for more than 75 percent of this figure (Fisher, 1992). The National Research
Council reported in 1989 that 26 states had detected pesticides in their ground water
reserves as a result of normal agricultural activities. Based on a national computer-based
literature search two years earlier, Canter (1987) identified 14 states as having serious
ground water problems associated with nitrate contamination and only six associated with
pesticide contamination. However, he warned that his research did not include localized
concerns that are present in nearly all states, particularly as increased monitoring is
undertaken.

At issue is the agricultural use of synthetic herbicides, insecticides and fungicides for
horticultural and row-crops as well as the use of organic and commercial fertilizers
(Stegman et al., 1983). Pesticides increase crop quality and yields by as much as 10
percent (Balling, 1992), while the addition of such nutrients as nitrogen, phosphorus and
potassium allows for continuous production of major row-crops without crop rotation or
other more labor-intensive inputs (National Research Council, 1989). Although scientists
still do not fully understand the complex processes involved in subsurface movement of
chemicals, it is clear that these materials behave differently according to environmental
conditions, soil type and their own unique structural properties. Nitrogen, for instance,
differs from phosphorus in that it does not readily bind to the soil during percolation. This is why some experts predict nitrate levels in ground water will continue to rise in the next few years (Miranowski, 1983). Despite such differences, consumers and news media often characterize all agricultural inputs as equally dangerous ground water contaminants, even as they make artificial and often inaccurate distinctions between chemically similar substances such as organic and commercial fertilizers. And, while no consensus exists as to what levels of contaminants constitute dangerous amounts, the federal government’s threshold standard of 10 parts per million of nitrates provides a benchmark for assessing such chemicals.4

Although agricultural chemicals are intended for highly specific purposes, they continue to exist and move in the environment after meeting their agronomic objectives. At such time as they enter surface or ground water supplies, they become “contaminants.”

Despite the recent “newsworthiness” of ground and surface water issues, agricultural chemicals have been shown to pose human risks in a number of ways other than through water supplies. A growing concern among consumers, again as manifest by increasing attention in the popular media, involves chemical contamination of the nation’s food supply. With the exception of water contamination, few issues evoke more public fear or controversy than the threat of chemical-tainted food (Segal, 1991). The entrance of unwanted chemicals in the nation’s food supply sometimes results from contaminated water supplies because water is a major component of many fresh and processed foods (National Research Council, 1993). The fruit-and-vegetable products industry alone uses about 100 billion gallons of water each year for processing and as an ingredient in syrups, brines and other products (Mrak, 1978). In addition, tapwater is often added to foods during home preparation, increasing the potential for food contamination.

Unfortunately, research has pointed to a variety of avenues through which chemicals can enter food supplies. For instance, traces of agricultural pesticides may remain on
horticultural crops as residues or be introduced to stored grain through applications of fungicides or other disease-control treatments used to protect crops after harvest. Although fungicides account for less than 10 percent of all agricultural pesticide use, experts believe they pose more oncogenic, or cancer-associated, risk than herbicides or insecticides combined (National Research Council, 1989). Recent research has focused on the extent and consequences of pesticide residues in fresh fruits and vegetables as well as processed foods (USDA, 1994; National Research Council, 1993).

Many of the undesirable consequences of crop-chemical usage endanger only those who live within a confined geographic area surrounding chemical applications. For instance, wind-blown chemical drift from ground applications of crop chemicals poses a potential threat to human beings, foliage and ornamental plants, but typically only within a relatively small geographic area (Ozkan, 1991). The number of injuries resulting from pesticide usage is not trivial, according to EPA statistics. While monitoring is difficult, experts believe that anywhere from 27,000 to more than 100,000 injuries and illnesses may be attributed to agricultural pesticides yearly (Fisher, 1992). While the bulk of research energy has focused on potential adverse effects to human beings (National Research Council, 1989), research suggests that beneficial plants, insects, livestock, and wildlife are also vulnerable to both direct and indirect effects of agricultural pesticides and fertilizers, although the extent of contamination is unknown. A rich literature documents the longstanding concerns of physical and social scientists for these issues.

A primary objective of this study is to examine the psycho-social processes by which farm operators form perceptions of agrichemical risks. A theoretical model derived from social learning theory and the risk assessment literature is used to guide the analysis and to develop hypotheses concerning farm operators’ perceptions of various agrichemical hazards. As discussed on the following pages, the ascendance of agrichemical-risk issues
and related topics on the public agenda can be traced to social trends that have developed well outside the farm gate.

The Environment, Agriculture and the Public

The 1960s are generally recognized as the era of birth for the new U.S. Environmental Movement. Some writers have pinpointed the origin of current interest in the environment at 1962 with the publication of Rachel Carson’s *Silent Spring*. This controversial book largely argued the case against DDT, an insecticide first introduced to the U.S. in 1942.

A number of unprecedented events in the 1980s refocused national and international attention on environmental issues as never before (White, 1992). In 1984, about 4,000 lives were lost following a leak of methyl isocyanate from a Union Carbide plant in Bhopal, India. In 1989, the Exxon Valdez oil spill resulted in the loss of 11 million gallons of crude oil across Prince William Sound, reducing property values, killing fish and wildlife, and destroying fishing and hunting grounds.

Collectively, these and other disasters have been credited as having brought a new urgency and public demand for environmental accountability on the part of U.S. business, including agriculture (Millstone & Watts, 1992). Although traditionally portrayed as an idyllic and wholesome livelihood, farming and its associated activities have become increasingly controversial topics in the past 25 years in both the scholarly and popular press. A variety of formerly “agricultural” issues are now reported in the news media as wider social and economic problems and not just farm or rural ills.

On the surface, one notes obvious differences separating the dramatic environmental disasters just mentioned and the usually less publicized instances of agricultural pollution. For instance, contamination by agricultural sources is often diffuse, so that the direct source of contamination is difficult if not impossible to ascertain. Conversely, most industrial accidents can be traced directly to a centralized, specific source. Furthermore,
agricultural chemical application is a highly visible activity that takes place according to a predictable, seasonal schedule. Indeed, these are routine, familiar operations in farming communities. By contrast, the processes involving chemical usage in industrial plants are far less visible to the public and are often viewed with greater alarm.

While these differences will be the focus of later discussion, it should be noted that they do not of themselves justify the examination of agricultural-environmental issues as a specialized sub-discipline. Rather, it is a unique combination of economic, social and legal factors that set U.S. farms apart from their counterparts in mainstream business and industry as a distinct domain of study.

Society has generally chosen to hold farm businesses to less-stringent environmental regulation than nonagricultural private businesses, which face strict monitoring and regulation by government environmental agencies. In effect, farm businesses have been exempted from much of the existing environmental legislation intended to reduce industrial pollution (Buttel & Swanson, 1986). This relative autonomy preserved in the agricultural sector has allowed farm owners or managers to make land-use decisions according to whatever criteria they deem appropriate and is particularly important in understanding why agricultural externalities persist at a time when technical solutions are readily available. Furthermore, only in the last decade have agriculturalists faced significant government resistance in farming their land in any way they perceived desirable (Napier, 1985). Prior to the landmark Conservation Reserve Title of 1985, governmental use of coercion in regulating private agricultural land management was viewed as politically unacceptable. Landowners have traditionally been viewed as having the right to allow their land to erode despite recognition that society must absorb the negative impacts.

Some researchers have argued that the lack of regulation in the farm sector has wrongly permitted farmers to view conservation practices and other environmentally conscious activities as simply more in a series of inputs to the agricultural production process (Batie,
1986). Haimes (1984) suggests that the lack of environmental regulations may be interpreted as “implied consent” by potential polluters. From this standpoint, producers may choose to adopt or reject socially responsible farming techniques using only such criteria as personal convenience or economic efficiency without regard to negative externalities and costs. Because sound farm management necessarily involves economic viability, it is necessary to justify adoption of new techniques on the basis of their profitability. Unfortunately, when viewed as inputs, many conservation practices, including reduced usage of agricultural chemicals, have not been shown to be profitable (Camboni et al., 1990; Batie, 1986; Buttel & Swanson, 1986).

Such issues illustrate some of the practical difficulties faced by change agents since the early 1900s in designing programs to curb or reduce agricultural chemical usage. While natural resources scientists, environmental groups and consumers have differed greatly in how public policy should address the issue of agricultural pollution, there is general consensus that technical solutions are not in themselves sufficient to eliminate the environmental problems caused by agricultural activities (Batie, 1986). Padgitt and Kaap (1987) suggest that a good many farm managers perceive there are no alternatives to intense chemical usage, particularly in the present era of financial difficulty in agriculture. These are relevant concerns since Ohio lost 2,000 farms in 1991 and again in 1992 (USDA, 1994; Stout et al., 1992). Buttel and Swanson (1986) argue that price instability and inflexible fixed costs in agriculture, coupled with climatic and other natural vagaries, may cause farmers to concentrate on short-term economic survival and to avoid agricultural practices, however innovative, that threaten established farming patterns.

In essence, the dilemma facing agricultural producers, consumers, and policymakers may be viewed in terms of competing and often contradictory assessment of risk. Economic viability remains one of the foremost concerns of farmers. Because agricultural chemicals help offset soil and management deficiencies that can reduce crop yields,
producers can seldom justify curtailing their use on economic grounds. Meanwhile, consumers are becoming more vocal about safety issues regarding their food, water and the environment, due in part to the increasing coverage of these topics through the mass media. Research indicates that chemical contamination of food and water constitutes an unacceptable risk for most consumers, despite the fact that agricultural chemicals have led to lower prices and greater selection of farm products. Finally, policymakers are charged with the unenviable task of creating legislation to maintain profitability in farming while ensuring public safety. The information available to them is subject not only to political manipulation but also to scientific uncertainties about the safety of agricultural and other chemicals.

It is clear that public involvement in previously “scientific” or technical decision making will continue to increase throughout the 1990s, particularly for issues perceived by consumers to influence quality of life, standard of living, and community and public safety (Krimsky & Plough, 1988). The issue of agricultural externalities has already proven to be one of the most controversial public issues of the decade. While the risks posed by agricultural chemicals are not new, the level of consumer response to this issue through mobilization of special interest groups and other political organizations is unprecedented. For some observers (Batie, 1986), public involvement in such issues constitutes a new paradigm regarding attitudes toward conservation policy. Where the traditional policy focused on maintaining the status quo and measuring impacts of policy on farmers, the emerging approach emphasizes the effects of farmers’ actions on the general public. One manifestation of this concern is the increasing visibility of nonagricultural agencies and organizations who are able to influence farm policy in directions they feel will benefit the environment (Swanson & Buttel, 1986). The new approach maintains no protective stance toward farmers, who are seen more as business-persons and less as stewards of the land.
Because the overarching issue confronting agriculturalists, consumers and policymakers involves a clear definition of **acceptable risk**, it is informative to survey the scholarly literature for a more complete understanding of the concept and of methods used in its assessment. As shown in the following discussion, lessons learned from the debate and resolution of other public-safety issues provide a unique perspective from which to view some of the agricultural and environmental questions raised in the current analysis. Such insights are gleaned from an expansive body of research subsumed under the general topic of **risk assessment**.

**Risk Assessment**

The countless books and journal articles spawned by the publishing of *Silent Spring* in the early 1960s have been credited with ushering in a new genre of popular literature. However, the environmental-hazard issues they address comprise but one facet of a growing academic specialization known as **risk assessment**. A special issue of *Science* magazine published in April 1987 was devoted entirely to risk-assessment topics and introduced with the following statement:

> “Risk implies uncertainty and is often presented as a probability, such as that of surviving or dying. In many cases, such numbers are not instinctively meaningful. The purpose of risk assessment is to help inform decisions about the hazards causing risks and whether they can be avoided, reduced, or managed. ...” (p. 237)

The rapid emergence and growth of a risk-assessment literature reflects the burgeoning concern in both private industry and the academic community in understanding the processes by which consumers evaluate health and safety risks and the factors governing which risks are selected for attention. Implicit in much of the risk-assessment literature is the notion of a declining public confidence in science, medical and other “third-party” experts to rank risks that will ultimately be shouldered by private citizens (McGuire, 1985).
There is widespread agreement that modern science has lost since mid-century its status as an unquestioned authority on such issues as health and public safety (Brooks, 1980). The paradox that scientific assurances of safety and acceptable risk have increasingly gone unheeded at a time when life expectancies and standard of living are at all-time highs has received attention in a number of circles, including the scholarly literature (Slovic, 1987; Clark, 1980), congressional hearings (Fisher et al., 1994), and popular media. At the center of the issue is the charge that science and scientists have lost their unquestioned status as the final arbiter of risk issues. Some (Kasper, 1980), for instance, argue that the public’s “blind trust” in expert opinion has ended as consumers have grown increasingly resentful of perceived insensitivity and arrogance on the part of scientists. This assertion has profound implications for risk analysis because the public image and perception of science play an important role in individuals’ evaluations of technological risks.

One of the most dramatic examples of the power of public opinion is illustrated by the case of DDT, which has been thoroughly documented in the literature (Whelan, 1985; Dunlap, 1981). This insecticide was first patented in 1939 by a Swiss chemist who was awarded the Nobel Prize in medicine in 1948 because of DDT’s success in replacing a number of extremely toxic chemicals. Concerns about potential contamination of the food chain and delayed adverse effects on human health led to an EPA-imposed ban in 1972. However, Whelan (1985) offers evidence that no clear consensus exists today among scientists and other experts as to the necessity of the ban on this controversial substance, which has “prevented more human death and disease than any other man-made chemical in all of recorded history” (p. 67). Clearly, such decision making is influenced by politics as well as science. In the case of DDT, the most influential forces leading to its ban did not emerge from the testing laboratory, but rather from the public arena as lobbyists, environmentalists and frightened consumers asserted political pressure on EPA and other federal agencies.
As subsequently discussed, modern approaches to risk assessment acknowledge the critical contributions made by consumers in defining issues of public safety (Krimsky & Plough, 1988). Among these issues are the risks associated not only with water quality and food safety, but also from such disparate activities as air and automobile travel, nuclear power and warfare, and a host of other enterprises. The diversity of substantive topics treated in the literature underscores the notion that risk is ubiquitous in modern society (Russell & Gruber, 1987; MacCrimmon & Wehrung, 1986; Eckholm, 1977). Experts have employed a broad range of research methods and theoretical orientations to help guide inquiry into the processes by which individuals evaluate various risk phenomena. Examples include the statistically-based work of Lowrance (1980), who has defined risk as a compound measure of the probability and magnitude of adverse effect of some phenomenon. Starr’s (1969) early work involved quantitative modeling to evaluate benefits relative to costs. His research suggested that the public is willing to accept voluntary risks roughly 1,000 times greater than involuntary risks, such as the societal obligation to participate in war.

While the method of using historical data to statistically estimate future risks is intuitively appealing, the literature suggests a number of drawbacks to this approach. One of the most limiting problems is that such methods cannot be extended to new technologies, substances or activities for which there is no historical database. Slovic (1987) points out that technologies whose harmful consequences may be rare and delayed lend themselves neither to statistical analysis nor to trial-and-error experimentation. Unfortunately, it is precisely these phenomena in which scientists and consumers are highly interested. Furthermore, even where reliable historical data do exist, there is no consensus among experts as to the best or most equitable methods to use in ranking human threats numerically (Douglas & Wildavsky, 1982).
Risk perceptions are greatly influenced by the methods used to generate them (Wilson & Crouch, 1987), so it is not surprising that expert opinion has varied considerably regarding the riskiness of certain hazards and enterprises. Despite continuing success in applying statistical and probability modeling techniques to gain insights into human decision making, researchers have generally embraced the notion that risk assessment depends not only on a mathematical approach, but also on social-scientific theory because experts and laypersons have been shown to differ significantly in their evaluation of risks. Scientists employing economic-theory-based models have been faced with one of two unattractive scenarios in explaining the discrepancies between expert and laypersons' evaluations of risk: (1) acknowledge the inadequacy of a theoretical framework used extensively, and successfully, in other social-scientific areas, or (2) conclude that increasingly educated human beings are nonetheless prone to consistently “irrational” risk judgments regarding their health and safety. Tversky and Kahneman (1981) have argued that seemingly irrational choices made by consumers often result from their use of heuristics, or mental “short-cuts,” which help them organize complex information and make decisions about complicated risk situations. While this style of decision making often leads to poor judgments, the behavior itself is rational if one considers the amount of mental effort that would be required to explore alternative frames.

Formation of successful public policy depends on some degree of consensus among legislators, technical experts and voting consumers on basic risk issues, such as which risks pose unacceptable levels of danger and the degree to which the government should be involved in controlling such risks. While private citizens are seldom experts on the scientific issues involved in risk analysis, their participation is justified on the basis that many decisions about risk have local consequences that must be borne by the public, as well as by scientists and other experts (Burton et al., 1993). Because risk management in a democratic society involves informing and protecting individuals who are free to choose
their actions in a variety of situations, public perceptions have increasingly been viewed as an essential element of risk analysis (Scherer, 1991).

While evidence of the association of cognitive and behavioral tendencies has been questioned in the social-psychological literature (Wicker, 1969; McGuire, 1989), broad support has long existed for the use of perceptions in studying general behavioral dispositions (Campbell, 1963; Mueller, 1986; Breckler & Wiggins, 1989). The recognition that individuals’ perceptions are imperfect but frequently accurate predictors of behavior is present in environmental psychology (Stern & Oskamp, 1987), diffusion theory (Rogers, 1983), and consumer behavior and marketing research (Engel et al., 1986). A persistent theme in recent studies is that stronger empirical verification of the link between behavior and cognitions will depend on improved definition and measurement of existing concepts and intervening factors, rather than alternative grand theories that discount cognitive processes (Upmeyer, 1982; Himmelweit, 1990; Breckler & Wiggins, 1989). For instance, Ronis et al. (1989) suggest that some repeated behaviors may result more directly from an individual’s habits than by cognitive functioning, but that attitudes and beliefs still play a major role in forming and modifying such habits. Cacioppo et al. (1981) argue that the relationship between attitudes and behavior is robust when methodological conditions are tightly controlled. Extension of this theoretical approach to risk analysis casts individuals’ judgments and perceptions as “implicit, covert responses” (McLaughlin, 1971) or “latent, underlying dispositions” (Jaspars, 1982) capable of mediating or influencing overt human behavior in certain risk situations.

As subsequently discussed, laypersons’ perceptions of various risk situations are often influenced by a number of nonstatistical criteria. For instance, while individuals may indeed conceptualize risks in mathematical terms, such as economic costs and benefits, they also depend on psychological processes and social influences to help them determine what risks are acceptable (Short, 1984). Lave (1987) suggests that the processes
surrounding the siting of certain enterprises, such as nuclear reactors and herbicide plants, are inherently social because individuals living in the vicinity must shoulder the bulk of the associated risks. Douglas and Wildavsky (1982) argue that negotiated agreement by human beings to emphasize certain risks over others derives from common fears and, hence, common values. Other writers (Maxey, 1979) have argued that recognition of a particular hazard or risk depends solely on subjective human values and cannot be established objectively. For these writers, the existing culture dictates the individual’s selection of unacceptable hazards and dangers, so that risk perception is a singularly social process.

Similarly, Bailar and Thomas (1985) write about the current trend in the United States as one of “socializing” risk, whereby risks are transformed from private matters into largely collective, or public, problems. They suggest the trend is indicative not only of the increasing concerns surrounding some dangers, but also in changing sentiments about government involvement in the management of societal risks and rewards.

Douglas and Wildavsky (1982) conceptualize risk as a product of two factors: (1) knowledge about the future and (2) consent about the most desired prospects. Where knowledge is certain and consent complete, they conclude that the problem is technical and the solution is calculable. Where knowledge is certain, but consent contested, the problem is one of disagreement, and the solution depends on either more discussion or coercion. In the third scenario, where incomplete knowledge is coupled with consent, the solution lies in additional research. In the final situation, where both knowledge and consent are lacking, they argue that only social consent can keep an issue out of public debate. It is this fourth scenario that typifies the current status of risk assessment.

Scherer (1991) discusses an emerging risk paradigm that requires full participation of experts, policymakers and consumers in examining and defining public policy. Any risk
analysis that ignores the social structure within which individual decisions are made may fail to clarify either the process or consequences of those decisions (Burton et al., 1993).

Social scientists studying public opinion have discovered a number of qualitative factors that have been shown to influence laypersons' perceptions of risk. Their collective contributions suggest that laypersons tend to conceptualize risk more broadly than probability experts, frequently incorporating a number of nonstatistical attributes into their evaluations of risk acceptability (Krimsky & Plough, 1988; Slovic, 1987; Fischhoff et al., 1976, cited in Rescher, 1983). Specifically, laypersons tend to be more amenable to risk-taking when the activities in question are perceived as voluntary, avoidable, controllable, familiar, well-understood, not dreaded, and remote.

**Involuntary risks** include those activities that are societally imposed, such as participating in war. Whereas an individual may use his or her own value system to evaluate choice for voluntary activities, involuntary activities are evaluated and promoted by government agencies, political entities, authorities or opinion-makers (Starr, 1969). The polar extremes are easily identified, where suicide might serve as an example of voluntary loss of life, and a totally involuntary fatality caused by a natural disaster, such as a tornado, would illustrate the reverse end of the spectrum. However, a range of phenomena occupy the middle range of this criterion, such as a swimming accident which involves some agency on the part of the victim who willfully took the risk in the first place.

Among those **unavoidable risks** are so-called "acts of God," which are typically attributed to nature and not considered preventable. Tornadoes, earthquakes and similar phenomena are the archetype examples, but by no means are such risks confined to atmospheric or other natural disturbances. Influential individuals and news media may be instrumental in portraying other less-obvious or less-understood risks as excessively dangerous, out-of-control, or unavoidable. For instance, much of the controversy
surrounding the book *Silent Spring* stems from its ability to portray consumers as victims of the increasingly severe and largely unavoidable threat of environmental contamination.

Decades of research have shown that the perceived presence or absence of control is critical to laypersons in judging the acceptability of various risks (Allman, 1985). For instance, although smoking and driving are statistically far more dangerous than commercial flying or risks from industrial pollution, much research has shown people fear the latter activities far more because of the perceived lack of control associated with them. Likewise, dynamite is rightfully viewed as potentially deadly, but the demolition expert reserves control over its use. Passersby who do not share in this control may judge its risk as more severe even though they are technically less at risk than the personnel physically closer to it.

Ames et al. (1987) point out that scientists know very little about the carcinogenic potential of naturally occurring chemicals such as plant toxins, and particularly about their long-term interaction with synthetic pollutants. Still, it could be argued that naturally occurring substances enjoy a perceived degree of familiarity because of their “uncontrived” status. The lingering popularity of organic farming is arguably linked to people’s tendency to view familiar, naturally occurring substances, such as organic fertilizers, as part of a more healthful approach to agricultural production despite the fact that organic chemicals pose similar health risks to those produced synthetically. In discussing the “double-standard in regulatory science,” Phelan (1985) suggests the tendency to be more guarded against synthetic substances is not unique to laypersons, but also helps explain why so little is known about natural carcinogens.

Similarly, risks that involve new technologies or phenomena that are only vaguely understood are likely to be viewed with more suspicion and fear than those with which people feel some level of familiarity. For instance, Wilson and Crouch (1987) report Center for Disease Control data for two toxic chemicals, aflatoxin B1 and dioxin. Although the
materials have similar toxicities and carcinogenic potency, much more stringent standards have been legislated for dioxin even though aflatoxin has been shown to be a potent initiator of cancer in animals (Whelan, 1985). In addition, the public generally associates dioxin as a synthetic component of the controversial chemical Agent Orange, while naturally occurring aflatoxins have not been featured as prominently by news media.

The risk literature indicates that various media, including the popular press and interpersonal methods of communication, have a significant collective influence on how laypersons interpret risks from various natural and technological phenomena. Kaase (1980) argues that citizens’ views of the world are selectively shaped by news agencies and particularly electronic media, which play a major role in sustaining public fears over various issues. The portrayal of dramatic phenomena, such as plane crashes and nuclear disasters, has been shown to instill dread in individuals across a number of studies. Normally, such fears are kept in check because the most highly dreaded phenomena, such as nuclear accidents, are generally perceived as a remote threat. Nonetheless, psychological research indicates that subjects consistently overestimate the relative probability of events that are particularly striking or memorable (Rescher, 1983), owing in part to increased coverage by electronic and other national news media. Clearly, communications media play a key educational role for a variety of hazard phenomena because individuals often must evaluate risks with which they have little or no direct experience. As discussed below, research into the social amplification of risk addresses the levels of risk portrayed by various communications sources — media, scientists, activists, informal networks of friends and family — and their potential to weaken or reinforce certain attributes of risk activities (Burton et al., 1993).
Communicating About Risk

Extensive scholarly critique has focused on the popular press as an intermediate, yet problematic, channel between scientists and laypersons (Hadden, 1989). Much attention has focused on the difficulties faced by the press in accurately conveying scientific and technical concepts to laypersons. A common criticism is the lack of appropriate scientific training on the part of media writers and reporters (Crone, 1986). Television, in particular, has been associated with graphic, and frequently inaccurate, reporting of environmental disasters (Markovits & Deutsch, 1980). Because media personnel are trained to view conflict as an essential determinant of news value, controversial issues are *newsworthy* by definition. Controversial issues are often featured in the front pages of newspapers and the opening segments of radio and television programs, while resolution of such issues might be displayed far less prominently (Krimsky & Plough, 1988). The result is a frightened, confused public that “is left to flounder in a maze of technical jargon, half-truths, and gross simplification” (Crone, 1986). Among the most controversial and frightening news stories featured by mass media are those that deal with cancer risks present at home or in the workplace, such as from exposure to synthetic chemical compounds (Eckholm, 1977). Such reports often rely on emotional accounts of victims and carefully selected experts to suggest that the risk of contracting cancer and other serious illnesses is increasing rapidly.¹⁰

Whelan (1985) thus argues that biased media reports have made consumers victims of “toxic terrorism” at a time when modern technologies have actually boosted quality of life to the highest levels in history. She suggests that investigative journalism has been virtually absent in the health and environmental arenas and that a relatively small but vocal group has dominated public dialogue on such issues. Others (Brooks, 1980) note that a number of anti-science groups have become particularly influential in shaping public opinion owing to their shrewd use of communications media as diffusion instruments. Because of heightened
consumer sensitivity to environmental and health issues (Clark, 1980; Train, 1978), public agencies, multinational corporations and agribusiness have indeed become increasingly sophisticated in their use of mass media to foster consumer public relations (Millstone & Watts, 1992). Most recognize that while consumers rely heavily on news media for risk information, specific audiences may vary greatly in their tolerance of certain risks. For instance, audiences have been shown to react differently to risks depending on the nature of the message, the channels used to transmit the message, and their age, gender, education, income and experiences (Burton et al., 1993).

The collective result of private- and public-sector information campaigns intended to influence consumers’ risk perceptions is a new information commodity known as risk communication.

**Risk Communication.** Hadden (1989) delineates the task of risk communication as that of providing consumers with understandable information about risk that is relevant to their needs and lifestyles. Scherer (1991) suggests that risk communication traditionally has had a persuasive bent for its target audiences in terms of encouraging or discouraging specific behaviors. Throughout most of the 1900s, risk-communication practitioners were concerned largely with disseminating technical information to a lay public, supplemented with an expert, or scientific, view intended to put questions of risk into perspective. While there was some investigative reporting during this period, media served largely as messengers for scientists, who often acted as the arbiters of debates ranging from food safety to atomic power (Lear, 1970; Nelkin, 1987).

In the case of agricultural chemicals, Trost (1984) argues that industry and the scientific community were unanimous in their view throughout the 1940s and 1950s that nearly all commercially available chemicals were not only efficient, but safe: “This was the generation that was hitching its star to the wagon of technology, and there was something very close to hero worship going on between Americans and science. It was a relationship that
precluded doubts. Other writers have similarly argued that scientists have enjoyed virtually unquestioned authoritative status throughout much of the 1900s (Starr, 1969).

As information has become an increasingly important commodity in shaping public opinion, the private sector has stepped up its risk-communication efforts within the media environment. The typical corporate response has been to disseminate information so as to create a favorable public image for its products and services. Through marketing and public relations departments, corporations strive to create positive recognition and goodwill in the marketplace and to create a favorable context in which to stage other promotional efforts. Many such efforts involve ongoing information programs aimed at stressing the positive aspects of their industry’s business practices through positive public relations and advertising (Strelow, 1992). For example, agricultural chemical manufacturers are now positioning themselves as “crop-protection” companies in the face of mounting consumer concerns about pesticides, food safety and ground water contamination (Bradley, 1994). A recent issue of Farm Chemicals magazine was devoted exclusively to educating farmers on facts and methods for use in defending agricultural chemical usage to the local press and community. Similar efforts are under way in the public sector as government agencies and nonprofit organizations attempt to reach consumers with timely and relevant information for a multitude of issues.

The unprecedented availability and access to mass-media technology by private corporations, government agencies and environmental groups is one of the distinguishing features of contemporary democratic society and, to its credit, consumers now have more information at their disposal than at any other time in history. However, the diversity of sources using mass media precludes generalizations about the essential content or mission of any given medium, as well as comparison among media. Nonetheless, much risk communication research has tended to concern itself with the comparative advantages afforded by various methods of communication, such as the differential effects of
interpersonal versus mass media channels of information (Coleman, 1993; Tyler & Cook, 1984). Likewise, a number of agricultural communication researchers have studied farmers’ use and preference for various methods of communication, such as print media, videotapes, or interpersonal communication (Oskam, 1995; Bruening, 1992; Bouare & Bowen, 1990; Kramic, 1987). While such studies provide interesting information about agricultural audiences, they reveal little about how farmers evaluate and use various sources of agricultural information, such as different government agencies or agribusiness firms.

**Contribution of This Study**

In view of an already-substantial literature documenting the social and monetary costs of agricultural externalities in the 1930s and 1940s, experts have for some time been concerned about environmental consequences associated with farm production activities, including agricultural chemical usage. It is surprising that decades would pass before such issues would emerge as priorities on the public agenda.

One possible reason for the delay in public response was the entrance of the United States into World War II in the early 1940s, which directed attention to international turmoil and more pressing matters of national security (Trost, 1984). Others argue that consumers in recent years have simply become more knowledgeable about the range of activities threatening the environment and of the link between the environment and public health.

In any case, the increasing attention manifest in both the popular and scholarly press suggests heightening public anxieties about potential environmental-safety risks from a range of business and industrial activities, including application of farm chemicals. Agriculturally-induced environmental risks have struck a particularly sensitive chord with consumers for several reasons. First, it is through domestic agricultural activities that the bulk of food and fiber is produced for U.S. families. The research reviewed here suggests that risks associated with chemical contamination of food are unacceptable to most
consumers (Segal, 1991). Second, farming takes place in local communities whose residents may include large numbers of nonfarm consumers. Agricultural externalities, such as ground water pollution or airborne chemical drift, may affect large numbers of consumers, many of whom have chosen to live in rural areas to avoid these same risks, which traditionally have been associated with urban areas. Finally, consumers have become increasingly sensitive regarding the uses to which their tax dollars are directed. They have become increasingly aware that public revenues finance farm subsidies and that these subsidies have encouraged intensive agricultural production and cultivation of erodible lands.

Taxpayers are now demanding accountability for these public expenditures and are increasingly skeptical about the positive return on investment for policies that appear to be fostering environmental degradation. While much debate and rhetoric have surrounded agricultural-environmental issues, few would dispute that these concerns have become critical to businesses facing increasing government regulation and public scorn for practices perceived as environmentally damaging.

Brown (1994) discusses three policy options for protecting ground water reserves from agricultural activities — economic incentive approaches, regulation and voluntarism. Economic incentives, while popular with farmers, would require significant public expenditures and be effective only as long as farmers found it profitable to participate (Swanson et al., 1986). The second option, regulation, is not only politically unpopular, but also would require significant funding for increased monitoring and enforcement. The third alternative, voluntarism, has been the favored policy tool throughout the 1900s owing to its political acceptability in the agricultural sector and the relatively low costs associated with its implementation (Napier, 1994).

Research has documented a host of difficulties associated with the use of a voluntaristic approach to encourage agricultural conservation practices. Harrington et al. (1985) suggest
that four criteria be considered when assessing the prospects for voluntary adoption of conservation practices. First, the landowner or operator must believe that a problem exists and that relevant solutions exist for its amelioration. Second, noncompliance must be easily observable so that societal pressures help encourage adoption. Third, the costs of adoption must not greatly outweigh the benefits. Fourth, there must be some threat that non-adoption will eventually lead to government intervention or regulation. Using these criteria, it is easy to understand the frustration of some environmental groups and natural resources scientists with current agricultural policy and its heavy reliance on voluntarism. While the literature indicates that technical solutions have long existed to address such problems as soil erosion (Batie, 1986), there is no widely accepted substitute for agrichemical applications on large-acreage farms. Therefore, farmers may believe there are no alternatives to chemical applications (Padgitt & Kaap, 1987). Furthermore, consumers have no way to reliably discern whether or not chemical applications are being conducted accurately. This situation makes impractical the use of societal pressure to encourage responsible farm-chemical applications. Also, noted earlier were the difficulties in justifying reduced application rates using solely economic criteria. Indeed, farm managers may believe it is necessary to exceed recommended chemical rates to justify their fixed costs of fuel and equipment-related expenses involved in making applications.

In spite of the difficulties associated with the voluntaristic paradigm, it is important to recognize the political realities that have preserved its popularity as the favored farm policy tool. Although recent farm bills have increasingly embraced elements of regulation to further conservation objectives, voluntarism remains the most popular policy tool for encouraging adoption of conservation practices. From this standpoint, efforts to identify factors that influence farmers’ decision making constitute an important contribution to the natural resources literature. A relatively small number of agricultural producers determine the extent of agrichemical usage in domestic food and fiber production. While the adoption
of conservation practices, including reduction of agrichemical usage, cannot be justified on a solely economic basis, it is important to note that successful marketing campaigns for a host of innovations have traditionally relied heavily on economic criteria (Rogers, 1983; Engel, 1986). Working within the current voluntaristic policy environment, natural resources scientists have been understandably frustrated by low levels of conservation-practice adoption and the inability to promote such practices by appealing to economic efficiency.

It is argued that risk-assessment research conducted in other areas of human activity may provide insight into the process whereby farm operators form evaluations of agrichemical risk. Specifically, application of general risk-theoretical principles may offer a partial solution to the current impasse surrounding the failure of the voluntaristic paradigm to encourage farm-level adoption of agricultural conservation practices. Different levels of perceived risk from agrichemical usage may offer a fuller understanding of the factors that motivate adoption decisions at the farm level. For instance, it is possible that farmers who have experienced health or water-quality problems from agricultural chemical usage or who believe such usage poses a severe risk to them or their families might curb or reduce applications regardless of the loss in economic efficiency. This assertion is consistent with the fact that human beings rely on more than economic calculations in deciding where and how they will live, work and spend their leisure hours. Indeed, as discussed earlier, it is the individual's tendency to consider such nonstatistical attributes of various risks that accounts for a significant portion of the variance between between their risk evaluations and those of experts. A fuller understanding of the factors influencing farmers' perceptions of risk from agrichemical usage might offer a more complete account of why some agricultural producers have resisted appeals to adopt conservation practices, including possible constraints that hinder adoption.
A critical question not addressed in existing literature is the extent to which farm operators believe they are at risk from agrichemical usage and what factors influence perceived levels of risk. Research must demonstrate not whether farmers believe agricultural chemicals pose generalized risks, but whether they perceive personal risks from agrichemical usage in their local environment. A necessary step in this endeavor is to assess farmers’ current risk perceptions regarding agrichemical usage and to model the factors that help explain differential levels of perceived risk among farmers.

For instance, extremely high levels of perceived risk might suggest that farmers are aware of much of the literature regarding the possible dangers of agrichemical usage, but may believe they cannot remain economically competitive without the aid of chemical applications to offset poor soil structure or uncertain weather conditions. In such a case, regulation could be necessary to force farmers to comply with environmental regulations, despite their awareness that chemical usage poses a variety of personal risks. The use of educational programs that rely primarily on the provision of information, as advocated by diffusion researchers, would not be expected to substantially increase adoption of conservation practices under such circumstances.

On the other hand, extremely low levels of perceived risk might suggest that farmers possess a false sense of security regarding the safety of agrichemical usage. Such a finding would be consistent with research showing that individuals generally acknowledge an abstract potential for public injury or harm from a variety of activities, but tend to underestimate their own probability of coming to harm from these same activities. This phenomenon has been referred to in the risk-assessment literature as *optimistic bias*, referring to the tendency of individuals to view society as more susceptible than them to various dangers, such as accidents and diseases (Coleman, 1993). In such instances, targeted educational programs and farm demonstrations stressing interpersonal communication would be necessary to help make farmers aware of personal risks.
associated from agrichemical usage. Such programs could eventually lead to increased adoption of conservation practices at the farm level despite their lack of economic appeal.

This study draws liberally from the conservation-adoption and risk-assessment literature in identifying factors posited to influence farmers' perceptions of personal risk from the use of agricultural chemicals. The goal of agricultural policy is to encourage behavior that prevents negative externalities or to bring about behavioral change to ameliorate negative consequences.

As previously discussed, the social-scientific enterprise concerned with minimizing farm-related pollution and other agricultural externalities has developed into a unique academic specialty owing to its emphasis on the unique character of rural life and domestic agricultural production. However, few studies have treated farmer's perceptions of personal risks from agricultural chemicals as the primary variable to be explained. The lack of research in this area is surprising given the importance of farmers' perceptions in the current policy environment that relies heavily on voluntary compliance. Additional reasons can be cited to apply risk-assessment insights to the study of farmers' perceived risks from agrichemicals. One justification is the sheer number of individuals who are exposed to these substances. Although much attention has focused on the dwindling number of family farms, substantial numbers of farmers, managers and migrant workers continue to work directly with farm chemicals each year. While farming is commonly cited as the most dangerous business in the United States, the statistics behind such statements are based largely on mechanical and equipment-related accidents (Oskam, 1992). For reasons discussed in the opening pages of this chapter, it has not been possible to assess the long-term effects of agricultural chemicals on applicator health, water and food supplies, and flora and fauna in the local environment.

This study thus conceives of risk as a multidimensional concept with regard to agrichemical hazards. A theoretical framework is developed in the following chapter to
adapt insights from the risk-assessment literature to the current study of farmers' perceived levels of risk from agrichemical usage. As will be subsequently discussed, the independent variables selected for the study acknowledge the critical importance of various information sources in shaping farmers' perceptions not only of societal-level risks, but personal risks.
CHAPTER ENDNOTES

1 American agricultural products were exported to more than 160 countries in the 1993 fiscal year with sales totaling $42.5 billion (USDA, 1994). U.S. foreign food aid constitutes more than half of the world's annual total.

2 The information, published in the New York Times and through the Associated Press, reported that "unhealthy doses" of farm pesticides threatened millions of people nationwide.

3 Selected findings from a 1993 Gallup Poll illustrate the public's perceived sense of urgency in curbing agriculturally-induced environmental pollution. More than 75 percent of the 1,009 respondents in a national telephone survey felt that pesticide residues on food posed a substantial health risk. Seventy-five percent felt that pesticide use should be curbed even if it resulted in higher food prices. Nearly half of the respondents (46 percent) agreed with the statement that agricultural activities were causing "irreversible damage" to the environment.

4 The danger thresholds established by EPA vary for different chemical substances. The Delaney Clause of the Federal Food, Drug and Cosmetic Act prohibits the use of any pesticide in processed foods or animal feeds if there is evidence that it "induces cancer," regardless of how small the risk or the threat of actual exposure. This statute is at odds with other federal regulations dealing with pesticide registration and use (Fisher, 1992).

5 The environmental movement that had its genesis in the 1960s has been compared to a movement that emerged in the late 1800s (White, 1992). In his review of recent books on the history of environmentalism, Kevles (1994) writes that the early movement emphasized preservation of nature outside the cities, while the current environmentalism has taken "pollution and the poisoning of metropolitan industrial society" as a primary concern.

6 Historic writings on the importance of farmers and farming are surrounded by a great deal of lore and romanticism. Thomas Jefferson thought agriculture the "first and most precious of the arts." And according to Daniel Webster, "When tillage begins, other arts follow. The farmers, therefore, are the founders of civilization."

7 In a 1990 survey of Ohio farm and nonfarm populations, nonfarm rural residents indicated that the seasonal round of agricultural activities such as plowing, planting and harvesting was one of the most appealing aspects of living in a farming community (Bollinger et al., 1992).
The Los Angeles Times published a three-part series on how mass media have elevated public fears and anxiety despite unprecedented levels of safety and health among Americans. The series, which was printed in September 1994, was titled “Living Scared: Why Do the Media Make Life Seem So Risky?” Clark (1980) writes that contemporary American society enjoys greater health, knowledge and material welfare than previous generations, but is nonetheless “frightening itself into virtual catatonia, unable to mobilize the risk-taking efforts necessary for coping with the unknown.”

The recognition that laypersons evaluate various hazard situations using different, broader criteria than those used by experts has been thoroughly documented. Following the terminology used most frequently in the literature, the term “qualitative” is used in this analysis to refer to the nonstatistical, culturally based factors used by the laity in assessing the severity of a particular risk situation. See Krimsky and Plough (1988) for a relevant discussion of such factors.

Crone’s (1986) analysis of cancer-mortality rates indicates that frequency of cancer deaths has not increased substantially in recent years and that escalating public fears about chemicals are unfounded.

This view has met with controversy in the literature. For instance, Crone (1986) rejects what he refers to as “conspiracy theory,” or the notion that science and big business have joined forces to forestall closer scrutiny or criticism of the chemical industry. He suggests that the competing interests of scientists, executives, government personnel and others serve to keep the various parties in check as each watches the activities of the other. The extensive social-science literature on the sociology of science suggests validity in both of these views, although it is doubtful that the issue will ever be fully resolved.
CHAPTER II
THEORY

Introduction

The range of hazards posed by agrichemical usage arguably comprises one of the most challenging public issues of recent times. A number of complicating factors precludes a simple solution to the dilemmas posed by agrichemical usage. As previously discussed, the unique social and economic aspects of domestic agricultural development have culminated in a basically voluntaristic approach to farm-level adoption of conservation practices, including agrichemical usage. Within broad limits, farm operators are legally entitled to determine whether and to what extent to apply agricultural chemicals on their land, using whatever subjective criteria they choose.

Within this voluntary atmosphere, the diffusion model has been the favored theoretical approach among university experts and government agencies to influence farm-level adoption and decisionmaking. The model was popularized most through the research of Everett Rogers, whose successive works refined the basic model and led to his widely cited and classic text, *The Diffusion of Innovations* (1983). While the model has enjoyed broad success in encouraging adoption of a host of agricultural innovations at the farm level (Fliegel, 1993), two important factors have reduced its utility in the specific case of conservation practices. First, because conservation practices cannot be marketed on the basis of profitability, they are at once fundamentally different from other agricultural innovations for which the diffusion model has worked so well, such as hybrid seed and modern machinery. The latter innovations confer economic efficiencies and relative
advantage to early adopters so that non-adopters are forced to accept a diminished market position. Second, most conservation practices, including reduction of agrichemical usage, belong to a class of innovations termed *preventive innovations*. The appeal of preventive innovations rests on their ability to prevent unwanted consequences of an event that may or may not occur at some point in the future. The uncertainty surrounding their potential benefits tends to instill only weak motivation in potential adopters and has led to disappointing rates of adoption (Rogers, 1983). Conservation and agrichemical-reduction practices may even be more likely to produce low motivation among the already-sluggish class of preventive innovations because of the awareness that environmental resources, such as surface and ground water, are vulnerable to contamination by a number of nearby or remote sources, regardless of the individual actions of any single producer.

Despite debate among experts as to the appropriate policies for ameliorating the problems associated with agricultural externalities, decades of experience among conservationists and natural resources scientists have firmly established that the mere availability of technical solutions is, in itself, a critical but insufficient solution to environmental problems (Stern & Oskamp, 1987; Batie, 1986). As previously argued, the lack of economic advantage offered by conservation practices is an often-cited factor in explaining the poor performance of the diffusion model in encouraging their adoption. Because the case for adoption of agricultural conservation practices fails on economic and other grounds, an alternative to the diffusion approach is needed to advance theoretical modeling in this specialized area. Research is needed to identify the factors or circumstances that make preventive innovations, such as conservation practices, more attractive to potential adopters. One possible avenue for encouraging reduction of agrichemical usage is to make producers more aware of the possible health-related risks associated with chemical application.
Earlier discussion was focused on the economic advantages offered by agricultural chemicals. However, it is informative to note that farm operators are in fact confronted with a case of double-jeopardy stemming from agrichemical usage. First, as chemical applicators, they face the occupational hazard of direct exposure from the transfer and handling of toxic materials from the container to the field. Second, as residents in the local environment, they face risks brought about by their physical proximity to agricultural production, such as possible contamination of local water reserves. Because of their concurrent status as local residents and agricultural producers, farm operators and their families are much more likely than their nonfarm counterparts to suffer adverse or delayed effects from agricultural chemicals. The seriousness of potential hazards facing farmers would suggest that rational, informed choices regarding agrichemical usage would include perceptions of risk from agrichemical usage in addition to economic considerations.

Surprisingly, incorporation of farmers’ perceptions of agrichemical usage has been practically nonexistent in diffusion modeling. The seriousness of such risks would suggest that researchers in the diffusion tradition have been remiss in characterizing negative consequences of agrichemical usage as “externalities” because farm operators cannot export all of the negative consequences from agrichemical usage and, in fact, are highly vulnerable to the health-related dangers associated with their use.

Accordingly, this study examines agricultural producers’ perceived levels of risk from the use of farm chemicals. It is surprising that agricultural producers have been neglected in the risk-assessment literature considering their relative autonomy in determining the extent of agrichemical usage in domestic food and fiber production. The theoretical orientation used to guide the study draws liberally from the risk-analysis, sociological and social-psychological literature for insights into farm operators’ risk decisionmaking behavior.

As conceptualized in the social-psychological literature, perception refers to an internal, cognitive activity through which an individual attends to a subset of stimuli selectively
drawn from an environment that would be impossible to process in its entirety. Writers
describing the mental processes by which stimuli are chosen for and eliminated from
consideration have used such metaphors as filtering (Simon, 1963), selecting (Gerow,
1989), and extracting (Forgus & Melamed, 1976). Perceptions embody all of an
individual’s attitudes and beliefs associated with a given phenomenon and, as previously
discussed, have traditionally been viewed in the social-science literature as critical factors in
understanding human behavioral predispositions (Cacioppo et al., 1981). For instance,
Fishbein and Ajzen (1981) have argued that behavioral intentions result from the interaction
of individuals’ attitudes about a phenomenon with their beliefs as to whether significant
others think they should or should not perform a particular behavior. According to this
model, behavioral change is produced by changing an individual’s beliefs and attitudes,
such as through targeted persuasive information. While variations to this model may be
found in the literature, most make the general assumption that underlying attitudes and
beliefs join other variables in forming the basis for human decisionmaking.

As subsequently discussed, the inclusion of consumer perceptions in probability-based
modeling schemes in risk analysis reflects the integration of a number of academic
disciplines in the study of how humans evaluate various hazard situations.

Theoretical Approaches to Risk Assessment

Writers in the risk-assessment genre frequently allude to the fact that risk analysis has
no single theoretical origin or academic home (Brown, 1994; Short, 1984). In effect, risk
assessment has developed as a subdiscipline of a variety of social-scientific fields,
including economics, anthropology, geography, political science, psychology and
sociology (Slovic, 1987). Important contributions to the risk-assessment literature have
also come from the related but distinct field of natural-hazard research, which considers
physical, biological and technological hazards in the environment and their implications for
such over-arching issues as public policy and sustainable development (Burton et al., 1993). The joint participation of these diverse disciplines has fueled scholarly debate as to the proper methods for studying risk and to the appropriate level of public involvement in determining what risks are acceptable.

The traditional approach to understanding how individuals evaluate risks has been based on economic theory (Rescher, 1983). Such an approach assumes that the risk-averse individual, operating within the cognitive domain, makes rational choices based on accurate information about expected costs and outcomes of actions (Fischhoff et al., 1982). Rescher (1983) points out that the traditional strategy for comparing and evaluating a risk is through the calculation of an expected value, a process derived from expected utility theory originally formulated by John Bernoulli in the 18th century. According to the model, the utility of a risky activity is equal to the expected utility of its outcome. The expected utility of the outcome is calculated by weighting the utility, or value, of each possible outcome by its probability. Based on their field studies of consumer and worker behavior, Viscusi and Magat (1987) argue that the expected-utility approach is not only intuitively appealing, but also a frequently good predictor of actual behavior. Zeckhauser and Viscusi (1990) assert that the expected-utility model is the most fully developed framework for understanding choice under uncertainty, although they acknowledge that many decisions made by human beings do not conform to the model.

The success of economics-based models relies on decisionmakers undertaking only those activities with the highest expected utilities. As would be expected, this assumption has drawn both criticism and support in the literature. Because the criticisms strike at the validity of the model, they warrant consideration in the current analysis. For instance, Machina (1987) writes that a growing tension within decision theory concerns the large body of conflicting empirical evidence suggesting that laypersons frequently violate the critical assumption of rationality. Studies have repeatedly shown that objective risk
evaluations made by probability experts often share little congruence with those of laypersons. Scientists have been hard pressed to account for the seemingly “irrational” decisions made by intelligent, informed people (Fischhoff et al., 1987). Because informed dissent should be permitted in a democratic society, some researchers have voiced concern over experts’ possible confusion between irrationality and citizens’ legitimate personal preferences (Zeckhauser & Viscusi, 1990). Other researchers have explained discrepancies between expert and laypersons’ evaluations of risk by differences in the way choices are framed or formulated (Tversky & Kahneman, 1981).

In the context of cost-benefit analysis, rationality is couched in terms of maximizing benefits and minimizing costs according to an economic market. This assumption has led some researchers to question whether cost-benefit and related analyses are appropriate for the range of human activities to which they have been applied (Hoos, 1979). Douglas and Wildavsky (1982) maintain that economic markets are not, by themselves, valid indicators of what a rational individual may hold valuable, and, further, that a mixture of resources is often required to maximize benefits, rather than any single resource. From this standpoint, the use of cost-benefit models to understand how individuals evaluate a range of human risks has serious limitations as a policy tool.

Zeckhauser and Viscusi (1990) suggest that both economists and laypersons have been quick to invoke market values with little regard for practical consequences. Much criticism has focused on attempts to assess the value of saved lives, for example. Based on his assessment of various methods used to apply an economic market to the value of human life, Rescher (1983) suggests that all of the methods yield questionable results. Furthermore, he argues that attempts to appraise the value of human lives direct attention away from research that shows society views various life-threatening activities differently, and that a number of nonstatistical, or qualitative, attributes associated with risks are often of more concern to individuals than loss of life. Collective research into the psychology and
sociology of risk supports the assertion that laypersons consistently incorporate a number of noneconomic and cultural criteria into their personal evaluations of various risks and that such criteria are typically ignored by probability experts and hazards researchers (Krimsky & Plough, 1988). As discussed earlier, individuals tend to be more amenable to risks perceived as voluntary, avoidable, controllable, familiar, well-understood, not dreaded, and remote. The variety of empirical studies and theoretical models examining how human beings assess different types of risks forms a collective framework useful in bringing conceptual order to the study.

Research has shown that individuals are more willing to shoulder voluntary risks than those mandated by government or other authorities (Rescher, 1983). Similarly, community residents generally are more willing to accept risks that arise from their own actions or those that could yield potential benefits such as through economic prosperity. Similarly, proposed projects that confine risks to a relatively small geographic area often are highly resisted by those in the affected area, even for beneficial or needed facilities such as a waste-disposal site in a local community (Hadden, 1989).

Researchers have also documented that laypersons tend to characterize risk occurrences according to the degree to which they may be prevented or avoided. Empirical evidence suggests that individuals tend to fear more those risks that are deemed unavoidable as compared to those that may be sidestepped or delayed. Individuals often perceive that such phenomena are beyond their personal control, which has also been shown to influence their perceived acceptability of risk. For instance, the probability of being in a fatal auto accident is markedly higher than that of a fatal airline crash, but the latter tends to produce higher levels of fear among most people because of the perceived loss of control in preventing or avoiding such a mishap. Over-confidence that develops with perceived control is itself a risk because consumers may ignore important safety information they feel has little benefit (Viscusi & Magat, 1987).
Perceived familiarity with a given phenomenon has also been shown to influence individuals’ judgments as to the acceptability of risk. Hadden (1989) noted that citizens protesting the siting of nuclear facilities or waste incinerators in their neighborhoods were typically more concerned about the facilities than the trucks that carry the materials to or from the site. While many experts would agree that the transport of these materials poses a greater risk than their disposal, laypersons apparently understand the use of trucks and have not generally chosen to make them part of the issue. Similarly, risks that involve new technologies or phenomena that are only vaguely understood are likely to be viewed with more suspicion and fear than those with which people feel some level of familiarity.

In addition, events that are particularly striking, dramatic or memorable have been shown to instill dread on the part of individuals, regardless of the statistical probability of their fruition. Research has shown that the qualitative attributes of risks tend to be correlated with each other for various hazard situations, particularly for those that are perceived as frightening or marked by high degrees of uncertainty. For instance, factor analytic modeling has shown that phenomena marked by lack of control, catastrophic potential, and fatal consequences tend to be highly intercorrelated in terms of perceived risk. Not surprisingly, laypersons fear most those hazards that load heavily on the factor that Slovic (1987) has termed “dread risk,” and are more likely to favor regulation or other measures to reduce such risks, such as accidents associated with a nuclear reactor or commercial aviation. A second factor, defined as “unknown risk,” is marked by hazards perceived as unobservable, new or unknown, and delayed in their harmful effects, such as food preservatives and x-rays. In robust results obtained from studying both experts and lay populations, synthetic pesticides tend to load most heavily on the unknown-risk factor and moderately on the dread-risk factor (Fischhoff et al., 1987). Finally, research has shown that individuals typically exhibit more tolerance for risk phenomena whose probabilities or geographic location appear far-removed or remote.
Because these and other qualitative factors are not normally considered in cost-benefit analyses, alternative theoretical approaches based in psychology, sociology and other disciplines have increasingly been proposed to address the limitations of economics-based modeling in risk assessment. The predominant view now emerging from the literature is that while individuals rely heavily on cognitive processing to conceptualize risks, such as when they evaluate economic costs and benefits, their perceptions are mediated by psychological processes, social influences, and cultural factors that determine what risks are acceptable (Short, 1984; Hadden, 1983). Maxey (1979) argues that environmental hazards do not exist objectively, but are "structured" from human values and subjective decisions as to what phenomena are essential or desirable. Other writers have pointed out that mathematically based models of decisionmaking often give the illusion of objectivity when, in fact, their use itself is frequently motived or otherwise influenced by political or social factors usually not acknowledged in the literature (Hoos, 1979).

The broad recognition of social and social-psychological processes influencing how human beings define and rank various risks suggests that a theoretical model which ignores these processes in favor of a solely cognitive-based approach will be inadequate (Kasper, 1980). As prior discussion has established, perceptions, and cognitive functioning more generally, are influenced by factors in their social environment in addition to individuals’ prior experiences and beliefs. Because cognitive, environmental and behavioral factors are considered in this analysis as important prerequisites to understanding individuals’ evaluations of risk, theoretical modeling should provide a mechanism for examining these interdependent domains. Social learning theory, with its emphasis on cognitive, environmental and behavioral factors in explaining human decisionmaking, appears to offer an appropriate theoretical framework from which to examine farm operators’ evaluations of risk.
Social Learning Theory

The origins of social learning theory derive from the behaviorism school of psychology, whose proponents argue that social science would best proceed by concentrating on events and processes that can be observed or measured, as opposed to internal, and invisible, cognitive processes. The behaviorist approach avoids reference to individuals' internal states primarily because of the supposed impossibility of observing or measuring private, subjective cognitive processes (Gerow, 1989). Rather, behaviorists emphasize environmental conditions affecting behavior to the exclusion of subjects' elusive internal processes, thoughts and ideas.

While social learning theory acknowledges the importance of environmental factors in explaining human behavior, it goes decisively beyond behaviorism in asserting that thinking, reasoning individuals may also act upon and alter their environments. The recognition of a reciprocal linkage between individuals and their environments relies not on an extension of behaviorism, but on the incorporation of formerly incompatible elements of humanistic and cognitive psychology. Gerow (1989) describes humanistic psychologists as those whose chief concern was to "get the person back into psychology." Collectively, humanistic and cognitive psychologists emphasize affective and emotional states of mind as well as physiologically based processes such as memory and language.

While a number of scholars have long argued for the integration of various psychological approaches in analyzing human learning and behavior (Bandura, 1977; Rotter, 1982), others have resisted their assimilation into a larger theoretical framework. For instance, until his recent death, B.F. Skinner continued to justify behavioristic inquiry as the true science of psychology. Likewise, many humanistic and cognitive psychologists remain loyal to their individual approaches and consider them to be comprehensive and holistic in their own right. A counter movement against behaviorism, which included the emergence of humanist and cognitive psychology, supplied the conceptual elements
necessary to the formulation of social learning theory. From the social learning standpoint, human thought and behavior are shaped by the mutual interaction of cognitive, behavioral, and environmental factors, which are linked through Bandura’s conception of reciprocal determinism.

**Cognitive factors** are distinguishing characteristics of human beings (Bandura, 1977). Internal processes, functioning through ideas, motivations, and other internal events, allow humans to exercise some degree of control over their own behavior. Although the type and degree of control vary with different circumstances, the important point is that individuals do not simply react to external influences. Rather, they have the capacity to organize and transform stimuli with which they come in contact.

Behaviorists emphasize human behavior as the proper subject of scientific investigation. Social learning theory emphasizes **behavioral factors** not as an end in themselves, but because the outcome of an individual’s behavior can influence his or her environment as well as cognitive functioning in future situations. Individuals who behave differently in similar situations will experience different results, such as varying degrees of personal satisfaction or discomfort. To the extent that this information is retained and used in future situations, behavior can be said to have produced cognitive changes. Like the two other determinants, behavioral factors come into play only if activated.

The term **environment** recently has been used in ecological contexts as well as in family-life and occupational descriptions so that its meaning should be clarified in the current discussion. Bandura (1977) proposes a dual conception of environment consisting of a potential environment, which is the same for all actors in a given situation, and the actual environment, which depends upon individual behavior for activation. Individuals do not have the sensory capacity to process the wealth of information necessary to experience the totality of any given social setting, which comprises their potential environment. Instead individuals attend only to those facets they perceive as relevant and, in doing so,
“construct” their actual environment. Human beings may serve either as objects or agents of environmental control, depending on their position in society, level of social skills, intellect, values, and other numerous personal and social characteristics. The term “environment” can refer to physical surroundings, organizational climates, or more abstract social conditions.

In the language of Kaplan (1963), the connectedness of social learning theory is achieved through reciprocal determinism, which links previously disparate concepts into a framework suitable for analyzing a broad range of human decisionmaking. For Bandura, it is the mutual dependence of the three interlocking determinants that is critical in explaining human behavior:

“Social learning theory approaches the explanation of human behavior in terms of a continuous reciprocal interaction between cognitive, behavioral, and environmental determinants. Within the process of reciprocal determinism lies the opportunity for people to influence their destiny as well as the limits of self-direction. This conception of human functioning then neither casts people into the role of powerless objects controlled by environmental forces nor free agents who can become whatever they choose. Both people and their environments are reciprocal determinants of each other.” (p. vii)

Borrowing from Zetterberg (1965), reciprocal determinism establishes a contingent relation between any given pair of factors because of the condition imposed by the third factor. That is, no single factor is, by itself, sufficient to effect a change in another factor. Even though the three factors are viewed as interlocking and reciprocal, it may be the case that one or more simply is not activated in a given situation. For instance, changes in an environment have the potential to change an individual’s motives, beliefs, or attitudes present in the cognitive factor's attribute space. However, this holds true only if the individual is aware of the environment’s influence. If the individual misinterprets or fails to perceive the phenomenon in question, no change in his or her cognitive makeup can be expected. Likewise, if the individual correctly perceives the phenomenon, but is capable of
mitigating or otherwise disarming its influence through his or her behavior, then the individual’s cognitive processes may not be affected. Although the formation of perceptions is generally regarded as a cognitive activity, social learning theory stresses the critical roles played by environmental and behavioral factors.

Bandura (1977) argued that efforts to measure the relative influences exerted by the three factors would yield only marginally useful results because of the broad differences in individuals’ cognitive makeup and in the variability present in different types of situations. His writings suggest that a comprehensive explanation of human behavior would result only from addressing the collective influence of the three factors.

Social Learning Theory and the Evaluation of Agrichemical Risk

Social learning theory suggests that individuals’ perceptions of risk are influenced by the interaction of cognitive, behavioral, and environmental factors. Incorporating into this perspective the qualitative factors shown to influence laypersons’ evaluations of risk provides a unique vantage point from which to assess farmers’ risk perceptions.

Information about risk is commonly generated through direct human experience (Zeckhauser & Viscusi, 1990), conceptualized in social learning theory as a behavioral determinant of learning. Personal experience is considered an essential element of learning for both children and adults across a wide range of human activities.

However, some hazardous activities do not encourage direct trial-and-error behavior because of the attendant physical or economic harm that is likely to result. In such cases, it is difficult for experiential learning to take place. According to social learning theory, human beings have the unique ability to acquire and reproduce integrated patterns of behavior and knowledge by observation, or vicarious learning (McLaughlin, 1971). Because experimentation can be extremely costly or harmful, one can envision many activities in which it is simply more prudent to learn from others’ mistakes, such as
observing accidents in the workplace (Zeckhauser & Viscusi, 1990). As individuals perceive greater hazards or costs are associated with mistakes, they tend to rely more heavily on vicarious learning by modeling others’ behavior (Bandura, 1977, p. 12). Because of the variety of opportunities for observational learning in nearly all areas of human activity, it is generally unlikely that individuals might use all possible sources of accessible information in acquiring knowledge on a given topic, but rather would be limited to those in their actual environment. In effect, television and other channels of communication have broadened individuals’ actual environment and expanded the opportunities for symbolic modeling and information. With the advent of computer information services and electronic bulletin boards, people are increasingly reliant on vicarious learning through the new media technologies to supplement the limited knowledge they can infer from their immediate surroundings (Bandura, 1977).

Given the host of physical hazards and economic uncertainties that characterize farming occupations, it is clear that agricultural producers rely heavily on vicarious learning in addition to direct experience. By observing the behaviors of other people and noting the consequences resulting from their behavior, individuals avoid costly or hazardous repercussions. Forms of vicarious learning in the agricultural context might involve a farmer’s informal visit to a neighboring farm or to an on-farm demonstration sponsored by a local agricultural business or state extension service. A broad spectrum of technical bulletins, magazines and other print media provide additional avenues of educational information for farm operators. Many government agencies and agribusiness firms have become extremely adept at using mass media and other channels of communication to reach their target audiences. Electronic media in particular are instrumental in disseminating information on which individuals base much of their decisionmaking (Rogers, 1983; Bandura, 1977).
Because of the strict competition among media for advertising revenues, recent attention has focused on the ability of powerful industrial corporations to control news content in the popular press (Nelkin, 1987). Similar concerns have surfaced in the agricultural press, where a relatively few industries, such as animal-health and crop-chemical firms, command a disproportionate share of advertising revenues. Research has confirmed that agricultural journalists feel greater pressures from advertisers than their counterparts in mainstream journalism (Reisner, 1991). If advertising does indeed exert the chief “brake” on news content, as suggested by Crone (1986), agricultural media arguably face severe constraints on their environmental and personal safety reporting by agrichemical companies with vested interests in such matters. In the extreme, balanced journalistic reporting of agricultural and environmental issues could be compromised by advertising pressures on media to provide favorable coverage. Many such concerns have been raised by agricultural journalists themselves, stirring controversy and debate within the profession.9

Such issues are important in understanding the structural constraints to objective news coverage by the popular press (McQuail, 1985). However, it is important to keep in mind that agricultural and mainstream media generally function more as methods, or channels (Lionberger & Gwin, 1991), of communication rather than as “sources” of information despite the fact that terminology surrounding communication methods and sources has generally been used interchangeably in the agricultural communication literature (Oskam, 1995; Bruening, 1992; Bouare & Bowen, 1990). The distinction is particularly critical from a social-learning standpoint because the theory suggests that individuals will be attracted to certain information sources regardless of the medium through which they are available. Unless limited to using certain media channels, information-seeking individuals will move freely among various communication channels and methods to access sources they perceive as relevant (Bandura, 1977; Coleman, 1993). Grunig et al. (1988) demonstrated that farmers were particularly active in seeking instrumental information from
a variety of interpersonal and mass media sources at their disposal. Indeed, individuals’ information-seeking behaviors have proven remarkably persistent across a variety of circumstances, as when smokers are shown to exhibit high levels of interest for potentially dissonant information about the association between smoking and lung cancer (Feather, 1982). Such a finding suggests that certain risk-information behaviors may be driven by more complex priorities than simply a preference for a particular communication method or a psychological need to avoid incongruent information, as hypothesized in dissonance theory.

**Sources of Agrichemical Risk Information.** Access to technical information has long been recognized as a critical prerequisite to sound farm management. For example, diffusion theory asserts that accurate and timely information about various alternatives forms the basis of potential adopters’ decisionmaking to maximize rewards and minimize costs (Camboni & Napier, 1994). Low levels of adoption for conservation and other sustainable agriculture practices have frequently been viewed as evidence of a lack of information at the farm level or inadequate communication efforts by change agencies (Oskam, 1992; Alonge & Martin, 1992). From the diffusion standpoint, relevant educational programs administered by respected information sources and opinion leaders play a critical role in the adoption of desirable agricultural practices.

Because of the growing universe of agricultural-production information available from the Land-Grant universities, agribusiness, and federal and state agricultural agencies, farmers generally must emphasize a relatively few sources they judge most relevant and to disregard or place lower priority on countless others. Social learning theory further suggests that individuals will seek out competent, credible, or otherwise engaging models and ignore those who do not meet their particular standards (Bandura, 1977). The assertion that credible information sources are more likely to alter an individual’s beliefs than those with low credibility is backed by strong empirical evidence in the social-
psychological literature (Hass, 1981). Individuals who receive information from sources they perceive as credible usually are more receptive to the information and less likely to question its accuracy (Mueller, 1989).

To this end, agribusiness has made extensive use of advertising and public relations campaigns in electronic and print media which frequently feature well-known or otherwise persuasive spokespersons to promote public awareness and acceptance of their products. The ultimate goal of such efforts is to create a corporate image among agricultural producers and consumers as a trustworthy and reliable source of accurate, up-to-date information about issues in the public interest. Despite the success of many such campaigns, producers have become alert to the vested interests of firms whose profit motives might interfere with objectivity of information. Information gleaned through mass media often stimulates interpersonal dialogue among family and friends as farmers seek to verify the accuracy of such messages.

The recognition of the association between interpersonal and mass communication is made explicit in theoretical approaches such as the classic “two-step flow model” of communication that emerged in the 1950s. According to the model, mass communication tends to stimulate interpersonal communication among individuals within an audience, which leads to further information-seeking. Thus, interpersonal and mass media channels are viewed in the model as conceptually distinct but interrelated, as when messages disseminated by mass media form the basis for subsequent interpersonal communication among peers. A particularly important application of this process to the diffusion model involves the interpersonal communication initiated by influential individuals in encouraging or recommending the trial of an innovation among potential adopters. While the oversimplicity of the two-step flow model has diminished its popularity as a theoretical approach in development communication and other circles (Hornik, 1989), most contemporary researchers have retained its important assumption that the content of
interpersonal communication is frequently based on messages in the mass media (Avery & McCain, 1982).

Decades of research in agricultural communication confirm agricultural producers' heavy reliance on family members and influential peers as sources of information for farm decisionmaking (Lionberger & Gwin, 1991; NPAC, 1955). While informal networks of friends, neighbors and family members seldom offer the most accurate or detailed information available to farmers in the information age, social learning theory would suggest that they are appealing sources of information owing to their perceived trustworthiness. Hass (1981) reports that information sources that are perceived to possess personal qualities similar to recipients are frequently judged more credible, even when the similarities are irrelevant to the content of the message. Lionberger and Gwin (1991) suggest that agricultural producers prefer information from their peers because of the assurance that fellow farmers and local agribusiness contacts developed over many years have a great deal of practical experience. Information provided by peer networks is likely to be highly compatible with farmers’ existing values, which further encourages their use (Hadden, 1989).

While individuals comprising these peer networks have been framed in the current discussion as sources of information for farm operators, it is important to acknowledge they are also information receivers, whose perceptions and vicarious learning are likewise susceptible to influence by a variety of environmental factors. Because of much recent publicity, and extensive media attention, surrounding conservation issues and the negative environmental impacts of agricultural production, it is highly likely that these individuals have been exposed to numerous reports of risks associated with agricultural chemicals, and that such information might well influence or even dictate their perceptions of agrichemical usage in the local environment. The application of social learning theory would therefore suggest that agricultural producers’ use of family and peer networks as sources of soil and
water conservation information will be significantly associated with higher levels of perceived risk from agricultural chemicals.

In addition to family and peer networks, farmers increasingly have turned to a number of institutionalized sources for information about agricultural practices (Bruening, 1991; Bouare & Bowen, 1990). Such agencies are administered at the federal, state and county levels and provide information on a variety of agricultural and environmental issues, usually at no cost to the producer. Farmers traditionally have perceived such agencies as credible and objective sources of agricultural information because of their status as non-profit institutions that are not in competition with agribusiness. The growing complexity of agricultural subsidy policies in particular has tended to increase producers’ information needs from several government agencies charged with farm program administration. For instance, county officials of the Agricultural Stabilization and Conservation Service (ASCS) maintain crop histories of local producers that are used to determine eligibility for a host of commodity programs. ASCS also works with the Soil Conservation Service (SCS) in providing cost-sharing and other assistance to help curb erosion of fragile croplands.

The introduction of conservation-compliance programs in the Food Security Act of 1985 requires that farmers work closely with both of these agencies to maintain access to federal farm program benefits (Napier, 1990). Farm programs themselves have become increasingly complex so that farmers generally must consult government experts for information about specific commodity programs. While the primary task of agencies such as SCS is to provide technical assistance, most are also involved in disseminating information and advice on conservation and land-use alternatives. Because the underlying objective of all such agencies is to encourage adoption of sustainable agricultural practices, it is likely that their information programs explicitly address agrichemical usage and its attendant risks. Agency personnel are likely to be perceived as having a high degree of
source credibility, so theory would suggest that farmers' use of technical and nontechnical agricultural agencies as sources of soil and water conservation information will be significantly associated with higher levels of perceived risk from agricultural chemicals.

It has been argued that farmers are obliged to work with a number of agricultural agencies to ensure eligibility for federal program assistance, but they may well draw upon additional sources and government agencies for agricultural conservation information. Public entities such as the Environmental Protection Agency (EPA), for instance, do not have a direct role in administering farm programs or providing technical assistance to farmers, but often work closely with agricultural agencies in setting environmental standards and formulating policy on which such programs are based. Such agencies have information staffs or personnel who communicate environmental information to both farmers and nonfarm clientele. Whether farmers purposely seek conservation information from such sources or come in contact with them casually such as through mass media, theory would suggest that increasing use of resource-conservation agencies and related organizations as sources of soil and water conservation information will be significantly associated with higher levels of perceived risk from agricultural chemicals.

While the acquisition of risk information from various sources is argued to constitute an important avenue by which farmers may become aware of dangers surrounding agrichemical usage, social learning theory suggests that environmental factors alone are not sufficient to explain human decisionmaking. The recognition that media messages, for example, account for only a portion of the variance in human behavior first emerged in the mass communication literature as early as the 1930s (Wimmer & Dominick, 1987). Recent research has attempted to define further the limitations of mass media in informing individuals' risk judgments. Coleman (1993), for instance, found that mass media are useful primarily for generalized risk information about others, while information on personal-level risk judgments is likely to be sought across a variety of channels.
The lackluster performance of mass media and interpersonal channels of communication in explaining variance in individuals’ judgments of personal risk has encouraged the introduction of individuals’ characteristics, such as personality variables, into risk communication modeling (Coleman, 1993; Tyler & Cook, 1984). One of the assumptions motivating this work is that it is possible to identify certain uniform personality traits that are associated with specific behaviors or dispositions. The inference of an individual’s behavior from his or her personal characteristics has been a common approach in both marketing and diffusion research. Eagly (1981) indicates that personality approaches were popular in the 1950s and 1960s for studying individuals’ reactions to various types of information campaigns. For instance, the two-step flow model of communication was predicated on the pivotal role played by certain influential individuals, or opinion leaders, whose progressive personality traits would enable them to diffuse mass media messages to the more passive masses of the population (Cox, 1967). The diffusion model builds on a similar conceptualization of five adopter categories in which descriptive, personal characteristics of clientele are associated with their behavioral tendencies. According to this scheme, “innovators” are described with such personal adjectives as venturesome, daring and rash, while “laggards” are characterized as isolated and suspicious (Rogers, 1983). More recent approaches have incorporated cognitive concepts such as individuals’ perceived levels of control, or self-efficacy, into analyses of decisionmaking behaviors (Bandura, 1977b).

The concept of reciprocal determinism within social learning theory provides the mechanism by which individuals’ personal and cognitive characteristics might mediate or otherwise influence their perceptions and behavior. For instance, the controversy surrounding the pesticide ethylene dibromide (EDB) ignited quickly in the 1980s following graphic mass media pictures portraying the suffering of poison victims. Krimsky and Plough (1988) argue that such messages became part of the public’s “prior experience”
with EDB and provided a context against which subsequent messages were evaluated. In the current analysis, social learning theory would suggest that individuals’ perceptions of risk from agrichemical usage would result from the interaction of environmental factors, such as exposure to various information sources, with cognitive factors, such as existing beliefs and attitudes generated through prior experience or vicarious learning (McLaughlin, 1971). Farmers’ cognitive activity, manifest though their pre-existing beliefs about agrichemical usage, might tend to confirm or discount information received through mass media or interpersonal sources, depending on the strength of the individual’s belief structure. When one views belief orientations as being based on a lifetime of direct experience, observational learning and information processing, it is easy to understand why environmental factors such as media messages are potentially important but insufficient in themselves in conceptualizing human attitude formation and decisionmaking.

In recognizing the salience of personal and cognitive factors in predicting farm operators’ evaluations of agrichemical risks, the foregoing discussion suggests additional hypotheses for the current model. While information as to the possible health and safety risks from agrichemical usage is pervasive, such messages may be dampened or amplified by the individual’s cognitive belief structure. Individuals whose experiences and observational learning suggest that agrichemical usage is marked by high levels of risk to personal health will be more likely to attend to relevant risk information, while those whose learning indicates agrichemical application is a relatively safe activity may tend to ignore or avoid such information. Farmers who perceive high levels of potential risk from the industry’s widespread use of agrichemicals would be likely to consider the possible impacts of such risks on themselves and their families. Therefore, it is hypothesized that farm operators’ beliefs that family health is threatened by agricultural pesticide usage will be significantly associated with higher levels of perceived risk from agricultural chemicals.
An “optimistic bias” has been demonstrated for a variety of phenomena wherein individuals frequently underrate the probabilities of coming to personal harm from the certain risks. Such individuals often forecast dire predictions for abstract “others” relative to a particular risk, even as they underestimate their own susceptibility to the same dangers. One possible reason for such a miscalculation is that risk-optimistic individuals do not consider themselves to be within close proximity to the phenomenon in question. In the current analysis, then, it is necessary to make a distinction between potential risks from general agrichemical usage and risks present within the respondents’ actual environment. Applying social learning theory’s dual conception of environment to the current study suggests that respondent attitudes indicating a perceived problem with agrichemical pollution in the Darby Creek Watershed will be significantly associated with higher levels of perceived risk from agricultural chemicals.

Agricultural producers’ awareness of environmental risks is associated not only with access and exposure to key information, but also with individual-level characteristics such as memory and aptitude that enable them to process, organize and assimilate large amounts of data. This is particularly true in the case of agrichemical-risk information. Despite the wealth of available data, knowledge and understanding of agrichemical risks depends on the individual’s proficiency in processing technical, often conflicting, information about abstract concepts over which experts themselves frequently disagree. This situation suggests that training and education of farmers are becoming increasingly important in sound farm decisionmaking. Farmers with higher levels of formal education would be expected to assess agrichemical risks as more hazardous because of their increased knowledge of the possible avenues by which contamination can occur. In addition, highly educated producers are more likely to be aware of the fact that scientists and other experts do not have perfect knowledge of chemical fates in the environment or their potential for human carcinogenicity. By highlighting the uncertainties surrounding the
long-term health effects of agrichemicals, *exposure to education will be significantly associated with higher levels of perceived risk from agricultural chemicals.*

It is important to note that the state of knowledge about environmental impacts of agrichemicals has developed rapidly in recent years. To keep current, many agricultural producers have participated in educational programs or seminars sponsored by Land-Grant universities or extension services. By law, applicators of restricted-use pesticides are required to participate in certification programs stressing environmental safety and proper use of agrichemicals. Such programs constitute one of the most important methods by which agricultural producers may keep abreast of agrichemical safety. Therefore, the model used in the current study would suggest that *farm operators’ participation in relevant educational programs will be significantly associated with higher levels of perceived risk from agricultural chemicals.*

In addition, an individual’s willingness to participate in educational programs should provide an indication of his or her desire for risk information about agrichemical usage as well as a general concern for agricultural chemical issues. Because active information-seeking involves use of a variety of channels to satisfy informational needs, individuals’ willingness to participate in educational programs is likely to be associated with increased reception to agrichemical risk information via interpersonal and mass media methods. Such receptivity is hypothesized to dispose individuals to actual behavior, so *willingness to participate in educational programs is expected to be significantly associated with higher levels of perceived risk from agricultural chemicals.*

**Research Hypotheses**

Social learning theory has suggested that farmers’ perceived levels of risk from agrichemical usage will be positively associated with a number of cognitive and personal
factors interacting with environmental factors in an individual's actual environment. These hypotheses will be tested in the current analysis.

1. The greater the use of family and local peer networks as sources of information about soil and water conservation in the primary farm operator's county, the greater the perception of risk from agricultural chemical usage.

2. The greater the use of institutionalized, agricultural agencies and sources of information about soil and water conservation in the primary farm operator's county, the greater the perception of risk from agricultural chemical usage.

3. The greater the use of natural-resource agencies and other nontechnical sources of information about soil and water conservation in the primary farm operator's county, the greater the perception of risk from agricultural chemical usage.

4. The greater the perceived threat to family health by pesticide contamination in the primary farm operator's county, the greater the perception of risk from agricultural chemical usage.

5. The greater the primary farm operator's perceived threat of agriculturally-induced pollution present in the Darby Creek watershed, the greater the perception of risk from agricultural chemical usage.

6. The more years of formal education reported by the primary farm operator, the greater the perception of risk from agricultural chemical usage.

7. Farm operators' participation in educational programs aimed at reducing chemical inputs while maintaining high farm-productions levels will increase the perception of risk from agricultural chemical usage.

8. The greater the primary farm operator's willingness to participate in educational programs on reducing chemical application rates while maintaining high farm-production levels, the greater the perception of risk from agricultural chemical usage.
**Model Specification**

Hypotheses generated by social learning theory will be used in this analysis to specify antecedent factors that are argued to explain variance in the dependent variable. According to the model, farmers' perceptions of risk from agrichemical usage are assumed to be linearly associated with the independent variables outlined below:

Equation 1.

\[ Y = f \{ F, A, N, T, C, E, P, W \} \]

where \( Y \) equals farmers' perceived level of risk from agrichemical usage; \( F \) represents the use of family and peer networks as sources of information about county soil and water conservation; \( A \) represents farmers' use of technical and nontechnical agricultural agencies as sources of information about county soil and water conservation; \( N \) represents farmers' use of natural-resource and related sources of nontechnical information about county soil and water conservation; \( T^{12} \) represents farm operators' perceived threat to family and personal health posed by agricultural chemicals; \( C \) represents perceived threat of environmental contamination by agricultural activities in the Darby Creek watershed; \( E \) represents years of formal education reported by the primary farm operator; \( P \) represents whether the primary farm operator has actually participated in educational programs to reduce chemical-application rates while maintaining high farm-productions levels; and \( W \) represents farm operators’ reported levels of willingness to participate in educational programs on reducing chemical-application rates while maintaining high farm-production levels.

The following chapter discusses operationalization of these variables and the statistical tests used to assess the performance of the proposed model.
CHAPTER ENDNOTES

1 The traditional diffusion model is the culmination through meta analysis of more than 3,000 publications (as of 1983) on diffusion theory and practice, representing such academic fields as education, sociology, communication and marketing. In Rogers' (1983) vocabulary, *diffusion* involves an innovation, such as a product or practice, that is communicated by various communication channels over time to individuals comprising a social system. A primary objective of change agents, marketers or others using the diffusion model is to bring about client awareness and, ultimately, "adoption" of a particular idea, product, or service.

2 See Simon (1963) for a brief but interesting discussion of the use, and misuse, of such metaphors in psychological research.

3 Burton et al. (1993) suggest that the union of natural-hazard research and risk assessment is far from complete: "Indeed, the research traditions flowed like two streams in roughly parallel courses in an alluvial valley — touching here or there, joining each other during high water, but for the most part separate, with few direct connections." (p. 247)

4 As defined in the previous chapter, qualitative factors — also referred to as "outrage factors" in the literature — refer to a number of attributes laypersons may project onto a given hazard to help them evaluate its seriousness, or "riskiness." Segal (1991) and others (Fischhoff et al., 1976, cited in Rescher, 1983) suggest that laypersons rely heavily, sometimes exclusively, on qualitative factors when assessing various risk situations. Conversely, experts tend to depend more on statistical or quantitative data, e.g., death rates, when ranking various risks.

5 Behavioristic and humanistic approaches to human behavior were not compatible prior to the development of a theory that included both in its explanatory scheme. Staunch advocates of behaviorism, such as John Watson in the early 1900s and, more recently, B.F. Skinner, argued that examination of invisible internal or cognitive processes had no role to play in the scientific study of human behavior.

6 In his classic discussion of theories and laws, Kaplan (1963) writes: "... theory is not the aggregate of ... new laws but their connectedness, as a bridge consists of girders only in that the girders are joined together in a particular way. The theory explains the laws, not as something over and above them, but by giving each the strength and purpose which derives from the others." (p. 297)

7 Oskam (1992) reports there were approximately nine deaths per 100,000 workers in nonagricultural occupations in 1990, and approximately 42 deaths per 100,000 workers in agriculture.
Experts have long recommended that communication practitioners use a variety of delivery methods, even if evidence suggests that clientele prefer a particular method for some types of information. Agricultural extension agents, for example, may well communicate with clientele through county-level meetings (interpersonal), extension publications and newsletters (direct mail), and through personal columns in local newspapers (mass media), with each method reaching a different segment of the target population (Richardson & Mustian, 1994).

An example is the lively debate that developed among agricultural magazine editors following a 1983 editorial in *The New Farm* titled “Editors on the Dole: A Behind-the-Scenes Look at How Big Business Wines and Dines the Farm Press” (DeVault, 1983). The article questioned the objectivity of farm editors whose professional meetings were sponsored by powerful agricultural corporations such as Dow Chemical and DuPont AgriChemical.

A relevant example reported in the 1994 Mid-February issue of *Wallaces Farmer* is the consumer-awareness campaign recently launched by American Cyanamid titled “Tending to the Earth Every Day.”

The Soil Conservation Service (SCS) changed its name to the Natural Resources Conservation Service (NRCS) in 1994 to reflect the agency’s broad mission. The abbreviation SCS is used in subsequent references to maintain consistency within this document and between this document and the survey instrument.

As shown in the Appendix (Table 11, pp. 104–105), the independent variable T differs from the dependent variable in that the former measures perceived risk to family health from a single, specific source (pesticide contamination). The dependent variable is a more inclusive indicator of agrichemical risk that measures perceived levels of threat not only to human health, but also to such items as wildlife, beneficial plants, and farm animals. In addition, the dependent variable is not limited to pesticide risks, but also may include hazards associated with synthetic fertilizers, fumigants, or other materials.
CHAPTER III

METHODOLOGY

Description of Study Area and Population

The data used in this study were collected from 245 farm operators within the Ohio Darby Creek hydrologic unit in the winter and spring of 1994. Livestock and mixed grain production are the primary farming activities within the Darby Creek watershed, which is traversed by the Little Darby and Big Darby creeks in portions of Champaign, Franklin, Logan, Madison, Pickaway, and Union counties. The six counties comprising the study area are located in one of the most productive agricultural regions in the state. Increased housing and urban development have reduced the number of acres available for agricultural enterprises in the region and have further encouraged the adoption of technology-intensive systems on the remaining farmland. The use of modern agricultural systems and the superior quality of farmland have enabled regional farm operators to maintain high levels of production. A large portion of the study area is prime agricultural land because of high levels of soil fertility and flat to gently rolling topography (Napier et al., 1994). Corn and soybeans are the major agricultural commodities produced in the study area, and based on 1992 data, Ohio ranks sixth nationally in the value of cash receipts for each of these two commodities (USDA, 1994).

The study area is agriculturally diverse owing not only to favorable soil and topographical conditions, but also to personal characteristics of its residents. A large minority of Amish/Mennonite residents are particularly influential in increasing the variety of farm enterprises within the study area. Amish farmers tend to diversify not only to offset market risks but also to maintain a degree of isolationism from mainstream society.
that would not be possible without producing multiple products for their families and for market (Sommers & Napier, 1993). In addition, Amish culture has generally valued the use of family farm labor over the adoption of large machinery and other technologies, which further discourages large-scale production of a single crop and encourages diversification. While their unique cultural and farm-production orientation varies markedly from the larger population, the Amish/Mennonite subpopulation is highly respected and integrated within the region’s social structure, indicating a high degree of social cohesiveness within the region.

In addition to its agricultural diversity, two other circumstances combine to make the Darby Creek watershed an ideal study area. First, a significant monetary commitment has been made to the study area over several years through a variety of soil and water conservation programs. Efforts have been sponsored by such agencies as the Ohio Department of Natural Resources, the Environmental Protection Agency, the Soil Conservation Service, Ohio State University Extension and others. It is therefore of interest to determine what effect such programs have had and to generate research-based suggestions for future resources. Second, the study area is located in proximity to one of the state’s largest urban centers, Columbus, where water quality and environmental safety have become significant public issues (Camboni & Napier, 1994). Results from this study, then, could have implications not only for residents within the specific study area, but also for more than 1 million residents of the neighboring metropolitan community.

Sample Selection

A systematic random sampling technique was used to select landowner-operators to participate in this study. Farm operators at every other occupied farmstead within specified subsampling areas of the Darby Creek watershed were asked to complete a structured questionnaire. Maps of the hydrologic unit were used to identify townships to be sampled,
and Agricultural Census data were used to determine the proportionate number of interviews to be conducted in each township. Only those farm operators earning at least $2,500 from the sale of agricultural products or rent of land were asked to participate. Two hundred forty-five farm operators completed the questionnaire, yielding a response rate of 86 percent.

The locations of completed interviews were recorded on detailed county maps to help monitor response patterns within the canvassed research areas. Inspection of these maps during and following the data collection phase of the study indicated that all regions of the study area were represented. Because of the high participation rate, the uniformity of the response pattern, and the random procedures used to select respondents, the sample is argued to be representative of the study area.

Operationalization of Variables

The dependent variable is the perceived level of risk from farm chemicals. The concept of “agrichemical risk” subsumes a number of essentially different hazard situations that arise during chemical handling and application. Other hazards are associated with exposure to chemicals after they have been applied. These various exposure hazards accrue not only to farm operators and their families, but also to the local physical environment, which further intensifies the collective risk to local residents. To capture the complexity of the dependent variable in this study, agrichemical risk was operationalized by a number of separate attitude items tapping various aspects of hazard identified in the literature. Respondents were asked to indicate the extent of perceived risk posed by farm-chemical usage to nine separate items: water quality, food safety, food quality, health of applicator, health of farm animals, wildlife, beneficial plants, beneficial insects, and human health. The possible responses to the items ranged from no risk (weighted 0) to serious risk (weighted 8). Item analysis was performed to assess the reliability of the nine-item scale,
yielding a standardized item alpha of .96. The high degree of reliability indicates that the separate items were highly intercorrelated and measuring the same attitude trait. Based on the magnitude of the coefficient, the weighting values of the separate items were summed to form a composite risk score for each respondent.

The independent variables used in this analysis were selected for inclusion on the basis of the social learning perspective used to guide the study. The variables included information sources such as family and peer networks in addition to institutionalized sources of soil and water conservation, including technical and nontechnical agricultural agencies, and natural-resource and related agencies. In all, 17 sources were identified from the literature review as important outlets for agricultural conservation information in the Darby Creek watershed. Such variables are conceptualized in social learning theory as environmental factors and are argued to constitute the major sources of agricultural conservation information within the study area.

Information-source variables were operationalized by asking respondents to indicate the number of times they received soil and water conservation information from each of the 17 sources during 1993. Included in this list were informal organizations and peer networks such as Other Farmers; Agri-Chemical Dealer; Financial Officer; Family Member; Friend; Nature Conservancy; Local Conservation Club; Mass Media; and Farm Implement Dealer. More formal, institutionalized sources included the Environmental Protection Agency (EPA); USDA Soil Conservation Service (SCS); USDA Agricultural Stabilization and Conservation Service (ASCS); Department of Natural Resources (DNR); Operation Future Program; Soil Conservation Districts; Ohio State University Extension Agent; and the U.S. Geologic Survey. Each source was a single-item measure used to determine the frequency of respondent use during 1993. Possible responses ranged from 0 to 25.

While the relatively large number of information sources included in the analysis provides a useful and thorough profile of conservation-information usage among the
respondents, inclusion of the 17 variables in regression modeling would be methodologically suspect due to their high intercorrelations and the likelihood of multicollinearity. Therefore, factor analysis using principal components analysis was used to transform the 17 variables into a smaller number of factors while retaining most of the information in the original variables (Dunteman, 1989).

The three factors emerging from the factor analysis were rotated orthogonally and used to build scales suitable for subsequent regression modeling. The first factor, which included the variables Family Member, Friend, Nature Conservancy, Local Conservation Club and Farm Implement Dealer, tapped local, largely interpersonal, sources of information. The sources of information were subjected to item analysis to assess scale reliability. The item analysis yielded a standardized item alpha of .82, indicating that the variables were highly intercorrelated. The relatively high degree of internal consistency suggests that the five variables are working together to discriminate among individuals’ responses and provides support for the theoretical framework used to justify scaling of these variables. The second factor identified through the factor analysis was composed of information sources that were more institutional in nature: EPA, DNR, Soil Conservation Districts and Financial Officer. Submission of this four-variable pool to item analysis resulted in a standardized item alpha of .82. The third factor produced by factor analysis included only three variables, ASCS, OSU Extension Agent, and Operation Future Program, all of which are agriculturally-oriented sources of relatively non-technical information. Item analysis for these variables resulted in a lower but acceptable standardized item alpha of .64.

Factor analysis successfully reduced the information-source data to three substantively meaningful factors using 12 of the 17 original variables. Although the SCS variable exhibited a moderate loading on the third factor, its inclusion was not compatible with the theoretical framework because of its primary role as a provider of technical agricultural
assistance. Other variables comprising the factor on which SCS loaded most highly emphasize relatively non-technical information. Normally, the theoretically incompatible variable could justifiably be excluded from further analysis. However, because the SCS variable exhibited a statistically significant zero-order correlation with the dependent variable, it was included in subsequent regression modeling along with the three information-source scales and other hypothesized variables.

While environmental factors have been a regular part of social-scientific research since its inception, the literature reviewed previously has generally shown such factors to explain only a limited portion of variance in individuals' attitudes and behavior. Moreover, as discussed in the previous chapter, environmental factors, such as use of various information sources, have been shown to exert indirect as well as direct influences on decisionmaking, based on the strength of the individual's belief structure. As conceptualized in social learning theory, indirect influences result from the process of reciprocal determinism, whereby environmental factors interact with cognitive and behavioral factors in influencing human behavior. In such a situation, environmental factors are likely to be insufficient in themselves to predict human behavior or attitude formation. Instead, such factors must be considered in concert with other factors to account more fully for variance in human decisionmaking. Therefore, a number of cognitive factors were included in the current analysis of farmers' perceptions of risk from agrichemicals.

Two such independent variables were constructed to measure farm operators' perceptions of the current state of agrichemical risk within the Darby Creek watershed. Collectively, these measures address two important aspects of agrichemical risk identified in the literature: the level of perceived agrichemical hazard accruing to oneself and family, and the level of perceived threat to the quality and safety of the local physical environment.

Perceived health threat from agricultural chemicals was a single-item measurement used to gauge the perceived level of threat posed to personal and family health by pesticide
contamination of ground water. Responses were arranged along a continuum ranging from no threat (weighted 0) to serious threat (weighted 10).

**Attitude toward ground water pollution in the Darby Creek watershed** was measured using six Likert-type statements that assessed respondents’ level of agreement with various issues regarding pesticide and fertilizer usage and their effect on ground water and environmental quality in the Darby Creek watershed. Responses to each of the six statements ranged from strongly agree (weighted 1) to strongly disagree (weighted 5), with higher values indicating increased sensitivity toward agricultural pollution issues. Reliability of the six items was assessed through item analysis, which yielded an alpha coefficient of .70. The weighted values for the six items were summed to form a composite attitude score for each respondent and used in subsequent regression modeling.

Additional independent variables generated by the cognitive component of social learning theory address respondents’ cognitive potential as manifest through their level of education and attitude toward increasing their expertise in agrichemical-application techniques. Collectively, these education-related variables provide a broad indication of respondents’ current state of knowledge about conservation and agrichemical-risk issues, and of their ability and attitude toward processing and assimilating additional technical information accessible within their actual environment.

**Years of formal education** was measured using a single-item indicator and was one of the two variables that served as a proxy for extent of learning and education. Respondents were asked to enter the value representing years of formal education. Possible responses ranged from 0, representing no formal education, to 23, representing graduate or other advanced educational training.

**Participation in educational programs** was also used as proxy for extent of education. Respondents were asked to indicate whether they had ever been involved in educational programs focused on reducing fertilizer application rates while maintaining high production
levels. A dummy-variable coding scheme was used so that positive responses were weighted 1, and negative responses were weighted 2.

Attitude toward participation in educational programs was a single-item measure used to gauge respondents' willingness to participate in educational programs focused on reducing pesticide application rates while maintaining high production levels. The measure is important from a social learning perspective in providing an indication of respondents' interest and receptivity to environmental sources of information, such as agrichemical-related programming. Possible responses ranged from very unwilling (weighted 0) to very willing (weighted 10).

Hypothesized relationships between the independent variables and the dependent variable were discussed in the previous section.

**Statistical Analysis**

Descriptive and multivariate statistics were used to evaluate the usefulness of the theoretical model in explaining variance in respondents' perceptions of risk from agrichemical usage. Descriptive statistics, including frequencies, means and standard deviations, were helpful in gaining a clearer picture of broad attitudinal and demographic characteristics of respondents. Bivariate correlation analysis was used to assess the magnitude and direction of association between each of the hypothesized independent variables and the dependent variable. Multiple regression analysis was used to assess the relative utility of the factors included in the analysis to explain the variance in the dependent variable when all variables are considered simultaneously. The multiple regression equation is additive, as each independent variable accounts for a unique portion of variance in the dependent variable. The computer software package used to generate the descriptive and multivariate statistics reported in this study was the Statistical Package for the Social Sciences (Norusis, 1993).
Appropriate use of ordinary least squares regression analysis requires that researchers ensure a number of assumptions are satisfied in both the data and in interpretation of the results (Pedhazur, 1982), particularly when sample data are used to make inferences about a population. Among these assumptions are the absence of specification error, measurement error, and multicollinearity (Lewis-Beck, 1980). Several assumptions also concern characteristics of the error term, or residual, in the regression equation. Specifically, homoscedasticity is assumed, as well as normality of the error term and absence of autocorrelation, or correlation between error terms (Schroeder et al., 1986).

Steps were taken prior to statistical modeling to ensure that these assumptions were satisfied. Factor analysis with orthogonal rotation was used to transform the relatively large number of information-source variables into factors suitable for regression analysis. Inspection of the correlation matrix for these and other variables used in the study revealed no serious breaches of the multicollinearity assumption. The correlation matrix is presented in Table 12 of the Appendix. In addition, a more rigorous test for multicollinearity was administered, as recommended by Pedhazur (1982), wherein each independent variable was regressed against all others. Relatively high coefficients of determination would suggest unacceptable levels of multicollinearity. None were noted in tests of the current data. Standardized-residual plots were also generated and inspected to test for specification error and homoscedasticity. No irregular patterns were detected in the plotted residuals that would suggest either of these problems.

Finally, to salvage cases containing small amounts of missing data, variable means were substituted for nonresponses, as recommended by Bailey (1987).
CHAPTER ENDNOTES

1 Hydrologic units are watersheds designated by the USDA Natural Resources Conservation Service. A watershed is an area or region that drains to a single outlet.

2 Ohio lost about 4,000 farms between 1991 and 1993. Although the loss is partially offset by a growing average farm size, the state still lost about 500,000 acres of agricultural land during this same two-year period (USDA, 1994). Agricultural statistics indicate similar trends nationally.

3 The Amish form one segment of the Mennonites, an Evangelical Protestant Christian sect that practices a more traditional lifestyle and relies heavily on agriculture for financial support (Camboni & Napier, 1994).

4 See Footnote 11, Chapter 2.

5 Mass media are more accurately viewed as a channel, rather than a source, of information. However, inclusion of mass media as a source variable in this study may be justified on the basis of their widespread use among farmers. Factor analysis demonstrated little intercorrelation between use of mass media and other information sources examined in this study, which indicates the mass media variable was not serving as a proxy for the other information source variables.

6 According to the conventional criterion discussed in the literature (Kim & Mueller, 1978), only those factors with eigenvalues greater than 1 were considered significant.

7 Within the context of this study, "nontechnical" refers to specific types of relatively general agricultural or conservation information disseminated either by interpersonal channels or mass media. Such information is general in the sense that it is often based on aggregated state- or even national-level data and intended for broad management decisionmaking, such as planting dates or market news. By contrast, the adjective "technical" is used to refer to information generated by professional consultants, scientists, or other agricultural experts that is based on highly local or farm-level data. Such information is typically highly site-specific and may include recommendations to optimize agronomic or economic goals of the farm operator. Because of the consultant's high level of expertise and access to targeted, quality data, the information and recommendations generated by such experts are generally understood to supersede less technical types of information available to the farm operator.

8 Bivariate correlation coefficients were generated for each of the 17 separate information-source variables with the dependent variable. SCS exhibited a statistically significant zero-order correlation with the dependent variable (r = -.163, p < .05, two-tailed test), which further justifies its retention and use in subsequent modeling.
CHAPTER IV
FINDINGS

Descriptive data reported in Table 12 of the Appendix provide a general overview of the respondents' demographic characteristics and financial status (Napier & Camboni, 1994). Farm operators in the Darby Creek watershed are generally middle-aged with about 12 years of formal education and nearly 25 years tenure operating their own farms. More than three-fourths (76.3 percent) of the respondents were non-Mennonite. The average number of acres farmed in the study area was just under 700 acres, although the figure varied widely among respondents. Corn and soybeans were the major sources of farm income, followed by dairy, wheat and beef production.

Farm income data suggest a bimodal distribution of many relatively large and small farm operations. More than one-third of the respondents reported their 1993 farm income was less than $50,000, while more than 27 percent reported farm income of $200,000 or more for the same period. While the numbers of farm operators appear to be relatively equal for these two groups, it is important to note that the latter group accounts for the bulk of state agricultural production. According to Ohio farm data reported by Stout et al. (1992), farm operators with sales of less than $40,000 comprised more than 67.2 percent of all operators within the state in 1990, but their combined sales amounted to only 13.1 percent of the state total. Farm operators whose yearly sales totaled $250,000 or more comprised 4.2 percent of all operators and 31.3 percent of total sales (Stout et al., 1992).

Environmental issues, particularly those surrounding surface and ground water quality, are of particular importance in the study area owing to intensive local agricultural
production as well as proximity to one of the state’s major urban centers (Camboni & Napier, 1994). The study respondents have a particular stake in the quality of ground water in the Darby Creek watershed, as about 93 percent rely on well water for household consumption (Table 12, Appendix). More than one-third (38.6 percent) of the respondents who reported using well water also indicated that the well had been tested for nitrate and pesticide contamination within the last three years. Of those who reported having the well tested, only about 2 percent indicated nitrate or pesticide problems, which suggests that agrichemical contamination of ground water is not currently a serious problem in the region.

The low incidence of water contamination helps explain why the overwhelming majority of farm operators in the Darby Creek watershed continue to rely on wells as the major source of drinking water. Even so, a number of respondents reported using purification systems or alternate sources of water to supplement well-water usage. For instance, more than 12 percent indicated using bottled water within the past five years (Table 12, Appendix). Significantly fewer of the respondents made substantial investments to secure alternative drinking-water supplies such as installing a reverse osmosis filtering system (4.9 percent); drilling a new well (3.3 percent); or securing water from a city or county water system (1.2 percent).

To further investigate farmer perceptions of risk, respondents were also asked their attitudes toward a number of statements relating agricultural production to ground water pollution in the Darby Creek watershed. As shown in Table 1, most respondents do not believe that agricultural chemicals pose a significant threat to ground water quality within the watershed, nor do they support regulatory measures that would force farmers to reduce fertilizer or pesticide applications to protect ground water reserves. By the same token, respondents were relatively neutral toward requiring periodic testing of ground water on
Table 1. Attitudes Toward Ground Water Pollution Within the Darby Creek Watershed (N=245), Presented in Percentages

<table>
<thead>
<tr>
<th>Attitude Statement</th>
<th>SA</th>
<th>A</th>
<th>Neither Agree nor Disagree</th>
<th>D</th>
<th>SD</th>
<th>Mean</th>
<th>Std Dev</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Farmers in the Darby Creek watershed should be required to reduce fertilizer application rates to protect ground water from pollution.</td>
<td>4.1</td>
<td>9.0</td>
<td>19.2</td>
<td>50.2</td>
<td>17.1</td>
<td>2.3</td>
<td>1.0</td>
<td>0.4</td>
</tr>
<tr>
<td>2. Farmers in the Darby Creek watershed who pollute ground water should not be permitted to participate in government farm programs.</td>
<td>6.9</td>
<td>31.0</td>
<td>32.2</td>
<td>23.7</td>
<td>6.1</td>
<td>3.1</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>3. Farmers in the Darby Creek watershed should be required to periodically test levels of ground water pollution on their property.</td>
<td>4.1</td>
<td>29.0</td>
<td>29.4</td>
<td>25.3</td>
<td>12.2</td>
<td>2.9</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td>4. Farmers in the Darby Creek watershed should not be required to reduce pesticide application rates to protect ground water from pollution.</td>
<td>11.0</td>
<td>28.2</td>
<td>29.8</td>
<td>26.1</td>
<td>4.1</td>
<td>2.8</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>5. Agricultural chemicals have not significantly polluted ground water in the Darby Creek watershed.</td>
<td>14.7</td>
<td>42.9</td>
<td>29.0</td>
<td>11.0</td>
<td>2.4</td>
<td>2.4</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>6. Most farmers in the Darby Creek watershed could reduce chemical application rates without significantly reducing productivity.</td>
<td>5.3</td>
<td>35.9</td>
<td>24.9</td>
<td>26.9</td>
<td>6.9</td>
<td>3.1</td>
<td>1.1</td>
<td>0</td>
</tr>
</tbody>
</table>

1 Items 1, 2, 3, and 6 were weighted 5 to 1 from Strongly Agree to Strongly Disagree; items 4 and 5 were weighted 1 to 5 from Strongly Agree to Strongly Disagree.
their property as well as toward withholding government farm-program benefits to farmers who pollute ground water.

Separate indicators were used to measure respondents’ perceived threat to health from both fertilizer and pesticide applications (Tables 2 and 3). While mean levels of perceived risk were slightly higher for agricultural pesticides than for fertilizers (means = 3.5 and 3.1, respectively), the respondents indicated relatively low levels of perceived risk for both. About 65 percent indicated that agricultural fertilizers posed little or no threat to ground water, while 57 percent indicated that pesticides posed little or no threat. The firm conclusion drawn from the findings presented in Tables 1, 2, and 3 is that most respondents do not view agrichemical usage as a major threat to ground water reserves in their home county.

Table 2. Perceived Health Threat from Agricultural Fertilizer Contamination of Ground Water in County of Residence among Primary Farm Operators (N=245), Presented in Percentages

<table>
<thead>
<tr>
<th>No Threat</th>
<th>Little Threat</th>
<th>Some Threat</th>
<th>Considerable Threat</th>
<th>Serious Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.6</td>
<td>10.6</td>
<td>28.2</td>
<td>15.5</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Mean = 3.1  Std. Dev. = 2.4  Missing Data = 0.4 Percent
Despite the relatively low levels of perceived health risk associated with agrichemical contamination of ground water, many of the respondents held positive attitudes toward personal efforts to reduce agrichemical usage in the Darby Creek watershed. For instance, more than 40 percent reported they had at some time participated in educational programming to reduce fertilizer rates while maintaining production levels (Table 4).

Because farmers’ actual involvement in educational programming may be determined by factors other than simply their desire to participate, an additional question was used to measure attitudes toward participating in related educational programs (Table 5).

<table>
<thead>
<tr>
<th>No Threat</th>
<th>Little Threat</th>
<th>Some Threat</th>
<th>Considerable Threat</th>
<th>Serious Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.3</td>
<td>8.6</td>
<td>24.5</td>
<td>16.7</td>
<td>15.1</td>
</tr>
</tbody>
</table>

Mean = 3.5  Std. Dev. = 2.3  Missing Data = 0.4 Percent

| Have participated in educational programs | 40.8% |
| Have not participated in educational programs | 57.1% |

Missing Data = 2 Percent
Table 5. Farmer Attitudes Toward Participating in Educational Programs to Reduce Pesticide Application Rates while Maintaining Production Levels (N=245), Presented in Percentages

<table>
<thead>
<tr>
<th>Very Unwilling</th>
<th>Somewhat Unwilling</th>
<th>Neither Willing nor Unwilling</th>
<th>Somewhat Willing</th>
<th>Very Willing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.1</td>
<td>2.4</td>
<td>3.7</td>
<td>3.7</td>
<td>0.8</td>
</tr>
<tr>
<td>18.8</td>
<td>3.3</td>
<td>11.4</td>
<td>23.3</td>
<td>11.4</td>
</tr>
<tr>
<td>10.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean = 6.5</td>
<td>Std. Dev. = 2.7</td>
<td>Missing Data = 6.5 Percent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the mean score for attitude toward participating in educational programs was not high (mean = 6.5), more than three-fourths (78.8 percent) of the respondents indicated neutral or positive attitudes toward participating in such programs, and nearly half (45.3 percent) indicated they were somewhat or very willing to participate.

To supplement information on farmers' participation and attitudes toward informal or periodic educational programs, respondents were also asked to provide their overall levels of formal education. As shown in Table 6, farm operators in the Darby Creek watershed are fairly well educated, as more than half indicated completion of at least 12 years of formal education, and nearly one-fourth (24.4 percent) indicated at least one year of college or other post-secondary training.
Table 6. Years of Formal Education Completed by Primary Farm Operator (N=245), Presented in Percentages

<table>
<thead>
<tr>
<th>Years</th>
<th>0</th>
<th>1-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10</th>
<th>11-12</th>
<th>13-14</th>
<th>15-16</th>
<th>17 / &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.2</td>
<td>.8</td>
<td>2.8</td>
<td>0</td>
<td>3.7</td>
<td>8.1</td>
<td>54.2</td>
<td>9.0</td>
<td>11.4</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Mean = 12.0  Std. Dev. = 3.2  Missing Data = 4.5 Percent

In addition to educational programs, the respondents have access to a variety of other sources for soil and water conservation information in the Darby Creek watershed, as indicated by descriptive data reported in Table 7. Of 17 such sources, government agricultural agencies tend to be tapped most frequently by the study respondents. About half of the respondents indicated they had received soil and water conservation information from both ASCS and SCS at least once in 1993. Other sources of information in descending order of use among respondents were Ohio State University Extension, soil conservation districts, and agricultural chemical dealers.

It is interesting to note in Table 7 that while agricultural chemical dealers rank among the top five sources according to the number of clients served, they rank in the top three according to the overall number of times they provided information to any of those clients. That is, just under 25 percent of the respondents reported receiving information from agricultural chemical dealers during 1993, while OSU Extension and soil conservation districts were used by more than 28 percent. Although agrichemical dealers reached slightly fewer clientele than either OSU Extension or soil conservation districts during 1993, they tended to interact more frequently with the individuals they did reach during this period,
Table 7. Sources of Information about Soil and Water Conservation Used by the Primary Farm Operator in 1993 (N=245)

<table>
<thead>
<tr>
<th>Information Source</th>
<th>Percent Using Source 1 or More Times</th>
<th>Sum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCS/USDA</td>
<td>51.0</td>
<td>658</td>
<td>3.80</td>
<td>4.28</td>
</tr>
<tr>
<td>SCS/USDA*</td>
<td>49.0</td>
<td>596</td>
<td>3.47</td>
<td>3.67</td>
</tr>
<tr>
<td>OSU Extension agent</td>
<td>28.5</td>
<td>322</td>
<td>1.98</td>
<td>3.66</td>
</tr>
<tr>
<td>Soil conservation districts</td>
<td>28.2</td>
<td>302</td>
<td>1.89</td>
<td>3.48</td>
</tr>
<tr>
<td>Agricultural chemical dealers</td>
<td>24.9</td>
<td>360</td>
<td>2.22</td>
<td>4.87</td>
</tr>
<tr>
<td>Other farmers</td>
<td>19.2</td>
<td>284</td>
<td>1.78</td>
<td>3.64</td>
</tr>
<tr>
<td>Mass media</td>
<td>15.9</td>
<td>289</td>
<td>1.84</td>
<td>4.20</td>
</tr>
<tr>
<td>Department of Natural Resources</td>
<td>15.5</td>
<td>103</td>
<td>.64</td>
<td>1.94</td>
</tr>
<tr>
<td>Operation Future Program</td>
<td>13.1</td>
<td>118</td>
<td>.74</td>
<td>2.10</td>
</tr>
<tr>
<td>Farm implement dealers</td>
<td>12.7</td>
<td>112</td>
<td>.71</td>
<td>2.45</td>
</tr>
<tr>
<td>Friend</td>
<td>10.6</td>
<td>97</td>
<td>.61</td>
<td>1.86</td>
</tr>
<tr>
<td>Family member</td>
<td>9.0</td>
<td>125</td>
<td>.80</td>
<td>3.21</td>
</tr>
<tr>
<td>Nature Conservancy</td>
<td>5.7</td>
<td>61</td>
<td>.39</td>
<td>1.98</td>
</tr>
<tr>
<td>Local conservation club</td>
<td>5.3</td>
<td>39</td>
<td>.25</td>
<td>1.13</td>
</tr>
<tr>
<td>EPA</td>
<td>5.3</td>
<td>77</td>
<td>.49</td>
<td>2.90</td>
</tr>
<tr>
<td>Financial officer</td>
<td>3.7</td>
<td>36</td>
<td>.23</td>
<td>1.69</td>
</tr>
<tr>
<td>U.S. Geological Survey</td>
<td>0.4</td>
<td>2</td>
<td>.01</td>
<td>.16</td>
</tr>
</tbody>
</table>

* See Footnote 11, Chapter 2.
providing information 360 times compared to 322 times for OSU Extension and 302 times for soil conservation districts. In other words, agricultural chemical dealers tended to support a relatively small but loyal client base of “repeat customers” compared to other high-ranking sources of conservation information.

A similar situation exists with regard to the use of family members and, to a lesser extent, EPA, as sources of conservation information. While family members rank 12th according to overall numbers of respondents served, they rank 8th in terms of the number of times they were tapped for such information. Similarly, EPA ranks 15th according to overall numbers of respondents using the agency as a source of information, but that position increases in importance to 13th when one considers only the number of times the agency provided information to any of the clientele.

Perceived Risk from Agrichemical Usage: Descriptive Findings

Descriptive data are provided in Table 8 for the dependent variable in this study, perceptions of risk from agrichemical usage. As discussed in the previous chapter, this research operationalizes risk as a multidimensional construct composed of nine elements that face potentially negative effects from agrichemical usage. As shown, mean values for the nine elements ranged from 2.4 to 3.9, indicating that respondents generally perceived low levels of risk from agrichemical usage. Among the nine elements, respondents indicated that applicator health was most seriously threatened by agrichemical usage, followed by water quality and wildlife. Food quality, food safety, and beneficial plants were perceived to face the least risk from agrichemical usage on the basis of mean values.

While the mean values provide one indication of the relative magnitude of risk attributed to each element, other criteria may also be used to rank the various risk situations.
<table>
<thead>
<tr>
<th>Risk Item</th>
<th>No Risk</th>
<th>Little Risk</th>
<th>Moderate Risk</th>
<th>Serious Risk</th>
<th>Mean</th>
<th>Std Dev</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Quality</td>
<td>6.1</td>
<td>8.2</td>
<td>18.8</td>
<td>26.1</td>
<td>9.8</td>
<td>10.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Food Safety</td>
<td>15.9</td>
<td>14.7</td>
<td>23.3</td>
<td>17.6</td>
<td>8.6</td>
<td>7.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Food Quality</td>
<td>20.0</td>
<td>15.1</td>
<td>21.6</td>
<td>16.7</td>
<td>6.5</td>
<td>6.5</td>
<td>4.9</td>
</tr>
<tr>
<td>Applicator Health</td>
<td>7.8</td>
<td>8.6</td>
<td>13.1</td>
<td>17.6</td>
<td>9.4</td>
<td>11.4</td>
<td>15.9</td>
</tr>
<tr>
<td>Animal Health</td>
<td>12.7</td>
<td>13.9</td>
<td>15.9</td>
<td>17.6</td>
<td>8.2</td>
<td>11.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Wildlife</td>
<td>12.2</td>
<td>15.9</td>
<td>11.4</td>
<td>15.1</td>
<td>10.2</td>
<td>9.0</td>
<td>10.6</td>
</tr>
<tr>
<td>Beneficial Plants</td>
<td>17.1</td>
<td>13.9</td>
<td>18.0</td>
<td>20.4</td>
<td>7.8</td>
<td>8.2</td>
<td>5.7</td>
</tr>
<tr>
<td>Beneficial Insects</td>
<td>13.9</td>
<td>15.9</td>
<td>14.7</td>
<td>16.7</td>
<td>8.6</td>
<td>9.8</td>
<td>9.8</td>
</tr>
<tr>
<td>Human Health</td>
<td>13.1</td>
<td>15.5</td>
<td>15.1</td>
<td>18.4</td>
<td>8.2</td>
<td>9.8</td>
<td>7.8</td>
</tr>
</tbody>
</table>
For instance, the observed variance in standard deviation scores shown in Table 8 suggests that responses tended to cluster differently around the mean values for each of the nine elements, indicating relatively less consensus on perceived risk for some of the items. As shown, responses for water quality exhibited the lowest standard deviation among all the elements (1.90), which suggests that respondents were in comparative agreement as to perceived risk, or vulnerability, to water resources from agrichemical usage. Accordingly, it is interesting to note that the comparatively high mean value for water quality (3.34) results mainly from the virtual absence of extremely low levels of perceived risk rather than a preponderance of high values. Indeed, only about one-fourth of the respondents (25.3%) indicated moderate to serious levels of perceived risk to water quality from agrichemical usage. Thus, when the nine elements are ranked again, this time according to the number of respondents indicating moderate to serious levels of risk, water quality declines in importance to sixth place, behind applicator health (39.9%); wildlife (30.2%); farm-animal health (27.8%); beneficial insects (27%); and human health (27%).

In preparation for subsequent modeling, bivariate correlations were computed to assess the direction and relative strength of association for each independent variable with the dependent variable in the study. As shown in Table 9, four of the hypothesized model’s independent variables exhibited statistically significant zero-order correlations with the dependent variable at the .05 level (two-tailed test). The variables were perceived health threat from pesticide contamination of ground water in the Darby Creek watershed (.505), attitude toward ground water pollution in the Darby Creek watershed (.395), attitude toward participation in pesticide-education programs (.192), and frequency of use of SCS as a source of conservation information (.163). As indicated by the positive direction of most correlation coefficients, all variables except the SCS information-source variable supported the model’s expectations.
Table 9. Bivariate Correlation Coefficients of Level of Risk from Agrichemical Usage and Independent Variables (N=245)

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived threat from pesticide contamination</td>
<td>.505*</td>
</tr>
<tr>
<td>Attitude toward ground water pollution in watershed1</td>
<td>.395*</td>
</tr>
<tr>
<td>Attitude toward educational programs</td>
<td>.192*</td>
</tr>
<tr>
<td>Use of SCS/USDA as information source</td>
<td>-.163*</td>
</tr>
<tr>
<td>Use of nonagricultural information sources2</td>
<td>.095</td>
</tr>
<tr>
<td>Use of nontechnical agricultural information sources2</td>
<td>.055</td>
</tr>
<tr>
<td>Use of family and peers as information sources2</td>
<td>-.022</td>
</tr>
<tr>
<td>Years of formal education</td>
<td>.010</td>
</tr>
<tr>
<td>Participation in educational programs</td>
<td>.006</td>
</tr>
</tbody>
</table>

* Significant at the .05 level, two-tailed test.
1 See Chapter 3 and Table 1 for a discussion of variables comprising scale item.
2 See Chapter 3 and Table 7 for a discussion of variables comprising scale item.

The bivariate correlations suggest that respondents perceiving the greatest risks from agrichemical usage believe that agricultural pesticides pose potentially serious risks to their families’ health and, specifically, that water quality is threatened in the Darby Creek watershed. Those perceiving high levels of risk from agrichemical usage are also favorably inclined toward pesticide-education programs. Use of SCS, a relatively technical source of conservation information, was inversely associated with perceived risks from agrichemical usage, indicating that increased exposure to SCS information reduced perceptions of risk. Correlation coefficients for the remaining variables were statistically insignificant, indicating their reported levels of association with the dependent variable occurred by chance.
Results of Regression Analysis

Multiple regression analysis was conducted as a more rigorous test of the strength of the independent variables in accounting for variance in the dependent variable. Specifically, variance in respondents' perceptions of risk from agrichemical usage was regressed against the nine independent variables to examine the degree of association between the dependent and independent variables when all of the latter were considered concurrently. Results of the analysis are presented in Table 10, which indicates that the hypothesized model was moderately efficient in predicting respondents' perceived levels of risk from agrichemical usage in the Darby Creek watershed.

Table 10. Regression Findings for Perceived Risk From Farm Chemicals (N=245), Standardized Regression Coefficients

\[
Y = 0.397x_1^* + 0.191x_2^* + 0.175x_3^* + 0.140x_4^* - 0.133x_5^* + 0.081x_6 + 0.068x_7
- 0.028x_8 + 0.008x_9
\]

Adjusted Coefficient of Determination = 0.3199

\[
Y = \text{Perceived risk from farm chemicals} \\
X_1 = \text{Perceived health threat from pesticide contamination of ground water} \\
X_2 = \text{Attitude toward ground water pollution in Darby Creek watershed} \\
X_3 = \text{Use of nontechnical agricultural sources of conservation information} \\
X_4 = \text{Attitude toward participation in educational programs} \\
X_5 = \text{Use of SCS/USDA as source of conservation information} \\
X_6 = \text{Years of formal education} \\
X_7 = \text{Use of family and peer networks as sources of conservation information} \\
X_8 = \text{Participation in educational programs} \\
X_9 = \text{Use of institutionalized, nonagricultural sources of conservation information}
\]

* Variables significant beyond the .05 level.
As noted in Table 10, five of the antecedent variables were statistically significant at the .05 level in explaining nearly 32 percent of variance in the dependent variable. Inspection of the standardized coefficients reveals that perceived health threat from pesticide contamination of ground water was the best predictor of perceived risk with a fairly strong positive effect (.397).

Attitude toward ground water pollution in the Darby Creek watershed (.191), use of nontechnical agricultural information sources (.175), and attitude toward participation in educational programs (.140) were the three next strongest predictive variables, with positive although much smaller effects. The final significant variable, use of the SCS as a source of conservation information, exhibited a negative effect on risk perception (-.133).

The five-variable model suggests that farmers who perceive that pesticide contamination of ground water threatens their family's health and those who perceive that ground water pollution is a serious problem in the Darby Creek watershed are the most likely to assess high levels of risk to agrichemical usage. Heightened levels of perceived risk from agrichemical usage are also associated with farmers' use of nontechnical agricultural sources of information, such as ASCS and Cooperative Extension, as well as their willingness to participate in pesticide-education programs, whether or not they have actually done so. Contrary to expectations, farmers who relied more heavily on SCS as a source of conservation information tended to assess lower levels of risk to agrichemical usage. The four remaining variables hypothesized by the model generated small and statistically insignificant beta coefficients, indicating that their effects on the dependent variable as illustrated in Table 10 may have occurred by chance.

**Discussion of Regression Analysis**

Of the nine independent variables hypothesized to predict perception of agrichemical risk among farm operators in the Darby Creek watershed, five exhibited statistically
significant effects. All but one of the predictive variables exerted a positive effect on the dependent variable. Only farm operators' use of SCS as a source of conservation information tended to reduce perceptions of risk, contrary to the model's hypothesis. Before concluding that the unexpected effect is inconsistent with the theoretical model, it is necessary to examine more closely the assumptions used in formulating the information-source hypotheses.

As discussed in the theoretical formulation presented in Chapter 2, social learning theory asserts that three interactive and reciprocal factors influence human decisionmaking: cognitive factors, behavioral factors, and environmental factors. The latter are of particular interest in the current discussion because the hypothesized importance of environmental factors formed the basis for the inclusion of selected information-source variables in the model. The expectation that all the information-source variables would be positively associated with farmers' perceived levels of risk is based on the dual assumptions that (1) potential risks are indeed associated with agrichemical usage, and (2) information sources included in this analysis are in general agreement as to the severity or state of agrichemical risk specifically within the Darby Creek watershed. Under such assumptions, conservation and risk information would be expected to produce a linear, or cumulative, effect on target audiences as risk messages intercepted from various sources are corroborated by mass media, interpersonal channels and other sources carrying similar messages.

The validity of the first assumption, which regards the question of risks associated with agrichemical usage, is largely supported by a multidisciplinary literature reviewed in prior chapters. While experts have not achieved universal consensus as to the actual severity or extent of agrichemical hazards, extensive scientific evidence developed over several decades has documented the potential seriousness of such risks. Because few experts would object to the conservative assertion that possible risks are associated with
agrichemical usage, there is little reason to suspect a breach of the first assumption resulted in the unexpected finding.

Turning to the second assumption, one likewise finds little reason to doubt its validity on face value. The state agencies under consideration generally are staffed by agricultural and other professionals with comparable levels of education and training. In addition to the cooperative working arrangements developed among SCS, ASCS, and OSU Extension personnel, it is important to note that inter-agency cooperation is highly institutionalized by federal and state mandates. Accordingly, it is highly likely that personnel from the various agencies may at times work closely with one another in administering programs on the local level and sharing access to educational materials and various common resources made available though the U.S. Department of Agriculture and other organizations. Certainly, the mere existence of cooperative relationships and similar missions among the agencies does not automatically suggest a convergence of opinion must also exist regarding agrichemical risks. However, recognition of such commonalities does tend to reduce the probability that the observed discrepancy in client perceptions of risk should be attributed to basic differences in philosophy or orientation among the agencies.

Still, important differences do exist among the agencies, some of which may partially account for the differences in perceived risk expressed by their clientele. As recalled from previous discussion, a notable point of difference distinguishing SCS from the other agencies is its unique role in providing on-farm technical assistance, consulting and information. While all of the agricultural agencies considered in this analysis provide information to farmers, SCS differs in that its client recommendations are likely to be based primarily on farm-level data and other local-site characteristics in addition to more general or state-level data available through other sources. The reliance of SCS on local data, coupled with its mission of on-farm technical assistance, not only sets it apart from the other agencies considered here, but may also account for the unexpected differential impact
on client perceptions of risk. That is, SCS might well assess some hazard situations differently from other agencies largely because of its access to and use of a unique data source to generate risk information and recommendations. According to this argument, contradictory statements regarding the seriousness of certain hazards result largely from the agencies’ use of different data and methods as opposed to errors in judgment or assessment techniques.

In the case of agrichemical usage, the tendency of SCS to reduce clients’ risk perceptions may be due to the agency’s determination of only slight levels of risk based on the local attributes and characteristics of the Darby Creek watershed. Indeed, evidence presented here has already suggested that ground water contamination is not currently a serious problem in the Darby Creek watershed, which would support such an evaluation. SCS information might thus be expected to influence farmers’ perceptions of agrichemical risk independently of more general risk messages owing to its technical nature and farm-level specificity. Meanwhile, other agencies considered in this analysis might reasonably continue to stress the potential hazards associated with agrichemical usage based on their use of more general risk data. For reasons discussed earlier, such information would be expected to increase audience perceptions of risk, as specified by the theoretical model.

While differences in the data used to generate risk messages may indeed provide some basis for the unexpected finding, another possible explanation can be traced to fundamental differences in farmers’ social-psychological response to various sources of information. Such an argument makes use of the reciprocal deterministic mechanism conceptualized in social learning theory whereby environmental factors may indeed exert direct influences on human behavior, but may also operate indirectly, through behavioral factors, cognitive factors, or both. In the current example, the provision of technical assistance by SCS (an environmental influence) may also serve to increase farmers’ sense of self-efficacy (a cognitive factor) in negating some of the risks posed by agrichemical usage. Cited
frequently in the risk-assessment literature (Coleman, 1993; Bandura, 1977b), self-efficacy refers to the degree of perceived self-control exercised by an individual in managing or coping with a difficult or uncertain situation. Application of this concept to the current study would suggest that the provision of technical information or assistance to farmers could provide individuals with some sense of personal control over their family’s environmental safety as they discover methods of avoiding, ameliorating or otherwise reducing agrichemical risks. Therefore, a heightened sense of self-efficacy would be expected to reduce perceptions of risk from agrichemical usage as individuals increasingly feel empowered to control their own fate in particular hazard situations.

While current discussion has focused largely on a single unexpected *reduction* in levels of perceived agrichemical risk, it is important to recall that four of the five statistically significant independent variables predicted *higher* levels of perceived risk, as hypothesized. Given the model’s relative utility in identifying correlates of agrichemical risk, coupled with farmers’ awareness of the multiple hazards that result from agrichemical usage, a final question arises as to the relatively low levels of perceived risk expressed by the respondents.

The low levels of perceived risk are surprising in that they would appear to vary significantly from those expressed by the nonfarm public. Although the current analysis does not include data for nonfarm subjects, previous discussion has documented high levels of perceived risk among consumers, who have become increasingly sensitive to safety issues regarding the quality of food, water and environmental resources (Douglas & Wildavsky, 1982). Indeed, several national surveys and Gallup polls have found that consumers believe certain types of environmental protection should be pursued “regardless of cost,” often citing agriculture as a primary culprit of environmental degradation. The heightening environmental concerns voiced by consumers through conservation organizations, political mobilization and other means⁴ raise questions as to why the current
study respondents registered such low levels of perceived risk from agrichemical usage. In addition, previous discussion has established that farm operators face many of the same risks as consumers from contamination of food and water supplies as well as substantial exposure risks from application and airborne drift. Recognition of such hazards would suggest that farm operators in the Darby Creek watershed would voice higher levels of perceived risk than indicated by the data. As argued in the following section, a partial explanation for farmers' relatively low levels of perceived risk from agrichemical usage, and for the apparent disparity between farmers' and nonfarmers' perceptions of such risk, may be found in the risk-assessment literature.

**Contribution of Risk-Theoretical Literature**

A number of researchers writing within the risk-assessment genre have argued that laypersons frequently evaluate risk phenomena using other than strictly cost-benefit criteria and related quantitative approaches favored by probability experts. As specified in prior discussion, laypersons tend to rely heavily on a number of qualitative criteria in their evaluations of various hazards, such as whether associated risks are voluntary, avoidable, controllable, and well-understood. Consideration of these criteria from the agricultural operator's standpoint is relatively straightforward and provides a unique perspective from which to analyze apparent discrepancies between farmers' and nonfarmers' assessments of risk from agrichemical usage.

First, while significant economic repercussions may result from not applying agricultural chemicals, individual producers voluntarily control decisionmaking as to whether agrichemical applications are used on their own farms. And, because of their ready access to technical experts and their wide latitude in the manners and methods used to apply chemicals, producers are also likely to judge agrichemical usage as familiar and well-understood.
Nonfarm consumers, on the other hand, are likely to view agrichemical usage as an involuntary activity over which they exercise very little control. Indeed, as previously discussed, the voluntaristic political atmosphere that has typified domestic agricultural production throughout the 1900s reserves most farm-level decisionmaking with farm operators, even when poor farm management can produce negative environmental consequences. While nonfarm populations may offset some of the risk through the use of bottled water and careful selection of chemical-free food products, such options are relatively expensive and do not address all of the possible hazards from agrichemical usage. Additionally, most consumers generally do not have a good understanding of agrichemical application procedures, nor are they aware of the precautions that most farm operators take to ensure that these materials are applied properly. It is understandable that the combination of such factors would serve to increase perceptions of agrichemical risk on the part of nonfarm publics.

While farmers and nonfarmers face similar objective risks from agrichemicals, agriculturalists generally face such risks voluntarily, with greater knowledge, and with comparatively more control than nonfarmers relative to the extent of agrichemical application in their local environment. Indeed, nonfarm consumers and farm operators arguably represent opposite extremes for nearly all of the qualitative risk factors as applied to agrichemical usage. The risk-assessment literature appears, then, to serve as a useful adjunct to social learning theory in helping explain the disparity between farmers’ and nonfarmers’ perceptions of risk. However, additional factors may also help account for the relatively modest levels of risk indicated by Darby Creek farm operators. These are discussed in the following chapter, along with related policy issues and implications for future work.
CHAPTER ENDNOTES

1 See Chapter 3 for a discussion of the factor analysis used to construct scale items for correlation and regression analysis.

2 All statistically significant variables except nontechnical agricultural information sources also exhibited statistically significant bivariate correlational relationships with the dependent variable, as shown in Table 9.

3 Owing to the complexity of such hazards, this research operationalizes agrichemical risk as a composite score of nine indicators which represent various hazard situations discussed in the literature. While the nine variables do not capture all of the possible risk situations arising from agrichemical usage, they collectively address those threats discussed most frequently.

4 Consumers are increasingly exercising economic leverage in the marketplace to sanction firms whose products and/or services are perceived as endangering the environment. A recent Roper Starch poll published in American Demographics reports that a company's environmental record is quickly gaining importance as a factor influencing consumers' decisions to purchase a product brand.
CHAPTER V
CONCLUSIONS

Social learning theory was used in this study to identify and model factors influencing farm operators' perceptions of risk from agricultural chemical usage. Results of the regression analysis revealed the theoretical model performed moderately well, explaining nearly 32 percent of the variance in perceived risk from agricultural chemical usage. The model was helpful in illuminating the causal process by which perceptions of agrichemical risks are formed. Various principles from the risk-theoretical literature also proved valuable in interpreting the findings.

Farmers in the Darby Creek watershed recognize not only the benefits but also some of the concurrent hazards posed by agrichemical usage, including contamination of drinking water and threats to wildlife. Farmers also recognize that some of the most serious negative consequences of agrichemical usage cannot be externalized. For instance, a number of hazards ranked most highly among the respondents represent risk situations most prevalent on or near the farmstead where applications take place, including risks to applicator health, wildlife and farm animals.

Despite their apparent awareness of possible health-related and other dangers associated with agrichemical contamination, farmers in the Darby Creek watershed expressed consistently low levels of perceived risk for a variety of hazard situations involving agrichemical usage. For instance, while agricultural pesticides solicited slightly higher levels of perceived risk than fertilizers, neither was viewed as a serious health or environmental hazard. Overall, then, while farmers acknowledged agrichemical usage as a
hazardous activity with the potential for negative consequences for themselves and their families, such risks were not judged to be so serious as to warrant modifying current production practices or submitting to increased regulation to ensure protection of ground water resources.

Cognitive and environmental factors hypothesized by social learning theory were shown to be particularly influential in shaping perceptions of agrichemical risks among farm operators in the Darby Creek watershed. Cognitive factors suggested by the theoretical model proved to be the best predictors of agrichemical risk. That is, farm operators who perceived high levels of risk from agricultural pesticide usage and those who perceived high levels of ground water pollution in the Darby Creek watershed were most likely to attribute high levels of risk to agrichemical usage. In addition, farmers holding positive attitudes toward educational programming on reducing pesticide application rates were also likely to attribute greater levels of risk to agrichemical usage.

Before concluding, however, that cognitive factors are the most important or powerful predictors of risk perception of agrichemical usage, it is necessary to remember that cognitive functioning may be tempered or otherwise influenced through the process of reciprocal determinism within social learning theory. The concept of reciprocal determinism is used to describe the collective influence of cognitive, behavioral, and environmental factors in understanding human decisionmaking. According to the theory, human decisionmaking and behavior emerge from what is, in essence, a complex system of “checks and balances,” whereby each factor has the potential to intensify, override or otherwise alter the effects of the remaining factors. Whether such functioning actually occurs depends on the relative strength of the factors in a given situation, including such cognitive variables as the individual’s belief structure and prior experience, and such environmental factors as access to relevant information.
In the current study, a variety of information sources operating within the Darby Creek watershed proved to be highly influential environmental factors, playing a significant role in the formation of farmers’ risk perceptions. Institutionalized sources of information, especially government agricultural agencies, were instrumental in providing conservation information, followed by agrichemical dealers and other farmers. Government agricultural agencies served not only as the most frequent sources of conservation information, but also as the most important sources in predicting farmers’ perceptions of agrichemical risks. It is likely that such agencies are favored information sources not only because of their perceived objectivity and county-level accessibility among farm operators, but also because of the current policy environment that requires farmers to work with these agencies in order to maintain eligibility for farm subsidies. As previously discussed, ASCS and SCS serve as the lead agencies for a variety of farm programs so many agricultural producers are obliged to gain some familiarity with them by necessity if not choice.

Despite the similar missions among these and other government agencies examined in this study, farmers using SCS as a source of conservation information drew significantly different conclusions about risks from agrichemical usage than from other information sources. Specifically, use of SCS as a source of conservation information was found to be negatively associated with perceived risk, contrary to expectations, while use of nontechnical agricultural sources of information tended to increase perceived levels of risk, as hypothesized. The differential nature of risks portrayed by the agencies likely results from their use of different data sources rather than from philosophical or other disagreements as to the potential seriousness of environmental issues. Nonetheless, such differences were shown to produce essentially contradictory perceptions of risk on the part of clientele, as their evaluations of agrichemical hazards were heightened by nontechnical agricultural sources of information, but reduced with use of technical information provided by SCS. The finding that SCS produced objectively different, and less severe, perceptions
of agrichemical hazards existing in the Darby Creek watershed suggests clearly that conservation information should not be viewed as a homogeneous commodity that may be acquired with the same effects from just any source.

Indeed, from a social-learning standpoint, the finding constitutes additional evidence of the importance, and complexity, of the process by which environmental factors alter individuals' cognitive responses, including their attitudes and beliefs. While information variables did play a role in shaping farmers' perceptions of agrichemical risk, the importance of this role varies greatly among individuals and tends to be limited by a number of factors out of the control of communication practitioners. For instance, farmers tend to interpret and internalize messages differently according not only to form and content, but also according to conformity or compatibility with personal experience. Attitudes, beliefs and intentions are thus formed largely on the basis of an existing cognitive orientation that is in constant flux, shaped by continual exposure to environmental sources of information, vicarious learning and individuals' own personal experiences.

While recognition of these complex processes illustrates some of the basic challenges in encouraging adoption of conservation practices at the farm level, it also suggests a number of implications for researchers, policymakers and communication practitioners.

Implications of the Study

The current study conceptualizes risk perception as a psycho-social activity whereby individuals draw liberally from their environmental and cognitive repertoire to recognize, evaluate and rank various hazard situations. Laypersons generally differ from experts in methods they use to assess risk, often incorporating qualitative, noneconomic criteria into their evaluations. As argued, the diffusion of risk information by various agencies, organizations and individuals constitutes an important avenue by which the public learns
about risk, although the mental processes involved in decoding and interpreting such information appear to be more complex than previously thought.

One erroneous assumption borne out by this study regards the notion of alleged similarity among agricultural and other government agencies in their approaches to managing public risks. While popular wisdom suggests that government agencies would use basically similar informational approaches to educate the public about various risks posed by agrichemical usage, the information sources operating within the Darby Creek watershed were shown to produce qualitatively different perceptions among clients about the nature of such risks. As previously argued, this unexpected finding should not undermine confidence in the current application of social learning theory per se, but does provide useful insight for agricultural and natural-resource researchers and practitioners in understanding the diffusion of environmental information to public audiences.

One implication of this finding is that more coordination is needed among these agencies in administering educational and information-dissemination programs. Field personnel, information staff and administrators from the different agencies perhaps need more formal avenues of communication through which increased interaction and planning might take place. It is important that clientele be made aware not only of the potential severity of agrichemical and other environmental risks, but also of possible solutions or precautions to help prevent or minimize such hazards. Collectively, the agricultural and environmental organizations examined in this study have the expertise and resources to provide effective informational and educational programs and, as previously discussed, producers in the Darby Creek watershed frequently depend on these agencies for conservation information. Given the environmental and economic implications of conservation-adoption behaviors, it is important that farm-level decisionmaking be based on the most timely and accurate data available. Evidence presented here thus suggests that agency personnel need to be more proactive in sharing information and in maintaining
communication among themselves so as to provide the most current research-based programming and recommendations to their clientele.

Another implication suggested by this research questions the common approach used in the agricultural communication literature to study farmers' information needs. As previously discussed, much of that literature has emphasized the study of audience preferences for various communication methods and does not adequately address the dynamics by which farm operators evaluate different information sources. The application of social learning theory has shown that the issue of farmers' preferred sources is of more practical importance than that of preferred methods, because the latter serve only as channels or vehicles used by a variety of different sources. Accordingly, identifying individuals' preferred methods for receiving information tells the researcher or policymaker little about the specific type or content of information being sought.

Moreover, measures intended to identify the communication methods preferred by farmers may be serving merely as proxies for preferred sources of information. For instance, farmers' stated "preferences" for mass media methods, such as those reported by Alonge and Martin (1992), may result simply because these methods are most likely to feature favored sources or specific types of information perceived most relevant and not because of a true channel preference. While other objections have been raised in the literature regarding the term *media*, the implication considered here addresses the range of human communication channels, from mass media to interpersonal methods. The central point is that an overly simplistic orientation that treats "method" and "source" as interchangeable terms not only confuses fundamentally different concepts, but also overlooks empirical evidence that shows audiences use a variety of methods in search of the types and sources of information of interest.

With this said, a number of additional issues arise in the endeavor to increase the sophistication of the informational aspects of the model. As this analysis has pointed to the
critical role played by various sources in informing risk judgments, an important question arises as to how individuals evaluate information-source characteristics and form preferences for different sources. Research is needed to understand more fully the criteria used by farm operators in judging source credibility. What source characteristics, whether real or perceived, tend to enhance credibility or trustworthiness in the eyes of the audience? For instance, producers might reasonably refer questions about conservation practices to agricultural agencies and related experts. However, what criteria might laypersons use to evaluate information sources for broader hazard situations with no clear-cut authorities, such as risks involving household radon? A related issue regards the role of channel characteristics in influencing client perceptions of source credibility. For instance, how and to what degree do the new electronic technologies influence client images of various sources? Additional research is also needed to elucidate the unique processes or mechanisms by which individuals interpret risk information. Also, how do individuals’ cognitive processes vary for risk-related information specifically sought out as opposed to information encountered casually?

Farm operators’ low levels of perceived risk concerning agrichemical usage constitute one of the more interesting findings that warrants further examination. As noted earlier, the low levels of perceived risk appear to contradict research which has consistently shown high levels of public anxiety regarding agricultural and industrial chemical usage. The complexity of agrichemical hazards is such that farmers cannot externalize all or even most of the negative consequences of agrichemical usage. Indeed, they face the same or possibly more severe hazards as their nonfarm neighbors. One explanation for the unexpectedly low levels of perceived risk was offered based on insights from the risk-theoretical literature. Application of various qualitative factors discussed in the literature provided a unique vantage point from which to compare farm operators’ and nonfarm consumers’ perspectives on agrichemical hazards. The major conclusion drawn from the comparison
between farmers and nonfarmers was that these two groups share few similarities in their relative levels of knowledge and perceived control of agrichemical usage. Nonfarmers’ relative lack of knowledge and control, compounded by frightening media reports of abstract dangers from agrichemical usage, has understandably fueled their anxiety and perceptions of risk and provides some basis for the differential hazard assessments among farmers and nonfarmers.

Additional factors may also help explain the modest levels of risk expressed by agricultural operators. For instance, it is possible that other farm-level risks simply overshadow the hazards associated with agrichemical usage. It is important to note that while various farm risks are analytically distinct, they are in practice often interrelated so that farm operators can evaluate a particular hazard only in comparison with other possible hazards to establish priorities and minimize losses. In such an instance, risk associated with agrichemical usage might willingly be absorbed to help guard against possibly more severe risks posed by inclimate weather, pest infestations or weak economic markets. Such comparisons among competing risks arise frequently not only in common vernacular, but also in the scholarly literature, as one frequently reads of various risks being ranked or otherwise prioritized according to their potential for public or personal costs. It is plausible, then, that farmers’ low levels of perceived risk for agrichemical usage are likely to be based not necessarily on the assumption that chemicals are “safe,” but simply that competing physical or economic risks pose more eminent, damaging, or immediate dangers.3

Finally, it is possible that disparities in perceived risk between farm operators and nonfarm consumers are linked to the cognitive processes by which consumers acquire and interpret information on agrichemical usage. Much of what the nonfarm public knows about agrichemical usage is learned through agricultural advertising and related commercial messages disseminated through television and radio. Such messages attempt to target farm operators as the primary audience and often stress the potency and economic efficiency of
various chemicals and chemical-related products. It is highly likely that in their attempts to boost sales, some of the advertisements have unintentionally passed along negative impact effects\(^4\) to nonfarm audiences who have become increasingly sensitive to intensive chemical usage in agriculture. Because of their limited knowledge of agricultural production practices, consumers would be expected to view such messages differently from farmers, possibly even viewing chemical applications as basically unnecessary or damaging in their effects. While unintentional, such impact effects have the potential to dramatically influence individuals’ perceptions of risks even for phenomena not explicitly mentioned in the communication (Fishbein & Ajzen, 1981).

**Concluding Statements**

While American folklore frequently glamorizes the adventurous risk-taker who narrowly avoids economic ruin or personal harm to achieve fortune and notoriety, risk-taking in the realm of personal safety is clearly unacceptable to most persons. But while our conception of rationality dictates that we not actively seek out and engage in potentially harmful behaviors (Wilson & Crouch, 1987), that is precisely what we must do everyday. There is no safe haven from risk.

The tendency of both experts and laypersons to compare and rank various risk situations derives from the truism that risk is ubiquitous and all human activities contain some element of hazard. According to this line of thought, it is more prudent to acknowledge that risk cannot be totally avoided, but that hazards can be minimized on occasion by ranking and selecting from among those risk situations that offer the lowest probability of personal harm or loss. However, substantial disagreement exists as to what situations pose unacceptable risks and how these should be dealt with in the public sphere (Douglas & Wildavsky, 1982).
The current study provides insight into the unique environmental, economic and social characteristics that influence farmers’ perceptions of risk from agrichemical usage. While much more work will be necessary to refine the theoretical modeling, the findings suggest that the mechanisms by which individuals select, rank and cope with various risks are indeed social processes mediated by the interaction of cognitive, behavioral and environmental factors. These factors also appear to account for much of the disparity noted between farmers’ and nonfarm consumers’ perceptions of risk relative to agrichemical usage. Even though farm operators comprise less than 1 percent of the total U.S. population (USDA, 1994), their perceptions of agrichemical risk and related environmental issues are of critical importance within the current voluntaristic policy atmosphere. Only by understanding the social processes and constraints that influence farm-level decisionmaking can natural-resource scientists, legislators and consumers forge policies that will help achieve the elusive goals of economic, agricultural and environmental sustainability.
CHAPTER ENDNOTES

1 Roberts and Maccoby (1985) have argued that the term *media* is far too general to capture the fundamentally different orientations and agendas of such diverse channels as radio, television, newspapers, and other informational organizations.

2 As recalled from earlier discussion, the eight qualitative criteria involve whether a given risk situation is viewed by the individual as voluntary, avoidable, controllable, familiar, well-understood, not dreaded, not potentially disastrous, and remote.

3 While more than 10 years have passed since the onset of the 1980s financial crisis in agriculture, Stout et al. (1992) report that Ohio farm operators continue to indicate high levels of personal stress and lingering doubts about the future of farming as a livelihood for their children and relatives.

4 Fishbein and Ajzen (1981) have identified three distinct cognitive processes mediating persuasive communication. *Acceptance*, they argue, involves an individual’s acknowledgment of information that tends to support existing beliefs, while *yielding* refers to an actual change in beliefs resulting from exposure to a persuasive message or argument. *Impact effects* operate indirectly by influencing beliefs not explicitly mentioned in the communication.
APPENDIX

ADDITIONAL MATERIALS
Table 11. Independent and Dependent Variables Appearing on Survey Instrument

V1. Listed below are several statements about GROUND WATER ISSUES IN THE DARBY CREEK WATERSHED. There are no right or wrong answers to any of the statements. Please circle the number that best represents the feelings of the primary farm operator about each statement. If he/she strongly agrees with the statement, circle 1. If he/she agrees with the statement, circle 2. If he/she neither agrees nor disagrees with the statement, circle 3. If he/she disagrees with the statement, circle 4. If he/she strongly disagrees with the statement, circle 5.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

a. Farmers in the Darby Creek Watershed should be required to reduce fertilizer application rates to protect ground water from pollution.

b. Farmers in the Darby Creek watershed who pollute ground water should not be permitted to participate in government farm programs.

c. Farmers in the Darby Creek watershed should be required to periodically test levels of ground water pollution on their property.

d. Farmers in the Darby Creek watershed should not be required to reduce pesticide application rates to protect ground water from pollution.

e. Agricultural chemicals have not significantly polluted ground water in the Darby Creek watershed.

f. Most farmers in the Darby Creek watershed could reduce chemical application rates without significantly reducing productivity.
Table 11. (Continued)

V2. Some people believe that agricultural pesticides have contaminated ground water to the point that human health is THREATENED in your county. Others believe that pesticides do not pose a threat. Please tell us how the primary farm operator feels about the issue. Circle the number that best represents his/her feelings about the threat of ground water pollution from pesticides to the health of YOUR FAMILY.

<table>
<thead>
<tr>
<th>NO THREAT</th>
<th>LITTLE THREAT</th>
<th>SOME THREAT</th>
<th>CONSIDERABLE THREAT</th>
<th>SERIOUS THREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V3. Has the primary farm operator ever participated in EDUCATIONAL PROGRAMS designed to reduce fertilizer application rates while maintaining high levels of productivity?

_____ Yes, _____ No

V4. How does the primary farm operator feel about participating in EDUCATIONAL PROGRAMS designed to reduce application rates of PESTICIDES while maintaining high levels of production? Please circle the number that best represents his/her feelings.

<table>
<thead>
<tr>
<th>VERY UNWILLING</th>
<th>SOMEWHAT UNWILLING</th>
<th>NEITHER WILLING NOR UNWILLING</th>
<th>SOMEWHAT WILLING</th>
<th>VERY WILLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V5. How many years of formal education has the primary farm operator completed?

_____ Years.
Table 11. (Continued)

V6. Listed below are several sources of information about soil and water conservation in your county. Please tell us the NUMBER OF TIMES the primary farm operator received information about soil and water conservation during 1993 from each source. Please enter the number of times in the space provided for each source.

- a. EPA
- b. SCS/USDA
- c. ASCS/USDA
- d. Department of Natural Resources
- e. Operation Future Program
- f. Other Farmers
- g. Agri-Chemical Dealers
- h. Soil Conservation Districts
- i. Financial Officer
- j. Family Member
- k. Friend
- l. OSU Extension Agent
- m. U.S. Geologic Survey
- n. Nature Conservancy
- o. Local Conservation Club
- p. Mass Media
- q. Farm Implement Dealers

Dependent Variable

Some people believe that farm chemicals pose a RISK to many things, while others believe that farm chemicals can be used without risk. Please tell us how the primary farm operator feels about the level of risk for each thing listed. Circle the number that best represents his/her feelings. If he/she feels that farm chemicals pose a serious risk, circle 8. If he/she feels there is no risk, circle 0.

<table>
<thead>
<tr>
<th>NO RISK</th>
<th>LITTLE RISK</th>
<th>MODERATE RISK</th>
<th>SERIOUS RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Water Quality</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. Food Safety</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. Food Quality</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d. Health of Applicator</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e. Health of Farm Animals</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f. Wildlife</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>g. Destruction of Beneficial Plants</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>h. Destruction of Beneficial Insects</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>i. Human Health</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 12. Characteristics of Darby Creek Watershed Respondents (N=245)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Descriptive Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age of Primary Farm Operator</td>
<td>50.5 years</td>
</tr>
<tr>
<td></td>
<td>S.D. = 12.7 years</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Mennonite = 23.7 percent</td>
</tr>
<tr>
<td></td>
<td>Non-Mennonite = 76.3 percent</td>
</tr>
<tr>
<td>Mean Years Operating Own Farm</td>
<td>24.8 years</td>
</tr>
<tr>
<td></td>
<td>S.D. = 13.9 years</td>
</tr>
<tr>
<td>Mean Acres Usually Cultivated</td>
<td>691.1 acres</td>
</tr>
<tr>
<td></td>
<td>S.D. = 815.2 acres</td>
</tr>
<tr>
<td>Received Technical Assistance for Conservation</td>
<td>Yes = 22.9 percent</td>
</tr>
<tr>
<td></td>
<td>No = 77.1 percent</td>
</tr>
<tr>
<td>Received Financial Assistance for Conservation</td>
<td>Yes = 15.9 percent</td>
</tr>
<tr>
<td></td>
<td>No = 84.1 percent</td>
</tr>
<tr>
<td>Mean Farm Output per Acre</td>
<td>Corn 127.4 bushels</td>
</tr>
<tr>
<td></td>
<td>S.D. = 24.2 bushels</td>
</tr>
<tr>
<td></td>
<td>Soybeans 42.0 bushels</td>
</tr>
<tr>
<td></td>
<td>S.D. = 8.1 bushels</td>
</tr>
<tr>
<td></td>
<td>Wheat 59.9 bushels</td>
</tr>
<tr>
<td></td>
<td>S.D. = 13.2 bushels</td>
</tr>
<tr>
<td>Use Well Water</td>
<td>93.1 %</td>
</tr>
<tr>
<td>Well Tested for Contamination</td>
<td>38.6 %</td>
</tr>
<tr>
<td>Nitrate or Pesticides Detected in Well</td>
<td>2.1 %</td>
</tr>
<tr>
<td>Used Bottled Water</td>
<td>12.7 %</td>
</tr>
<tr>
<td>Installed a Reverse Osmosis Filtering System</td>
<td>4.9 %</td>
</tr>
<tr>
<td>Drilled New Well to Access Uncontaminated Water</td>
<td>3.3 %</td>
</tr>
<tr>
<td>Secured Water From City or County Water System</td>
<td>1.2 %</td>
</tr>
</tbody>
</table>
Table 12. (Continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Descriptive Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farm Financial Status</strong></td>
<td></td>
</tr>
<tr>
<td>Mean Days Primary Operator Usually Works Off-Farm for Wages or Salary</td>
<td>54.6 days S.D. = 93.2 days</td>
</tr>
<tr>
<td>Mean Days Mate Usually Works Off-Farm for Wages or Salary</td>
<td>82.6 days S.D. = 105.8 days</td>
</tr>
<tr>
<td><strong>Gross Farm Income 1993 Crop Season</strong></td>
<td></td>
</tr>
<tr>
<td>Less than $24,999 = 22.0 %</td>
<td></td>
</tr>
<tr>
<td>$25,000 to $49,999 = 11.5 %</td>
<td></td>
</tr>
<tr>
<td>$50,000 to $74,999 = 9.6 %</td>
<td></td>
</tr>
<tr>
<td>$75,000 to $99,999 = 3.3 %</td>
<td></td>
</tr>
<tr>
<td>$100,000 to $124,999 = 7.2 %</td>
<td></td>
</tr>
<tr>
<td>$125,000 to $149,999 = 7.2 %</td>
<td></td>
</tr>
<tr>
<td>$150,000 to $174,999 = 4.8 %</td>
<td></td>
</tr>
<tr>
<td>$175,000 to $199,999 = 7.1 %</td>
<td></td>
</tr>
<tr>
<td>$200,000 and above = 27.3 %</td>
<td></td>
</tr>
<tr>
<td>Missing data = 14.7 %</td>
<td></td>
</tr>
<tr>
<td><strong>Farm Debt-to-Asset Ratio</strong></td>
<td></td>
</tr>
<tr>
<td>0 to 10 percent = 34.3 %</td>
<td></td>
</tr>
<tr>
<td>11 to 20 percent = 15.1 %</td>
<td></td>
</tr>
<tr>
<td>21 to 30 percent = 11.4 %</td>
<td></td>
</tr>
<tr>
<td>31 to 40 percent = 7.3 %</td>
<td></td>
</tr>
<tr>
<td>41 to 50 percent = 4.5 %</td>
<td></td>
</tr>
<tr>
<td>51 to 60 percent = 2.0 %</td>
<td></td>
</tr>
<tr>
<td>61 to 70 percent = 1.6 %</td>
<td></td>
</tr>
<tr>
<td>71 to 80 percent = 0.0 %</td>
<td></td>
</tr>
<tr>
<td>81 to 90 percent = 0.0 %</td>
<td></td>
</tr>
<tr>
<td>91 to 100 percent = 0.4 %</td>
<td></td>
</tr>
<tr>
<td>Missing data = 23.3 %</td>
<td></td>
</tr>
</tbody>
</table>
Table 13. Correlation Matrix of Dependent and Independent Variables, Darby Creek Data (N=245)

<table>
<thead>
<tr>
<th></th>
<th>ChemRisk</th>
<th>Pollute</th>
<th>PestThreat</th>
<th>ProgPartic</th>
<th>ProgAttitud</th>
<th>Fam/Peer</th>
<th>Institutional</th>
<th>SCS</th>
<th>AgNonTech</th>
<th>Educ</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChemRisk</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollute</td>
<td>.3948*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PestThreat</td>
<td>.5047*</td>
<td>.4420*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProgPartic</td>
<td>.0060</td>
<td>.0534</td>
<td>.1296*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProgAttitud</td>
<td>.1918*</td>
<td>.1546*</td>
<td>.0600</td>
<td>-.1761*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fam/Peer</td>
<td>-.0215</td>
<td>-.1746*</td>
<td>-.1291*</td>
<td>-.2067*</td>
<td>-.0097</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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* Significant at .05 level, two-tailed test.
LIST OF REFERENCES


Bradley, J. (1994). Distinguished Service Award acceptance speech. Annual meeting of the American Agricultural Editors' Association, St. Louis, MO.


