RISK RELATED EXTERNALITIES FROM APPLYING MUNICIPAL BIOSOLIDS TO AGRICULTURAL LAND

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CHAPTER 1

INTRODUCTION

Towards the end of the 1960s, concerns about environmental degradation received national attention with stories of Love Canal, various scientific studies and Rachel Carson's Silent Spring. However, through the popularity of television and a particular set of public service announcements, the image of a crying Indian on horseback surveying the polluted countryside, became firmly entrenched in the minds of a new generation of Americans. As a result of the national attention of the 1960s and 1970s, there has been a social call for greater environmental responsibility, both personally and corporately. This raises many questions for policy makers and industry leaders.

Waste is a by-product of existence. As a country develops, the economy grows and societal tastes and preferences change, prompting the public to place more emphasis on luxuries of safety and a cleaner environment. In fact, cleanliness is a major ingredient of America's civil religion, the body of values held in common by society. Health concerns are reduced and disease prevention is enhanced through promotion of a clean personal environment. As a component of environmental responsibility and development, waste disposal services are desirable in American society.

Problem Statement

One waste disposal service desired in our society is wastewater treatment. In the purification process the solids are separated from water and treated. The solids, or biosolids, accumulate and must be used or disposed of by application to the land, by incineration, by landfilling or through surface disposal. Some of the costs of municipal biosolid disposal are quantifiable while many are incorporated in complicated personal perceptions of risk. Risk perceptions are beliefs based upon an individual's personal characteristics and exposure, knowledge and bias towards a practice or technology, and thus, are difficult to measure. Risks associated with wastewater treatment, as opposed to risk perceptions, are limited and identifiable by experts, and may be said to be real. While perceptions of risk concerning wastewater treatment may be unrealistic or improbable to experts, society's beliefs or perceptions of risk exist and influence individual's behavior towards and willingness to accept various wastewater treatment technologies. Regardless of complexity, perceptions of risk embody social costs which must be considered by state and local planners evaluating the economics of biosolid disposal.

Most Oklahoma municipal wastewater treatment plants, about 60%, apply biosolids to agricultural crop and pasture land, a process considered beneficial by the Environmental Protection Agency (EPA) because of biosolids value as a fertilizer and soil conditioner. Recently, some Oklahomans have had opportunities to apply out-of-state municipal biosolids to their agricultural land thereby reducing agricultural production costs through lower commercial fertilizer needs. However, the proposition to import out-of-state biosolids has met great opposition (Associated Press, March 1992; Hutchinson; and Kimball). The question becomes, "What price are Oklahomans willing to pay to avoid municipal biosolids, and what factors influence the perceptions of risk from municipal biosolids?"

Objectives

The general objective of this study is to increase understanding of the true costs associated with the practice of applying municipal biosolids to agricultural land, while the specific objectives are to

(1) determine Oklahomans' willingness to pay to avoid perceived risks from land application of municipal biosolids, and

(2) determine factors which influence Oklahomans' perceptions of risk from the practice of applying municipal biosolids to agricultural land.

Scope and Limitations

In order to address the objectives of this study, it was determined that a survey would be an appropriate mechanism for determining Oklahomans' willingness to pay to avoid land application of biosolids and for determining which factors influence Oklahomans' perception of risk from land application of biosolids. Individuals from Alva, Fairview and Medford, communities from three northwestern Oklahoma counties, were asked to participate in this study. Researchers collected data from participants through a mail survey. The survey instrument solicited knowledge levels, perceived risk, demographic characteristics and estimates of willingness to pay to avoid land application of locally generated biosolids.

This study is limited by its static look at individual responses from each of the communities. No time series data were collected during the study. The data is limited by individual responses, therefore, excessive generalizations should be avoided. Additionally, researchers failed to analyze bias potentially created by the sequence of the questions in the survey instrument.

Outline of Thesis

Chapter 2 summarizes the background and theory literature in the areas of biosolids, economics, information, risk perception, public trust and property rights as each relates to environmental concerns. Chapter 3 describes the procedures and methods used in determining what some Oklahomans are willing to pay to avoid the application of municipal biosolids on agricultural land and in determining what factors contribute to Oklahomans' perception of risk related to land application of biosolids. Chapter 4 provides the results and analysis of the procedures and methods described previously through descriptive statistics, comparative tables and econometric analysis. Finally, Chapter 5 yields conclusions, points to policy implications and identifies areas for further study.

CHAPTER 2

THEORY AND BACKGROUND

Biosolids

Municipal biosolids are products of the municipal wastewater treatment process. Also, referred to as treated sewage sludge, biosolids are the solids, semi-solids and liquids removed from wastewater. Municipal wastewater may contain domestic wastes (soaps, human excrement, detergents, food and household hazardous wastes, such as oil or pesticides), pre-treated industrial wastewater and/or stormwater runoff (Basta). The composition of municipal biosolids depends on the composition of the wastewater and the treatment process.

As efforts to remove pollutants from wastewater have become more effective, the quantity of biosolids produced annually in the United States since 1972 has nearly doubled (U.S. EPA, 1993). Municipalities generated over five million metric tons of biosolids (dry weight basis) in 1993, or approximately 47 pounds per person per year (U.S. EPA, 1993).

Municipal treatment plants may use one or more treatment levels (primary, secondary or tertiary) for cleaning wastewater including methods to control or reduce odor. At each level of treatment wastewater is made cleaner and more biosolids accumulate.

Biosolids resemble manure and consist mainly of organic matter mixed with chemicals (alum, lime) added during wastewater treatment (Basta). Many desirable plant nutrients (nitrogen, phosphorous, sulfur, calcium, magnesium) and micronutrients (iron, copper, manganese, zinc, nickel, boron, cobalt, molybdenum) may be present in municipal biosolids and in significant quantities (Furr et al.; Sommers). In addition and depending on treatment level, *trace* amounts of heavy metals (listed in Table 2-1), household organic chemicals (from pesticides and petroleum products) and pathogens (including bacteria, viruses, protozoa, and/or eggs of parasitic worms) may be found in biosolids (Basta). As a result, the EPA in 1993 put in place restrictions banning land application of biosolids that contain high levels of heavy metals and unsafe organic chemicals (U.S. EPA, 1993).

The biosolids, or sludge, produced by the treatment process may be further treated to reduce pathogens. Some biosolids are treated "to significantly reduce pathogens" (U.S. EPA, 1993). This process may involve aerobic or anaerobic digestion, composting, air drying or lime stabilization. Biosolids receiving this level of treatment are allowed for land application. Other biosolids, or "exceptional quality" biosolids, are additionally treated, usually with heat, "to further reduce pathogens" (U.S. EPA, 1993). These biosolids are suitable for marketing to the public or for land application to public access areas (public parks, golf courses or highway rights-of-way).

Municipal biosolids may be used or disposed of through land application, incineration, landfilling and/or surface disposal. Formerly biosolids were dumped into the ocean, but that practice was prohibited by the Ocean Dumping Ban Act of 1988. However, stories of illegal ocean dumping occasionally surface in the press. Land application of biosolids is a practice where biosolids are incorporated into agricultural, forest, recreational or reclaimed soils, or are marketed to the public as fertilizer and soil conditioner. Incineration is the process of burning biosolids in an incinerator. Biosolids may be disposed of through burial in a landfill. Surface disposal is the continual piling or heaping of biosolids on a piece of land. While landfilling and surface disposal are methods of disposal acceptable for all biosolids, land application, and in some ways incineration (energy generation subject to air pollutants and ash disposal), is considered a beneficial use of acceptable biosolids by both the EPA and Oklahoma Department of Environmental Quality (ODEQ)(U.S. EPA, 1993; OAC 252:647).

Land application of municipal biosolids is considered beneficial because it allows biosolids, composed of significant quantities of plant nutrients and organic matter, to be used as a fertilizer and soil conditioner. Research shows that land-applied biosolids produces high crop yields and high quality crops similar to commercial fertilizers (Coker; Ippolito et al.; Knuteson et al.; Reed et al.). Researchers and farmers estimate large savings (up to \$15/acre) in commercial fertilizer (Chaney; Associated Press, 1992). Also, research of application of biosolids to forage and crop lands indicates that natural soil-plant-animal barriers minimize risks to livestock from the uptake of toxic trace elements, organic compounds and pathogens (Bray et al.; Cottenie et al.; Dowdy et al.; U.S. EPA, 1993). Livestock that graze forages or use crops grown on biosolids amended soils are safe for human consumption (Basta; Lue-Hing et al.). Biosolids benefit forest soils by increasing the available nutrients (Burd), organic matter (Pritchett and Fisher) and water holding capacity (Basta). Deer and elk preferentially browse plants in areas land-applied with biosolids because of the increased plant protein content (Basta). Land application of biosolids has also been effective in stabilizing and revegetating areas disturbed by mining, dredging and construction (Sopper and Kerr). Gardeners, nursery owners, landscapers and homeowners have been using "exceptional quality" biosolids as an organic technique to enhance gardens, houseplants and lawns (U.S. EPA, 1993). In addition, exceptional quality biosolids may be applied on golf courses and city parks. The White House lawn, Walt Disney World Epcot Center gardens, the Rose Bowl playing field and the grounds of Mount Vernon are other places benefiting from biosolids (U.S. EPA, 1993; U.S. EPA, 1994; Washington Suburban Sanitary Commission).

Land application of municipal biosolids is governed by both federal and state regulations. In 1993, the EPA handed down new federal regulations, codified in 40 CFR 503 (Part 503), concerning the use and disposal of biosolids. Part 503 regulations govern the use and disposal of biosolids according to their pollutant concentrations, pathogen levels and the vector attraction reduction process (a process to reduce the attraction of birds, insects and animals that can transfer pathogens and spread disease to humans) undergone (Standards for the Use or Disposal of Sewage Sludge, 1993). The federal regulations require permitting, monitoring, recordkeeping and reporting of both the character of the biosolids and the land application sites. Rates for land application are determined by the agronomic rate for nitrogen, the annual application rate designed to provide the crop nitrogen requirement while minimizing the amount of nitrogen that will pass below the crop's root zone to the groundwater (US EPA, 1993).

Part 503 regulations establish two criteria for biosolids regarding heavy metal pollutant content. Table 1 establishes pollutant ceiling concentrations and Table 3 provides maximum pollutant concentrations for higher quality biosolids (Standards for the Use or Disposal of Sewage Sludge, 1995)(See Table 2-1) Similarly there are two categories of biosolids regarding pathogen reduction processes. Class A biosolids undergo processes both "to significantly reduce pathogens" and "to further reduce pathogens", while Class B biosolids only undergo processes "to significantly reduce pathogens" (Standards for the Use or Disposal of Sewage Sludge, 1993). Additionally, Part 503 requires vector attraction requirements be met. In order for biosolids to be applied to land, biosolids must

(1) contain less heavy metals than Table 1 ceiling concentrations (Table 2-1),
(2) satisfy the Class B pathogen reduction requirements, and
(3) meet the vector attraction reduction requirements (Basta).

Biosolids that do not meet the above requirements are prohibited from land application and must be either incinerated, landfilled or be disposed of by means of surface disposal.

Table 2-1. Heavy Metal Limits and Loading Rates Governing Land-Application of Biosolids in EPA Regulations, 1995.

Pollutant	Table 1 Ceiling Concentrations (mg/kg)[a]	Table 2 Cumulative Pollutant Loading Rates (kg/ha)	Table 3 Pollutant Concentrations (mg/kg)[a]	Table 4 Annual Pollutant Loading Rates (kg/ha/365 day period)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	--	--	--
Nickel	420	420	420	21
Selenium	100	100	100	5.0
Zinc	7,500	2,800	2,800	140

Source: 40 CFR 503, 1995.
[a] Dry weight basis

Land-applicable biosolids may meet more stringent standards, commonly referred to as "exceptional quality" (biosolids with fewer heavy metals and pathogens), and thus be subject to fewer restrictions than lower quality biosolids. Beyond the requirements listed above for land-applicable biosolids, "exceptional quality" biosolids must contain fewer heavy metal pollutants than the Table 3 pollutant concentrations, and must fulfill the Class

A pathogen reduction requirements (Basta). Biosolids to be applied to agricultural, forest, reclamation or public use sites do not have to be exceptional quality. However, land that has received "exceptional quality" biosolids will not be subject to restrictions that limit harvesting and public or livestock access. In addition, the sites applying biosolids other than "exceptional quality" are bound by Tables 2 and 4 (Standards for the Use or Disposal of Sewage Sludge, 1995)(Table 2-1). Exceptional quality biosolids are exempt from these restrictions and may be sold to the public for application to gardens and lawns.

States are allowed to promulgate their own regulations governing the use and disposal of biosolids, provided the state regulations are no less demanding than the federal regulations (Standards for the Use or Disposal of Sewage Sludge, 1993). Several states, including Oklahoma, have passed more stringent regulations concerning the use and disposal of biosolids. In July 1996, Oklahoma regulations, OAC 252, Chapter 647 (Chapter 647), went into effect. Chapter 647 adopted the federal Part 503 rules and modified tolerable pollutant levels, placed more restrictions on land application practices and altered the basis for land application rates. Oklahoma is one of few states having approved sludge management plans with the EPA. The ODEQ is the agency responsible for the administration of Chapter 647 rules.

Chapter 647 encourages the beneficial use of biosolids through land application subject to protection of state water quality, protection of human health and safety and pollution prevention. While Part 503 regulations allow for land application, incineration, surface disposal and landfilling, Chapter 647 prohibits surface disposal and encourages land application. Under Chapter 647, biosolids must be land-applied or landfilled unless a municipality presents cost-effective analysis to ODEQ demonstrating less benefits than costs associated with current disposal alternatives.

Regarding heavy metal concentration levels, the Part 503 Tables 1-4 still apply (Table 2-1), however, anyone applying biosolids exceeding Table 3 pollutant concentrations must submit a "corrective action plan" for the reduction of heavy metal concentrations to normal concentrations (OAC 252, Chapter 647). In addition, the Oklahoma regulations prohibit land application of biosolids containing greater than 10 mg/kg (dry weight) of polychlorinated biphenyls, a potentially toxic organic chemical found in some pesticides.

Chapter 647 places restrictions on all land application operations regardless of the quality of the biosolids being applied. These regulations include efforts to prevent degradation of the land, to protect groundwater and surface water, to control odor, to discourage runoff, to prevent harming endangered or threatened species and to limit land application to periods of favorable weather. In addition, Oklahoma goes beyond federal regulations by requiring soils accepting biosolids have a minimum pH of 5.5. While federal regulations limit the application rate of biosolids to either the pollutant loading rate or the nitrogen agronomic rate, Oklahoma additionally limits the application rate to the phosphorous agronomic rate.

Oklahoma is the first state to simultaneously encourage the beneficial use of biosolids through land application and reduce the pollutant content of biosolids through regulation (Basta). It is important that the content of the biosolids meet federal and state regulations, that the soil accepting the biosolids be satisfactory, that the climatic conditions be suited for the practice of land application and that the manner used to apply biosolids is appropriate. By following the federal and state regulatory guidelines, land application of biosolids may meet the beneficial use expectations of both the EPA and ODEQ.

Although land application of biosolids is considered a beneficial use of biosolids by EPA and ODEQ, this practice is not without costs. In a typical land application program, the city provides for land application of the biosolids (labor, capital and management) and the land owner provides the land to accept the biosolids. The city's direct costs may include hauling the biosolids, spreading and incorporating the biosolids or injecting the biosolids, monitoring the application site, permitting and the additional treatment to the biosolids for pathogen and vector attraction reduction. However, additional costs, externalities, may exist in the form of public opposition. The benefits of lower input costs (reduced fertilizer bill) to the farmer and the benefits of lower biosolids disposal fees (cost of landfilling or incinerating) minus the municipal costs of operating a land application program approximate the net welfare to society of dealing with biosolids through land application.

Other methods of using biosolids are also costly. Marketing of "exceptional quality" biosolids to the public, another beneficial use program, requires a minimum of expensive treatment "to further reduce pathogens", transportation to a central processing facility, packaging capabilities and distribution to the public. Incineration, having some beneficial use, as biosolids may be burned for energy, requires a facility capable of incineration and energy capture and transportation to such facility. The costs of incineration also include capture of air borne pollutants and disposal of ash. Marketing and incineration may be possible options of dealing with biosolids, however, the capital outlay may prevent their feasibility in places other than great urban centers with large volumes of biosolids.

Other methods for dealing with biosolids are simply non-use methods of disposal. Landfilling is an approved method of disposing of all levels of biosolids. However, existing landfills are filling up and many Oklahoma landfills have been closed. These closures have increased landfill rates at existing landfills and increased hauling rates to find open landfills. Surface disposal, another disposal option nationally, but not allowed in Oklahoma, piles biosolids upon a piece of land or in lagoons as the biosolids terminal destination. Care must be made to select land capable of containing the city's future needs for disposal. For this option to be feasible the value of the land must be less than other methods of dealing with biosolids.

While the Clean Water Act "reserves the choice of use and disposal practices to local communities, EPA preference is for local communities to reuse this resource (biosolids) in beneficial ways (U.S. EPA, 1993)." Although the nutrient value of biosolids is best realized through some use program, the overall value of biosolids is to be determined by each community.

Economic Theory

Basic Consumer Theory[1]

Most commodities (goods or services) have a price determined by the demand for and the supply of that commodity. The quantity of a commodity one may consume is based on his or her ability to purchase the commodity (income), and on his or her willingness to purchase the commodity (utility). Income is the amount of money available to be used in the consumption of commodities and in savings. Utility is the level of satisfaction that one derives from the consumption of commodities. People attempt to maximize their utility subject to their income constraints. Individuals budget their income to satisfy their desires for food, clothing, housing, transportation, entertainment, medical services, savings and consumption of other commodities.

The price of many commodities is easily determined in the marketplace, however, the price of some desirable commodities is not readily recognizable. Such is the case with land application of biosolids. The price of land application of biosolids is determined by the cost of biosolids treatment, the cost of application, the cost of complying with regulations and the benefit to land owners in reduced input costs (fertilizer). However, externalities, other costs not directly related to biosolid treatment or application, exist. In the case of land application of biosolids, the externalities are vague and difficult to evaluate. The externalities are vague because they are based on perceptions of risk to human and environmental health, and are difficult to evaluate because of their vagueness and because human and environmental health are not easily bought and sold. Regardless of their value, externalities derived from perceptions of risk influence individuals' level of utility, and thus, affect the value of land application of biosolids.

Welfare Theory

Some Oklahomans are opposed to land application of biosolids because of

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[1] For readers desiring more background and or detail in this area, the author suggests any basic microeconomic text. For example, see Microeconomic Theory by J.P. Gould and C.E. Ferguson.

concerns for human health or environmental degradation, or because of a simple dislike of the practice or its idea. Often those opposed to this practice live in areas where little, if any, land application of biosolids occurs. Others opposed to land application of biosolids live in areas where increases in biosolids for application have been proposed. It can be argued that a resident's present level of utility in either area is higher than it would be if a future increase in land application occurred.

Hicksian compensating surplus and Hicksian equivalent surplus are two measures which evaluate a decrease in an environmental commodity (perception of risk to human or environmental health). According to Mitchell and Carson, consumer property rights determine which of the measures is most appropriate (1989). Agricultural producers providing the land for application of biosolids own the land, and they hold the property rights associated with that ownership. Presently the residents enjoy a quality of human and environmental health perceived to be better than in a situation where land application of biosolids increased. Therefore, the appropriate welfare measure for evaluating an external cost, or in this case an environmental external cost, is Hicksian equivalent surplus which is measured by *willingness to pay* to avoid a perceived decrease in environmental quality (Mitchell and Carson, 1989). Microeconomic theory of utility maximization is the basis of the modeling of this process (Varian).

The value a resident places on environmental quality is reflected in the resident's utility function:

[1] $$U1 = U1(X, Q1)$$

where U1 is the level of utility from which a change in welfare is measured, X is a vector of quantities of private goods, and Q1 is the level of environmental quality were the land application of biosolids begun or increased. The resident's current level of utility is reflected by:

[2] $$U2 = U2(X, Q2)$$

where U2 is greater than U1, and Q2 is the level of environmental quality associated with the current level of land application of biosolids (Roberts, et al).

Consider maintaining the quantity of biosolids allowed for land application given that the resident has the right only to Q1, the environmental quality with land application of biosolids. To value this change, the associated dual minimization problem will be addressed. The objective of the dual problem is to minimize total consumer expenditures to maintain a given level of utility. Minimum expenditures with land application of biosolids can be obtained by solving the problem in (3), while minimum expenditures with the current level of land application of biosolids can be obtained from (4):

[3] $$\text{Minimize } \Sigma\, PjXj \text{ subject to } U1 = U1(X, Q1), \text{ and}$$

[4] $$\text{Minimize } \Sigma\, PjXj \text{ subject to } U2 = U2(X, Q2),$$

where Pj is the price of private good j and Xj is the quantity of private good j. The solutions to these problems define the expenditure functions presented in equations (5) and (6), which by duality also define the consumer's income levels.

[5] $$E1 = E1(Pj, Q1, U1) = Y1, \text{ and}$$

[6] $$E2 = E2(Pj, Q2, U1) = Y2,$$

where Y1 and Y2 are the consumer's income levels before and after the policy decision to restrict the quantity of biosolids to be land-applied, holding U at U1 (Varian).

Therefore, the decrease in income required to maintain the resident's level of utility at U1 when Q changes from Q1 to Q2 can be defined as:

[7] $$Vi = Y2 - Y1$$

The difference, Vi, represents the maximum WTP by a resident to avoid an increase in the amount of land application of biosolids (Mitchell and Carson, 1989). This amount can be viewed as the external cost to a resident of land application of biosolids in their county.

Methods for Evaluating Non-Market Goods

The external costs of applying municipal biosolids to agricultural land (perception of risk to human or environmental health) are not valued in the marketplace, which makes them difficult to estimate. Several approaches to estimating similar external costs are the damage-avoidance approach (Raucher), hedonic price analysis (Fisher and Raucher; Havlicek, et al.), and the contingent valuation method (Mitchell and Carson, 1989; Randall, et al.). The damage-avoidance approach is based on the premise that the value of reducing expected human suffering from environmental contamination is at least as great as the expected costs of restoration, containment, or avoidance if contamination were to occur (Roberts, et al.) In the context of land application of biosolids the costs of a potential crisis are disputable and vague. Hedonic pricing methods use changes in similar property values as an estimate of the value of the external costs of pollution. However, there is a question of reliability with so few sources of data (e.g., low numbers of property sold), and it is difficult to delineate other external costs. The contingent valuation method is the measurement of total external values attributable to a particular practice including non-use values (Randall, et al.). In this study the total cost of biosolids being applied to agricultural land is of primary concern. This method allows external costs to be estimated using a survey. A hypothetical market is created and the respondents are asked to indicate the maximum amount of money they would be willing to pay to avoid an increase land application of biosolids in their county (Mitchell and Carson, 1989).

There have been several criticisms of the contingent valuation method. Participants cannot put a price on the priceless; the process is based on a hypothetical market yielding pretend values; the estimates of willingness to pay are unbounded; participants try to influence decisions by excessive bids; and others bid nothing in order to receive the benefits of those bidding (protest bids or free-riders) are a few of the criticisms of the contingent valuation method (DiBona; Kahn; Pearce and Markandya).

However, efforts can be made to improve the reality of the contingent market. Protest bids or free-riders can be identified and should be removed from the survey sample when evaluating willingness to pay (Freeman). Bids can be made more realistic by providing estimates of taxes, utility bills or other goods for comparison when making willingness to pay estimates (Mitchell and Carson, 1989).

Information

Information and its source have extremely important functions in evaluating risk perception. Rational economic behavior does not mandate that individuals always make perfect decisions, but that they learn from repeated decisions (Smith and Desvouges). Smith and Desvouges found that as information about radon increased, the subjects' perceptions of risk increased indicating a changing risk perception. The Smith and Desvouges study testifies to the importance of information, and the way that risk perceptions can be shaped by information. Researchers determined that information may be an important factor in determining an individual's willingness to pay or perception of risk regarding land application of biosolids.

An important point made by Kunreuther and Patrick (1991) is that the media is not always an accurate communicator of "true hazards." Few facts and little public education produce little more than an emotional debate over perceived environmental hazards.

Two studies emphasize the need for the public to have the information about an environmental concern and then be able to act as a community (Kunreuther and Kleindorfer; Mitchell and Carson, 1986). Kunreuther and Kleindorfer suggest a sealed bid auction mechanism where communities indicate their willingness to accept (WTA) a noxious facility. By using competitive bidding each community is able to evaluate its own perception of risk or WTA a noxious facility. The solution suggested by Mitchell and Carson is for states to specify in law the use of referenda to recognize collective property rights (1986). This allows a community to determine its own fate. This system is likely to result in a Pareto-improving outcome, a situation realizing the interests of some without forfeiting the interests of others, and greater community harmony (Mitchell and Carson, 1986).

Risk Perception

A person's values, attitudes, social influences and cultural identity influence their perception of risk (Renn, et al.). Perceptions of risk, based on various qualities and quantities of information, are a real problem confronting industry and governmental agency personnel (Hance, et al.). In the 1980s, benzene, a carcinogen, was found in

Perrier bottled water and led to an expensive effort to restore the reputation of Perrier and regain public confidence (Wandersman and Hallman). "At stake was the pristine reputation of the bubbly mineral water 'It's perfect. It's Perrier.' . . . Perrier astutely realized that these days the perception of risk is as important to the health-conscious American public as the reality of risk," stated C. Russell (p. 45). In addition, people view themselves as more vulnerable to the dangers posed by technology despite improvements in health, safety and longevity of human life (Kasperson, et. al.).

Personal knowledge generated by accurate information seems to be an important element when considering risk perceptions. As the availability of accurate information increases, perceptions of risk tend toward a more informed assessment of risk (Smith and Desvouges). This does not mean that one's belief about the risk to human health from a certain practice decreases with more accurate information, but that more accurate information concerning a practice and its possible effects on human health produces a decision based on understanding rather than on emotions. In fact, one's perception of risk may increase when given more complete information (Smith and Desvouges).

There is a definite contrast in the seriousness of risks perceived by the public and those perceived by experts (Johnson and Tversky; Mitchell; Roberts; Slovic). Experts tend to evaluate hazards using cost-benefit analysis with more complete knowledge and information (Svenson). The public perception of risk has a high impact on its reluctance to make these cost-benefit tradeoffs (Kunreuther and Patrick). "According to most risk perception studies, people give higher priority to hazards that are characterized by being catastrophic, new, imaginable, involuntary, morally bad, 'dreaded' and put children at risk," reports Malcolm Peltu, a scholar in the role of the mass media in risk communication (p.

4). "To develop acceptable public policies for managing the risks of hazardous waste, policy makers must understand why the two groups (scientists and the public) view the problem differently (Kunreuther and Patrick, p. 14)."

Several reasons have been given for differences in risk comparisons between the public and experts. Scientists tend to base their risk assessment on technological risk (probabilities and magnitude) of danger to human health, while public evaluation of risk is based on severity or degree of danger (catastrophes) and fear or dread of danger (Renn, et al.; Slovic). Some have argued that the public is uninformed, and others claim that the public acts irrationally, however, neither perspective is supported by empirical research (Slovic, et al.; Freudenberg and Pastor). Freudenberg and Pastor suggest that the public is really either selfish or prudent regarding their evaluation of risk. One other suggestion for the difference in risk determination is an apparent lack of faith in the scientific community's ability to accurately evaluate risk (Kunreuther and Patrick). Even in a technologically based society, the public's belief in technology's ability to prevent danger is low (Kasperson, et al.).

Credibility is an additional factor important in the discussion of information as it affects risk perception. An individual may be provided information based upon years of scientific research, however, he or she may choose to believe that the information is unreliable. Also, as scientists disagree on the nature of risks, the public does not know how to deal with the controversies (Kunreuther and Patrick). An individual's belief about the accuracy or reliability of information shapes their decision to accept or reject the information. In turn, this determination affects the perception of risk.

Regardless of the reasons for differences in public and expert risk determinations, the public's perceptions of risk influence their support or opposition to various practices. Public support or opposition in a representative democracy gets policy makers attention and shapes public policy.

Several methods have been considered for measuring risk perception. However, there has been little success in measuring perception of risk. The essential problem is to create a variable that has a common interpretation among all survey respondents. For example, some studies have asked respondents whether they regarded a particular practice risky (yes/no or high/low) (Roberts, et al.). This variable fails because risk is not defined among respondents. Similarly, researchers considered defining perception of risk on a subjective scale (1 to 10). This variable suffers from the same problem as the high/low risk variable. Using Slovic's empirical work on risk perception, researchers considered creating a linear scale of health and environmental risks. Participants would then be asked to indicate where on the scale participants believed land application of biosolids belonged. Such a scale would make the basis of the estimation common among all respondents, however, the proposed scale would be based on data from a small, 15 year old study with a sample likely unrepresentative of Oklahomans.

Looking further into the psychology literature, another possible way to measure perception of risk was found. Weinstein and Sandman suggest that an individual's behavior is modified by their perception of risk. For example, if an individual believes a practice is risky, then he or she will oppose the practice. The more strongly a person feels about a practice, the stronger he or she will support or oppose its use. This method of evaluating behavior is the precaution adoption process method (Weinstein and Nicolich;

Weinstein and Sandman). The problem with using the precaution adoption method to establish a perception of risk variable is that it would in some ways be a surrogate for willingness to pay because the question is predicated on the practice of land application of biosolids rather than an individual's risk perception level. Thus, the risk variable would not be an independent variable, but a dependent variable. Intuitively, the precaution adoption process method seemed most useful for evaluating one's perception of risk.

At least one study attempted to correlate demographic characteristics, respondent's age, income, sex and race, with risk perceptions, but found that "80-90% of the variation in risk perceptions across individuals is a function of that person's character rather than demographic features" (Savage, p. 419). Another study, attempting to explain risk perceptions through the use of demographic variables, found proximity to hazard and the presence of small children to be important demographic factors (Stefanko and Horowitz). The best explanation for the relationship between demographic characteristics and perception of risk from a hazard is perceived personal exposure to the hazard (Savage). Another study suggested that by focusing on word associations made by individuals when describing their support or opposition to a practice presents a clearer picture of factors influencing perception of risk (Slovic, et al.).

Public Trust

The attitude of Oklahomans concerning the issue of land applying out-of-state biosolids has been consistent with the popular "not in my backyard" (NIMBY) syndrome. The attention drawn to the land application practice from proposals to import sludge has called into question land application of local biosolids. Mitchell and Carson (1986) note that homeowner resistance to undesirable facilities has occurred for a long time, but the degree of opposition has increased. As the population has become more environmentally aware, people have focused their activity on issues affecting their neighborhoods, towns, counties and states (Armstrong-Cummings).

Property Rights

In each community, the determination of whether to land apply biosolids is subject to a land owner willing to apply biosolids to their land. The land owner has a number of rights incorporated in his or her ownership of property. The property interests, commonly referred to as property rights, are limited only by the land owner's desires and public regulation. Public regulation may take many forms including zoning restrictions, municipal or county codes, court imposed restrictions and legislative or agency regulations.

Public regulation of property creates rights in that property for so long as that property is used consistent with public regulation (Bromley). The EPA has created national regulations for the use or disposal of biosolids (Standards for the Use or Disposal of Sewage Sludge, 1993). Similarly, ODEQ has set state regulations for the use or disposal or biosolids (OAC 252, Chapter 647). Both the federal and state regulations outline the tolerable qualities of biosolids for land application, the allowable quantities of biosolids for land application, the acceptable procedures for land application of biosolids, the necessary characteristics for land where biosolids are applied and requirements for permitting and monitoring land application of biosolids practices. These regulations create a property right for a land owner choosing to land apply biosolids subject to the current state and federal regulations. As the regulations change, the rights associated with land use change.

In Oklahoma, properly permitted land owners may apply properly treated biosolids of a certain quality to their land using appropriate means (OAC 252, Chapter 647). Oklahoma land owners have the property rights associated with the land application of biosolids. However, several commodities are thought to be held in common by the public (Bromley). Several public goods associated with land application of biosolids include human health and safety, prevention of environmental degradation, clean smelling air and community reputation. These public goods are not individually owned; therefore, no property right accrues for their use or protection. However, since they are held in common, an interest in their preservation exists (Bromley). The community interest in public goods can be protected using political means to modify the rights associated with land ownership.

A driving force behind public dissatisfaction on many environmental issues relates to involuntary risk exposure (Kunreuther and Patrick). One of the ways to minimize involuntary exposure to risk is to assign aggregate property rights through a local referendum. Perhaps importing biosolids into Oklahoma, unlike using locally generated biosolids, constitutes an involuntary risk exposure because not all concerned citizens are given a voice in the decision to apply biosolids within the area. Thus, the tensions of the community are enhanced because the residents are not choosing to accept the perceived threat posed by the land application of out-of-state biosolids.

CHAPTER 3

PROCEDURES AND METHODS IN EVALUATING EXTERNALITIES

Procedures to Implement Willingness to Pay

The contingent valuation method using willingness to pay was selected to evaluate the externalities related to land application of biosolids. Willingness to pay measures all externalities from land application of biosolids, not just risk perception. Other factors captured by willingness to pay may be pride (reputation or image) and public distrust (Flynn, et al.; Hance, et al.).

The independent variable, willingness to pay, is believed to be influenced by individuals' demographic characteristics. Some of the demographic variables, respondent's age, gender, education, income, exposure to practice (community), years lived in community and number of persons living in household, were suggested by previous research (Roberts, et al.). Three other demographic factors were included to help explain willingness to pay: respondent's knowledge, relationship to production agriculture and presence of minor children in household.

Researchers addressed many of the criticisms of the contingent valuation method by basing the willingness to pay estimate on realistic factors. Participants were provided average monthly water and sewer service rates for their community (See Table 3-2), and then asked to indicate whether they were willing to pay to avoid land application of biosolids. Those that were not willing to pay anything were asked whether they supported or opposed land application of biosolids. The participants who indicated a zero willingness to pay, but opposed the practice were deemed protest bidders and dropped from the sample used to estimate willingness to pay (Freeman). The willingness to pay estimates were based on a hypothetical market evaluating commonly held commodities (perception of risk, pride or public trust), however, researchers attempted to bind willingness to pay responses to reality.

Procedures to Measure Risk Perception

The precaution adoption process method was adapted to determine perception of risk. It was important to first determine if respondents had heard of the practice of land application of biosolids. The next step in the precaution adoption process method was to determine what participant response to land application of biosolids had been. Five possible levels of activity were identified as important in determining participant perception of risk. A participant who had heard of land application of biosolids was asked which level of support best described himself. The levels of support concerning land application of biosolids were "neutral," "support," "oppose," "publicly support" or "publicly oppose" the practice of land application of biosolids. These levels formed a decision tree for evaluating participant perception of risk from land application of biosolids.

The modified precaution adoption process method gave researchers a practical way of evaluating an individual's perception of risk. However, the resulting variable, perception of risk, yielded participants' perception of risk regarding land application of biosolids, not each participant's risk perception level. As such, perception of risk is a dependent variable.

Several demographic factors were solicited from participants to attempt to explain perception of risk. The selected demographic characteristics were gender, education, presence of minor children in home and community (exposure), as suggested by previous studies (Savage; Stefanko and Horowitz). Additionally, researchers considered demographic factors, knowledge and relationship to agriculture, not found in the literature.

Researchers included a comment section in the questionnaire where participants were encouraged to state any feelings or opinions about land application of biosolids. Some research indicates that factors influencing an individual's perceptions are best identified through the word associations used to communicate their concerns (Slovic, et. al.). For example, one may express that their concern about land application of biosolids is with its potential odor. Such a comment suggests a perceived threat to their enjoyment or quality of life, rather than a threat to human health or a threat to the food or water supply. Word associations identifying factors contributing to perceptions of risk from land application of biosolids were anticipated to be collected from the open comment portion of the survey instrument.

The Model

The Variables

Dependent Variables

Dependent variables, or endogenous variables, are variables which have outcome values determined through joint interaction with other variables (Judge). Two dependent, or endogenous variables, were determined to be important in this study. Evaluating Oklahomans' willingness to pay to have municipal biosolids disposed of in an alternative way and quantifying Oklahomans' perception of risk from land application of municipal biosolids are subjective questions whose answers are contingent upon several other factors unique to each individual. The dependent variables selected to be the desired variables to address the objectives of this study were *willingness to pay* and *perception of risk*.

In order for an individual to determine his or her *willingness to pay*, he or she must consider whether they have a desire to pay, and then they must determine whether they have an ability to pay, and finally they must make some judgment as to how much they would pay to avoid land application of municipal biosolids. It is evident that an individual's *willingness to pay* is contingent on a variety of other factors.

Similarly, for an individual to evaluate his or her *perception of risk* they must consider what poses a risk, whether the risk affects them and how much risk they believe they are subjected to. Again, a variety of personal characteristics influence an individual's *perception of risk*.

Independent Variables

Independent variables, or exogenous variables, are those variables which affect the outcome of the dependent variables, but whose own values are determined independently (Judge). Independent variables, thus, are assumed to condition the outcome values of the dependent variables, but are not reciprocally affected because no feedback relation is assumed. In the context of this study, *income*, *education* and several other variables are examples of independent variables. Their values are assumed to affect the values of *willingness to pay* or *perception of risk*, while the values of *willingness to pay* or *perception of risk* are assumed to have no effect on the values of *income* or *education*.

Several independent variables were ascertained to be necessary for addressing the objectives of this study, determining factors which influence Oklahomans' perceptions of risk from land application of municipal biosolids and determining which factors contribute to Oklahomans' willingness to pay to avoid perceived risks from land application of municipal biosolids. One of the independent variables was based on participants' particularized knowledge, however, most of the independent variables selected were based on demographic characteristics of the participants.

Conceptually, the value of information was evaluated to be important in determining an individual's *perception of risk* and *willingness to pay* to avoid such risk. Therefore, it was determined to be a necessary component of the model. It is difficult to assess an individual's actual knowledge regarding the subject of land application of biosolids. However, some estimator was needed to determine if an individual's *willingness to pay* or *perception of risk* were influenced by an individual's actual knowledge. The independent variable, *knowledge*, was used to estimate the respondents' level of understanding about the practice of land application of municipal biosolids.

Several demographic characteristics were determined to be necessary for analyzing either *willingness to pay* or *perception of risk*. Four typical demographic variables, *age*, *gender*, *income* and *education*, were chosen because of their suspected influence on *willingness to pay* and *perception of risk*. *Age* was selected to discern any relationship between respondents of similar age and their *willingness to pay* and *perception of risk*.

Gender was selected to distinguish gender influences on *willingness to pay* and *perception of risk*. *Income* and *education* were selected because income levels and education levels are expected to affect *willingness to pay* and *perception of risk*.

Five other demographic characteristics were chosen to help explain participants' differences in *willingness to pay* and *perception of risk*. These demographic characteristics, while less traditional, seemed especially important in the context of evaluating the externalities associated with land application of municipal biosolids. It was determined to be important to know more about the composition of the household, specifically the *number of persons living in the home* and the *number of children living in the home*. Also, determined to be important was the *community* where the participant resided, the *length of time* the participant had been a resident of that county and the participant's involvement in *production agriculture*. These five factors, *number of persons living in the home*, *number of children living in the home*, *community*, *length of time* and *production agriculture*, were specifically selected because of their suspected influence on *willingness to pay* and *perception of risk* related to land application of municipal biosolids.

Associated with the respondents relationship to production agriculture, four additional independent variables were believed to be relevant. Those included size of agricultural operation, both by *number of acres* and *number of livestock*, prior experience with land-applied livestock *manure* and previous experience with land-applied municipal *biosolids*. These independent variables, *number of acres*, *number of livestock*, *manure* and *biosolids*, were evaluated only on those who were involved in production agriculture.

The ten independent variables, *knowledge*, *age*, *gender*, *income*, *education*, *number of persons living in the home*, *number of children living in the home*, *community*, *length of time* and *production agriculture*, constitute the basic independent variables of the models for *willingness to pay* and *perception of risk*. In addition, a minor model using only those respondents with agricultural involvement included the additional agricultural independent variables, *number of acres*, *number of livestock*, *manure* and *biosolids*. It was determined that the independent variables selected could be used to best explain the variation in *willingness to pay* and *perception of risk* among all respondents and among those participants involved in production agriculture.

The Models

The range of responses to the dependent variables in this study are limited by the response options available. Considering the average monthly water and sewer rate for individuals from each community is less than $25 (See Table 3-2), monthly *willingness to pay* estimates are expected to be less than $25 with many respondents selecting zero. Thus, the range of *willingness to pay* estimates should be fairly limited (between $0 and $25) and concentrated around zero. Similarly, *perception of risk* estimates are limited, as there are only five possible risk perception levels for participants who have heard about land application of biosolids. These limited dependent variables require using methods other than least squares to obtain asymptotically efficient estimates.

Two models will be used for econometric analysis of the survey data. The tobit model with selectivity will be used to analyze the *willingness to pay* estimates, and the ordered probit model will be used to analyze the *perception of risk* estimates. These two models will help researchers address some of the problems confronting limited dependent variables.

The tobit model with selectivity is used when dependent variables are bounded and bunched at either end of the estimate range (Judge, et al.). The *willingness to pay* estimates are expected to be concentrated near zero. Additionally, the dependent variable, *willingness to pay*, is only observable when the estimate is zero or some positive value. Least squares estimates produce biased and inconsistent estimators where the dependent variable is limited (Judge, et al.). However, the tobit model uses maximum likelihood estimates to provide asymptotically efficient estimates (Kennedy). Selectivity means that the samples used in the model are those samples with a probability of a given response. For example, the samples selected for the tobit model were those with the probability of *willingness to pay* not being a protest bid. The tobit model then estimates the probability of an expected *willingness to pay* value.

The ordered probit model is useful when dependent variables are both dummy variables and ordinal, continuous variables (Kennedy). The dependent variable, *perception of risk*, is based on whether a participant has heard of land application of biosolids (yes = 1; no = 0). The next step is to determine the participant's behavioral response to having heard about land application of biosolids. Participants were asked to indicate whether they "publicly supported (0)," "supported (1)," "had formed no opinion (2)," "opposed (3)" or "publicly opposed (4)" land application of biosolids. The ordered probit model, using maximum likelihood estimates, examines the probability of an individual's *perception of risk* from land application of biosolids.

The software, LIMDEP, was chosen to analyze the tobit with selectivity and the ordered probit models. This software is specially marketed for analyzing models with limited dependent variables.

The Survey

The Sample

Oklahomans have had various levels of exposure to land application of biosolids. Many towns land-apply biosolids. Several proposals have been made to export biosolids to Oklahoma for application to agricultural land. The experience with and attention to this practice are varied across the state. Some communities, both urban and rural, participate in land application programs, other communities have no relationship to this practice. Proposals for land application of out-of-state biosolids have received statewide media coverage (Associated Press, March 1992; Hutchinson). However, those areas targeted for accepting the biosolids have had significant attention directed toward the practice of applying biosolids to land, both from local press, town meetings and citizen groups (Dobbins; Hutchinson).

The Population

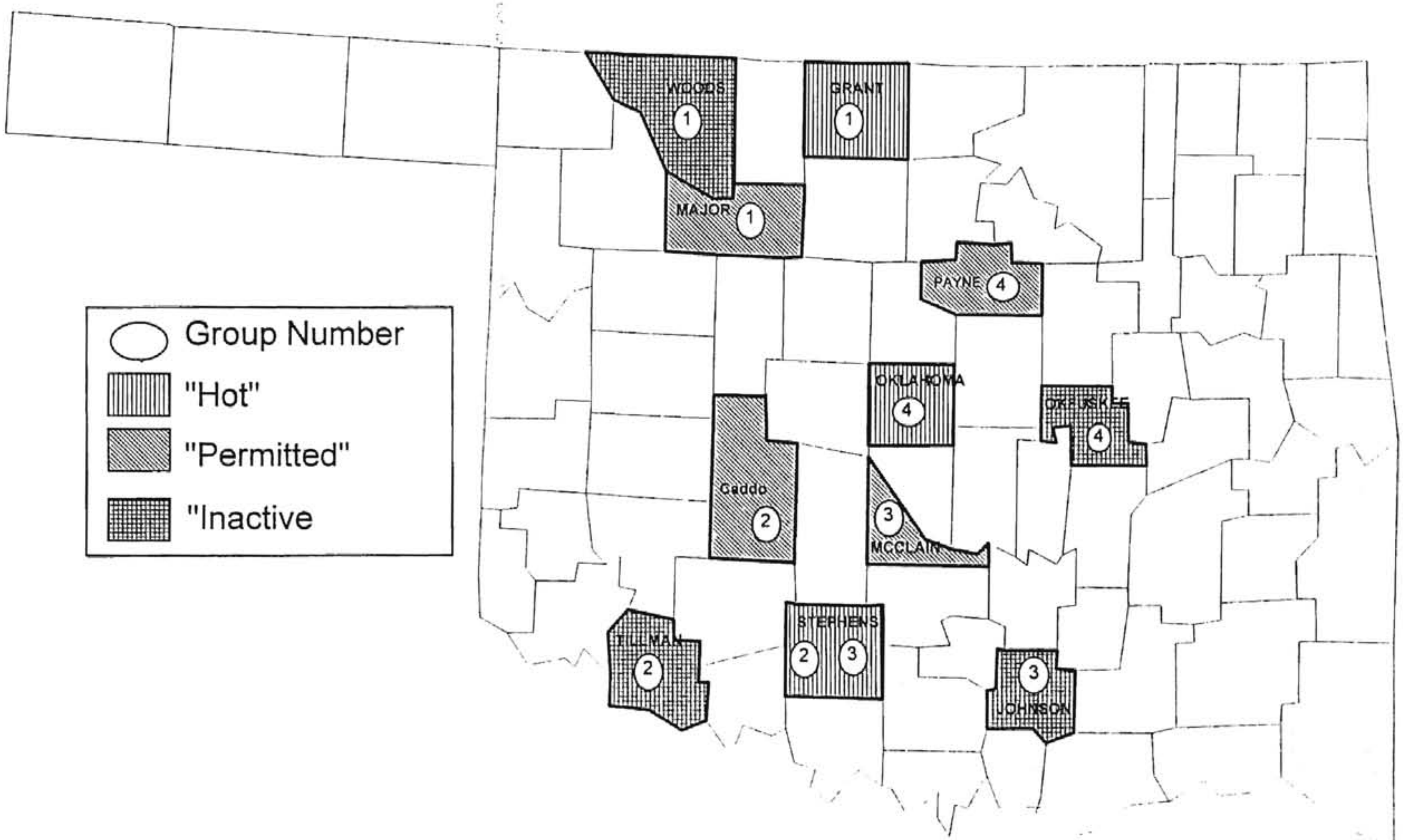
In order to capture the various levels of exposure to the practice, or proposed practice, of applying biosolids to agricultural land, the survey sites were carefully chosen. Three levels of exposure were identified: "hot", "permitted", and "inactive". Counties were categorized with respect to exposure to land application of biosolids programs. Counties previously exposed to proposals to accept foreign (not locally generated) biosolids for land application comprised the "hot" category. Counties with towns where land application programs are permitted by ODEQ constituted the "permitted" category. And, counties with towns having no land application permits, nor proposals to accept biosolids for land application made up the "inactive" category. These categorizations distinguish counties by their exposure to the practice of land application of biosolids.

To determine which areas to survey, "hot", "permitted", and "inactive" counties were grouped by geographic region, primary industry and population. Four possible survey populations were identified and grouped together (See Figure 3-1). Each of the possible survey population groups included one "hot" county, one "permitted" county, and one "inactive" county.

Because of their demographic similarities Grant, Major, and Woods Counties were chosen to be the survey population. Medford (Grant County), Fairview (Major County), and Alva (Woods County) were the towns specifically chosen as the survey population. These communities have important demographic similarities: rural, northwestern Oklahoma setting; similar population levels, less than 7500 people; and a common economic base, wheat farming and ranching.

Other possible survey population groups were not chosen because of drastic differences in size of communities between the counties, differences in economic bases between the counties and differences in type of agriculture between the counties. However, the other groups of counties offered one advantage not fully captured by Grant, Major and Woods Counties. The counties in the other possible survey population groups share no common county lines, thus, they offer no buffer zone against public sentiment from other counties towards various exposures to land application of biosolids. Even so, researchers felt that the benefits of sentiment insulation did not outweigh the demographic

Figure 3-1. Four Groups of Counties for Possible Survey Population in Biosolids Survey, 1995



Source: Hodges, D.C. "Database of Oklahoma Counties with Permitted Land Application of Biosolids Program." Letter. 1995 differences mentioned earlier. The selected survey population does have some insulation against public sentiment towards the various exposures to land application of biosolids, as Major and Woods Counties share no common county lines with Grant County, the "hot" county in the selected group.

The survey sample consisted of residents from Alva, Fairview and Medford, Oklahoma. Each of these communities is on the high plains of northwestern Oklahoma, and each community is the county seat of their respective county. Northwestern Oklahoma is predominately rural and sparsely populated, less than ten persons per square mile (Oklahoma Almanac). The major industry in the region is agriculture and the major crops are wheat, livestock and grain sorghum (Oklahoma Almanac). Besides each communities' different exposure to land-application of biosolids, the communities were selected because of their similarities (See Table 3-1). These communities each have a similar economy, geography, population and culture.

Alva, the county seat of Woods County, is the largest of the three communities sampled. In 1990 the population of Alva was 5,492, and more than 25% of the population over 25 years old held a bachelor's degree or higher (U.S. Census). The median household income was $18,957 and per capita income was $11,479 for Alva in 1989 (U.S. Census). North West Oklahoma State University (NWOSU) is located in Alva, and provides employment opportunities for the community. Some manufacturing and tourism to Little Sahara Recreation Area and NWOSU also contribute to the local economy. However, agriculture is the primary industry (677 farms in the county) with 90% of the county land used in farming (Oklahoma Almanac). Although larger than many communities in northwestern Oklahoma, Alva is representative of the area's rural culture.

Table 3-1. Demographic Statistics from 1990 and Income Statistics from 1989 for Three Oklahoma Communities.

	Alva	Fairview	Medford
Age (% of population)			
< 20 years	26.4%	28.7%	25.2%
20 - 39 years	30.4%	21.7%	23.8%
40 - 59 years	16.9%	20.5%	21.0%
60 + years	26.3%	29.0%	30.1%
Gender (% of population)			
Male	47.7%	45.2%	47.2%
Female	52.3%	54.8%	52.8%
Household Population (% of persons per household)			
1	35.0%	29.3%	32.2%
2	36.1%	35.2%	35.9%
3	12.9%	12.7%	14.5%
4	10.4%	16.8%	12.2%
5 +	5.6%	6.0%	5.2%
Household Population of Children (% of households with minor children)			
w/Children	24.0%	33.4%	28.4%
w/o Children	76.0%	66.6%	71.6%
Average Children (# per household with minor children)	2.0	2.0	1.8
Single Parent Families (% of families with minor children)	19.9%	18.5%	17.0%
Education Level (% of population 25 years or older)			
High school graduates or higher	74.7%	66.5%	78.6%
Bachelor's degree or higher	25.9%	15.3%	16.5%
Household Income (% of households per income level)			
< $25,000	61.5%	56.6%	62.0%
$25,000 - $49,999	26.5%	35.7%	26.3%
$50,000 - $74,999	8.8%	5.0%	8.5%
$75,000 +	3.2%	2.7%	3.3%
Median Household Income	$18,957	$21,750	$18,958
Per Capita Income	$11,479	$10,630	$11,584
Households with Self-Employed Farmers (% of households)	9.9%	11.5%	15.8%
Same County of Residence in 1985 (% of population 5 years or older)	74.6%	80.3%	87.6%

Source: U.S. Census, 1990: Census of Population and Housing [CD-ROM]. (1990). Oklahoma Census. Available: 1990 Census of Population of Housing Summary Tape File 3A File: Oklahoma Census.

Fairview is the county seat of Major County. The population of Fairview in 1990 was 2,805, and the average per capita income for 1989 was $10,630 with a median household income of $21,750 (U.S. Census). Similar to Alva, the predominant industry in the Fairview area is agriculture, however, there is some manufacturing and tourism to Glass Mountain State Park. Greater than 80% of the land in Major County is used in farming with the average farms of 583 acres (Oklahoma Almanac). Fairview, like Alva, seems typical of northwestern Oklahoma communities.

Medford, the county seat of Grant County, is the smallest of the communities sampled. According to the 1990 census, the population of Medford was 1,159, and the median household income in 1989 was $18,958 (U.S. Census). More than 75% of Medford residents (older than 25 years) were at least high school graduates (U.S. Census). Once again, the primary industry of Grant County is agriculture with more than 90% of the land used in farming (Oklahoma Almanac). Although Medford is smaller than Alva and Fairview, there are several similarities.

Alva, Fairview and Medford each seem to be representative of communities and people in northwestern Oklahoma. The average income levels of the three communities were similar. Each community shared agriculture as a common economic base. Although the population of the communities was different, each community was the seat of county government for their county, and each community was the largest community in their county. Researchers believed that the demographic characteristics of Alva, Fairview and Medford were similar enough that most of the variation in responses between the three communities could be attributed to their exposure to land-application of biosolids.

The Individuals

The residents of three northwestern Oklahoma communities, Alva, Fairview and Medford, were selected as the survey population for this study. Researchers determined, based on time and resources, that about 300 residents from each community were needed to participate in the survey. Because of the nature of the issue, wastewater and biosolids, and the need for similar information, names and current addresses, from each community, it was suggested that the water and sewer customer list for Alva, Fairview and Medford would be a useful source.

In March 1995, researchers(author and Dr. Pat Norris) met with the city managers of Alva, Fairview and Medford to discuss the possibilities of using the water and sewer customer lists for the survey. Prior to the meetings, city managers received draft copies of the survey instrument and cover letters for the survey participants. Another reason for meeting with the city managers was to obtain estimates of average city water and sewer bills. The city managers agreed to allow researchers to use the city water and sewer route lists and to provide average monthly, residential water and sewer rates for their communities (See Table 3-2).

Table 3-2. Average Monthly Residential Water and Sewer Service Rates for Three Oklahoma Communities Participating in the Biosolids Survey, 1995.

	Water	Sewer	Total
Alva	$13.53	$2.05	$15.58
Fairview	$11.83	$4.85	$16.68
Medford	$14.00	$8.00	$22.00
Average	$13.12	$4.97	$18.09

Source: Average monthly water and sewer service rates provided by the city managers of Alva, Fairview and Medford, Oklahoma in March 1995.

About 300 residents from each community were selected to receive the survey materials (cover letter, instrument and necessary reminders) and to participate in the survey. Each household chosen was randomly selected from each neighborhood in each community. This was done so that a cross-section of the entire community would be represented in the study. Researchers, using the water and sewer service lists that had been divided into service routes, determined the number of households to be represented in the survey from each route in each community. Then using a list of random numbers, researchers selected residents from each route in the water and sewer service lists for the survey sample. Commercial businesses were not included in the survey sample, nor were those residents who were not receiving either city water or sewer service.

The use of the water and sewer service routes in selecting the survey sample provided researchers with current residents and addresses, allowed researchers to concentrate on households, rather than commercial businesses, and helped researchers target those individuals responsible for paying for the use or disposal of biosolids. One of the main advantages of using the residential water and sewer lists was the ability to tether participants' willingness to pay estimates to their real costs of water use and biosolids use or disposal. The opportunity to encourage realistic willingness to pay estimates is not dependent on the use of water and sewer service route lists, but it does provide credibility to the study, as responses from non-customers will not be solicited.

However, there were some limitations associated with using water and sewer customer lists as a source. Researchers were not able to differentiate between residents owning their homes and those renting. Biosolids use or disposal may create a stakeholder's interest in the party contributing to biosolids accumulation, provided that individual or household is paying for water and/or sewer service. Often landlords pay for water and sewer service for rental property. Another limitation of using the residential water and sewer service route lists is that commercial business are not included when they, too, are stakeholders in community decision making regarding biosolids use/disposal. Even so, responses from commercial businesses would not be easily adapted to responses from community households. In addition, some business owners concerns may be captured through residential sampling.

The Instrument

The survey instrument began with a paragraph describing biosolids and the practice of land application. Four basic sections, ascertaining participant information level, risk perception level, willingness to pay to avoid land application of biosolids and demographic characteristics, comprised the survey instrument. Also, included was a sub-section, highlighting participant involvement in production agriculture, a place for comments and a place to request more information on land application of biosolids (See APPENDIX A). The survey instrument was printed in booklet form with the title of the survey and a picture on the cover. Researchers limited the length of the survey instrument to both sides of four pages.

The purpose of each question was clearly explained and the directions for completing each section were set off in bold print. Each answer was printed in capital letters, and in an effort to increase response rates and decrease intrusiveness, answers to requests for personal information (age, income and education) were in the form of groups (Dillman; Mitchell and Carson,1989).

The first section in the survey booklet included a battery of six questions seeking to ascertain each participants level of accurate knowledge regarding biosolids and the practice of land application. The questions were statements requiring a true-false response. The questions were the same for each community, however, the correct response to the first question depended on the participant's community. The correct response to the other questions was the same for all communities. To evaluate a respondents level of accurate information, a score would be generated for each respondent based on the accuracy of their responses to the six questions.

The second section of the survey instrument used the precaution adoption method to determine risk perception levels. Participants were asked to choose which of six statements best described their familiarity and response to land application of biosolids. Respondent perception of risk level was based on the statement with which each best identified.

In the third major section of the survey booklet, researchers attempted to create a contingent market. First, respondents were provided with the current average monthly water and sewer service rates for their community from Table 3-2. Respondents were asked to consider these figures when responding to the fourth major section. The respondents were then asked to indicate the highest amount that their household would be willing to pay each month to have biosolids disposed of in another way. The three options were:

- "We are not willing to pay more, and we are not opposed to land application of biosolids.", or
- "We are not willing to pay more, but we are opposed to land application of biosolids.", or

- "We would be willing to pay $__ more monthly to have biosolids disposed of in another way."

These responses were used to determine each respondents willingness to pay to avoid land application of biosolids.

The final major section of the survey booklet sought a variety of demographic characteristics from each respondent. Participants were asked to specify their age, gender, education level and income level. This section also asked participants to indicate the number of people living in their home, the number of minor children living in their household, the number of years that they had been living in the current county and their involvement in production agriculture. An individual's involvement in production agriculture was a purely subjective determination, as this term was intentionally undefined by researchers. The responses to this section provided valuable demographic information, useful in evaluating the representative capability of the survey sample and in determining which factors influence a respondent's perception of risk and willingness to pay to avoid land application of biosolids.

If participants affirmed their involvement in production agriculture (a subjective determination), they were asked to complete a subsection regarding their relationship to production agriculture. This subsection asked participants to indicate the kind (crop type) of production agriculture with which they were involved, the size (acres and/or head of livestock) of their farm or ranch operation and whether they had ever land-applied livestock manure or municipal biosolids.

Following the subsection on production agriculture, one blank page was provided for all participants to express their feelings about the practice of land application of biosolids or to make any comments about the survey. Respondent comments were recorded for analysis.

On the back of the survey booklet a place was provided for participants to request more information on land application of biosolids or to request a summary of the survey responses. A list of those requesting either more information or a survey summary was compiled and they will receive such upon conclusion of this study.

The Procedure

Before the questionnaires were sent to the selected residents of Alva, Fairview and Medford, researchers pre-tested the survey (Dillman). About 35 university students and 10 family members and friends participated in the pretest. The results of the pretest demonstrated understanding of the four basic sections, information, risk perception, willingness to pay and demographics. The pretest identified no major problems with the survey instrument. However, most of the pretest participants had little or no exposure to land-application of biosolids.

The questionnaires were originally mailed to the survey sample in June 1995. Each mailing included a cover letter introducing researchers, the practice of land-application of biosolids and study objectives and expressing appreciation to those choosing to participate (See APPENDIX B). Also, included in the first mailing were booklet copies of the questionnaire and postage paid return envelopes. The return envelopes were coded so that those completing the questionnaire would not be sent follow-up reminders.

It was suggested that postcards, thanking those who had participated and reminding those who had not, be sent shortly after the original mailing (Dillman).

Researchers sent such postcards two weeks after the original mailing to those from whom researchers had not received responses (See APPENDIX B).

As questionnaires began being returned, researchers began to mark those responding on the survey sample list. There were a considerable number of postal returns, a few from Alva (6) and Medford (4) and several from Fairview (24). Several reasons were given for postal returns, such as, wrong address, moved, deceased and several others. As it was early enough in the survey process, researchers were able to replace those individuals for which postal returns were received with the next individual on the water and sewer service lists.

In July 1995, two weeks after the postcard reminder had been sent, researchers conducted another mailing. The replacement individuals were sent an original cover letter, a copy of the questionnaire and a coded, postage paid return envelope. At the same time, researchers mailed new cover letters, reminding and encouraging non-respondents to complete the questionnaire, replacement questionnaires and coded return envelopes, as suggested by Dillman (See APPENDIX B).

In mid-September 1995, several months after the original mailings, another cover letter, another replacement questionnaire and another return envelope was mailed to each non-respondent. The cover letter informed non-residents that their questionnaires had not been received, emphasized the importance of their participation and thanked them for their prompt return of the completed questionnaire (See APPENDIX B).

The Returns

Approximately 900 residents from Alva, from Fairview and from Medford were selected as the survey sample (about 300 from each town). Each of the individuals selected were originally mailed cover letters, explaining the need for their participation, questionnaires and return envelopes, and were later mailed follow-up reminders and letters. The overall response rate for the survey was just over 35%. Several responses received by researchers were non-useable, such as, postal returns, responses indicating the death or incapacitation of survey sample members or respondents sending items rather than the questionnaire in the return envelope (for example, a credit card application). These 26 non-useable responses were subtracted from the selected survey sample (900) producing a modified sample number. The number of responses was divided by the modified sample number yielding a modified response rate of 38% (See Table 3-3).

Table 3-3. Modified Response Rates for Participation in Biosolids Survey from Three Oklahoma Communities, 1995.

	Original Sample (#)	Non-Useable Responses (#)	Modified Sample (#)	Useable Responses (#)	Modified Response Rates
Alva	304	10	294	119	40%
Fairview	298	19	279	98	35%
Medford	298	7	291	108	37%
Total	900	36	864	325	38%

Source. Summary of responses to study survey.

Alva had the highest response rate with more than 40% of the modified Alva sample responding. Medford and Fairview followed with modified response rates greater than 35% (Table 3-3). An interesting aspect of the response rates occurs when calculating the percentage of the community population comprising the survey sample For instance, over 50% of Medford households were sampled, while less than 15% of Alva households were part of the survey sample (See Table 3-4). When response rates are calculated using the number of households of a community, the response rates indicate the ability of the sample to represent the population.

Table 3-4. Households Included in the Survey Sample and Households Responding to the Questionnaire in Biosolids Survey for Three Oklahoma Communities, 1995.

	Households in Survey Population (#)	Modified Sample (#)	Households of Population in Sample	Useable Responses (#)	Response Rate of Households in Survey Population
Alva	2,288	294	13%	119	5%
Fairview	1,132	279	25%	98	9%
Medford	518	291	56%	108	21%
Total	3,938	864	22%	325	8%

Sources: Summary of responses to study survey, and U.S. Census, 1990: Census of Population and Housing [CD-ROM]. (1990). Oklahoma Census. Available: 1990 Census of Population of Housing Summary Tape File 3A File: Oklahoma Census.

As questionnaires were returned, researchers and staff recorded the responses in a database. dBase III was the software used for recording the data. Researchers verified the data upon conclusion of data entry (December 1995) and again prior to analyzing the data (June 1996).

CHAPTER 4

RESULTS AND ANALYSIS

Introduction

During the summer and fall of 1995, researchers, attempting to evaluate Oklahomans' willingness to pay to avoid land application of biosolids and to determine factors influencing Oklahomans' perception of risk from land application of biosolids, selected approximately 900 individuals from three Oklahoma communities to participate in a mail survey. Response rates to the survey reached nearly 40%. The survey instrument comprised several sections including a battery of questions ascertaining knowledge about biosolids and the practice of applying biosolids to agricultural land, a section identifying risk perception levels, a section evaluating willingness to pay, a battery of questions on demographic characteristics, a subsection for those involved in production agriculture and a place for comments.

Survey responses indicate a similar sample among residents from each of the three communities. The average, or mean, responses are summarized in Table 4-1 and provide a profile for the average respondent from Alva, Fairview and Medford.

The profile of the average respondent from Alva indicates an individual willing to pay $1.91 per month to avoid land application of biosolids and has formed no opinion regarding land application of biosolids (neutral). The typical respondent was female between 40 and 59 years of age with a college degree. She scored 67% on the knowledge battery of questions. There were three persons in her household, one of whom was a minor. This individual had an annual household income between $20,000 and $39,999, had lived in Woods County for nearly 30 years and was not involved in production agriculture.

Table 4-1. Mean Descriptive Statistics for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Alva	Fairview	Medford
Willingness to Pay* ($ per month)	$1.91	$1.81	$2.78
Perception of Risk (category)	formed no opinion	formed no opinion	formed an opinion
Knowledge (% correct)	67.1%	59.4%	65.0%
Age (years)	40-59 years	40-59 years	40-59 years
Gender (male/female)	female	female	female
Household Population (# per household)	2.5	2.5	2.4
Household Population of Children (# per household)	0.6	0.6	0.6
Education Level	college degree	some college	some college
Income Level (annual $ per household)	$20,000 - $39,999	$20,000 - $39,999	$20,000 - $39,999
Years in County (# of years)	29.7	26.9	33.8
Involvement in Production Agriculture (yes/no)	no	no	yes
Type of Crop	cattle, field crops, hay	cattle, field crops, hay	cattle, field crops
Size of Agricultural Operation (# of acres)	1068.7 acres	868.3 acres	594.7 acres
Size of Agricultural Operation (# of head of livestock)	316.6 head	169.8 head	190.3 head
Experience with Spreading Manure (yes/no)	no (56.8%)	no (55.2%)	no (57.7%)
Experience with Land Application of Biosolids (yes/no)	no (94.6%)	no (96.6%)	no (94.2%

Source: Summary of response to study survey. * Protest bids were omitted.

A profile for the average respondent from Fairview was willing to pay $1.81 per month to avoid land application of biosolids and reported a neutral risk perception level (formed no opinion). The demographic profile for Fairview was very similar to that of Alva. However, the average Fairview respondent scored only 59% on the knowledge battery of questions, had attended but not completed college and had lived in Major County for over 25 years.

The Medford profile while similar in many respects to the Alva and Fairview profiles, was quite different in other respects. The average Medford respondent was willing to pay as much as $2.78 per month to avoid land application of biosolids and responded that they had formed an opinion about land application of biosolids. More often than not, they opposed land application of biosolids. The profile of an average Medford respondent was female between 40 and 59 years of age and scored 65% on the knowledge battery of questions. Her household had an average annual income between $20,000 and $39,999 and a population of three, one of whom was a minor. She had attended college, but had not completed a degree. She had been a resident of Grant County for nearly 35 years. Someone in her family was involved in production agriculture, raising field crops and 190 head of cattle on nearly 595 acres. Her family had no experience in applying livestock manure or biosolids to the land.

These profiles are generalizations, however, they do provide useful information for evaluating the sample with respect to the population. Comparing Table 3-2 with Table 4-1 illustrates the representative ability of the survey sample to speak for the population of Alva, Fairview and Medford. The average respondent profiles from the different communities show some of the differences in common attitudes to land application of biosolids.

Descriptive Statistics

A Battery of Questions Evaluating Knowledge

The survey instrument contained a battery of questions concerning the participants knowledge about the land application of biosolids. Grading the six true-false questions as a test generated a score which could be compared among respondents. Correct answers were summed and divided by six. Missing responses to a question were treated as incorrect responses. Of the 325 respondents 275 answered one or more of the six questions in this battery, and 231 answered all six questions.

For the 275 respondents answering one or more of these questions, the average score was 64.2. Scores ranged from 0 to 100 (See Table 4-2). The scores ranged from 0 to 100 in Fairview and from 17 to 100 in Alva and Medford. The average scores from Alva, Fairview and Medford were respectively 67 1%, 59.4% and 65.0%.

Table 4-2. Distribution of Scores to a Battery of Questions Evaluating Knowledge for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

Number Correct	Scores	Percent of Participants
6	100	7.3%
5	83	23.0%
4	67	32.5%
3	50	25.5%
2	33	8.0%
1	17	3.6%
0	0	.1%

Source: Summary of 275 responses to study survey.

Nearly 69% of the 263 responding to question one, asking whether biosolids were or were not land applied in their county, answered correctly (See Table 4-3).

At least 80% of the 262 responding to question two, concerning the accumulation of biosolids, answered correctly that more biosolids were generated when wastewater was made cleaner (Table 4-3). This high level of correct responses indicates respondent understanding of how biosolids accumulate.

Only 54% of the 247 responding to question three, asking about regulation of biosolids, answered correctly that land application of biosolids was regulated in Oklahoma (Table 4-3). This moderate level of correct responses indicates that roughly half of those answering were unaware that the practice of land-application is controlled and regulated. Accurate information and education might reduce some concerns about applying biosolids to agricultural land.

At least 87% of the 269 responding to question four, concerning the composition of biosolids, answered correctly that biosolids are composed of soaps, human waste, food, detergents and household wastes (Table 4-3). This high level of correct responses indicates that those participating in the survey know what biosolids are, or guessed correctly.

More than 70% of the 246 responding to question five, addressing the preferred method of dealing with biosolid accumulation, answered correctly that the EPA considered applying biosolids to agricultural land beneficial (Table 4-3). This high level of correct responses indicates that the participants know that science or federal government agencies consider this practice beneficial.

Almost 50% of the 247 responding to question six, considering the marketing potential for biosolids, answered correctly that biosolids can be sold to the public as fertilizer (Table 4-3). This low level of correct responses indicates the participants lack of knowledge about the safety and possibly about the benefits of biosolids as a soil amendment.

Table 4-3. Percentage of Correct Responses to a Battery of Questions Evaluating Knowledge for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

True-False Questions	# Responding	% Correct
"Biosolids are land applied in my county."	263	68.8
"When wastewater is made cleaner, more biosolids are generated."	262	80.2
"The process of applying biosolids to agricultural land is regulated in Oklahoma."	247	54.3
"Biosolids may be composed of soaps, human waste, food, detergents, or household hazardous wastes."	269	87.0
"The United States Environmental Protection Agency (USEPA) considers applying biosolids to agricultural land beneficial."	246	70.3
"Biosolids can be sold to the public as fertilizer."	247	49.8

Source: Summary of 275 responses to study survey.

A Question Evaluating Perception of Risk

Based on the precaution adoption process method of determining risk perception levels, participants were asked to choose which of six statements best described them. Of those participating in the survey, 294 responded to the question evaluating perception of risk. The six possible statements and the response rates for each community and the entire survey sample are available in Table 4-4. Less than 10% of those responding were polarized, or at either of the extremes (publicly supported or protested). These results indicate in a practical way the perception of risk associated with land application of biosolids among the survey population.

Table 4-4. Statements and Response Rates for Perception of Risk Segment of Biosolids Survey from Three Oklahoma Communities, 1995.

	All	Alva (109)	Fairview (87)	Medford (98)
"I did not know about land application of biosolids before reading this survey."	20.4%	30.3%	23.0%	7.1%
"I have heard about land application of biosolids, but I have formed no opinion about it."	30.6%	29.4%	33.3%	29.6%
"I have heard about land application of biosolids, and I am not opposed to it."	18.7%	23.9%	18.4%	13.3%
"I have heard about land application of biosolids, and I am opposed to it."	21.4%	13.8%	20.7%	30.6%
"I have publicly supported land application of biosolids because I believe it is beneficial."	3.1%	1.8%	2.3%	5.1%
"I have publicly protested land application of biosolids because I believe it is risky."	5.8%	.9%	2.3%	14.3%

Source: Summary of 294 responses to study survey. ( ) indicates number of respondents.

Important differences in responses between the participants from the different communities was recorded (Table 4-4). Most of the differences can be explained by the participants' exposure to the practice of land application of biosolids. At the time of this survey, Alva did not have a land application permit from ODEQ and was disposing their biosolids in another way, Fairview had been applying their biosolids to agricultural land, but had recently completed a self-containment disposal unit where biosolids were continuously placed in aerated lagoons, and Medford, a community land-applying their own biosolids, had been propositioned, less than three years prior to this survey, to accept out-of-state biosolids for land application. Additional differences can be attributed to demographic similarities between Fairview and Medford. Both have more agricultural based economies and each has a significantly smaller population than Alva. These differences among the communities can best account for the differences in responses among the survey participants. The responses seem to confirm researchers expectations about risk perceptions from land application of biosolids and the relationship of community exposure to the practice.

A Question Evaluating Willingness to Pay

In the survey instrument researchers attempted to create a fictitious contingent market, whereby respondents could indicate their willingness to pay to have biosolids dealt with in an alternative way. Concerns about irrational responses prompted the inclusion of the average monthly water and sewer service rates for the particular communities participating in the survey. By incorporating the community water and sewer rates into this question and asking participants to indicate the additional amount that they would be willing to pay to have biosolids disposed of in another way, the participants' responses were tethered to realistic amounts. Use of community averages helps respondents more accurately budget their willingness to pay estimates and addresses common contingent valuation complaints that willingness to pay amounts are unbounded and unrealistic. However, some respondents still indicated extreme additional amounts that they would be willing to pay monthly to have biosolid accumulation handled in another way.

Participants were allowed to choose one of several responses to indicate their willingness to pay to avoid land application of biosolids.

- $0 "We are not willing to pay more, and we are not opposed to land application of biosolids."

- $0 "We are not willing to pay more, and we are opposed to land application of biosolids."

- $_ "We would be willing to pay $___ more monthly to have biosolids disposed of in another way." (Please circle the highest amount you would pay.)

$2.00	$10.00	$30.00
$4.00	$15.00	$40.00
$6.00	$20.00	$50.00
$8.00	$25.00	$ ___ Other Amount

The second option, where respondent is allowed to oppose the practice without contributing to its resolution is termed a protest bid. This choice, protest bid, reflects pure opposition to the practice of land application of municipal biosolids.

Of the 325 respondents, 272 participated in the willingness to pay portion of the survey, however, 77 responses were protest bids. The average willingness to pay amount for participants was $2.14 per month excluding free-riders. However, the average willingness to pay values for Alva, Fairview and Medford were $1.91, $1.81 and $2.78 respectively (See Table 4-5). These estimates are somewhat surprising considering that an average household produces less than ten pounds of biosolids per month (U.S. EPA, 1993). In essence, respondents would be willing to pay $2.14 in addition to what they already pay monthly to have their ten pounds of biosolids disposed of in another way.

As expected, the overall responses varied between respondents from each of the three communities. Greater than 65% of the respondents from Medford were either not willing to pay more and opposed, or willing to pay more to have biosolids dealt with in another way. However, fewer than 50% of Alva respondents were willing to pay more to avoid land application of biosolids or not willing to pay more, but still opposed to land application of biosolids.

Table 4-5. Willingness to Pay Values for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Range	Median	Mean
Alva (103)	\$0 – \$30	\$0	\$1.91
Fairview (80)	\$0 – \$15	\$0	\$1.81
Medford (89)	\$0 – \$30	\$0	\$2.78
All	\$0 – \$30	\$0	\$2.14

Source: Summary of 272 responses to study survey. ( ) indicates number of respondents.

The overall amounts that participants from the different communities were willing to pay also differed. Medford residents were willing to pay more to have biosolids dealt with by an alternate method, while less Alva and Fairview respondents were willing to pay anything to prevent land application of biosolids.

Medford respondents' higher level of opposition to land application of biosolids and greater willingness to pay to avoid land application was expected. In 1992, a plan was proposed by an Oklahoma corporation to import biosolids produced out-of-state into Oklahoma. Medford, Grant County and other area farmers were contacted concerning land-application of the foreign biosolids. Opposition to the proposal occurred in public meetings and local and state media. Therefore, it is not surprising that Medford residents participating in this study would have greater willingness to pay to avoid and more opposition to the practice of land application of municipal biosolids, as demonstrated by protest bids and willingness to pay amounts, than Alva or Fairview participants.

A Battery of Questions Evaluating Demographics

The survey instrument contained a battery of eight questions requesting demographic information about the survey participants. Participants were asked to indicate their age group, gender, size of household, number of minor children in home, level of education, level of income, length of time in the community and their involvement in production agriculture. The responses to the above questions determine the representative ability of the survey sample among the population.

Age

Participants were asked to mark which of four age groups best represented them: less than 20 years; 20 to 39 years; 40 to 59 years; or 60 or more years (See Table 4-6). Of those participating in the survey 293 responded to this question. The average age was between 40 and 59 years. None of the respondents were less that 20 years old. Over 25% of those responding were between 20 and 39 years, 35.5% were between 40 and 59 years, and 37.9% were over 60 years in age. These responses indicate an older sample population.

Table 4-6. Age of Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	20-39 years	40-59 years	60 + years
Alva (109)	28.4%	39.4%	32.1%
Fairview (89)	30.3%	32.6%	37.1%
Medford (95)	21.1%	33.7%	45.3%
All	26.6%	35.5%	37.9%

Source: Summary of 293 responses to study survey. ( ) indicates number of respondents.

Particularly interesting is the age distribution among the various. Fairview had the most balanced population distribution with a slight majority in the over 60 bracket.

Medford had the most skewed population distribution with a large majority in the over 60 category. However, Alva was the only community with the bulk of its population in a younger age group, 40 to 59 years. This analysis shows the age differences of the participants from the three communities and indicates an overall older population, significantly older in Medford.

Gender

Participants were asked to indicate whether they were male or female (See Table 4-7). Of those participating in the survey 295 responded to this question. More than 65% of those responding were female, while 33.2% were male. Roughly two-thirds of those responding to the survey were female.

Table 4-7. Gender of Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Female	Male
Alva (109)	70.6%	29.4%
Fairview (89)	65.2%	34.8%
Medford (97)	63.9%	36.1%
All	66.8%	33.2%

Source: Summary of 295 response to study survey. ( ) indicates number of respondents.

The distribution of female to male participants was fairly consistent among the three communities. Alva had a higher percentage of female respondents than Fairview and Medford, but all three communities had high percentages of female participants.

Household Population

Participants were asked to indicate the number of people living in the home (See Table 4-8). Of those participating in the survey 294 responded to this question. Responses ranged from 1 to 8 persons. The average number of people living in the homes of those responding was 2.5 persons. More than 20% of those responding lived alone, and 40.8% lived with only one other person. These results indicate smaller overall households.

The household population distribution was similar among the participants of the various communities. Each community was represented by good numbers of both single and multiple person homes. Nearly 30% of the Medford respondents lived alone, while slightly less than 20% of the Fairview respondents reported living by themselves. Surprisingly, Medford also had the highest percentage of households with greater than five respondents. Alva had the largest percentage of two person homes. Over the range of one to four persons, Fairview respondents were the most balanced in terms of number of persons in their homes.

Table 4-8. Number of Persons Living in Homes for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	1	2	3	4	5	6	7	8
Alva (109)	19.3%	45.9%	13.8%	11.9%	6.4%	1.8%	.9%	0
Fairview (88)	18.2%	39.8%	20.5%	20.5%	0	1.1%	0	0
Medford (97)	28.9%	36.1%	13.4%	11.3%	8.2%	1.0%	0	1.0%
All	22.1%	40.8%	15.7%	14.3%	5.1%	1.3%	.4%	.3%

Source: Summary of 294 responses to study survey. ( ) indicates number of respondents.

Household Population of Minor Children

Participants were asked to specify the number of minor children living in the home (See Table 4-9). Of those participating in the survey 294 responded to this question. The average number of children living in the home was 0.6 children. More than 65% of those responding live without any children in their homes. These results indicate children living in few of the homes surveyed.

Table 4-9. Number of Minor Children in Homes for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	0	1	2	3	4	5
Alva (109)	70.6%	9.2%	10.1%	8.3%	.9%	.9%
Fairview (89)	62.9%	12.4%	23.6%	0	1.1%	0
Medford (96)	66.7%	13.5%	13.5%	5.2%	1.0%	0
All	67.0%	11.6%	15.3%	4.8%	1.0%	.3%

Source: Summary of 294 responses to study survey. ( ) indicates number of respondents.

Each of the communities had high numbers of respondents with no minor children living in their homes. Alva respondents reported the fewest percentage of homes with minor children. Ironically, Alva respondents also reported the highest percentage of homes with three or more minor children. Fairview participants reported the largest percentage of homes with minor children. However, few Fairview respondents reported having more than two minor children. Of the Medford respondents who had minor children at home, they were balanced between those with one or two children.

Education Level

Participants were asked to mark which of seven categories best described their highest education level: some high school; high school diploma, some college; technical training; some college and technical training; college degree; or graduate or professional degree (See Table 4-10). Of those participating in the survey 291 responded to this question. The following represent the respondents' highest level of education: 4.5% responded some high school; 17.5% responded high school diploma; 24.7% responded some college; 10.7% responded technical training; 4.5% responded some college and technical training, 22.0% responded college degree; and 16.2% responded graduate or professional degree. Greater than 95% of those responding had completed high school, and 38.2% had completed college. These results indicate a fairly educated population.

In each of the communities, the respondents reported high incidents of high school completion (Table 4-10). At least 95% of those responding received a high school diploma. Most participants received more formal education beyond high school. Fairview had the most respondents with a high school diploma as their maximum education level.

Table 4-10. Education Levels for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Some High School	High School Diploma	Some College	Tech. Trng.	College & Tech. Trng.	College Degree	Grad./ Prof. Degree
Alva (109)	2.8%	11.9%	23.9%	6.4%	3.7%	25.7%	25.7%
Fairview (88)	5.7%	22.7%	21.6%	17.0%	4.5%	18.2%	10.2%
Medford (94)	5.3%	19.1%	28.7%	9.6%	5.3%	21.3%	10.6%
All	4.5%	17.5%	24.7%	10.7%	4.5%	22.0%	16.2%

Source: Summary of 291 responses to study survey. ( ) indicates number of respondents.

More significantly, in each community nearly 30% or more of the participants reported completing college. Greater than 50% of Alva respondents indicated that they had completed college (25.7%) or had acquired a graduate or professional degree (25.7%). Medford had the highest percentage of respondents who had taken college courses, but had not completed a degree. Overall the education levels for each town were quite high, especially those for Alva.

Income Level

Participants were asked to identify which of five categories best describes the income level of their entire household before taxes: less than $20,000; $20,000 to $39,999; $40,000 to $59,999; $60,000 to $79,999; and $80,000 or more (See Table 4-

11). Of those participating 267 responded to this question. The average income level was between $20,000 and $39,999. The following represent the responses to the various income levels: 22.5% responded less than $20,000; 34.8% responded $20,000 to $39,999; 28.5% responded $40,000 to $59,999; 7.5% responded $60,000 to $79,999; and 6.7% responded $80,000 or more. Nearly 65% of those responding were between $20,000 and $60,000. These results indicate a large middle class base in the population surveyed.

Table 4-11. Household Income Levels for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	< $20,000	$20-39,999	$40-59,999	$60-79,999	>$80,000
Alva (103)	20.4%	39.8%	25.2%	5.8%	8.7%
Fairview (80)	23.8%	30.0%	35.0%	7.5%	3.7%
Medford (84)	23.8%	33.3%	26.2%	9.5%	7.1%
All	22.5%	34.8%	28.5%	7.5%	6.7%

Source: Summary of 267 responses to study survey. ( ) indicates number of respondents.

The level of income distribution for each of the communities was quite similar (Table 4-11). In each community less than 25% of the participants recorded household income of less than $20,000. Fairview and Medford had the highest percentage of respondents reporting less than $20,000, while Alva had the fewest. Similarly, Fairview had the fewest participants indicating income greater than $60,000.

In each community participants recorded a large percentage of household incomes between $20,000 and $59,999. Alva and Fairview participants reported 65% in the $20,000 to $59,999 range, while nearly 60% of Medford's participants reported income in this range. Most of the participants from Alva indicate household incomes between $20,000 and $39,999, while most of the participants from Fairview indicate household incomes between $40,000 and $59,999. Generally, the responses for each community indicate large segments of middle class income households.

Years Residing in County

Participants were asked to indicate how long they had lived in their county (See Table 4-12). Of those participating in the survey 291 responded to this question. Responses ranged from one to 88 years. The average number of years respondents had lived in their county was 30.2 years. Only 27.8% of those responding lived in their counties ten years or less, while 56.4% had lived there more than 20 years, and 30.9% had lived there more than 40 years. These results indicate a well settled population with little movement out of or into the county.

Table 4-12. Number of Years Residing in County for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Range	Median	Mean
Alva (108)	1-87	26	29.7
Fairview (87)	1-87	20	26.9
Medford (96)	1-88	28	33.8
All	1-88	24	30.2

Source: Summary of 291 responses to study survey. ( ) indicates number of respondents.

In each community the participants indicate balanced, but well settled populations. The most well settled community appears to be Medford, as more than 30% of the respondents had resided in Grant County for 50 or more years. Each of the communities report similar percentages of newcomers, those living in the county less than 10 years. Fairview had more respondents with 20 or fewer years in the county than did Alva or Medford. The most significant point is that each community has a large portion, more than 50%, of respondents who have lived in their respective counties for more than 20 years, especially Medford where nearly 65% of the respondents had lived in Grant County for more than 20 years.

Involvement in Production Agriculture

Participants were asked to designate whether their family was involved in production agriculture, a subjective determination as the term was intentionally undefined in the survey instrument (See Table 4-13). Of those participating in the survey 297 responded to this question. Slightly more than 40% of those responding were involved in production agriculture. Their responses were purely subjective and production agriculture was not defined. However, the results of this question are not surprising as the areas represented by the survey sample are predominately rural.

Table 4-13. Involvement in Production Agriculture for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Yes	No
Alva (109)	35.8%	64.2%
Fairview (89)	33.7%	66.3%
Medford (99)	51.5%	48.5%
All	40.4%	59.6%

Source: Summary of 297 responses to study survey. ( ) indicates number of respondents.

While production agriculture plays an important role in each of the three communities, the most dramatic effect is in Medford where greater than 50% of the participants report being involved in production agriculture (Table 4-13). However, in both Alva and Fairview only about 35% of the respondents are involved in production agriculture. Overall, the number of participants involved in production agriculture are quite high.

A Battery of Questions Evaluating Relationship to Production Agriculture

The demographic battery of questions concluded with a question determining the participants' involvement in production agriculture. Next, the survey instrument contained a battery of four questions focusing on the type, size and practices of those involved in production agriculture. It was intended that only the 113 participants whose families were involved in production agriculture respond to this battery of questions. However, a few other participants responded to some of the questions in this battery.

Participants were asked to indicate with which type of production agriculture their family was involved: cattle, sheep, hogs, field crops, hay , or other with a space provided for identifying another type of agriculture (See Table 4-14).

Table 4-14. Types of Production Agriculture for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Cattle	Sheep	Hogs	Field Crops	Hay	Other
Alva (39)	61.5%	0.0%	2.6%	87.2%	51.3%	10.3%
Fairview (30)	83.3%	0.0%	6.7%	76.7%	56.7%	3.3%
Medford (51)	58.8%	3.9%	9.8%	84.3%	25.5%	5.9%
All	65.8%	1.7%	6.7%	83.3%	41.7%	6.7%

Source. Summary of 120 responses to study survey. ( ) indicates number of respondents.

Participants were asked to indicate the size of their farming or ranching operation. Responses could be recorded in terms of number of acres or number of head of livestock (See Table 4-15). Of the 120 participants involved in agriculture, 105 responded to question two by number of acres. Size of operations ranged from 10 to 7000 acres with the average size being 820.4 acres per farm or ranch. While 42.5% of those responding to question two had at least 640 acres, 83.0% of those responding had at least 160 acres.

These results indicate farming and ranching operations typical in size of the sample population.

Table 4-15. Size of Agricultural Operations in Acres for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Range	Median	Mean
Alva (35)	10-7000	640	1068.7
Fairview (26)	27-3000	640	868.3
Medford (44)	20-3000	344	594.7
All	10-7000	500	820.4

Source: Summary of 105 responses to study survey. ( ) indicates number of respondents.

In addition, participants responded to the size of their farm or ranch operation according to the number of head of livestock in their operation (See Table 4-16). From this perspective, size of operations ranged from 1 to 1500 head of livestock. Only half (52.8%) of those reporting owning or leasing land owned livestock. Of those owning livestock the average number was 190.3 head of livestock per farm or ranch. While 44.6% of the participants owning livestock recorded having 100 or more head of livestock, 64.3% indicated having at least 50 head of livestock. However, 25.0% recorded having 25 or fewer head of livestock. These results indicate balanced numbers of livestock across the range of those responding.

Table 4-16. Size of Agricultural Operation in Head of Livestock for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Range	Median	Mean
Alva (18)	7-1500	125	316.6
Fairview (14)	10-1200	75	169.8
Medford (24)	1-1200	40	107 5
All	1-1500	75	190.3

Source: Summary of 56 responses to study survey. ( ) indicates number of respondents.

Participants were asked to acknowledge whether they had applied livestock manure to their farm or ranch land (See Table 4-17). Of those participating 118 responded to question three. Of those responding, 43.2% had applied livestock manure to their farm or ranch land. These results indicate that nearly half of those responding had first hand experience with land application of livestock manure.

Table 4-17. Experience with Land Application of Livestock Manure or Biosolids for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Livestock Manure	Biosolids
Alva (37)	43.2%	5.4%
Fairview (29)	44.8%	3.4%
Medford (52)	42.3%	5.8%
All	43.2%	5.1%

Source: Summary of 118 responses to study survey. ( ) indicates number of respondents.

Similarly, Participants were asked to acknowledge whether they had applied biosolids to their farm or ranch land (Table 4-17). Of those participating 118 responded to question four. Of those responding 5.1% either applied, or had applied, biosolids to their farm or ranch land. It was surprising to find six participants who had a first hand experience with the land application of biosolids.

A Comment Section

At the end of the survey instrument participants were urged to express their opinions and beliefs about the practice of land application of biosolids or to make any comments about the survey. Participant comments were often not correlated with their previous responses in the questionnaire, however, each comment was recorded (See APPENDIX C). Of those participating in the survey 106 responded with comments. As might be expected by Medford's increased exposure to the practice of land application of biosolids, more than 40% of the comments were from Medford residents.

Participant comments addressed biosolids composition and use/disposal, economic considerations, lack of information, perceived risks, public distrust, property rights and general survey criticisms (See Table 4-18). Some comments illustrate participants' recognition of potential harms from the ingredients of the biosolids (heavy metals, chemicals/toxins and pathogens). Additionally, some comments highlighted perceived inadequacies in research, monitoring/technology and regulations as they pertain to biosolids and its use/disposal. Other comments expressed concerns for human health and environmental protection. More than 5% of the participants commenting spoke of a zero risk concern (there is no 100% guarantee of safety) with land application of biosolids.

Of particular interest to researchers was the way participants redefined issues of land application of biosolids through word associations. For example, researchers specifically limited the scope of the survey to locally produced biosolids, however, 15% of the comments addressed foreign biosolids, those produced either out-of-state or in a "big city." Another example of participants redefining a land application of biosolids issue is that the cover letter and survey instrument addressed the composition and treatment of biosolids, however, respondents equated biosolids with hazardous or toxic waste in 10% of their comments.

The participant comments answered some questions not otherwise solicited with the questionnaire, such as identifying factors involved in risk perception and/or opposition to land application of biosolids. In addition, the comment section allowed researchers to better understand participants' perceptions regarding land application of biosolids.

Comments from the survey provided more insight into the factors contributing to risk perceptions. Participants commented that they did not want out-of-state biosolids, and they equated biosolids with hazardous and toxic waste. Although land application of biosolids is regulated and closely monitored by EPA and ODEQ, participants were concerned with risks to human and environmental health from heavy metals, organic

Table 4-18. Categories and Number of Comments for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	All (106)	Alva (34)	Fairview (29)	Medford (43)
Biosolids				
Support				
Generally	5	3	1	1
Conditionally	12	5	4	3
Absolutely	5	2	1	2
Oppose				
Generally	5	2	1	2
Absolutely	15	5	2	8
Conservation				
Use	10	5	2	3
Recycling	1	1	0	0
Harmful Composition				
Generally	1	0	0	1
Heavy Metals	7	4	2	1
Chemicals/Toxins	15	4	4	7
Pathogens	2	0	1	1
Experience				
w/Biosolids	5	2	1	2
w/Biosolids Products	3	2	0	1
w/Manures	1	1	0	0
None	1	1	0	0
Word Associations				
Foreign (out-of-state/city)	16	3	2	11
Hazardous/Toxic Waste	11	7	2	2
Manure	1	0	1	0
Fertilizer	10	5	2	3
Alternatives (landfills, etc.)	4	1	2	1

Table 4-18 Continued. Categories and Number of Comments for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	All (106)	Alva (34)	Fairview (29)	Medford (43)
Biosolids				
Nuisance				
Generally	1	0	0	1
Odor	2	1	0	1
No Odor	1	1	0	0
Economics				
Generally	8	1	0	7
Lower Input Costs	2	2	0	0
Lower Disposal Costs	2	0	2	0
Lack of Information	22	9	8	5
Risk				
Generally	10	5	1	4
Health				
Contact	3	2	0	1
Food	7	2	3	2
Water	10	0	4	6
Disease	8	3	2	3
Environment				
Generally	6	1	2	3
Soil	8	2	2	4
Water	12	2	3	7
Zero Risk	8	5	1	2
Public Distrust				
Generally	1	0	0	1
Of Government	6	1	2	3
Of Corporations	1	0	1	0
Inadequacies				
Research	5	1	3	1
Technology/Monitoring	11	3	4	4
Regulation	11	4	5	2
Property Rights				
Our Problem	3	0	2	1
Their Problem	11	1	1	9
Our Decision (land owners)	3	2	0	1
Survey Comments				
Generally	1	1	0	0
Waste of Time/Money	3	1	2	0
Unable to Participate	4	1	1	2

Source: Summary of comments to study survey. ( ) indicates number of respondents.

chemicals and pathogens indicating either a need for education, or public distrust. Additional factors influencing risk perceptions were distrust of agencies and corporations, inadequacies in research, technology and regulation, and inability to assure zero risk from land application of biosolids. Each of these factors, including exposure, influence at least some Oklahomans perceptions of risk from land application of biosolids.

Requests for More Information

Participants were asked to indicate on the back of the survey instrument whether they would like more information on land-application of biosolids and/or a summary of the survey results. Nearly 20% of the respondents requested additional information and/or a summary of the survey results. The response rate for requests was similar among participants from Alva, Fairview and Medford.

Upon the conclusion of this study, researchers sent each participant requesting more information on land application of biosolids an Environmental Brief, a two page, 1995 fact sheet prepared by the Center for Agriculture and the Environment at Oklahoma State University, entitled "Land Application of Biosolids: An Introduction." For those requesting a summary of the survey results, the correct responses to the first six questions, average responses to the questionnaire for their community and response rates to the survey was prepared and mailed. Also, included in each mailing was a cover letter thanking respondents again for their participation and introducing the materials provided them.

Econometric Analysis

Missing values for the independent variables were replaced with average estimates of the same variables from the survey sample of the appropriate community. Observations with missing dependent variables were deleted. LIMDEP was the econometric software package used for analyzing the limited dependent variable models.

Prior to analyzing either the tobit with selectivity or the ordered probit models, some additional data specifications were necessary. The values for the variable, years in county, were divided by 10 to give values in the range of 0 to 10, as the previous values for years in county were large in comparison to values for other variables. Those observations with missing values for dependent variables were dropped from the data set for the model estimating the particular dependent variable. Table 4-19 provides a list of the available variables, a description of what they represent and their range of values.

Table 4-19. List of Variables, Description of the Variables and Range of Values for the Variables Used in the Econometric Analysis of Data from Biosolids Survey for Three Oklahoma Communities, 1995.

Variables	Descriptions	Range of Values
Dependent		
WTP4	willingness to pay (without protest bids)	0 - 30
RISK2	perception of risk (for those who had heard of land application of biosolids)	0 - 4
Independent		
KNOW_T	score on knowledge battery of questions	0 - 1
KNOW_1	question 1 on knowledge battery	0 - 1
KNOW_2	question 2 on knowledge battery	0 - 1
KNOW_3	question 3 on knowledge battery	0 - 1
KNOW_4	question 4 on knowledge battery	0 - 1
KNOW_5	question 5 on knowledge battery	0 - 1
KNOW_6	question 6 on knowledge battery	0 - 1
SURV_A	not from Alva	0 - 1
SURV_F	not from Fairview	0 - 1
SEX	gender	0 - 1

Table 4-19 Continued. List of Variables, Description of the Variables and Range of Values for the Variables Used in the Econometric Analysis of Data from Biosolids Survey for Three Oklahoma Communities, 1995.

Variables	Descriptions	Range of Values
Independent-cont.		
KIDS	presence of children in household	0 - 5
EDU	education level	1 - 7
INC	income level	1 - 5
YIC	years in county	.1 - 8.8
AG	involvement in production agriculture	0 - 1

Source: Summary of data available for use in econometric models analyzed in the study.

The Tobit with Selectivity Model

The tobit with selectivity model was used to evaluate respondents willingness to pay. Those respondents indicating zero willingness to pay, but opposed to land application of biosolids were identified as protest bids and dropped from the data sample when analyzing the willingness to pay model. Two forms, or versions, of this model were analyzed (See Table 4-20). One form included the variable for a score on the knowledge battery of questions. The other form included variables for each question in the knowledge battery of questions, rather than a variable for overall score. There were 188 useful observations in each of the variations on the tobit with selectivity model. The first variation of the tobit with selectivity model had only one significant variable (Table 4-20). Years in county was significant at the 10% level and was negatively related to willingness to pay. The results indicate that the longer one lived in their county the less he or she would be willing to pay, however, this may be influenced by their age as well. The first variation of the tobit with selectivity model yielded an extremely low R^2 of .06.

Table 4-20. Parameter Estimates and Summary Statistics of Two Tobit with Selectivity Models Used to Explain Willingness to Pay for Participants in Biosolids Survey from Three Oklahoma Communities, 1995

	Coefficient	t-ratio	R^2
Model 1			0.05839
Variables			
Constant	0.12273	0.102	
KNOW_T	-0.11324	-0.327	
SURV_A	-0.03306	-0.343	
SURV_F	-0.09053	-0.933	
SEX	0.04147	0.352	
KIDS	0.00924	0.090	
EDU	0.01797	0.245	
INC	-0.00120	-0.027	
YIC	-0.03693	-1.914*	
AG	0.13765	1.052	
LAMBDA	0.34692	0.293	
Model 2			.10446
Variables			
Constant	0.63414	0.860	
KNOW1	0.13662	1.979**	
KNOW2	-0.03891	-0.463	
KNOW3	-0.04061	-0.624	
KNOW4	0.00174	0.017	
KNOW5	-0.13379	-0.594	
KNOW6	-0.10350	-1 426	
SURV_A	-0.12261	-1.278	
SURV_F	-0 14451	-1.586	
SEX	0.06132	0.690	
KIDS	-0.03061	-0.543	
EDU	-0.00563	-0.128	
INC	-0.01403	-0.405	
YIC	-0.03976	-2.294**	
AG	0.07425	0.749	
LAMBDA	-0.13181	-0.181	

Source: Summary from regression of responses to study survey **, Significant at 5% level; *, significant at 10% level.

The second tobit with selectivity model variation also had few significant variables (Table 4-20). Again, years in county was significant, however, in this variation of the model the variable representing the first of the knowledge battery of questions was significant. Those respondents who answered question one (whether biosolids were land-applied in their county) correctly were likely to be willing to pay more than those who answered it incorrectly. The second variation of the tobit with selectivity model had a weak R^2 value of .10, however, this variation was somewhat more representative of the sample than the first variation of the tobit with selectivity model.

The results of the tobit models appear to be consistent with the research by Savage suggesting that an individual's character explains more about their responses than demographic variables. How can character be measured for econometric analysis? Arguably, demographic variables are used as a surrogate for measuring one's character. Perhaps the problem is with using econometric analysis to explain why an individual is willing to pay to have, or not have, biosolids disposed of in another manner. The possibility also exists that researchers incorrectly specified the models or the appropriate variables.

The Ordered Probit Model

The ordered probit model was used to evaluate respondents perception of risk related to land application of biosolids. Those respondents with a missing value for the dependent variable, perception of risk, were dropped from the group of observations used with the ordered probit model. There were 218 observations suitable for econometric analysis. Similar to the variations of the tobit with selectivity model, researchers used two variations of the ordered probit model (See Table 4-21). The first variation contained a variable representing a score to the battery of questions ascertaining knowledge, and the second variation included variables for each of the six questions in the knowledge battery. The same 218 observations were used with each variation of the ordered probit model.

The first variation of the ordered probit model contained three significant variables, two of which dealt with residence of participant and the other concerned the presence of minor children in the household (Table 4-21). The coefficients for the community variables were positive indicating that individuals from Medford had a greater probability of a higher risk perception level than those from Alva or Fairview. The coefficient for those with children was also positive indicating the probability of a higher risk perception level for those having minor children. The goodness-of-fit measurement, the log-likelihood ratio suggested by Kennedy, for the first version of the ordered probit model was -285 and signaled an ineffective model estimation.

The second variation of the ordered probit model also had three significant variables (Table 4-21). Similar to the first variation of the model, the location variables were significant and positively related to risk perception levels. However, in the second variation of the ordered probit model, containing variables for each question regarding knowledge of land application of biosolids, the variable representing the response to question five (whether EPA considers land application of biosolids beneficial) was significant. The indication from the positive relationship of the coefficient for question five is that those respondents, knowing EPA considered land application of biosolids beneficial, were probably going to have a higher perception of risk level which is perhaps

Table 4-21. Parameter Estimates and Summary Statistics of Two Ordered Probit Models Used to Explain Perception of Risk for Participants in Biosolids Survey from Three Oklahoma Communities, 1995.

	Coefficient	t-ratio	Log-Likelihood
Model 1			-285.1466
Variables			
Constant	0.89442	1.988**	
KNOW_T	0.55426	1.508	
SURV_A	0.45988	2.282**	
SURV_F	0.31231	1.645*	
SEX	-0.30369	-1.571	
KIDS	0.17265	2.047**	
EDU	-0.00352	-0.076	
INC	0.04482	0.546	
YIC	0.02753	0.788	
AG	-0.08823	-0.497	
MU(1)	1.2067	7.370	
MU(2)	2.2770	12.484	
MU(3)	3.5103	15.636	
Model 2			-277.9738
Variables			
Constant	0.91061	1.759**	
KNOW1	-0.26208	-1.531	
KNOW2	0.08095	0.383	
KNOW3	0.13575	0.845	
KNOW4	-0.07436	-0.290	
KNOW5	0.55937	3.424***	
KNOW6	0.00364	0.023	
SURV_A	0.63534	2.705***	
SURV_F	0.40687	1.923*	
SEX	-0.28367	-1.401	
KIDS	0.14510	1.641	
EDU	-0.00805	-0.163	
INC	0.03993	0.477	
YIC	0.05049	1.387	
AG	-0.12374	-0.685	
MU(1)	1.2688	7.342	
MU(2)	2.3853	12.504	
MU(3)	3.6369	15.884	

Source: Summary from regression of responses to study survey. ***, Significant at 1% level; **, significant at 5% level; *, significant at 10% level.

an indication of public distrust. The log-likelihood ratio for the second variation of the ordered probit model was -278, again indicating a poor probability estimation.

The results of the ordered probit models, like those of the tobit models, have little meaningful to communicate. The demographic variables specified in the ordered probit models did not significantly influence the probability of an individual's level or risk perception related to land application of biosolids.

CHAPTER 5

CONCLUSIONS, POLICY IMPLICATIONS AND SUGGESTIONS FOR FURTHER STUDY

Introduction

The issue of land application of biosolids arose in the early 1990s when a company proposed to import biosolids from another state into Oklahoma for land application in several rural areas of the state. Public opposition to this proposal was widely reported by the state media. Meanwhile, both the EPA and ODEQ regulate and encourage the beneficial use of biosolids through land application programs. Many Oklahoma communities apply locally-generated biosolids to agricultural land. Farmers, eager to reduce their fertilizer costs, willingly accept the biosolids and its application at no cost to the landowner. Researchers at Oklahoma State University questioned this paradox – approximately 65% of Oklahoma communities apply their biosolids to agricultural land, the process is encouraged, but regulated by state and federal agencies; yet, when a proposal was made to land-apply out-of-state biosolids, Oklahomans balked.

The objectives of this study were to determine how much Oklahomans were willing to pay to avoid land application of biosolids and to determine what factors contribute to an Oklahoman's perception of risk from land application of biosolids. A mail survey was conducted using about 300 residents from each of three Oklahoma communities. Each of the communities had different levels of experience with land application of biosolids. Participant knowledge level about biosolids, demographic characteristics and comments about the practice of land application were used to evaluate their willingness to pay to avoid land application of biosolids and risk perception levels from land application of biosolids through descriptive analysis, econometric modeling and word associations.

Summary of Findings

The Oklahomans participating in the survey were willing to pay an average of $2.14 per month beyond their water and sewer bills to avoid land application of biosolids. As many (77 individuals) were not willing to pay to avoid land application of biosolids, but were opposed to the practice, their willingness to pay estimates were excluded because of irrationality. Econometric modeling was conducted using willingness to pay as the dependent variable in a tobit with selectivity model. However, the results were weak in their ability to explain participant willingness to pay. One variable was consistently significant and indicated that the more years one had spent in the county, the less he or she was willing to pay. However, this variable may have been a proxy for age rather than for years in community. It is important to recognize that Medford residents had higher willingness to pay values than those from Alva and Fairview which is not surprising as the Medford area was proposed to accept out-of-state biosolids. Regardless of the explanations why Oklahomans were willing to pay the values they indicated, researchers accomplished the task of determining what Oklahomans were willing to pay to avoid land application of biosolids. These willingness to pay values provide policy makers with a measure demonstrating the level of their opposition to land application of biosolids. It is important to remember that a distinction was not made in the survey instrument between support/opposition to out-of-state biosolids and locally produced biosolids. Therefore, one's willingness to pay to avoid out-of-state biosolids may be different than their willingness to pay to have local biosolids disposed of in another manner.

The literature provided numerous factors explaining individual perceptions of risk. Researchers attempting to measure risk perceptions used the precaution adoption process method, a progression of behavioral responses to perceived risks. The risk perception measurement was intellectually stimulating and provided interesting descriptive statistics about risk levels, however, its use as a dependent variable in econometric modeling provided a little explanation for factors contributing to perception of risk from land application of biosolids. The participant's community was consistently significant in the econometric analysis. Medford residents have had greater exposure to land application of biosolids, and as such, they had a higher sensitivity to its practice. The value of information, the potential threat to human or environmental health, public distrust, the fear of the unknown from foreign biosolids and public exposure were some factors possibly affecting risk perception as demonstrated through participant comments.

The value of information, although it was not statistically significant in the econometric modeling of either willingness to pay or perception of risk, is important in the participants' evaluation of willingness to pay and perception of risk. More than 20% of the participants commented that they had a lack of information about land application of biosolids which affected their response to the survey instrument.

Policy Implications

Public opposition to a particular practice based on accurate or inaccurate information creates uncomfortable political situations. Policy makers and agency personnel must listen and understand the concerns expressed by the public (Hance, et al.). Efforts should be made to improve the image of agencies and the scientific community, as public distrust and inadequacies in both were recorded in survey comments and relevant literature. Specifically, some public education regarding land application of biosolids is necessary to provide information believed to be lacking or inadequate.

Additionally, policy makers should be aware that participants in this study were willing to pay an average $2.14 per month to avoid land application of biosolids. It is unclear whether participant willingness to pay estimates were based on a desire to avoid foreign biosolids, locally generated biosolids or both. Another important factor when considering the willingness to pay estimates is that 77 of the 272 participants responding to the willingness to pay question were dropped from the $2.14 calculation because of their irrationality, their unwillingness to pay to avoid a practice to which they are opposed. In light of these two considerations, two possible lines of analysis exist.

One scenario assumes that the willingness to pay estimates are based on participant desire to have locally generated biosolids disposed of in another way. Using the 195 households that were not protest bidders and their willingness to pay an additional $2.14 per month to avoid land application of biosolids, together these households would be willing to pay more than $5,000 annually to avoid land application of biosolids. Considering that the average participant household population is two and one-half persons and each person generates approximately 47 pounds of biosolids per year, these 195 households would be willing to pay an added \$5,000 to have 11.5 tons of biosolids disposed of in another manner, or \$435 per ton of biosolids. Depending upon the consistency, quality and quantity of the biosolids, the disposal cost of landfilling biosolids is estimated to be between eight and ten dollars per ton (Waste Management, Inc.). One must. If the \$2.14 willingness to pay estimate is based on local biosolids, policy makers mindful of other costs associated with these methods of use/disposal: land application – application equipment expense, local hauling and field monitoring; landfilling – disposal costs and larger hauling costs (due to fewer local landfills), might consider other methods of disposal.

However, the most likely scenario is that the \$2.14 willingness to pay estimate is a response to out-of-state biosolids. First, many participant comments referenced animosity towards out-of-state biosolids without a single reference to local biosolids. Second, Medford has had the highest exposure to foreign biosolids and consequently Medford participants had the highest willingness to pay estimates (\$2.78). Finally, because of the sheer disparity between use/disposal costs (landfilling at \$8 - \$10 per ton and the willingness to pay estimate of an added \$435 per ton to avoid land application of biosolids), one must assume that participant willingness to pay is driven by participant desire to avoid land application of foreign biosolids. Thus, policy makers considering allowing importation of biosolids must realize that participants representing 195 Oklahoma households hypothetically would be willing to pay over \$5,000 per year, the estimated cost of landfilling between 500 and 625 tons of biosolids, to avoid applying foreign biosolids to Oklahoma agricultural land.

Suggestions for Further Study

Researchers in the present study determined Oklahomans' willingness to pay to avoid land application of biosolids. Willingness to pay is a contingent valuation method for evaluating externalities. Externalities from land application of biosolids may include perception of risk to human or environmental health, selfishness, irrationality, ignorance or pride, any of a number of other commodities.

A current television commercial depicts several range-worn cowboys gathered around the campfire at mealtime when they exhaust the supply of a particular brand of salsa. The camp cook provides a jar of a different brand of salsa. Immediately the cowboys consult the jar label to determine where the salsa was made. The commercial closes with the exclamation, "New York City!"

Researchers in this study assumed that the reason for opposition to land application of biosolids was attributable to perceptions of risk. However, other factors, like pride, image and reputation, may also be included in the externalities measured by Oklahomans' willingness to pay to avoid land application of biosolids.

Further research may seek to uncouple the out-of-state versus local biosolids issue by asking whether individuals are willing to pay more to avoid land application of out-of-state biosolids. More information about why Oklahomans are willing to pay to avoid land application may be generated through word associations and comments made in personal or telephone interviews.

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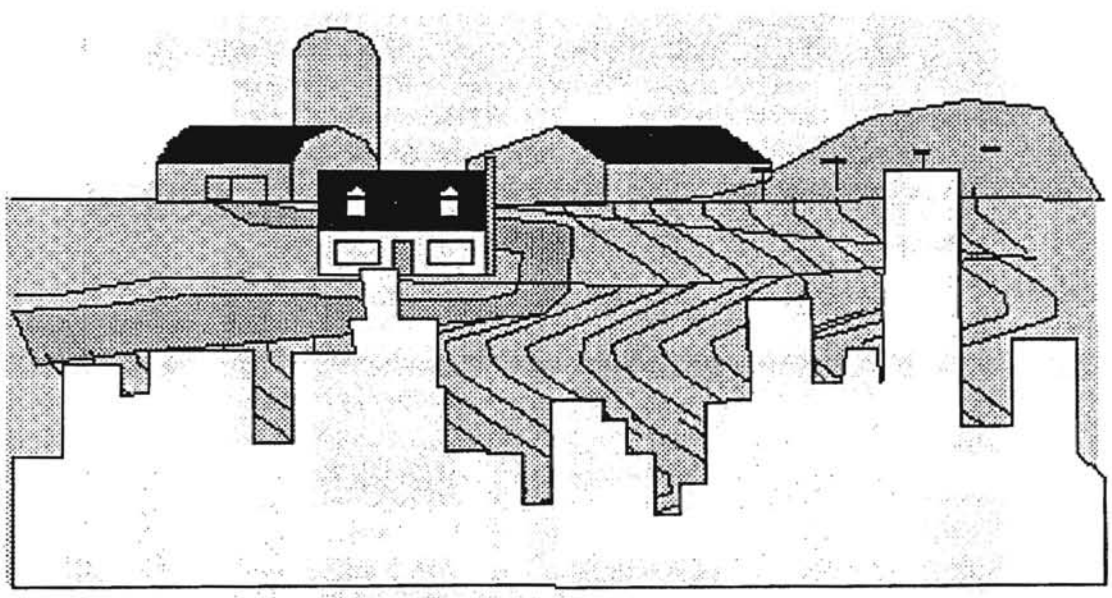
APPENDIX A

THE SURVEY INSTRUMENT

Land Application of Biosolids
A Survey for Oklahomans



Department of Agricultural Economics
Oklahoma State University
Stillwater, Oklahoma 74078

The word *biosolids* is used to describe treated sewage sludge. Biosolids are a by-product of wastewater treatment. The treatment plant collects wastewater from homes and businesses. During treatment, the plant removes solid and semi-solid waste materials from the water. The water is further treated and discharged. The remaining solid and semi-solid material (biosolids) must be disposed of properly. One method of disposal involves land applying the biosolids. In this process an individual either spreads biosolids on agricultural land and plows them into the soil or injects the biosolids directly into the soil.

....

The purpose of this section is to learn what you know about land application of biosolids. These statements are either true or false. **Please circle the best answer**.

1. Biosolids are land applied in my county.
   TRUE
   FALSE

2. When wastewater is made cleaner, more biosolids are generated.
   TRUE
   FALSE

3. The process of applying biosolids to agricultural land is regulated in Oklahoma.
   TRUE
   FALSE

4. Biosolids may be composed of soaps, human waste, food, detergents, or household hazardous wastes.
   TRUE
   FALSE

5. The United States Environmental Protection Agency (USEPA) considers applying biosolids to agricultural land beneficial.
   FALSE
   TRUE

6. Biosolids can be sold to the public as fertilizer.
   TRUE
   FALSE

....

7. The purpose of this section is to ask for your opinions about land application of biosolids and to find out whether you believe it to be a risky practice. **Please mark the <u>one</u> statement that best describes your opinion of the risks associated with land application of biosolids**.

______ "I DID NOT KNOW ABOUT LAND APPLICATION OF BIOSOLIDS BEFORE READING THIS SURVEY."

______ "I HAVE HEARD ABOUT LAND APPLICAION OF BIOSOLIDS, BUT I HAVE FORMED NO OPINION ABOUT IT."

______ "I HAVE HEARD ABOUT LAND APPLICATION OF BIOSOLIDS, AND I AM NOT OPPOSED TO IT."

______ "I HAVE HEARD ABOUT LAND APPLICATION OF BIOSOLIDS, AND I AM OPPOSED TO IT."

______ "I HAVE PUBLICLY SUPPORTED LAND APPLICATION OF BIOSOLIDS BECAUSE I BELIEVE IT IS BENEFICIAL."

______ "I HAVE PUBLICLY PROTESTED LAND APPLICATION OF BIOSOLIDS BECAUSE I BELIEVE IT IS RISKY."

....

The current average monthly water and sewer bill for residents in your community is $XX.XX. Think about your family's current water and sewer bills, which may be higher or lower than the average, when you answer the following question.

8. If you could be certain that biosolids would be disposed of in an alternative method to land application, what is the highest amount your family would be willing to have added to its water and sewer bill each month? **Please mark the amount that best describes your desire**.

$ 0 "WE ARE NOT WILLING TO PAY MORE, AND WE ARE NOT OPPOSED TO LAND APPLICATION OF BIOSOLIDS."

$ 0 "WE ARE NOT WILLING TO PAY MORE, BUT WE ARE OPPOSED TO LAND APPLICATION OF BIOSOLIDS."

$ __ "WE WOULD BE WILLING TO PAY $ __ MORE MONTHLY TO HAVE BIOSOLIDS DISPOSED OF IN ANOTHER WAY." (**Please circle the highest amount you would pay**.)

$ 2.00	$20.00
$ 4.00	$25.00
$ 6.00	$30.00
$ 8.00	$40.00
$10.00	$50.00
$15.00	$____ OTHER AMOUNT

....

9. Which age category do you fit into?
______ LESS THAN 20 YEARS
______ 20 TO 39 YEARS
______ 40 TO 59 YEARS
______ 60 OR MORE YEARS

10. Are you FEMALE___, or MALE___?

11. How many people live in your home? ______

12. How many children under age 18 live in your home? ______

13. What is your highest level of education?
______ SOME HIGH SCHOOL
______ HIGH SCHOOL DIPLOMA
______ SOME COLLEGE
______ TECHNICAL TRAINING
______ COLLEGE DEGREE
______ GRADUATE OR PROFESSIONAL DEGREE

14. What is the annual income of the entire household?
______ LESS THAN $20,000
______ $20,000 TO $39,999
______ $40,000 TO $59,999
______ $60,000 TO $79,999
______ $80,000 OR MORE

15. For how long have you lived in the current county? ______ YEARS

16. Is your family involved in production agriculture?
______ YES (**Please continue to question 17.**)
______ NO (**Stop here and return the survey. Thank you for your help.**)

....

17. In what kind of agricultural production are you involved? (**Mark <u>all</u> that apply**.)

______ CATTLE ______ SHEEP ______ HOGS
______ FIELD CROPS ______ HAY
______ OTHER ____________________

18. What is the size of your farm or ranch operation?

______ NUMBER OF ACRES OWNED AND/OR LEASED
______ NUMBER OF HEAD OF LIVESTOCK

19. Have you ever applied, or had applied, livestock manure to your farm or ranch land?

______ YES
______ NO

20. Have you ever applied, or had applied, biosolids to your farm or ranch land?

______ YES
______ NO

....

21. Please use this space to express your feelings about the practice of land application of biosolids or to make and comments about this survey.

☐ If you would like more information on land application of biosolids, please check this box and print your name and address on the back of the return envelope (**NOT on the survey booklet**).

Thank you very much for your participation in this survey. Your answers will help researchers address economic and social issues associated with the disposal of wastewater treatment by-products. If you would like a summary of the results of this survey, please print your name and address on the back of the return envelope (**NOT on the survey booklet**).

APPENDIX B

COVER LETTERS AND POSTCARD

First Cover Letter

June __, 1995

Mr. John Doe
123 Main Street
Somewhere, OK 12345

Dear Mr. Doe,

Clean water is important to all of us -- for drinking, bathing, cleaning, and recreation. As a result of our desire to have clean water, the cities and towns in Oklahoma provide treatment to our water before it enters and after it leaves our homes.

The water leaving our homes, or *wastewater*, is made cleaner through treatment. In the treatment process solid particles are separated from the water. These solids, or *biosolids*, are by-products of cleaner water and the treatment process.

There are several ways of disposing of the biosolids. One of the methods of disposal is by applying the biosolids to agricultural or forest lands for use as a fertilizer. The Department of Agricultural Economics at Oklahoma State University is interested in your knowledge of and opinions about this disposal practice.

We would like for you to respond to the questions in the survey booklet and return it to us in the provided envelope. Please do not put your name anywhere on the survey booklet. Your answers will be grouped together with the responses from others and will remain confidential and anonymous.

We appreciate your time and effort in completing these questions. Your answers will help researchers address economic and social issues associated with the disposal of wastewater treatment by-products.

Sincerely,

Patricia Norris
Assistant Professor

Joel Osborn
Graduate Research Assistant

Postcard

June __, 1995

Dear Survey Participant,

About two weeks ago we sent a survey booklet about the land application of biosolids. If you have not already done so, please take a few minutes to answer the questions and return the survey booklet.

Thank you for your help. Your answers will help researchers address economic and social issues associated with the disposal of wastewater treatment by-products.

Sincerely,

Patricia Norris
Assistant Professor

Joel Osborn
Graduate Research Assistant

Second Cover Letter

July ___, 1995

Mr. John Doe
123 Main Street
Somewhere, OK 12345

Dear Mr. Doe

About a month ago researchers from the Department of Agricultural Economics at Oklahoma State University began asking Oklahomans about their knowledge of and opinions about the land application of biosolids.

As you may remember, wastewater, the water leaving our homes, is made cleaner through treatment. In the treatment process biosolids, solid and semi-solid particles, are separated from the water. One of the methods for disposing of these biosolids is by applying them to agricultural or forest land use as a fertilizer.

If you have not returned the previous survey booklet, please take a few minutes and answer the questions in the enclosed booklet and return it in the provided envelope. Please do not write you name anywhere on the survey booklet. Your answers will be grouped together with the responses from others and will remain confidential and anonymous.

Thank you for your time an effort in completing these questions. Your answers will help researchers address economic and social issues associated with the disposal of wastewater treatment by-products.

Sincerely,

Patricia Norris
Assistant Professor

Joel Osborn
Graduate Research Assistant

Third Cover Letter

September ___, 1995

Mr. John Doe
123 Main Street
Somewhere, OK 12345

Dear Mr. Doe,

Several months ago researchers from the Department of Agricultural Economics at Oklahoma State University began asking Oklahomans about their knowledge of and opinions about the land application of biosolids. As you may remember, biosolids are a by-product of the wastewater treatment process. One of the methods for disposing of these biosolids is applying them to agricultural or forest land as a fertilizer.

You may believe that your responses will not contribute to our study. In fact, our research benefits from the responses of <u>all</u> survey participants. By completing and returning the survey form, you will help us answer important questions about wastewater treatment and the use of biosolids. Furthermore, we would like to receive a completed survey from you regardless of whether or not you farm or own land.

Please take a few minutes and answer the questions in the enclosed booklet and return it in the provided envelope. Please do not write your name anywhere on the survey booklet. Your answers will be grouped together with the responses from others and will remain confidential and anonymous.

Thank you for your time and effort in completing these questions. Your answers will help us address economic and social questions associated with the disposal of wastewater treatment by-products.

Sincerely,

Patricia Norris
Associate Professor

Joel Osborn
Graduate Research Assistant

APPENDIX C

COMMENTS SOLICITED IN THE QUESTIONNAIRE

We had a scare about dumping -- we don't want it!! More public knowledge please.

Biosolids applied for land usage should be regulated so as to not damage the soil for future generations. Too much usage might destroy all the minerals and nutrients currently in use. I think that biosolids should be buried and treated the same as toxic waste unless it can be determined to be 100% safe for return to the soil.

Because we have had no prior exposure to this topic, this survey seems to be invalid. Our opinion shouldn't pertain to your results because we really are not directly affected by biosolid disposal in our everyday lives.
We hesitated in filling out this survey because we have not been exposed to this topic and have almost felt harassed by receiving three separate copies at different times. In the future please refrain from including our household in your future questioning since we also have no clue as to why we would be on your mailing list.

Biosolids could help fertilize <u>except</u> there's no way to separate the "Good stuff" from (1) the chemicals that could be detrimental or (2) hazardous waste. So, for now it should NOT be applied to land.

I worked at labs in Los Alamos, N. Mexico and they used the treated water and biosolids to make the grass grow on all their parks and golf courses. There were no odor or offensive scenery from the use of this method of dispersing these waste. I think it would benefit the farm land in Oklahoma.

I think it can be used safely, if it is regulated to prevent contamination of streams, ponds, run off water, wells that are shallow or unprotected, etc. Also, it should not contain industrial wastes that may contain radioactive materials or dangerous chemicals, etc.

We need the facts of the risks involved in disposing of biosolids.

I only guessed at the answers because I didn't have any idea what you were talking about.

I believe biosolids possibly should not be applied to land. Because there is not any possible way to guarantee there is not any hazardous material in the biosolids. If there happens to be any hazardous materials, it is possible that a farmer's cow or one of his children would pick it up and eat it. Then they might have some type of radiation poison or some other type of disease.

I have used composted sludge (Nitrohumus) and am not opposed to its use. I do not believe that raw untreated biosolids should be applied to any land as is the practice in the orient.

I think the public, myself included, would like the facts about biosolids and the possible spread of disease from the material.

I do not know enough about biosolids to answer intelligently. I feel I am very much opposed to the use of biosolids.

If the waste contains no heavy metals or toxic waste, I am not opposed to the application of biosolids to farmland.

I have heard briefly of this. My brother-in-law is a wheat and cattle farmer and I have heard discussion of it around the Sunday dinner table when we are all together (nice dinner discussion topic, huh!) No one seemed to have a definite opinion, but even though we had nothing solid to back it up -- none of us particularly like the idea of it. Potential problems were discussed. I really didn't like the idea of accepting this stuff from other states. I think there needs to be long term studies made, controls in place and a choice given to land owners.

I do not know much about the use of biosolids. My answers are from my recollection of the media coverage of the "NEW YORK SLUDGE" controversy. If biosolids and "New York Sludge" are two different things then my answers might be different. Aren't there too many unknowns to use this in agriculture?

I am against this method of disposal!

I have farmed a place that received and had dumped on this farm from a hog operation. It cut my fertilizer bill in half. It also made the soil much easier to cultivate and appeared to be much mellower.

I have not used any biosolids, but my brother did. He said after a rain it smelled very bad for several days.

I would like to see the use of biosolids for fertilizer if there is a safe and fairly inexpensive way to get it done. Fertilizer costs are one of our biggest problems so if there is a possibility of lowering current fertilizer costs in a non-harmful way, I'd be interested.

I do not know very much about biosolids.

I am not as knowledgeable on the subject at this time. I would have to do more reading about it. I am not involved in any way with agriculture other than eating. I live in the out skirts of the city and use a septic tank for my sewage. We have to pay extra for the use of city water and trash collection.

I feel this is a form of recycling and would be good for our environment!

Biosolids should be applied to the soil only when free from hazardous and harmful materials.

I am no longer a land holder.

Please make the results of this survey public knowledge.

I am opposed to the practice of land application of biosolids. I believe it is a health risk, and it is not worth risking our health.

If is was possible to take out all hazardous solids, I would be for land applications.

I believe this would be better than commercial fertilizer.

Need regulations such as: maximum toxins, lbs./acre, frequency of application, should not be applied where there will be lots of human activity, and if used on consumer products, they should be labeled so. Pasture and grass fields would be the only places I would consider application of biosolids, and then nowhere near my home.

When a disposal method is available that would benefit agriculture or anyone, and we don't run into major problems with heavy metals and such I am certainly in favor of it.
My personal belief is that the EPA has gone overboard on some of their rules and regulations. When laws are applied that give precedent to animals or insects over the rights of landowners, something is askew in their thinking.

I am appalled to think that someone is considering sludge, you sanitize it my calling it "biosolids" is being considered for land application. Isn't the environment screwed up enough? Think of the high cancer rates, etc. in this area due, no doubt, to water table pollution. And someone is considering dumping more into the ecosystem? Sludge has high levels of heavy metals, etc. in it. Let big cities take care of their own problems and leave us alone.

I have used Mil-Organiate in the past as a garden fertilizer. It is a treated, sterilized and fully processed sewage by product produced and marketed by the City of Milwaukee, Wis. I consider its use safe and satisfactory.

I think this type of survey is a waste of taxpayers money. I didn't ask to be a part of it and this is the third one of these I have gotten.

I don't care how much you clean sewage sludge, you can never get all of the hazardous waste out, such as mercury, lead, etc. I sure would not want to eat any thing that has been grown on land which has been fertilized by biosolids.

I do not wish to do this survey. Thanks

They told us as a unit when arriving in Japan not to eat vegetables because they were fertilized with human waste? We did not eat vegetables in town cafe's.

Man creates all this waste, but then they aren't smart enough to know how to take care of it, so it won't come back to us in our water and food.

I think that if it is well tested before spreading on farmland, it can be beneficial for crops and hay ground.

Would like to be sure such a practice would be safe for the environment. Feel that regulation would be necessary, especially if there is some risk to the environment.

OK if it will not spread diseases, bacteria, or viruses. The Bible told the Israelites to bury their dung.

I know of farmers applying lime that was generated for the OKC sewage treatment plant. If this is the type of "biosolid" you are referring to I have no problem with this practice taking place.

Need more information.

Biosolids should never be applied to agricultural land because of the hazardous waste involved. Several of these questions are absurd. They have no relation to survey. Frankly all of those that I have answered as "not related to issue" is none of your damned business.

Need to know more information to be able to make rational and useful statement. I am for clean water and underground surveillance to keep our water supplies unpolluted.

I know that a number of years ago a company was wanting to spread waste from New York on land in Oklahoma. This issue has split a few towns that were possible sites. I have not heard much more about it since then, but my main concern was the heavy metals that would be left behind in the soil. Are biosolids the same thing? Biosolids must go somewhere, but where? I will be requesting more information on this subject.

Since I am not involved in agriculture I cannot honestly answer the questions. The county (Major) has Pig Farms which causes concern for clean and clear drinking water. Hopefully the land will not be contaminated by waste or bio-solids.

I'm sorry you have sent this to the wrong person. I'm very uninformed of any environmental problems in our area -- this is a great place to live.

My knowledge of biosolids is limited. But I would approve of more research and experiment plots to prove if it could be acceptable and practical. The possibilities are there.

My concern is that biosolids may be contaminated with heavy metals and complex hydrocarbons that can leach into the water table or find their way into the food chain. Any intelligent disposal plan must address the proper disposal of waste that is not 100% biodegradable.

We should be more informed regarding the use of biosolids and the effect it has on underground water. If there is not, there should be strict controls of the use of biosolids

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I am in favor of properly processed waste being applied to farm and ranch land.

Everyone work together to provide a healthier future for generations to come.

How much research has been done on biosolids? What are the pros and cons? Need more info to evaluate.

I feel we don't have enough knowledge at this time to feel totally confident in applying biosolids. I am opposed to bringing biosolids from another area to our community.

This looks like just another way to waste time and money. Any county agent can tell you all you need to know about this subject. If not then check with the Russians or Japanese, they've been spreading crap for centuries.

I am opposed to the application of biosolids to the land, but if it is to be done, I would like to see it regulated the same as all other hazardous matter is.

We produce the waste and we need to find a way to dispose of it that meets the needs of all the people in the great state of Oklahoma.

If land application of biosolids is safe and most economical method of disposal, I am in favor of continuing and expanding this method of disposal over other more expensive methods of disposal.

It is my opinion that the EPA of Oklahoma is not sophisticated enough to regulate the in-state toxic waste facilities such as USPCI, or other facilities that generate toxic waste such as PIC (Pig Improvement C--).
I feel blatant violations are being allowed and/or ignored to the grave determent of our valuable natural resources.
I feel topical application of biosolids would be disastrous; as regulation and control seem to be our weak point.
I have aligned my opinions with Oklahoma Toxic Campaign on these issues.

Landfills - I do not care for but if biosolids can be used for fertilizer, then go for it. We should find ways to use up all waste material.

I am not sure about this operation. I think it needs a lot more research to make sure that it won't spread Aids and such.

Retired

I wish EPA and State of Oklahoma laws would create stiffer laws and enforcement in these areas. The problem is that once a corporation has established a project, they start cutting corners to save money. Sludge pits, ground containers are not constructed well enough to keep harmful chemicals out of the groundwater. Once our groundwater has been contaminated, the governments will assess penalties, the company will move on, but what about the residents of the county that are forced to drink bottled water? What about the wheat, alfalfa, and cattle production? I have no faith in our Oklahoma and Federal laws as they stand in 1995, to protect the majority of a population from the actions of a single corporation.

I would be for the application of biosolids to farm land only if there was never any presence of hazardous chemicals and the land owner was never charged for the application.

My sister lives in an area that applied biosolids. Comments made were -- odor, regrets in allowing their application.
My comment: **IF** biosolids are allowed to be shipped in to Oklahoma from out of state, that state/co. should pay same or above what their state charges plus an insurance against "spills, leakage, etc." Enough of the environmental damages left for the Oklahoma citizen to pay for in raised taxes etc. Make others pay for use of our state's environment. Oklahoma has just so much area available for 'dumping.' When ours is gone, where do WE go to dump.

I think disposing of biosolids is a great idea. This way we can make land that's not very fertile produce as if it is the best of all soil. And this way we could produce more and better crops than before.

I know there is something we are going to have to do to care for our sludge problem but we are going to have to clean it up. You know there are chemicals in the sludge that I do not think best for our farm land. We have plenty of our sludge in our state and do not need any out of state sludge. Let some of these plants move their plants and payrolls to Oklahoma. Let's keep Oklahoma beautiful.

Don't know enough about it, but seems like if biosolids are in the water and have to be taken out to dump back in streams or bodies of water, then dumping the solids on land would be a form of pollution.

Disgusting

Only heard about biosolids when articles in papers talked about New York City biosolids were being considered for this area for application to area fields. It doesn't sound like a real healthy idea at all just from what I read. What actually, if any, health risks are possible from such applications, such as to drinking water, food grown on fields where it is applied, working in or around such applications? What is known about long term side affects, etc.? How could anyone be sure of it's health safety since the people proposing this are FOR it and will make money from it? They want it to happen for their own personal benefits and would say it's great with no risks regardless. The government's approval couldn't be taken completely as the truth either. How can we ever be certain it's 100% risk free?

I want no part of this program! It is not good for the country or anything else.

My husband is deceased but he was not for bringing the biosolids. We feel like every area should take care of their own regardless of how much it is pictured to be a good thing. Common sense tells you it will eventually be too much for our soil and water. I wish they would drop it and forget about doing it.

I do not believe we should apply biosolids. There is no way that anyone can tell where or what is in the waste materials, chemically or otherwise. I would not want it applied to my land. One biosolid company tried to come here to this county. But people were so against it that they went elsewhere.

I am not opposed to the idea if they have determined it will cause no harm to the soil or humans.

I am against biosolids on the land. It is different than animal manure because it doesn't have human illnesses and disease carrying germs that could contaminate our water supply. Sorry, I'm afraid of it giving us diseases we aren't able to take care of or afford. Think intelligently before agreeing to this.

Perhaps the company or whoever produces biosolids needs to pay for a satisfactory disposal.

I personally favor this application of disposal as long as it is controlled.

I believe if we must dispose of these solids that they be tested for 20 years and if used for food consumption that the food produced by these solids for the same amount of time.

The application of biosolids could affect our groundwater. For many that is our only source of safe water. We had better take every precaution to protect our groundwater.

The water here in Medford, OK is like grease water and when getting water, rocks comes out of it. The water here is terrible, awful, tasteful when pouring water in a glass to drink. I wish we would have real clean water to drink, but not only to drink but to bath and cook with it too.

Do not want any waste from other city or state.

Our family very much favors the use of biosolids being applied to farm land. We have used Mil-Organite for some time on yards, gardens, etc. We see great potential for the use of sludge -- after all it has to go somewhere -- and since it is usable and useful why not? We also realize the importance of testing and safety. We have offered the use of our land for sludge application and hope that someday.

I am opposed to sludge on our fields in Grant County

My concern was applying such from other states. What we went through some time again. It is what is contained in the product.

I am opposed to any biosolids used on my land.

No to application of biosolids.

Should be based on market and economic choice. If not, you are willing to pay more than cost of disposal under current means, I oppose its use.

Where is this practice presently being done?

We don't want all New York disease brought to this state. If its so good, why don't they put on their own New York soil.

If it was 100% safe to humans and animals there would be no controversy. If it was any other industry the regulatory agencies would ban it.

The generator should pay for the disposal. Hazardous substances should be monitored closely but not by a government agency that could be made public. Penalties should be established for offenders

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I'm curious about why we're doing this survey.

I would like to know more. The first dealings were when Merco wanted to land farm New York sludge in our county. My main concern is how much household chemicals and other hazardous materials are retained in the sludge.

I am afraid of chemicals, other than biosolids, that might be applied. We've been assured that no toxic or dangerous chemicals would be involved. All the assurances in the world, however, wouldn't solve the problem if some such chemicals "slipped by."

I think that biosolids, when adequately cleaned and carefully handled, are a natural God given fertilizer. Our county fought this battle -- and fear won.

Sorry to have not participated sooner My husband Jack _ is not mentally able to answer your questions.

I am against the practice of land application of biosolids.

I am concerned about the effects of soaps and detergents in streams and ponds. Shouldn't the solids be acidified to break down the soaps?

A few years back we were ready to apply biosolids to our land, but we had a lot of opposition in our community.

If application were voluntary or perhaps a one per year thing it would be more acceptable than a yearly minimum application contract in which you had to take X amount regardless of rainfall, etc.

I am not informed enough to have an intelligent opinion to most of your questions.

Our community had an opportunity several years ago to bring a sludge treatment facility to our area; and did not take advantage of it. I felt, and still feel that this was a mistake. The plant would have been a real shot in the arm to our local economy. Unfortunately there were too many skeptics afraid of contamination.

I don't believe any human waste should be put on any land. It will go into our water streams and drinking water wells. I might go for cattle, sheep, chicken, or hog waste.

Don't know any thing about this. If it is in fact an approved fertilizer, I have no problem with this.

I have used biosolids from our local sewage disposal plant on farm land. I have no objection to local biosolids. I would <u>hesitate</u> on using from distant cities because I would not know what chemicals that it would contain.

The introduction of New York Sludge was attempted in Grant County, Oklahoma several years ago. I am steadfastly against it's use because of the heavy metals that they contain, the chemicals that would build up and never go away, just steadily increase, while surely and steadily finding their way to the water supply underground. If billions of gallons of ocean waters won't neutralize their toxic affects, then spreading them in a semiarid agricultural climate would certainly kill the ground with the toxic trace metals then they would leach there way down to the water supplies, leaving the ground dead and useless, unable to support and supply the worlds needs, much less the few who actually live on the lands. NO! Burn it, incinerate it, destroy it (not us).

APPENDIX D

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 06-06-95 **IRB#:** AG-95-017

Proposal Title: RISK RELATED EXTERNALITIES FROM APPLYING MUNICIPAL BIOSOLIDS TO AGRICULTURAL LAND

Principal Investigator(s): Patricia E. Norris, Joel W. Osborn

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature: John H. Wyckoff Date: June 7, 1995
Chair of Institutional Review Board

VITA

Joel Wilson Osborn

Candidate for the Degree of

Master of Science

Thesis: RISK RELATED EXTERNALITIES FROM APPLYING MUNICIPAL BIOSOLIDS TO AGRICULTURAL LAND

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Albuquerque, New Mexico, February 9, 1967, the son of John and Geneva Osborn. Married to Rhonda (McCormick) Osborn, December 21, 1991.

Education: Graduated from Tipton High School, Tipton, Oklahoma in May 1985; received Bachelor of Science degree in AgriBusiness and Bachelor of Arts degree in Political Science from Abilene Christian University, Abilene, Texas in May 1992. Working toward Juris Doctorate degree at the University of Oklahoma, College of Law (anticipated completion May 1998). Completed the requirements for the Master of Science degree with a Major in Agricultural Economics at Oklahoma State University in December 1997.

Experience: Bank Courier, North Carolina National Bank (NCNB), Dallas, Texas, August 1987 to August 1988; Computer Operator, NCNB and Affiliated Computer Services, Abilene, Texas, January 1989 to May 1990; Ranch Hand, Bar Diamond Ranch, Lewistown, Montana, Summers 1990 and 1991; Student Assistant, Department of Agriculture and the Environment, Abilene Christian University, Fall 1990 to Fall 1992; Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University, Spring to Fall 1993; Executive Secretary, Center for Agriculture and the Environment, Oklahoma State University, December 1993 to August 1995.