Economic impacts of groundwater quality legislation on central Arizona cotton farmers

ECONOMIC IMPACTS OF GROUNDWATER QUALITY LEGISLATION ON CENTRAL ARIZONA COTTON FARMERS

by

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STATEMENT BY AUTHOR

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ABSTRACT

The profitability effects on central Arizona cotton producers resulting from the regulation of agricultural chemicals was estimated. Evaluating the economic effects on farmers is an important consideration in the development of groundwater protection policy as mandated by Arizona's 1986 Environmental Quality Act. A survey was taken of Pest Control Advisors in Maricopa and Pinal Counties to determine the substitutions which take place between various agricultural chemicals and the estimated resulting change in cotton lint yield. Technical data regarding nitrogen fertilizer applications was taken from local studies done by personnel from Cooperative Extension. This data was analyzed using comparative farm budgeting techniques. Significant effects were estimated for the elimination of certain specific agricultural chemical inputs, while others projected only minimal effects due to the availability of substitute products. Detailed sensitivity analyses were performed to determine the effects of changing production and cost parameters assumed in the model.

CHAPTER ONE

INTRODUCTION

The quality of the water we drink is an issue of increasing importance. Much public attention and research has been directed toward increasing the quantity of water available, especially in the western United States. Over the course of the last two decades, Americans have become increasingly concerned with factors which are believed to affect the quality of the water they consume.

Public attention has been initially directed toward the quality of the surface water in the nation's streams and lakes. It is important to note, however, that over ninety-seven percent of rural America's drinking water supply comes from underground sources (Nielsen and Lee, 1987). In addition, the dependence on groundwater is increasing over time. Nielsen and Lee (1987) report that groundwater withdrawals have increased 158 percent between the years 1950 and 1980. Withdrawals of surface water have increased only 107 percent. Therefore, the quality of the water in these underground supplies is a major concern.

With this increase in public attention has come a significant rise in the level of awareness of the problem on the part of state and federal lawmakers. Consequently, legislation designed to protect water quality has increased dramatically since the early 1970's. This legislation has been directed toward the areas of the economy which are believed to be the highest contributors to groundwater pollution.

The Role of Agriculture in Groundwater Contamination

One sector of the economy on which much attention has been focused is the agricultural industry. A partial explanation for the increase in attention is the continued rise in the use of agricultural chemicals. Figures 1 and 2 (Nielsen and Lee, 1987) show that the use of nitrogen fertilizers and agricultural pesticides in the United States has increased during the period in which the issue of groundwater pollution has attracted the most attention. For this reason, much of the recent environmental legislation aimed at reducing the contamination of groundwater supplies has been at least partially directed toward the agricultural sector.

The Nature of the Problem in Arizona

This problem first reached the public light in Arizona in 1979, when Dibromochloropropane (DBCP) was discovered in samples taken of groundwater in Maricopa and Yuma counties (Rich and Associates, 1982). This was the first finding of an agricultural pesticide in Arizona's groundwater. Public concern resulting from this finding led the Arizona Department of Health Services to commission a private firm to develop a program for testing samples of the state's groundwater for the presence of specific contaminants (Rich and Associates,1982). This program has revealed that there are certain agricultural chemicals which have the potential to pollute Arizona's groundwater.

Similar discoveries in other states prompted the initiation of several groundwater testing programs on a regional or national scope. Figures 3 and 4 (Nielsen and Lee, 1987) show the further results of

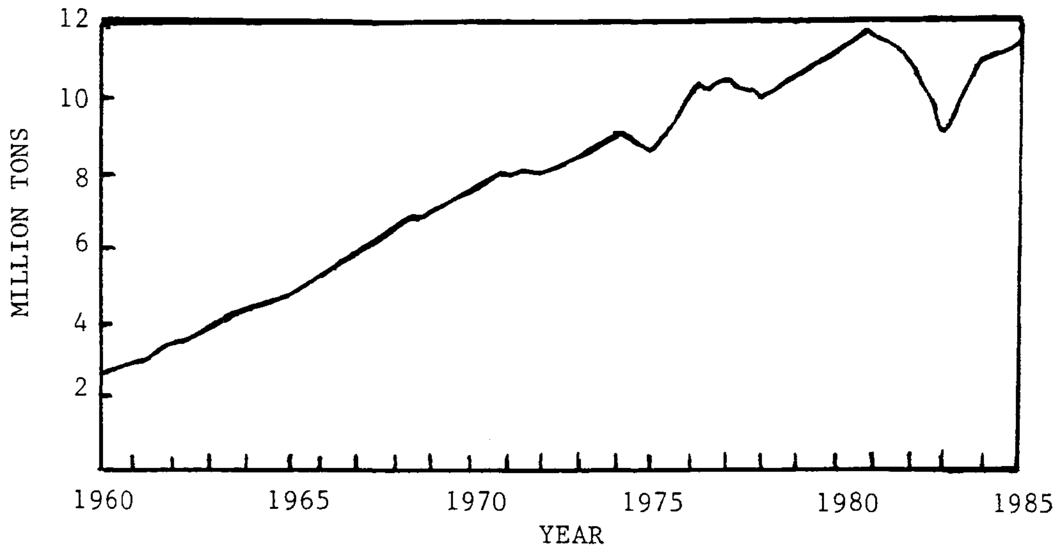


FIGURE 1 : TRENDS IN U.S. AGRICULTURAL NITROGEN USE, 1960-85

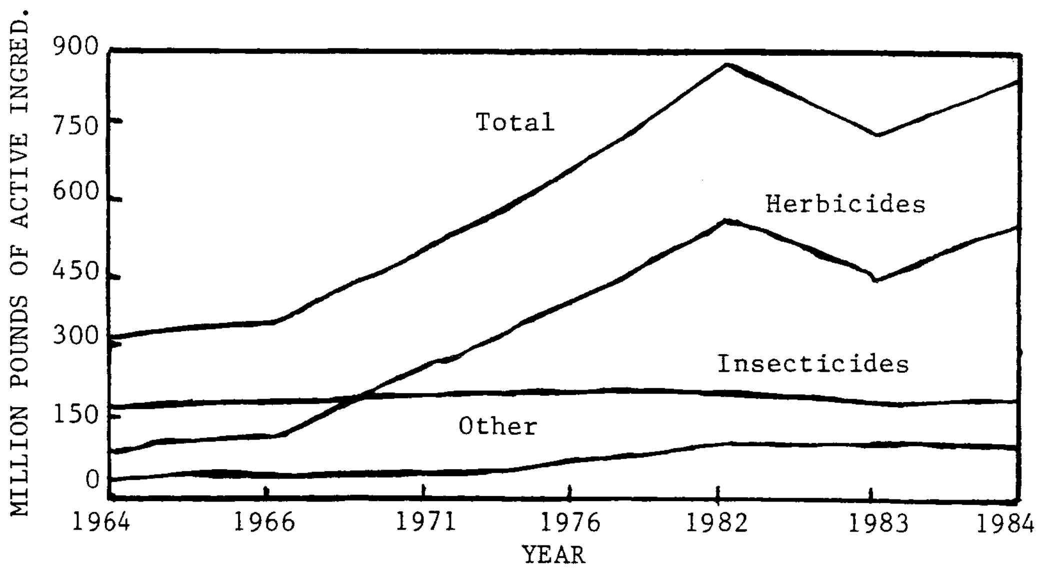


FIGURE 2 : TRENDS IN AGRICULTURAL PESTICIDE USE, 1964-84

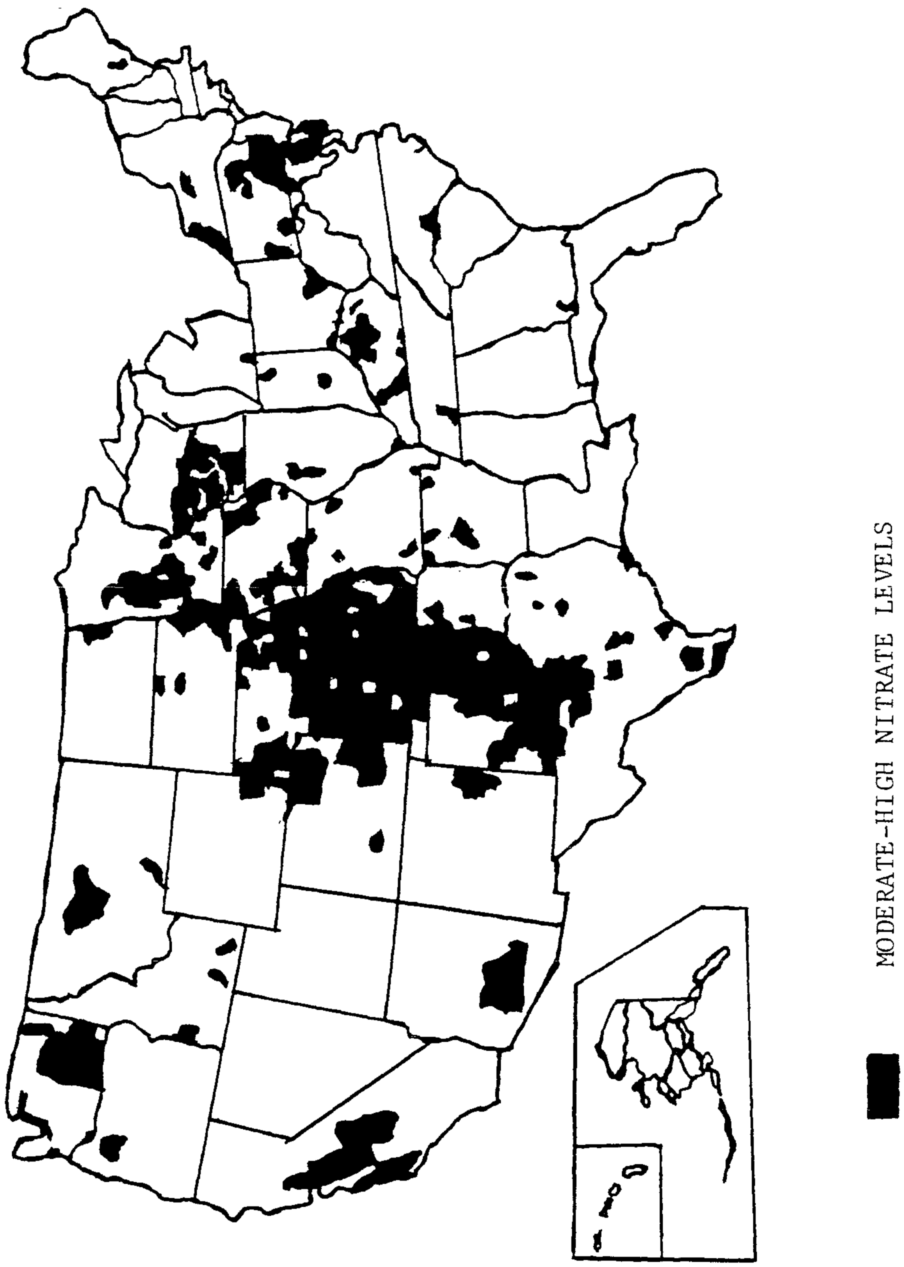


FIGURE 3 : NITRATE-NITROGEN DISTRIBUTION IN GROUNDWATER IN AGRICULTURAL AREAS

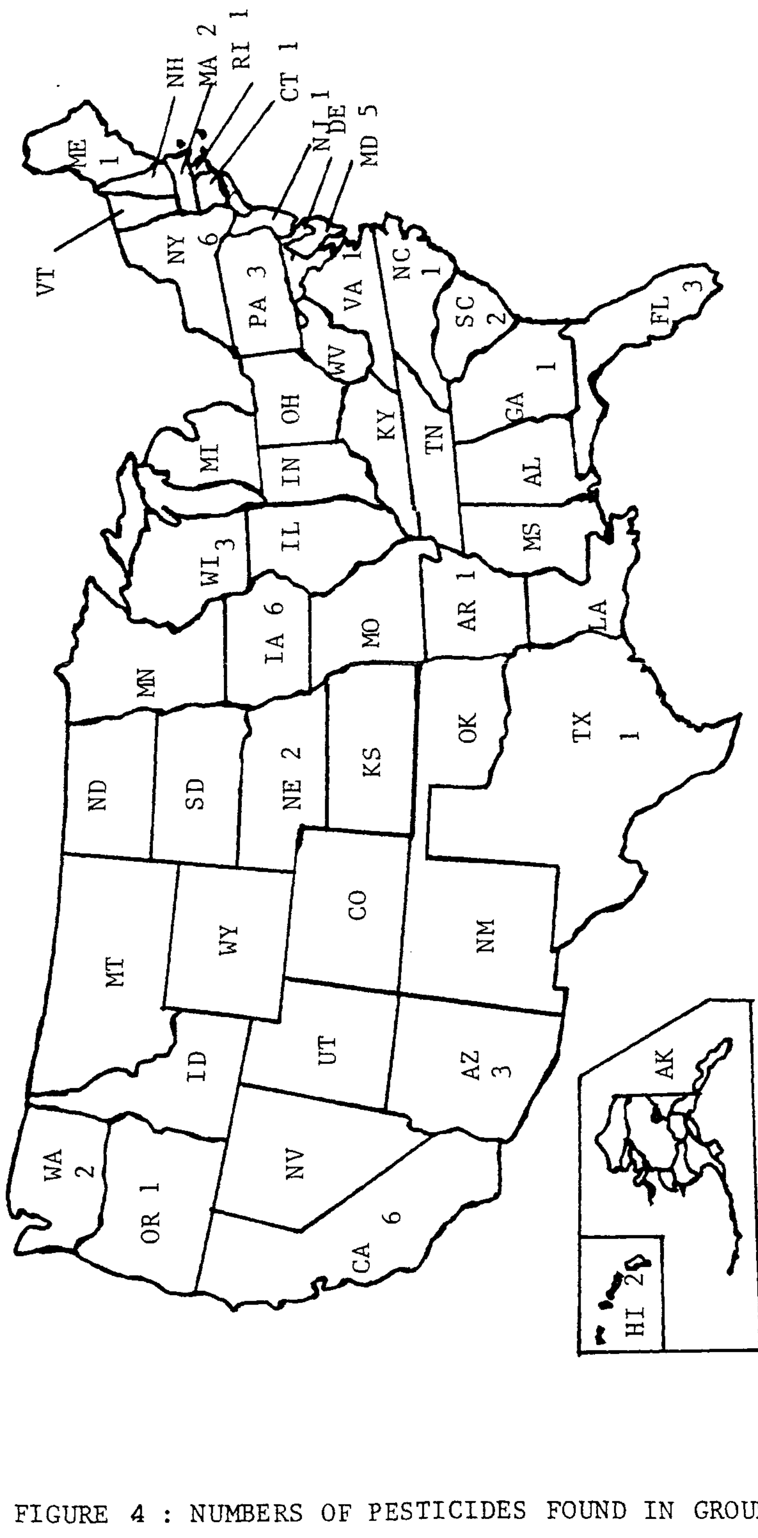


FIGURE 4 : NUMBERS OF PESTICIDES FOUND IN GROUNDWATER CAUSED BY AGRICULTURAL PRACTICES, 1986

groundwater testing for nitrogen and pesticides on a national basis. This information shows that Arizona does have contamination from both pesticides and nitrogen fertilizers to some extent.

Purpose and Structure of this Study

The regulation of practices which might pollute the groundwater will have some economic impact on those businesses which rely on such practices. The nation's farmers, already facing what some feel is the worst depression in agriculture in several decades, may not be in a position to withstand large negative effects on their financial position. For this reason, most legislation designed to protect groundwater quality has provided for the consideration of profitability effects of legislation on the regulated industries.

The purpose of this study is to estimate the economic effects of groundwater quality legislation on the typical central Arizona cotton farmer. This is accomplished through the use of computer-based farm budget models representative of typical farms in Maricopa and Pinal counties. Analyses include the estimation of economic effects of regulations which alter the use of both nitrogen fertilizers and chemical pesticides.

Chapter Two presents a review of current literature pertaining to public regulation of agricultural chemicals. With this, it presents an overview of policies which have been adopted in other areas. This information has been used to develop the models used in this study.

Chapter Three outlines the state and federal policies which affect the use of agricultural chemicals. A brief summary of federal legislation concerning groundwater quality and the regulation of chemicals used in agriculture is presented. In addition, an in-depth review of Arizona's new Environmental Quality Act is performed to determine which specific regulatory actions would be most useful to model.

The fourth chapter addresses the assumptions which have been made in order to perform this economic analysis. The choices of study area, study crops, cultural practices, and cost and revenue data are discussed in this section. Also, this chapter outlines the steps utilized in analyzing the effects of the government farm programs on the results of this study.

The results of modeling for pesticides and nitrogen fertilizers are presented in Chapters Five and Six, respectively. These sections not only present the estimates of the change in short-run net returns for the typical farmer under certain legislative constraints, but also discuss the results of technical analysis performed in order to obtain this data.

A summary and overview of implications for public policy is included in Chapter Seven. In addition, this chapter details the limitations to which this study is subject. The study concludes that certain regulatory practices for pesticides and nitrogen fertilizers can have significant effects on individual growers. The conclusions drawn concerning the magnitude of these effects should be helpful in the formulation of public policy relating to the regulation of agricultural chemcials in order to protect groundwater quality.

It is the intent of this thesis to derive a reasonable estimate of the effects of certain groundwater quality legislation on the average Arizona farmer. It is hoped that this information will be useful to policymakers in their attempts to maintain and improve the quality of the environment, while still allowing for a healthy and productive agriculture.

CHAPTER TWO

LITERATURE REVIEW

The study of agricultural impacts on water quality is a relatively new subject. Research on the matter did not begin until the mid-1960's. Originally, the main focus of attention was centered on sediment movement into surface water in the Corn Belt. Since this time, the subject has become of interest to researchers in several diverse fields- agronomy, entomology, hydrology, soil science, natural resource management, political science, and agricultural economics.

Due to the multi-disciplinary nature of the subject area, it is necessary in any review of current literature to focus on each of the main topics examined in the many disciplines involved. This literature review will attempt to do just that. This entails a detailed review of the literature pertaining to nitrogen fertilizer and pesticide use as they relate to water quality. The chapter is separated into four distinct sections, each covering a different aspect of the problem. The first section will review studies relating to the public policy aspects of the subject. This is the type of research most likely undertaken by political scientists and natural resource economists who analyze public policy. The second section reviews studies which concentrate specifically on the technical aspects of nitrogen fertilizer use. The third section involves a similar review specific to pesticide use. The fourth section consists of a review of empirical studies in which conceptual and technical information has been applied to a specific economic problem. These studies are often undertaken by a team of researchers representing the various disciplines involved.

Review of Public Policy Studies

Considerable attention has been focused on the public policy aspects of agricultural impacts on groundwater pollution. Groundwater quality is generally considered to be a public good. It is so considered because groundwater quality is seen to possess many characteristics of a public good. Due to the large costs associated with abatement, a collective effort is necessary to provide cleaner water. Once achieved, high quality groundwater is available to many people, both those who have contributed and those who have not. Selective exclusion is virtually impossible. Groundwater quality also involves externalities as it may be affected by land management decisions of private, as well as public, enterprises. Due to these various characteristics of public goods and externalities, it is often found that such issues are best approached in a public policy setting. Therefore, several analysts have viewed the problem of groundwater quality as one with substantial public policy ramifications.

Saliba (1985) states that a major difficulty of public policy formulation in this area is the lack of quantifiable data regarding the value of various levels of groundwater quality. This contention is in reference to the close relationship between water quantity and water quality. Several studies have been performed estimating the value of a given quantity of water. In this article, Saliba outlines the need to integrate the quality aspects into such analysis. The paper concludes that a mixture of private markets and public policy is necessary to assure accurate allocation of water, given both the quantity and quality considerations.

A similar institutional study performed by Sharp and Bromley (1979) points out that a major obstacle in the reduction of agricultural water pollution is the design of appropriate institutional framework. The article models both the agricultural firm and the management agency to illustrate the flexibility that both entities must exhibit in order to achieve efficient pollution abatement. According to the authors, effective policies must: 1) generate relevant information concerning progress toward meeting specified goals (i.e. water quality standards), 2) be able to adapt over time to changes in prevailing conditions, and 3) reconcile the conflicting interests of the parties involved. This article is in accordance with the idea of coordination between private and public entities set forth by Saliba.

Specific studies such as those done by Constant (1986) and Holden (1986) further emphasize this point. Constant critically analyzes state groundwater protection programs in nine agriculturally-oriented states and examines the features of individuals programs which show promise in addressing the issue. Through a comparative analysis of these various programs, Constant brings forth disucssion on policy formulation and implementation. Importantly, the author also recognizes and examines significant features of both agriculture and society that serve as constraints to comprehensive policy. Among these features is the autonomous nature of the agricultural industry. Farming has for centuries been one of the least regulated of all industries. As a political constituency, farmers do not easily accept government regulation which limits this autonomy. Also important is the fact that such regulation is highly related to other farm problems and issues. Regulation at a time when the industry is already under serious financial stress makes for a difficult implementation process. In view of these constraints, a study of key elements to be included in viable policies is performed. Several approaches are identified as having promise for state policy development, while others are discounted due to structural constraints. Among those strategies most favored are further research on the interactions between agriculture and groundwater, educational programs, comprehensive well monitoring programs, and the implementation of Best Management Practices (BMPs). Holden conducts related analysis on groundwater policies in four states. His methodology is similar to that used by Constant. The common denominator in the policies which are considered promising in each study is that all encourage and demand consideration of the interests of both society and agriculture, and emphasize coordination between them. While this seems a difficult task, it is necessary if program implementation is to be successful.

Proceedings from a recent conference, Agriculture and the Environment, published by Resources for the Future outline further complications with the protection of groundwater quality through public policy. In this instance, the discussion is specific to pesticide use. In Chapter 4, Lichtenberg and Zilberman (1986) consider the organizational difficulties in pesticide regulation practices. They particularly examine the tradeoffs between agricultural productivity and environmental quaility. On the agricultural side, the authors discuss the problems of estimating the productivity of pesticides. This estimation involves examining the contribution of pesticides to actual production. Such research is generally carried out using econometric or crop ecosystem simulation models. Another issue discussed is the varying effect of pesticide regulation on individual farmers. The authors note that effects will vary both between regions and among individual producers in a given region, differentiated by such factors as risk aversion, current cultural practices, and size of operation.

In Chapter 5 of the same book, Antle and Capalbo (1986) provide a more detailed background on pesticides policy. In accordance with the emphasis on coordination in the other studies, the authors state that any work on this subject should necessarily cover three general topics: 1) costs and benefits to agriculture, 2) costs and benefits to society, and 3) policies through which public entities may intervene when the social benefits do not equal or exceed the social costs. Through this analysis, the chapter presents a thorough agenda for public policy regulating agricultural chemicals in groundwater. Their policy conclusions are similar to those of Constant (1986) and Holden (1986).

The most widely-used method of public policy regulation of agricultural chemicals throughout the United States has been the derivation and enforcement of Best Management Practices (BMPs). This policy tool is designed to encourage and/or mandate the use of certain cultural practices which are shown to decrease the movement of nitrogen and pesticide residue into the water supply. These practices have been either encouraged through subsidy programs, regulated through legislative mandate, encouraged by educational programs, or promoted through some combination thereof.

The first region to promote intensive use of BMP programs was the Corn Belt. These practices were encouraged to reduce runoff of nitrogen fertilizer residue and sediment into surface water. A study done by Kaap (1986) in the Big Spring Basin of northeastern Iowa shows that farmers could cut their crop nitrogen, potassium, and phosphorous needs by up to 66% through the adoption of selected cropping practices. This would result not only in reduced introduction of these materials into the water source, but would also increase farm profitability. The paper discusses how nine area farmers reduced potential nitrogen losses and improved profitability by following recommended fertilizer practices in 1986.

Despite this and similar studies which have shown that it may be in the producers' best interest to adopt these practices, implementation in most areas has been a slow and difficult process. In 1983, Nowaak and Korsching studied various social and demographic characteristics among Iowa farmers which influence adoption of BMPs. Among these factors, size of operation, income, security of land tenure, length of planning horizon, experience, and education all had a positive correlation with the rate of BMP adoption. Factors which had a negative impact on BMPs included elevated debt levels, difficulty in obtaining operating and long-term credit, and age of operator. This study illustrates not only factors which individual producers consider in their management decision as to whether to adopt voluntary practices, but also important factors which regulators must weigh in the formulation of agricultural pollution policy.

Several studies such as that performed by Baker and Johnson (1983) have evaluated the effectiveness of BMP policy. Baker and Johnson conclude that these practices have, in general, been a reasonably effective method for the reduction of impacts on water quality.

A somewhat conflicting viewpoint on the effectiveness of BMPs is presented in the Sharp and Bromley (1979) study previously mentioned. Sharp and Bromley quote a federal study which concludes:

> An analysis that emphasizes adjustments at the farm level necessarily omits many feasible management alternatives. The current focus on best management practices (BMPs) stems from the fact that agricultural activity augments, and initiates, the flow of pollutants from the land resource. It is the practices of plowing, fertilizing, harvesting, and manure spreading that provide the inputs into a process which is essentially driven by hydrological phenomena. But, the delivery systems and receiving bodies of water are also amenable to change. Actually, the only requirement placed upon a set of locally determined BMPs is that they be the most effective and practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. (Federal Register, 1975)

Sharp and Bromley analyze this statement not as promoting the elimination of BMPs, but as reiterating the need for comprehensive policy. They call for policy which not only regulates individual producers, but which integrates this action with other existing and prospective water quality programs.

Although most studies reviewed deal with surface water quality and not groundwater, it can be inferred from analysis of policy-oriented literature that the regulation of agricultural impacts on water quality is a complex issue. The formulation of public policy is based upon highly technical aspects of many diverse disciplines. It will be necessary in this study of the effects of water quality legislation on agriculture to address each of these issues. This literature review now turns to a more specific analysis of certain segments of this technical information.

Review of Nitrogen Studies

The initial attention relating to agricultural operations and water quality was first focused on problems with the presence of nitrates (NO_3) and sediment in the water source. Much has been written on the effects of various farming practices on soil erosion and the resulting sediment movement into surface water in the Midwest. A substantial amount of literature also exists on the movement of nitrate-nitrogen applied as crop fertilizer into surface and ground water. As sediment pollution is not a factor in groundwater pollution, this section of this review concentrates on those articles relating to the use of nitrogen fertilizers. As there is a large amount of nitrogen literature available, time and space limiations preclude an exhaustive listing. The following studies were selected due to their relevance to this specific study and also because they comprise a representative sample of the nitrogen literature.

Many studies have been done by hydrologists to investigate the sources of nitrate contamination in water in specific areas. (Kreitler and Jones, 1975; Kreitler, 1975) One such study was performed in late 1980 by Spalding, Exner, Lindau, and Eaton (1982). The group collected groundwater samples from thirty-eight public supply and domestic wells in the Burbank-Wallula area in the state of Washington. The analysis concludes that the high nitrate values found are the result of agricultural leachates. Other similar studies have attributed considerable nitrate contamination to farm-induced causes.

Related research has been conducted to further analyze the specific farming practicies which lead to nitrate contamination. Burwell, Schuman, Saxton, and Heinemann (1976) performed a study similar to those discussed above, but also carried the research one step further to define which aspects of nitrogen fertilizer application were most conducive to nitrate leaching. They studied nitrogen in subsurface discharge and surface runoff in four agricultural watersheds near Treynor, Iowa over a five-year period. The study found that the principal cause in this sample was the application of nitrogen fertilizer in excess of crop needs. Few other practices were found to have significant on the rate of nitrate leaching.

Gerwing, Caldwell, and Goodroad (1979) undertook a similar study on a different soil type in central Minnesota. Similar to the previous study, this group found the rate of application to be an important determinate of leachate. However, this study also found that split applications of nitrogen have a much smaller effect on the concentration of nitrate-nitrogen in the aquifer than does a one-time full application. The total amount of nitrogen applied was identical in both scenarios of the study. Empirical results show that splitting the applications increase the nitrogen in the plant derived from fertilizer from 33.1% to 54.5%. This shows that, at least within the parameters of this particular study, a practice which decreases the amount of nitrate contamination actually increases the amount of nitrogen available for plant growth.

Baker and Johnson (1981) had similar results in a four-year study performed on corn, oats, and soybeans at the Agronomy and Agricultural Engineering Research Center near Ames, Iowa. They again found that the rate applied is a principal determinant of the leaching rate. Their study also found that such variables as method, number, and timing of application, the chemical form of nitrogen used, and the use of nitrogen inhibitors can be manipulated to better match nitrogen availability with crop needs.

The bulk of concern with nitrates has been in the Corn Belt; therefore, most research on the subject has been conducted there. Pending further research, however, it is logical to assume that factors affecting nitrate leaching in the southwestern United States are similar to those outlined in these studies. In summary, these factors include: 1) rate per acre at which N-fertilizer is applied, 2) number of applications in which this amount is applied (single or split), 3) method of application, 4) timing of application, 5) chemical form of nitrogen used, and 6) simultaneous application of other chemicals which inhibit nitrogen activity. These are some of the factors which will be analyzed in this study.

Review of Pesticide Studies

The most recent and intense public attention on agricultural impacts on water quality has been in reference to chemical pest control methods. Since the uproar caused by DDT in the early 1970's, pesticide use has been a highly salient issue with the American public. The national attention during the Environmental Era of the late 1960's and 1970's led to a substantial amount of regulatory legislation, as well as an increase in academic research in the area. Therefore, while there is less hard empirical data available on pesticide use than on nitrogen fertilizers, there is a wealth of theoretical literature available.

One interesting segment of the pesticide literature is that which relates pesticide use with risk and uncertainty. This type of research finds that pesticides are an input to the production process which not only increases average yield, but also decreases yield variability. Farnsworth and Moffitt (1981) performed a study in the San Joaquin Valley of California to conduct qualitative analysis of the effect of risk on the employment of various production factors under risk aversion as compared to a risk-neutral outcome. Farm machinery, labor, and chemicals were found to be inputs which served to reduce production risk.

The most notable concept pertaining to the relationship between pesticide use and risk is that of "the economic threshold". Feder (1979) uses this term to define the point at which the value of the marginal product of the pesticide input equals its unit price. His paper analyzes the impact of uncertainty on this threshold. Feder studies uncertainty regarding both the level of pest infestation and the effectiveness of the particular product. He concludes that providing information on such subjects to farmers is a worthy social goal. This is because he finds that an increase in farmer information levels will lead to a lower degree of uncertainty, which will in turn result in a lower overall level of pesticide use.

Plant (1986) also deals with uncertainty in the production process. He states that "economic threshold ... has been defined by economists to be the level of pest infestation that warrants an application of pesticide when the pesticide application rate is computed to maximize the grower's profit." (p.1) He criticizes both this and Feder's definition by asserting that these concepts assume that all parameters are known with certainty. Often this assumption is inaccurate. In reality, there is a great deal of uncertainty. Plant's study analyzes the of uncertainty on the economic threshold. On page one, he states, " In practice, a grower who is uncertain about the outcome of events is likely to apply more pesticide than theoretically optimal as a form of insurance. This tendency is that of risk aversion."

Miranowski (1980) had similar findings through a significantly different methodology. His study of corn producers in Iowa was designed to estimate the substitution effects between energy, herbicides, insecticides, and information. Findings are that as energy prices rise, information and monitoring services will substitute for chemical use. This shows that the gathering of technical data which decreases subjective uncertainty will decrease pesticide use. Once again, a direct relationship between the rate of pesticide use and the level of uncertainty is established.

A study performed by Pingali and Carlson (1985) presents one possible explanation for this relationship. They studied North Carolina apple farmers to estimate the effect of human capital factors on chemical usage levels in agriculture. They contend that farmer behavior in an uncertain environment is governed by subjective probability estimates of random events. A regression model was run to estimate the correlation between levels of chemical usage and variables such as farmer experience, education, pest scouting, and attendance at special extension training seminars. All variables were found to be negatively correlated with use levels. The data is interpreted to show that the farmer's upward bias in estimating pest damage, and the resulting tendency to elevated pesticide use rates, can be at least partially corrected through the use of information.

This segment of the pesticide literature pertaining to risk and uncertainty shows that most studies have found elevated pesticide use levels to be at least partially the result of uncertainty. It is evident that one effective method to reduce chemical use would be to reduce uncertainty in the production process. While the total elimination of uncertainty is impossible in a process which is influenced by natural factors, it has been shown that uncertainty, and therefore, chemical use can be reduced through educational and information dissemination programs.

Another issue which has received much attention in the literature is that of the intertemporal aspects of pest control. Pest control techniques undertaken during a particular season are necessarily related to practices in both previous and subsequent seasons. Study of this subject has generally involved the derivation of an optimal time path for pesticide use. Work at Cornell University by Shoemaker (1973a,b) investigated the application of several optimization techniques to model multi-period decision making in pest management. The study used dynamic programming to find an optimal combination of chemical (an insecticide) and biological (a parasite) control over a planning horizon. Shoemaker found that specific results are dependent upon the individual characteristics of the study. She also points out that it is important to closely examine the interactions between the factors involved in such analysis. For instance, in her example, the insecticide was toxic to the parasite and thus interfered with biological control methods.

The problem was also confronted by Carlson (1977). An additional aspect which Carlson examined was the development of increasing resistance to chemical control on the part of the target pests. Analysis of individual farm data showed that the marginal productivity of the insecticides studied had fallen substantially during the study period. The modelling performed led to conclusions that the farmers were shifting between insecticide types and adjusting use to avoid the development of further resistance to the major insecticides. Carlson asserts that the decline in pesticide productivity has been encouraged by the common property nature of the genetic pool of nonresistant pests and also by pesticide regulation. The common property nature implies that there is a finite number of pests which are not resistant to a specific chemical and that these pests are accessible to all. Therefore, the excessive use on one product by one farmer will increase the probability of the pests developing resistance to that product. This resistance will adversely affect not only that farmer, but other farmers as well. Had the farmer thought beforehand that all detrimental effects would be centered on him and not dispersed among others, he might well have decided not to perform the application. This factor, along with the cost of developing new products, has led to the decline in productivity.

Regev, Shalit, and Gutierrez (1983) took a more specific approach in a case study of the Egyptian alfalfa weevil in California. Their research utilized a theoretical model to develop a time path for pesticide use in the face of increasing resistance. The study results in some interesting conclusions, as follows:

> 1) based on the assumption that alternative pest-control techniques exist, an optimal time path of current pesticide practices may be found until the economy switches to one of the alternative technologies; and 2) if the central authority conducts its optimal policy only with respect to pest population while ignoring the effects of pest resistance, it is preferable not to intervene by increasing pesticide use. (p.87)

The authors call for public policy to discourage the increase of pesticide use per acre when productivity falls due to increasing resistance.

Plant, Mangel, and Flynn (1985) concur with this statement, "The grower in this situation may do better by sacrificing a portion of the present crop in return for reduced resistance to future application." (p.45) Their study analyzed the effects of timing of application on pest resistance. They found also that resistance may be reduced by application of pesticides at an earlier date, not necessarily at a higher rate, than would otherwise be recommended.

One policy problem associated with increasing pest resistance is that it aggrevates the effects of the ban of a particular product. The fewer products there are for a particular pest, the more drastic will be the effect of a loss of one of the remaining products. The increasing resistance problem can, however, also be reduced by a reduction in use of certain compounds mandated by pesticide regulations. Both of these circumstances are quite possible. This is why the effect of increasing resistance has been a key issue in the discussion of pesticide legislation.

Much of the economic study on pesticide use performed to date has been conceptual and theoretical in nature. An example of this type of work is the article presented in the Annual Review of Entomology by Norgaard (1976). Norgaard, an agricultural economist writing in an entomology journal, discusses the economic concepts which relate to agricultural pest control. Among those most mentioned are imperfect knowledge, transactions costs, and imperfect competition. The relevance of imperfect knowledge has been previously discussed in the review of the literature pertaining to uncertainty in pesticide use. Transactions costs are involved when a grower faces decisions regarding which chemical to use. There is a cost associated with obtaining the information necessary to make an intelligent pest management decision. Imperfect competition is relevant to pest management in that market power in both the markets for agricultural inputs and farm products influences pest management decisions. This article shows that, while there is an obvious need for multi-disciplinary research on the subject, it is first necessary to start with all parties possessing certain conceptual knowledge in common.

A more detailed conceptual economic analysis was performed by Schaub (1983). Schaub states:

> Pesticides are an integral component of economically efficient agricultural production. The rapid adoption of pesticide technology permitted significant changes in the U.S. agricultural production system, such as continuous cropping, increased plant populations per acre, greater regional flexibility in crop production, and decreased labor, energy, and machinery requirements. The consequences of most of these changes were higher levels of production at decreased costs, resulting in benefits to consumers and producers. These changes, however, did not occur without costs... (p.15)

Several other studies (Taylor, 1980; Feder and Regev, 1975; Regev, Gutierrez, and Feder, 1976) have examined other economic aspects in a general nature. Two of these studies are especially worthy of particular attention at this point. This first is a discussion presented by Reichelderfer (1980) in the American Journal of Agricultural Economics. Reichelderfer concisely summarizes the difficulties associated with the economic analysis of agricultural pest control. Among these are: 1) assumptions of maximum profit incentive versus minimization of risk exposure, 2) data problems, and 3) intertemporal aspects of pest management decisions. Her discussion contains points promoted in many of the other studies reviewed here, as well as some new ideas not previously mentioned. As with the Norgaard (1976) study, this article calls for good interdisciplinary communication. Similar to the risk-related studies, Reichelderfer states, "Evidence also is available to suggest that the real value of many pest management practices is reflected in a change in yield or income variability rather than a change in average expected yield or profit." (p. 1012) The intertemporal aspects of pest management are also discussed, as was the case in the time path studies reviewed earlier.

Reichelderfer also makes several relevant points not previously covered. She asserts that "data problems abound in pest management economics." (p. 1012) Data is lacking on the effect of pesticides on crop yield, as well as the relationship between chemical efficacy and other factors such as timing, application method, and infestation levels. A detailed critical review of methodological problems posed by this lack of data is presented. As stated on page 1013, "Generalization and oversimplification are exciting, but dangerous courses to follow in examining the complex issues of pest management economics."

One popular method of gathering data for economic study of pest management issues involves the use of the Delphi technique. This approach is generally used in situations in which verifiable field test data is unavailable. The technique involves "obtaining consensus estimates from a set of leading entomological and agronomic experts. One major drawback of this procedure is that the estimates are difficult to validate because they are no derived from formal quantitative analysis" (Lichtenberg and Zilberman, 1986). While this method has some disadvantages, it is often the best available means of data collection, given the lack of quanitifiable data available.

A final important theoretical aspect discussed briefly by Reichelderfer and analyzed in detail by Lichtenberg and Zilberman (1986) is the functional form by which to estimate pesticide productivity. Both articles stress the need for a damage control function rather than a traditional production function when dealing with such agents. Reichelderfer notes that the function is dependent on the initial level of pests present . She states, "Production functions for pest control are unrealistic if they do not express yield as a function of pest levels." (p. 1012) Lichtenberg and Zilberman note:

> One of the most important classes of factors of production is that consisting of damage control agents. Unlike standard factors of production (land, labor, and capital), these inputs do not increase (they may, in fact, decrease) potential output. Instead, their distinctive contribution lies in their ability to increase the share of potential output that producers realizing by reducing damage from both natural and human causes. (p. 261)

In summary of this point, it is believed that traditional production function specifications overestimate the productivity of damage control agents such as pesticides. The reason for this overestimate is an upward bias in the assumed shape of the marginal factor productivity curve for the damage control agent. The marginal factor product of such agents has been found to decrease more rapidly than that assumed by traditional production functions such as the Cobb-Douglas function. Rather than a direct production function, these articles combine to show that it may be best to model a "kill function" based upon assumed initial pest populations.

There has, indeed, been a considerable amount of conceptual and theoretical research done on pest control. The next section of this literature review will now turn to specific empirical economic studies related to pesticide use, nitrogen use, and public policy.

Review of Empirical Economic Studies

While the emphasis in literature pertaining to agricultural chemicals and water quality has been chiefly on the theoretical issues, some studies have been performed using empirical data. Many of these studies have involved the use of aggregate data on a national or regional level. Several studies have been done to estimate the aggregate economic effects of the regulatory elimination of certain specific substances. Others have estimated national-level effects of changes in particular pest control programs.

One such study is that performed by Taylor, Carlson, Cooke, Reichelderfer, and Starbird (1983). This group conducted an aggregate cost-benefit analysis of various regional programs for the control of the boll weevil on cotton in the United States. The study analyzed six different combinations of current and optimal strategies with and without program aimed a total areawide eradication of the pest. An econometric simulation model of production and consumption of major U.S. agricultural crops was utilized to estimate economic effects of the strategies. Net social benefits gave a different ranking of alternatives than did the cost-benefit ratio. Complete boll weevil eradication combined with effective pest management resulted in the highest net social benefits. Due to the high public cost associated with this program, however, optimum pest management without total eradication was found to have the highest benefit-cost ratio. This group concludes that decision as to the preferred program is dependent on the budget priorities involved.

A similar benefit-cost analysis was conducted by Reichelderfer and Bender (1979) on control of the Mexican bean beetle on soybeans in Delaware, Maryland, and Virginia. The analysis used a microanalytic simulation model to examine the relationships between the bean beetle populations, populations of a species of wasps which are parasites of the beetles, chemical control measures, and soybean yields. Benefit-cost ratios were calculated for each control strategy. Biological control using the parasitic wasps was found to be an economic alternative to chemical methods.

An area-specific study on aggregate effects of agricultural pollution control measures was performed by Taylor and Frohberg (1977). As in several studies, this work analyzed the effect on consumers' and producers' surplus resulting from changes in cropping patterns undertaken as a result of environmental legislation. The analysis did not estimate total welfare effects, as there was no calculation made for the value of pollution abatement or the administrative and enforcement costs of the public policies. A detailed linear programming model of crop production in the Corn Belt was utilized to estimate the effects of the following:

1) ban on the use of all herbicides,
2) ban on the use of all insecticides,
3) nitrogen fertilizer limitations of 50 and 100 pounds per acre,
4) elimination of straight row cultivation,
5) total soil loss restrictions of 2,3,4, and 5 tons per acre,
6) subsidies to encourage terracing, and
7) taxes on the gross amount of soil eroded.

The latter four techniques are specific to soil erosion control and therefore are irrelevant to the analysis of groundwater legislation. The former three controls, however, are pertinent to both surface and groundwater protection policy. Taylor and Frohberg estimated the changes as described in Table 1.

Table 1: Results of Taylor and Frohberg 1977 Study

Action	Change in Consumer Surplus	Change in Producer Surplus
Ban all herbicides	$ - 3.5 billion	$ + 1.8 billion
Ban all insecticides	- 632 million	+ 531 million
Limit N applied to:		
100 lbs/ac	- 231 million	+ 21 million
50 lbs/ac	- 3.33 billion	+ 2.04 million

It is important to note that while Taylor and Frohberg estimated regional effects, they do not delineate effects on individual producers. Talpaz, et al. (1978) did analyze effects on the farm level. Their work was specific to the eradication of the boll weevil for cotton producers. While this study did not directly analyze the effects of environmental legislation, it did arrive at optimal management techniques to maximize intertemporal benefits to the producer. A non-linear programming model is used to simulate the relationship between the boll weevil population and the cotton production system. Although reduced pesticide use and water quality is not a subject directly addressed in the study, the analysis does relect upon the economic efficiency aspects of insecticides. Optimality is achieved by the use of three separate insecticide applications spaced throughout the season. A sensitivity analysis was also performed to analyze the effects on the optimal solution of changes in price of both the cotton output and the chemical inputs. This analysis found that both timing and dosage levels are highly sensitive to price changes.

Casey, Lacewell, and Sterling (1975) also analyzed on-farm effects. Their study was designed to examine the profitability implications of pest management strategies in Texas. They obtained reliable budget and yield data from the farming operations managed by the Texas Department of Corrections. A mathematical programming model was not used. Rather than analyze the effects of policies on optimal production, they analyzed the problem using only common and accepted parameters. They analyze only those situations which are deemed feasible practices. This methodology makes sense in that certain crop rotational requirements are not subject to a continuous distribution. Most choices are actually taken from a fixed number of discrete options which are dictated by environmental, managerial, and agronomic conditions. Casey, Lacewell, and Sterling found that there is evidence that a carefully managed pesticide program of selective application can increase farm profitability, while substantially reducing the amount of chemical used. They found that optimal pest management in their 215,000-acre study area could: 1) increase production by 27.4 thousand bales, 2) reduce quantities of insecticides by over 50%, and 3) increase producer net returns by over $5 million. These results again show that it might be possible in some areas to decrease chemical use while increasing farm profitability.

One alternative policy promoted to reduce agricultural water pollution has been the use of an effluent tax. A study performed at the University of Nevada-Reno (Miller, et al.,1985) used this approach. The analysis was undertaken to derive an optimal pollution tax on salt discharge. A linear programming model was designed to simulate the production of alfalfa hay under typical Nevada growing conditions. Four separate irrigation management systems were examined. Results provide a level of pollution charge at which alfalfa production becomes unprofitable. A chief outcome of this paper is to emphasize the need for a interdisciplinary approach to the problem. The group included a team of economists, hydrologists, soil scientists, entomologists, and plant scientists.

Another approach to the same problem was taken by Horner (1975) in his study of crop production in the Central Valley of California. Horner used a multiperiod linear programming model with an infinite planning horizon to maximize the present value of all future returns to the individual grower. This model included four alternative fertilizer levels for eighteen crops and six soil types. The model was then used to determine the least-cost alternative to reduce salinity in drainage water from agricultural operations. Horner analyzed the cost of an alternative which involves in-stream treatment of drainage water versus farm-level strategies to reduce salinity content and quantity of tailwater. Results show that farm-level methods are substantially less expensive and more efficient than in-stream treatment strategies. While the treatment of tailwater is not an option when dealing with groundwater contamination, Horner's methodology is sound and could be applicable to any problem concerning pollution discharge from farming operations.

Horner's methodology is similar to that utilized by Gossett and Whittlesey (1976) in their study of the cost of reducing nitrogen and irrigation water use for farms in Washington's Yakima Valley. Gossett and Whittlesey examined the economic and pollution abatement effects of various pollution policies on a representative area farm. The authors investigated the effects of the following policies:

1) constraining total nitrogen outflow,
2) taxing nitrogen residuals on a per-acre basis,
3) subsidizing the farmer for each unit of nitrogen residual he eliminates,
4) constraining total sediment outflow,
5) taxing sediment residuals on a per-unit basis,
6) constraining total nitrogen fertilizer use,
7) constraining total irrigation water use,
8) taxing nitrogen fertilizer applied on a per-unit basis,
9) taxing water applied on a per-unit basis,
10) subsidizing the farmer for each acre of crops known to produce less soil erosion.

Results obtained from this analysis show the change in net revenues for the producer associated with each of these measures. It is important to realize that this study, while based on reasonable assumptions and utilizing sound methodology, it is not without limitations. The authors note, as seen in other studies reveiwed, that there is a lack of good data relating to yield response to various cultural practices. In addition, the study ignores the intertemporal aspects explored in multiperiod studies such as Horner's. Also, recognition is made of the problem that some generality had to be sacrificed in order to make the assumptions necessary to obtain reality.

McGrann and Meyer (1979) explored a similar matter in their study of the economic impacts of erosion control and reduced chemical use in western Iowa. This study focused on the impact on three simulated budget models representative of typical area farms. These budgets were then inserted into a linear programming model in order to estimate the effects of pollution protection policy. Their results show that soil erosion can be reduced substantially at a relatively minimal cost. Reduced chemical use, however, has more dramatic effects. Reducing fertilizer to three-quarters the recommended level produces a decrease in income of 12% and a yield loss of 10%. A fertilizer reduction to one-half normal levels results in a drop in income of 39% and a 25% yield loss. Results of a decrease in insecticide and herbicide levels are of a similar magnitude. In addition, synergistic effects are found to exist in that the effect of the reduction of nitrogen fertilizers and pesticides jointly is greater than the sum of changes imposed by the two factors alone.

The McGrann and Meyer study is notable in that it seeks to analyze the joint effects of various policies. This methodology is somewhat more realistic than study of individual policies. Pollution abatement policies are not implemented in a vacuum. In fact, in most instances when environmental legislation is passed, the regulation of several pollutants is begun simultaneously. Therefore, it is logical to assume that policies relating to nitrogen fertilizers, insecticides, and herbicides could be implemented concurrently.

Two other studies (U.S.D.A, 1981; U.S.D.A., 1982) performed by the U. S. Department of Agriculture, are of note. These studies are important, not for their empirical findings, but for their innovative approach to the problems of data collection. The first (U.S.D.A., 1981) involves the use of the Delphi method in gathering data for the economic analysis of boll weevil management programs on cotton. The Delphi approach used in the study involved gathering a panel of experts in the pesticide field for a three-day seminar. The seminar was designed to provide group interaction in order to gather panel responses to the questions involved.

The 1981 study focused on the cotton-growing regions of the southern United States and did not address the concerns of western growers. A similar study was performed (U.S.D.A., 1982) the following year which centered around the cotton producers in the West. This study also used to Delphi technique. This time it was used to estimate the change in lint yield which would result with a change from the pesticide program currently used by most growers to a program which was considered "optimal" by the panel of experts. These data were used to estimate cotton yield, pesticide use, and cost of pest control under both the "current" and "optimal" programs.

While there has been less empirical than theoretical work relating to the economics of agricultural water pollution abatement practices, some viable research has been conducted. Even though these studies are location- and pest-specific, the methodology in these empirical studies is worth noting for reference in conducting further research.

Summary of Literature Review

As evident by this review of relevant literature, the subject of the impacts of agricultural chemical management on water quality is a complex and technical one. This is a subject which involves not only economic issues, but also those related to public policy, technical agronomic and entomological information, hydrology, and financial management. An interesting point is made by Antle and Capalbo (1986) in the recent book published by Resources for the Future. The authors state that research into agricultural chemicals by agricultural economists generally falls into one of four distinct areas:

1) measure of chemical productivity,
2) derivation of optimal management practices,
3) economic evaluation of Integrated Pest Management Techniques, and
4) study of the economic effects of government regulation.

This study will attempt to investigate the latter area. It is the purpose of this literature review to analyze previous research in the area, take note of techniques which are especially useful, and take caution from any conceptual and analytical difficulties which have been encountered. This research should more closely examine the effects of controlling specific compounds in a specific region. In this manner, the current research into the farm-level impacts of groundwater protection policy on Central Arizona farmers will attempt to integrate points found in several of the studies reviewed with relevant new ideas. This is performed in an attempt to derive the best possible vehicle through which to analyze the proposed policies.

CHAPTER THREE

FEDERAL AND STATE POLICIES

Current public policy pertaining to agricultural chemicals and groundwater is a result of an evolution of laws and regulations dating back for more than seventy-five years. Regulation of this activity involves a combination of federal legislation, regulation by federal agencies, state laws, state agency action, and oversight by local agencies in the various communities.

This chapter presents an overview of federal legislation and policies relating to agricultural practices and water quality. In addition, this study analyzes the regulation of groundwater quality in Arizona in a more detailed fashion. The primary focus is on the state's new Environmental Quality Act and its effects on irrigated agriculture in the state.

Federal Regulations

The federal government has been reasonably active in the regulation of the impacts of agricultural production on water quality. This regulation has been centered in three main areas: 1) federal legislation regarding general water quality issues, 2) federal legislation directly regulating the use of agricultural chemicals, and 3) the ongoing role played by various federal agencies in regulating the impacts of agricultural activities on water quality.

Water Quality Legislation

The federal government has a challenging task in formulating water quality protection policy which is general enough to apply to the entire nation, yet specific enough to provide a framework for pollution abatement. Federal attention to water quality issues did not come until the environmental movement of the late 1960's and 1970's. Since that time, federal legislation has concentrated chiefly on the pollution of surface water. It seems quite natural that public attention and regulatory action was focused here first. Surface water is that which is most visible to the public. The contamination of an underground aquifer might continue for some time without notice by the general public. A polluted stream with dying fish and wildlife, however, is sure to spur almost immediate public uproar. The regulation of groundwater quality was neglected for a period following the time when comprehensive action was being taken on surface water pollution.

Federal regulation has also tended to focus on point sources rather than non-point sources. This is due to the difficulty in regulating non-point sources of pollution. Point sources are considered as those situations in which pollution flows directly to a water supply from an single identifiable source. Examples of point sources are storm sewers, municipal sewage treatment plants, and industry. Non-point sources are those more diffuse, wide-spread sources at which each individual polluter provides only a small portion of discharge, but all similar sources taken in total provide a significant pollution level. Among these are agriculture (both crop and animal production), urban storm sewer runoff, mine runoff, silviculture, and construction activities. As pointed out by Rosenbaum (1985) in his book Environmental Politics and Policy, " Nonpoint water pollution is an especially nettlesome problem for several reasons. Pollution originating from so many diffuse sources is not readily controlled technically or economically. And many pollutants are often involved."(p. 143)

Although there had previously been a limited amount of oversight regarding water quality protection, the first major piece of comprehensive legislation came in 1972 with the passage of the Federal Water Pollution Control Act Amendments. These amendments, also known as the "Clean Water Act", revised previous legislation and established the current structure of federal water pollution policy. One of the chief new aspects of this program was the concept of "forcing technology". Legislative guidelines for the amount of pollution discharge allowed were set at levels stricter than that which was attainable by the current technology in use at the time. The idea was to use these standards to force the industry to innovate and derive more efficient methods of waste management (Rosenbaum, 1985).

As with other early water pollution programs, FWPCA was designed to regulated surface water pollution only. The legislation provides that "...the discharge of pollutants into navigable waters of the United States be eliminated by 1985" (FWPCA, 1972). Implementation of FWPCA was slower than originally planned. The implementation phase which was initially planned to be completed by 1985 was not completely in place at that time. Despite this lag in enforcement, most critics agree that FWPCA and related legislation have been reasonably successful in lessening the increase in water pollution in the United States (Ingram, 1986).

The other major piece of federal legislation pertaining to water quality has been the Safe Drinking Water Act. Passed in 1974, the purpose of this act was to ensure that all public drinking water supplies met minimum health standards. This legislation mandated the creation of National Primary Drinking Water Standards which set maximum contamination levels for local areas (Rosenbaum, 1985). While this act has been complied with in many areas, its impact on water quality has not been so profound as the effects of FWPCA.

Agricultural Chemical Legislation

In addition to the legislation concerning water quality, the U.S. Congress has also taken some action to regulate the sale and use of agricultural chemicals, most notably pesticides. Public regulation of pesticide use first began in 1910, with the passage of the Federal Insecticide Act. This act was intended to protect farmers from mislabeled or faulty products (Bohmont, 1983). While this act did not protect consumers from pesticide exposure, it did protect the farmers as consumers of agricultural inputs.

Early pest control in agriculture involved the use of compounds commonly used for other purposes. These compounds were used in an effort to control pests. For instance, such compounds as sulfur, salt, arsenic, and copper were first used as pest control agents by nineteenth century farmers. In 1938, the U.S. Congress amended the 1906 Federal Food, Drug, and Cosmetic Act to include the limited regulation of compounds used as agricultural pesticides. This included such agents as lead, arsenate compounds, and Paris Green (Bloss, 1987). Paris Green, a mixture of copper and arsenic, was first used in 1865 to control the Colorado Potato Beetle (Bohmont, 1985). This was one of the most popular of the early insecticides.

The first comprehensive legislation primarily intended to protect the public from unsafe pesticide use was The Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA). This act was the first to require that the manufacturer of the product prove that it was safe for use prior to its being marketed (Bohmont, 1985). FIFRA, although amended several times, is still the basis of federal pesticide regulation policy. It was amended in 1964 to require manufacturers to register their products with the federal government and to provide the registration number on the label of the container.

In 1972, FIFRA was amended to produce the Federal Environmental Pesticide Control Act. Although this legislation bore a new name, it was a direct revision of FIFRA. Amended in 1975 and 1978, FEPCA includes the following provisions:

1) It requires that all pesticides must be classified as either general-use or restricted-use. A restricted-use pesticide is so classified because of its potential to harm humans or the environment.

2) It requires that anyone who is to apply restricted-use pesticides must be certified for such use. Certification involves a testing procedure examining the applicant's knowledge of the chemicals and competence in safe application.

3) The law requires that a pesticide not be used in any way other than as specifically directed on the label. An exception is when special local regulations allow use at a lower rate than the label recommends.

4) FEPCA also specifies proper disposal of the pesticide container and its contents.

5) It provides for penalties for those found not in compliance with these regulations. Penalties include both fines and jail terms. (Michigan Department of Agriculture, 1978)

FEPCA is the most recent and comprehensive piece of pesticide-related legislation in the United States. Implementation of the policies contained in FEPCA is handled through federal agencies and the various state governments.

Federal Agencies with Pesticide/Water Quality Jurisdiction

In addition to the formal legislation discussed above, much of the federal policy relating to agricultural chemicals and water quality is derived in the various government agencies with jurisdiction in the matter. Among these agencies are the Environmental Protection Agency (EPA), the United States Department of Agriculture (USDA), the Food and Drug Administration (FDA), the Federal Aviation Administration (FAA), and the Federal Department of Transportation (DOT).

The EPA oversees the majority of the issues relating to pesticide use and the environment. The agency is responsible for implementation and enforcement of all federal regulations such as FEPCA and related policy. EPA is the most important and visible agency dealing with agricultural chemical issues (Ingram, 1987).

The USDA deals with pesticides only indirectly through their program of meat and poultry inspection. This program monitors the quality of the product sold to the consumer. The sampling program inspects for elevated levels of pesticide residuals in the meat and bone of animals to be marketed (Bohmont, 1985).

The Food and Drug Administration monitors the food for humans and animals. This program, somewhat similar to the meat programs of the USDA, tests for pesticide residue tolerances. The Federal Food, Drug, and Cosmetic Act gives the FDA authority to seize any food or feed found to be in excess of established contamination standards.

The Federal Aviation Administration regulates pesticides only through the regulation of aerial application of chemicals. As a large number of agricultural chemicals are most commonly applied by airplane dusting, the FAA has played an increasing role in the oversight of pesticide application techniques. Chief among the policies implemented by the FAA is the regulation of the amount, rate, and type of agricultural chemicals which can be applied by air in a given area.

The Federal Department of Transportation deals with the transport of hazardous products in the United States. This includes most agricultural chemicals. The most notable of the regulations handled by the DOT involves classifying various materials as either Class A, Class B, or Class C Poisons. Class A Poisons are those seen as extremely dangerous. Class B Poisons are those classified as less dangerous than Class A, but with a known toxicity to man or the environment. The majority of pesticides are contained in this group. Class C Poisons are referred to as irritants, with little or no toxicity (Bohmont, 1985). In addition to these classifications, the DOT also supervises the following regulations regarding the transport of hazardous substances:

1) Each hazardous material transported must be packaged in its original container with the original label.

2) Vehicles transporting the materials must have a proper sign or placard noting that it carries hazardous chemicals.

3) Food must not be transported in the same vehicle with hazardous substances.

4) The DOT must be notified when a vehicle carrying hazardous materials is involved in an accident causing death or property damage in excess of $50,000 (Bloss, 1987).

Summary of Federal Regulations

It is clear that the federal government has a substantial role in many areas of the regulation of agricultural chemicals. Through the federal laws that have been passed controlling both water quality and chemical use, the various agencies involved have significant power and interest over the application of agricultural chemicals. Due to the differences between farming practices and hydrological characteristics in the various regions of the United States, it is still difficult for the federal government to control the water quality effects of chemcials on a national level. For this reason, it has been necessary for the individual states to also take an active role in such regulation.

State Regulations-California

Several states have taken at least some steps to regulate the impact of agricultural activity on the quality of their groundwater. A more detailed review of these types of programs can be found in Constant (1985); and Holden (1985) as mentioned in Chapter Two of this thesis. Most regulations enacted in other states regarding the effects of agricultural chemicals are not directly applicable to the situation in Arizona. This is due to: 1) the variety of crops found in the desert regions of Arizona, 2) the hydrological and geological features found in this arid region, and 3) the different crop management practices necessitated by these factors. While data can be used interchangably between regions in many situations, the specific regulations necessary for effective water quality protection in Arizona should best be taken from only those areas with similar features.

Although many state programs have been reviewed during the course of this study, it is felt that only California has the characteristics similar enough to Arizona to make regulation of agricultural activity in the state relevant to the regulation of Arizona agriculture. California has farming practices and environmental traits which are strikingly similar to those in Arizona. Among these are the extensive use of irrigation, the crop mix, the size and scale of farming operations, and general structure of physical and natural resources (i.e. soil types, hydrological characteristics, water quality). For these reasons, it is appropriate to include a brief overview of steps taken by California to control water quality in agricultural watersheds.

Monitoring of Effects of Agricultural Chemicals on Groundwater Quality

California has established a comprehensive system of taking groundwater samples. This is done at regular intervals and is used to determine the migration of specific agricultural chemicals into the aquifer. Compounds for which these samples have been tested in the past include DBCP, simazine, EDB, and carbofuran (Holden,1986). DBCP and EDB are designed to kill nematodes, a problem which is not prevalent in most cotton-growing areas of Arizona. Simazine and carbofuran are widely-used in Arizona and should be of concern in this state (Cooperative Extension Service, 1987). Several other agricultural chemicals are now being monitored in the California program. See Table 2 for details.

Efforts to Reduce Pesticide Contamination in Groundwater

California has also reviewed several farm management practices which have the potential to at least partially abate the contamination problem. One of these is the encouragement of increased irrigation efficiencies on the part of farmers. An increase in irrigation efficiency would allow growers to use less water in order to produce similar yields of irrigated crops. This would result in a smaller amount of water applied per acre, which should lead to a lessened amount of leaching of chemicals from the soil to the groundwater.

The state is also considering regulation of changes in the labels of various chemicals in order to alter the ways in which they are used. In addition to completely banning a chemical from use in the state, such options as a change in the rate per application or total quantity applied per acre, alteration of the time when a chemical is

TABLE 2: PESTICIDES DETECTED IN CALIFORNIA GROUNDWATER (GREATER THAN THREE OCCURRENCES)

PESTICIDE	PESTICIDE	PESTICIDE
Aldicarb	DNOC	Phorate
Aldrin	Dursban	Phtalates
Basagran	EDB	Simazine
Benzaldehyde	Endosulfan	Sevin
Chlordane	Endrin	Treflan
CIPC	Ethion	TCP
Dachtal	Ethylenethiourea	Toxaphene
DBCP	Furadan	Zytron
1,2-Dichloropropane	HCB	2,4-D
Delnav	Heptachlor	2,4,5-T
DDD	Kelthane	2,4,5-TP
DDE	Lindane	
DEF	Malathion	
Diazinon	Methylenechloride	
Diclone	Omite	
Dieldrin	Ordram	
Dimethoate	Paraoxon	
Dinoseb	Parathion	
Diphenamid	PCNB	
Disyston	PCP	

Source: Holden (1986)

applied, and a change in the formulation of certain chemicals has been considered and attempted in some cases.

Label changes are also associated with the implementation of Best Management Practices for pesticide use. This approach would be similar to that utilized in several Corn Belt states for the regulation of nitrogen fertilizer use.

A final step taken by California, which also has been promoted for use in Arizona, is the development of a program of Integrated Pest Management (IPM). This program involves the use of several different methods of pest control, in addition to the application of chemical pesticides when necessary. Although several aspects of IPM have been implemented and several more are performing well in research in the field, a comprehensive IPM program has yet to be successfully implemented on a large scale (Holden, 1986).

State Regulations-Arizona

Arizona has for some time taken steps to regulate the use of hazardous chemicals in order to protect the quality of the state's water supply. Arizona's regulatory approach took a major step forward on May 12, 1986, when Arizona Governor Bruce Babbitt signed into law House Bill 2518, commonly referred to as the Environmental Quality Act (Woodard, 1986). This legislation is said to have the potential of making a significant impact on the nature of water use and development in the state for many years to come. The act has been heralded by many as a bold measure in the management of water policy.

The bill represents the result of an extended period of political maneuvering on the part of environmental groups and those representing the interests of industry, mining, and agriculture. The issue first reached the public eye in October of 1985 when a group of private citizens, known formally as "Arizona Clean Water Advocates", launched an initiative to establish a state groundwater pollution policy (Capital Times, 1985). The purpose of the initiative drive was to collect the necessary 100,000 signatures to get the issue on the November 1986 ballot.

While the initiative never made it to the 1986 election, the movement did succeed in putting the issue on the public agenda. In December of 1985, Governor Babbitt appointed an 18-member committee to study the overhaul of the state's existing water quality legislation. This panel was to be a representative board, with members coming from both houses of the state legislature, regulated industries, and environmental groups (The Arizona Daily Star, 1985).

Still, through the winter of 1986, the legislature took no positive action. A strong force, however, was provided by the continuing support of the governor. Babbitt on several occasions used his access to the media to put additional pressure on legislators for action on the issue. The measure was passed by a 54-2 vote in the Arizona House of Representatives during the final days of the session.

One of the factors which necessitated such political maneuvering and delicate compromise is the fact that water quality legislation in general is a complex and highly technical issue. The Arizona legislation attempts to regulate both point and non-point sources of pollution. This section of the thesis will fully analyze the implications of specific provisions relating to non-point agricultural sources.

Establishment of the Arizona Commission of Agriculture and Horticulture

The EQA provides for the establishment of a six-member commission appointed by the governor to administer and enforce the provisions relating to agriculture. The composition of the committee is to be such that it is representative of the major agricultural commodity groups, with the inclusion of one member who is unrelated to the industry and is intended to serve in the interest of the general public (EQA, 1986).

The existence of this committee would seem to effect the agricultural industry in a positive manner. This body allows for substantial representation of the regulated parties. This group is designed to replace the abolished Board of Pesticide Control. That board had been widely criticized due to its nature as a "captured bureaucracy" dominated by the regulated interest. While there are limitations in the EQA to protect from excessive influence by agriculture in the regulatory process, this commission will at least give agriculture a representation in the process.

Best Management Practices/Agricultural General Permits

The most misunderstood, yet perhaps the most far-reaching provision of the legislation deals with the permitting process and related "Best Management Practices" (BMPs). The law requires that all entities which discharge any substance with possible groundwater contamination capabilities obtain a permit from the state (EQA, 1986). These permits have been divided into two classifications: individual permits and general permits. An individual permit is such that each entity must apply, be inspected, and pass the requirements of the code. A general pemit is given in the case that a large number of substantially similar sites are expected to discharge in a similar manner. In this instance, the Arizona Department of Environmental Quality will design Best Management Practices to be followed by the particular group or industry. These practices, if followed, will constitute compliance with the act for a particular entity.

For agriculture, these management guidelines are to be developed by two advisory committees, one designed to develop practices for the use of nitrogen fertilizers and the other for concentrated animal feeding operations. The seven-member advisory committee for nitrogen fertilizers will be comprised of one person from each of the five major crop producing industries in the state, one hydrologist from the University of Arizona, and one representative of an irrigation district. The committees are to develop management practices with specific regard to: "1) The availability, the effectiveness, and the economic and institutional considerations of alternative techniques, and 2) The potential nature and severity of discharges from the regulated agricultural activities and their effect on public health and the environment" (EQA, 1986).

The deadline for the establishment of these guidelines was set at October 1, 1988. No formal statements have been released as to their nature at this time. The advisory committees were chosen in the summer of 1987. The BMPs for nitrogen fertilizers and their effects on irrigated agriculture in Arizona are among the main focal points of this thesis research.

Regulations Pertaining to Agricultural Pesticides

The use of chemical pesticides is thoroughly regulated by the legislation. There are several components of the EQA which deal almost exclusively with chemical pest control methods in agriculture. Each of these components will be described in some detail.

Registration of Pesticides. Every pesticide sold, distributed, or used in Arizona is required to be registered with the state on an annual basis. The application for registration must include all information relating to the sale and manufacture of the chemical. In addition, a report of each active ingredient must be filed on the subject of water solubility and other factors which will specifically affect the possible dispersion of the substance to water sources (EQA,1986).

This policy, however, should have little direct effect on the average farmer in Arizona. The bulk of this work will be done by the chemical companies and their distributors. While Arizona and other western states have previously required registration of chemicals, the language in this law implies a much stricter enforcement procedure than the state has had in the past. The rigor of the registration process in Arizona will be similar to that now in place in other states. The tightening of registration guidelines could possibly discourage some companies from introducing new products into the Arizona market. This would be due to the fact that the market in Arizona might be so small as not to warrant this extra registration expense.

State lawmakers, however, have anticipated this problem and taken steps to a possible remedy. The state of California has recently passed related legislation calling for the registration of agricultural pesticides. The agencies implementing the Arizona program have agreed not to make the Arizona requirements substantially more stringent than those required in California. In this way, lawmakers hope that the combined market for pesticides in Arizona and California will be sufficient to warrant the additional expense necessary for the chemical manufacturers to provide this information (Eliottt, 1987).

Establishment of a Groundwater Protection List. The newly-established Department of Environmental Quality will use the information provided by registrants to establish a Groundwater Protection List of pesticides that "have the potential to pollute groundwater in Arizona" (EQA,1986). This list will be designated as those chemicals which do not meet pre-established standards based upon solubility and dispersion characteristics. Use of pesticides which have been placed on this list falls under stern regulation and notification procedures. A 90-day period of testing by the state will occur following inclusion of a chemical on this list. If the product fails these tests, its registration for use in Arizona will be cancelled. It is cancellations such as this which this research attempts to analyze in later chapters.

Buffer Zones. In order to allow for dispersion of hazardous chemicals which are not necessarily carried by water, the EQA establishes specific distances from various facilities within which the application of certain substances is prohibited (EQA, 1986). This includes agricultural, as well as non-agricultural chemicals. This section of the legislation deals with "odiferous and highly toxic" substances. The facilities in question include schools, day care centers, and health care institutions. Specific standards are set depending on the type of facility involved and the method of application utilized. While this regulation does not assure certain avoidance of drifting chemicals, compliance with the practices and the label of the pesticide establish a presumption of compliance with this portion of the regulation.

The effects of this designation on the industry should be minimal as spraying close to these facilities has traditionally been restricted by the possibility of complaints from the residents and an outraged community. This provision simply reflects a continuing trend involving conflict with spraying as agricultural and residential areas become closer in proximity.

Encouragement of Integrated Pest Management Programs. The EQA also provides for a new educational and research program to study the feasibility of Integrated Pest Management (IPM) in the state of Arizona. This program is designed to be a long-term solution to promote the lessened or eliminated use of chemicals in agricultural pest control. The program promotes further research into improved cultural practices, biological control, and pest-resistant plant varieties (EQA, 1986). The EQA also allocates specific funding for the dissemination of this information to farmers throughout the state.

Enforcement Provisions. An extensive program has been designed to assure that this legislation will be enforced as intended. Several of these provisions are detailed below.

The law provides for substantial civil penalties for violators. A maximum fine of $25,000 per day for each violation is set for those found in direct violation of any of the provisions of the EQA. The action also includes possible revocation of the discharge permit. The implication of such an action on any entity is obvious. A possibility of multiples of $25,000 fines coupled with the revocation of the discharge permit would lead to the almost certain demise of most small business enterprises.

Possible criminal penalties involved can range up to a classification as a Class 2 felony for performance of a prohibited act "with extreme indifference for human life" (EQA, 1986). Class 2 felony is the same criminal classification used for manslaughter.

In order to ensure adequate enforcement by the state agencies, the law allows for the commencement of civil action by private citizens to force compliance. The individual can bring suit against either the party in alleged violation or the director of the Department of Environmental Quality for lack of enforcement. Success in such a suit would require enforcement of the statute and reimbursement of legal expenses incurred by the plaintiff.

This provision should have the effect of encouraging full enforcement of the outlined regulations. It imposes no additional restrictions, only adds to the implemented strength of the established guidelines.

Conclusions

There is a large number of policies pertaining to agricultural chemicals and water quality. Regulations are implemlented by many agencies, at many levels of government, each with slightly different goals and incentives. The purpose of this thesis research is to deal specifically with the Environmental Quality Act as it relates to irrigated agriculture in central Arizona, in order to provide insight on the farm-level effects of water quality legislation.

CHAPTER FOUR

METHODOLOGY AND MODELING

The estimation of the potential impacts of regulation resulting from the Environmental Quality Act requires the derivation of a specific economic model. This chapter outlines the procedures involved in defining a model for this purpose. The techniques involved in generating technical data for input to this model are discussed in Chapters Five and Six.

The Representative Farm Approach

Several modeling options are available in examining the effects of public policy on the agricultural sector. Various studies have analyzed the effects on a national, regional, state, or local basis (Taylor,Carlson,et.al, 1983; Reichelderfer and Bender, 1979; Taylor and Frohberg, 1978). Another approach has been to derive a computer budget model of what is deemed a representative farm (Casey, Lacey, and Sterling, 1975; Miller, et al.,1985; Horner, 1975; Gossett and Whittlesey, 1976; McGrann and Meyer, 1979).

The most common problem with the representative farm approach is in determining which farming practices, revenues, and costs are typical for a given area. When this information is available and reliable, this approach is superior in certain regards. While the representative farm model does require some generalization, it is often more specific to individual farmers than are other econometric techniques. In cases in which local farm operators are the targeted audience of a study, the representative farm approach is more readily accepted.

The majority of the data relevant for this study is readily available for cotton production in Arizona. Arizona Cooperative Extension has developed sample budget information for the various counties (Hathorn, 1987). This information has proven reliable over years of use by numerous public and private entities.

This study to determine the effects of groundwater legislation on farm profits is, by nature, an exercise in applied economic research. Throughout the course of the study, there has been significant interest on behalf of Arizona farmers, policy makers, and agribusiness people.

Due to the availability of the information and the audience for which this research is intended, the representative farm approach has been utilized. The budgets prepared by Cooperative Extension have been refined for the specific purposes of this study through consultation with those directly involved with agriculture in the state. It should be mentioned that, although some revisions to the data were necessary, the sample budgets proved to be a good approximation of information given by the individuals questioned in the study.

Study Crop

In order to properly analyze the effects of any regulatory actions on agriculture, it is first necessary to determine which crop(s) to examine. Farmers in Arizona produce a wide variety of crops. A summary of the major crops produced in the state, their respective acreages, and cash receipts generated for 1985 is shown in Table 3.

TABLE 3

PRINCIPAL CROPS, RANKED BY VALUE OF CASH RECEIPTS:

ARIZONA, 1985 (1)

COMMODITY GROUP	CASH RECEIPTS (000 DOLLARS)	PERCENT OF STATE TOTAL	ACRES HARVESTED	PERCENT OF STATE TOTAL
Cotton	314,623	38.0	322,800	33.2
Lettuce	109,911	13.3	38,400	4.0
Hay	77,103	9.3	177,000	18.2
Wheat	34,581	4.2	9,600	9.9
Cauliflower	19,345	2.3	6,100	0.6
Grapefruit	18,032	2.2	7,100	0.7
Oranges	16,024	1.9	10,900	1.1
Lemons	15,087	1.8	16,500	1.7
Other Crops (2)	204,297	24.7	290,945	29.9
TOTAL	827,254	100.0	972,045	100.0

(1) Source: 1986 Arizona Agricultural Statistics, Arizona Agricultural Statistics Service, Phoenix, Arizona; Bulletin S-22, July, 1987.

(2) Producing less than 15,000,000 in cash receipts in 1986.

While a number of crops exist which are produced in significant quantity, cotton produces almost three times as much revenue as the next highest crop and is grown on almost twice as many acres. For this reason, this analysis has concentrated on the effects of environmental legislation on cotton producers. Because of the importance of cotton production to agricultural revenues in the state, cotton farmers have traditionally been a strong political and economic force in many areas of Arizona. Although total acreage of cotton has dropped in the past few years, the crop will be a factor in Arizona's economy for some time to come.

Study Area

The majority of cotton production in Arizona is centered in three geographic regions: 1) the central desert, including Maricopa, Pima, Pinal, and part of La Paz counties, 2) the Colorado River region, including Yuma and the western portion of La Paz counties, and 3) the Safford area in the eastern part of the state. Table 4 shows the production of cotton by county in the state. It can be seen from this table that the two highest producing counties (Maricopa and Pinal) combine to produce approximately 75% of the state's cotton. For this reason, these two counties were chosen as the study area in this analysis. Figure 5 outlines the study area.

Other Model Specifications

Analysis of cotton production and possible regulatory impacts in the two counties requires making several assumptions for each county

TABLE 4

COTTON PRODUCTION IN ARIZONA COUNTIES RANKED BY HARVESTED ACRES

ALL VARIETIES: 1986 (1)

COUNTY	ACRES HARVESTED	% OF TOTAL	PRODUCTION (BALES)	% OF TOTAL
Maricopa	120,100	37.2	318,700	38.7
Pinal	111,500	34.5	295,000	35.8
Yuma	21,200	6.5	57,000	6.9
Graham	20,600	6.3	39,700	4.8
La Paz	20,200	6.2	54,400	6.6
Cochise	13,500	4.1	23,700	2.8
Pima	10,800	3.3	23,600	2.8
Mohave	4,100	1.2	9,600	1.1
Greenlee	800	0.2	1,600	0.1
TOTAL (2)	322,800	100.0	823,300	100.0

(1) Source: 1986 Arizona Agricultural Statistics, Arizona Agricultural Statistics Service, Phoenix, Arizona: Bulletin S22, July, 1987.

(2) No cotton was produced in Apache, Coconino, Santa Cruz, Gila, Navajo, or Yavapai counties during the period.

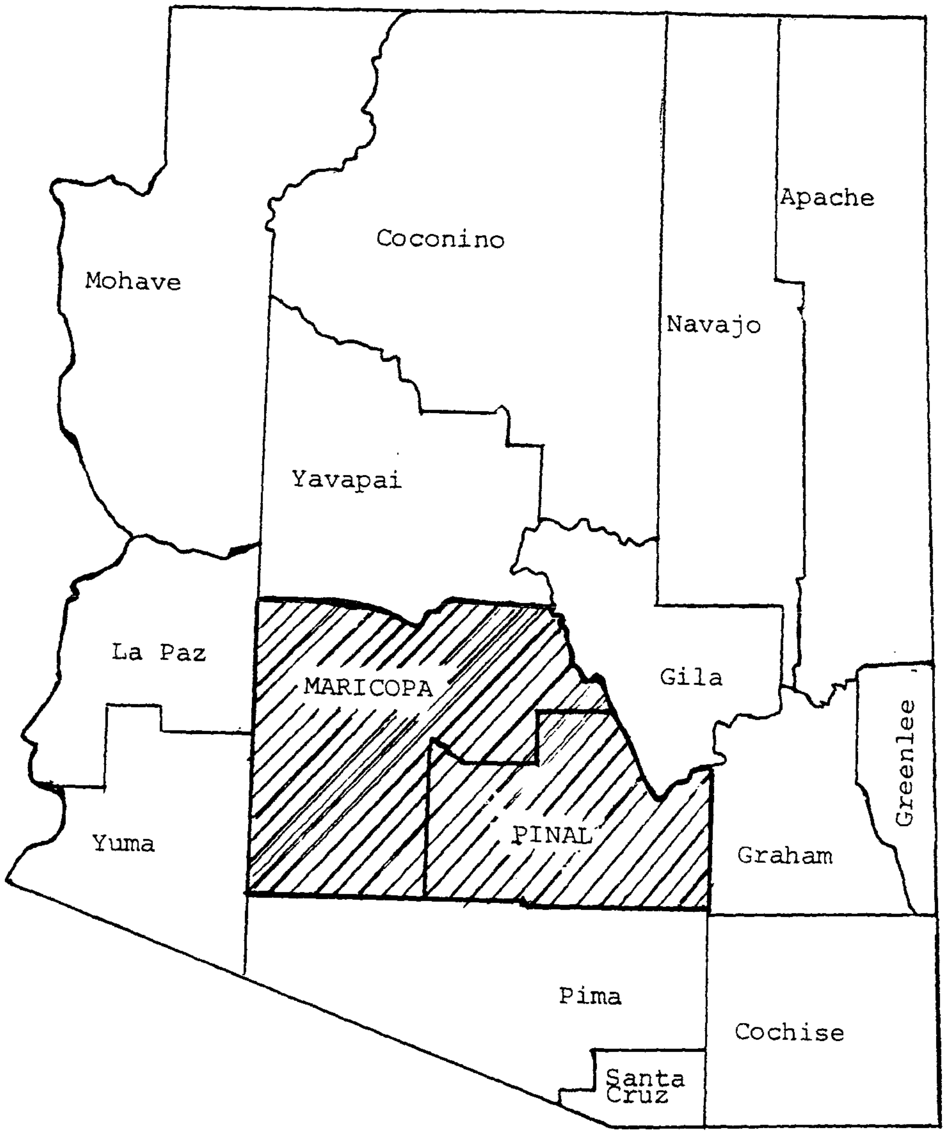


FIGURE 5 : STUDY AREA

regarding the specific features of a representative farm. These assumptions are outlined below.

Farm Size. Farming operations in Arizona vary substantially in size. Farms can range from a forty-acre parcel run by a high school student to a corporate enterprise consisting of several thousand acres. The majority of cotton produced in the state, however, comes from large-scale commercial operations in excess of 500 acres. For this reason, the representative farms in this model are assumed to cover 750 acres of irrigable cropland. Due to a lack of specific data regarding the distribution of farms with respect to size in Arizona, this assumption has been made based on a general familiarity with agriculture in the central part of the state.

Irrigation System. Due to the importance of irrigation to cotton production in Arizona and the rising cost of obtaining water, innovations in irrigation practices occur regularly in the industry. Such technological changes as drip and sprinkler irrigation have been promoted in the state with mixed success. While a final determination has yet to have been made on the effectiveness and profitability of such innovations, the majority of cotton produced in Arizona is currently grown under conditions of gravity-flow furrow irrigation. Therefore, this study has assumed that all production on the representative farms is done using such a system.

A study conducted as a part of this research has shown that less than 10% of the Pest Control Advisors consulted deal with drip or sprinkler irrigation on cotton on a regular basis. In view of this and other evidence discussed above, a furrow irrigation system is a reasonable assumption for a representative operation.

Crop Rotation. Cotton cannot be consistently grown year after year on the same soil without a significant decrease in expected yield. For this and other reasons such as enterprise diversity, cotton growers in the state regularly rotate their crops between fields on a yearly basis.

The production of cotton works to reduce the nutrients in the soil. Therefore, growers frequently use wheat as a rotational crop in order to restore the natural soil nutrients. The most common rotational pattern with Arizona cotton growers is a cotton/wheat mix which varies between 3:1 and 4:1. Due to this practice and the dominance of cotton as a crop in terms of acreage as evidenced in Table 3, this study assumes that an unregulated farmer will typically plant 60% of his cropland to cotton and 20% to wheat. This lends itself to a 3:1 cotton/wheat rotation and is consistent with the results of Table 3.

While cotton has traditionally been the most profitable crop, an efficient farm manager will often wish to diversify his cropping pattern to some extent in order to hedge against such problems as a price decline or heavy insect pressure. This study initially assumes that the farmer plants at least 10% of his cropland to alfalfa for such a reason.

Arizona farmers have participated heavily in the government upland cotton support programs (Ayer,1987). In order to be eligible for government payments, there are stringent cropping requirements which must be met. For this reason, the crop rotation discussed above is assumed only in the case in which the grower is not participating in the government program. In those cases in which the grower decides to participate, it is assumed that the farmer plants 100% of his "permitted cotton acres" to cotton, and splits the rest of his allowable acres as 66% to wheat and 33% to alfalfa.

In addition to the assumed rotations discussed above, a sensitivity analysis has been performed whereby several different crop rotations are modeled. This has been done to determine the effect on the results from changing the cropping patterns.

Cultural Practices. The techniques involved in growing cotton in the irrigated areas of Arizona vary somewhat between counties. A series of detailed farm budgets has been developed for each area of the state by Arizona Cooperative Extension (Hathorn, 1987). This study relies on these budgets for Maricopa and Pinal counties for data on cultural practices and production costs. This data has been used for cotton and also for wheat and alfalfa as rotational crops.

Derivation of Farm Budget Models

The assumptions outlined above have been used to create computer-based farm budget models for each scenario in each study area. These budget models are shown in the Appendices 6 and 7 . Each model has been used to estimate the effects of altering one variable (i.e. the use of a specific pesticide or the level of nitrogen fertilizer) while holding other factors constant. Through the use of these models, the effects of various policies discussed have been analyzed.

For example, one of the scenarios modeled in the portion of this research dealing with pesticides is that in which the product Cymbush is eliminated. The preferred substitute for this product is a compound known as Asana. The calculation of the effects of this substitution are performed using a model which would vary the factors which directly relate to the type of pesticide used and hold all other factors constant. The first step in the calculation would be to estimate the short-run net returns over operating costs using Cymbush. This involves the input of data regarding the assumed rate of application, cost per unit, cotton yield per acre, and application method used in applying Cymbush. This data would be used to calculate the total cost which would be attributable to the use of Cymbush. This factor would then be utilized to calculate the total growing cost, which in turn would lead to a figure for net returns over operating costs in the short run.

Next, the application data using Asana as a substitute would be input. An identical process would be performed whereby this information is used to determine total costs of production and total revenue generated when Asana is applied. The change in short-run net returns over operating costs is then found simply by subtracting the net returns calculated using Cymbush from those calculated using the data input for Asana.

It is important to note that this analysis assumes that the changes modeled have no effect on the fixed costs of the operation. This is possible because the study looks at the effects of legislative policies only on a one-year basis. As fixed costs are defined as those costs which are not variable within a given production period, this is a reasonable assumption. A more detailed understanding of the budget models can be gained by careful study of the contents of Appendices 6 and 7.

Summary

The purpose of this study is to estimate the profitability effects of pubilc groundwater policy on individual Arizona farmers. The approach used has involved the use of computer-generated representative farm budget models for the production of the state's biggest cash crop in the two counties which produce the majority of that crop. Specific technical data relating to the changes in production practices resulting from various legislative scenarios can be inserted into these models in order to examine the profitability implications of various regulatory actions. Chapters Five and Six turn to the accumulation of such necessary technical data for pesticides and nitrogen fertilizers.

CHAPTER FIVE

ANALYSIS OF PEST CONTROL REGULATIONS

One principal focus of this thesis is to estimate the change in net farm revenues associated with various legislative actions relating to the use of agricultural pesticides. These estimates are derived using the farm budget models discussed in Chapter Four. The first portion of this chapter describes the procedures followed in collecting data for use in the models for pesticide use. The latter portion of the chapter presents the numerical results of this modeling.

Pest Control Research and Data Collection

In order to properly analyze potential implications of various policies, it is first necessary to obtain technical data regarding the use of pesticides in cotton production in the state. A comprehensive search, of both academic and private sector research, failed to turn up data on the effects of differing levels of various pesticides on cotton yields which was satisfactory for use in this study. With secondary data unavailable, research was conducted to obtain primary data from knowledgeable individuals in the cotton production industry.

The intent of this data collection was to determine what changes in production and farming practices would result as a consequence of a ban of specific chemicals. The 1987 Field Crop Budgets produced by Scott Hathorn, Jr., of Arizona Cooperative Extension were chosen as the starting point for the individual counties. It is assumed that these budgets reflect typical pest management programs for each area. The study analyzes the impacts of regulations banning each specific chemical used in these budgets.

A large portion of the decisions made regarding pesticide use on cotton in the state is done with the help of a Pest Control Advisor. A Pest Control Advisor (PCA) is an individual who is licensed by the state to make recommendations pertaining to pest control methods. These individuals work with farmers in formulating control programs for the various farm enterprises. The data from this study was taken from interviews with these experts.

The procedure for gathering data from these individuals has involved the use of a modified Delphi approach. Due to financial restraints, the seminar-type application of the Delphi method discussed in Chapter Two has not been utilized. Instead, a sample of PCAs from private industry was chosen as the panel of experts. As with the Delphi method, this modified approach has specific advantages and disadvantages. Among the advantages are:

1) The method provides a systematic approach to gather data which is not available from verifiable experimental sources.

2) The approach involves the consideration of the opinions of several experts; inference is not based upon the opinion of any one individual.

3) The approach capitalizes on the use of informed, expert subjective judgement on a collective basis.

4) The method can minimize the bias associated with subjective judgement made on an individual basis.

Among the disadvantages to this method are:

1) The possible generation of "snap answers to ambiguous questions by creating an imprecise survey measurement" (U.S.D.A., 1981).

2) The necessity of choosing a "good" group of experts. The process is highly dependent upon the random sample of Pest Control Advisors.

In addition, this modified approach does not involve the portion of the Delphi approach which allows for feedback from the various respondents regarding the consensus opinion. Due to the high level of agreement on most decisions modeled, it appears that the inclusion of the final step would not substantially results. Despite these disadavantages, this approach has been deemed the most effective means by which to gather the necessary technical data.

A listing of all PCAs licensed to make recommendations in Arizona was obtained from the Arizona Commission of Agriculture and Horticulture. As of August 13, 1987, there were 326 individuals holding an Arizona PCA license. Having already decided upon Maricopa and Pinal Counties as the study area, the list was adjusted to delete all those individuals not residing in either of the two counties. The residence requirement could have indavertantly excluded certain individuals who reside outside the study area yet conduct business within the study area. However, given time and budget constraints, this was deemed the most efficient method by which to identify the targeted study group. In addition, due to the distance between the chief agricultural areas in the study area and the towns in surrounding counties, it is doubtful that there are many PCAs who reside outside the study area and work within the area.

It was found that of 325 Arizona PCAs, 138 had addresses in Maricopa County and 35 resided in Pinal County. Once the PCAs outside the study area had been eliminated, it was necessary to determine how many of those who resided within the area were active in pest control in cotton production. For this purpose, a phone survey was conducted. Each of the PCAs who met the residence requirement was contacted and asked a series of questions. These questions related to their involvement in the production of cotton and their willingness to take part in the later stages of the survey. A summary of the questions asked in this survey is provided in Appendix 1.

Figures 6 and 7 show the sampling process for this survey for the two counties. A total of 75 of the 138 PCAs who resided in Maricopa County were found to be actively involved in pest control on cotton. Likewise, 27 of the 35 Pinal County PCAs were found to be engaged in the cotton industry. Two factors which might account for the smaller percentage of the PCAs involved in cotton production in Maricopa County than in Pinal County are: 1) Maricopa County includes the Phoenix metropolitan area which offers a wider variety of non-agricultural pest-control employment opportunites than are available in Pinal County, and 2) many of the PCAs in Maricopa County specialize in turfgrass management areas (golf courses and parks) which are not as readily abundant in Pinal County.

Each of the PCAs found to be active in cotton production in their respective county was assigned a number. A random sample was then chosen using a Lotus 1,2,3 random number generator. A sample size of 15

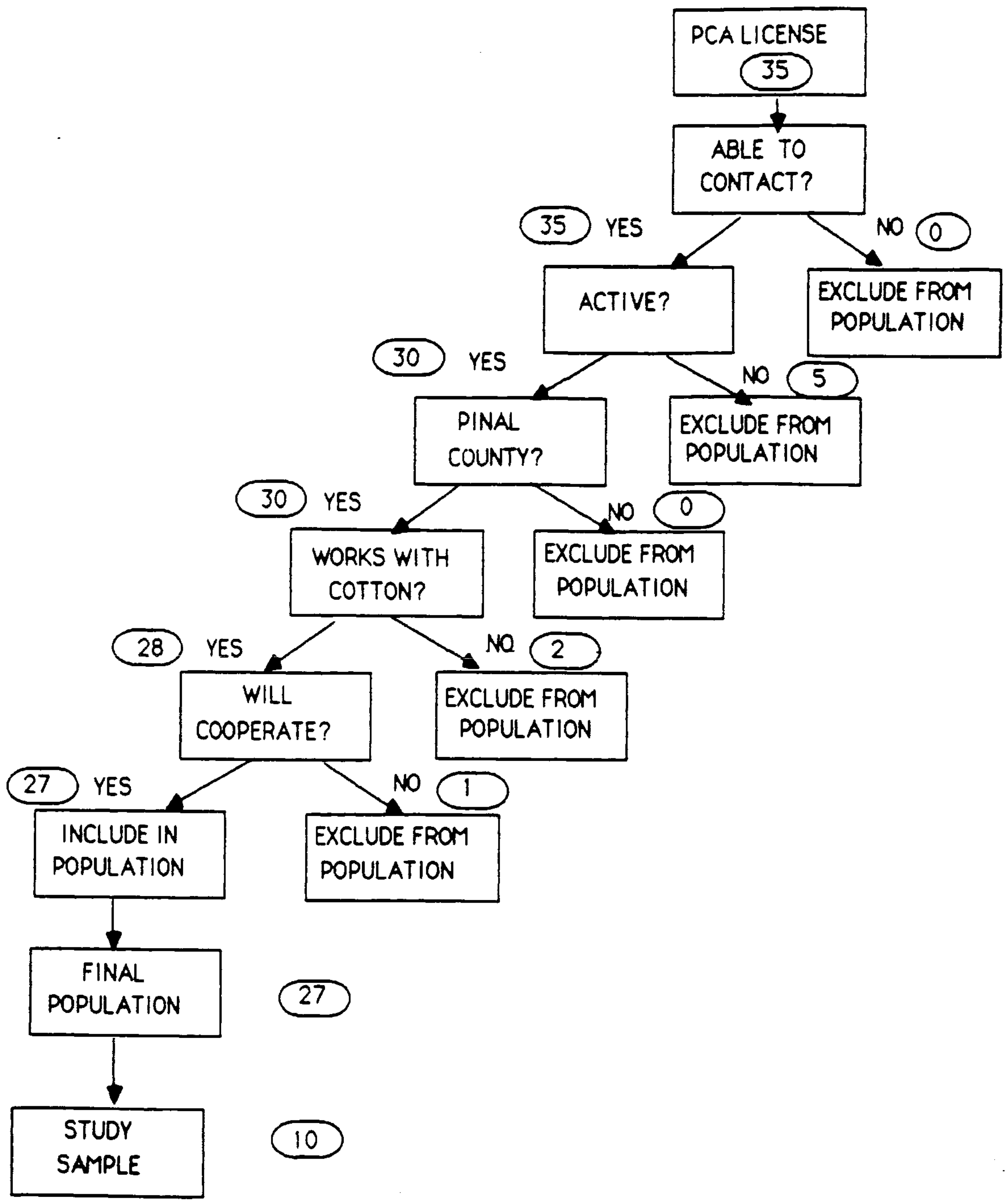


FIGURE 6: RESULTS OF PCA PHONE SURVEY-PINAL COUNTY

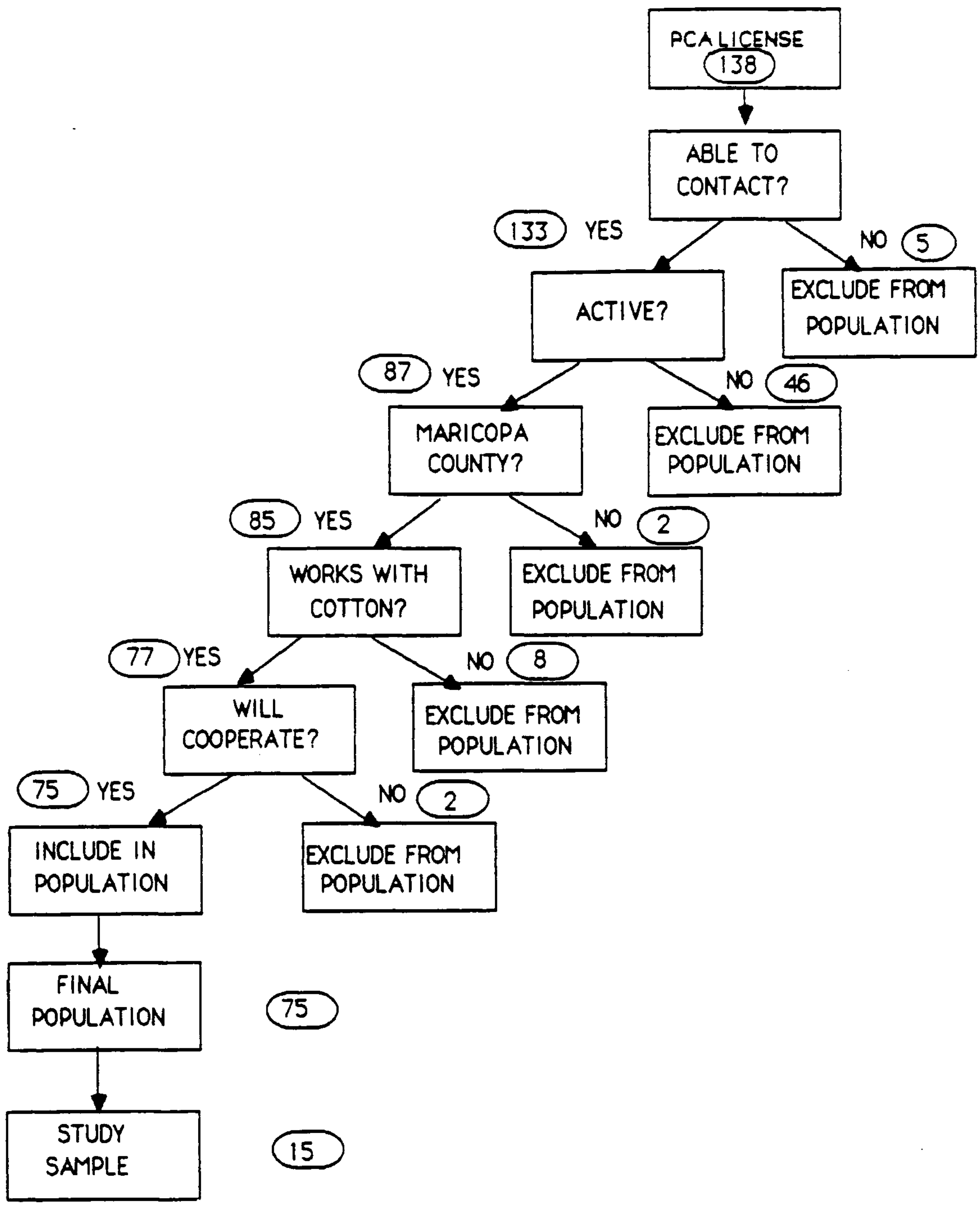


FIGURE 7 : RESULTS OF PCA PHONE SURVEY-MARICOPA COUNTY

(20% of the adjusted population) was taken in Maricopa County. A sample of 10 (28% of the adjusted population) was taken in Pinal County.

A Pest Management Survey was then developed for both Maricopa and Pinal County as a vechicle through which to elicit the necessary technical data from the sample respondents. The surveys are shown in their entirety in Appendices 2 and 3. Each survey consists of a variety of questions regarding actions taken to alter a recommended pesticide program in response to the elimination of a certain compound currently in use. Respondents are also asked to provide their estimate of the yield and cost effects of such a change. Finally, the survey gathers information on each respondent's experience and level of involvement in pest control in the cotton industry.

Prior to contacting the study sample, the questionnaire was pretested with several individuals in order to determine any serious defects in the structure of the questionnaire. This pre-screening involved contact with various university researchers, extension personnel, and cotton producers. Required revisions, although few in number, were performed before the survey was taken to the sample group.

Those PCAs chosen in the study sample were then contacted in order to set up individual personal interviews. The purpose of the individual interviews was to gather relevant information relating to the substitutability of various chemicals using the survey instruments. As a part of the interview, respondents were given a chance to voice their own views regarding any other substances which they believed would merit further research and possible changes in the format of the survey. Results of the survey have been analyzed in order to determine if a consensus exists among the resondents relating to the individual questions. In each case, the response which was most often gathered has been modeled using the farm budgets previously described. In some cases, respondents have listed more than one chemical as a subtitute. In these instances, both products have been considered. The next section of this chapter will outline the results of these surveys and the farm budget analysis of the scenarios modeled.

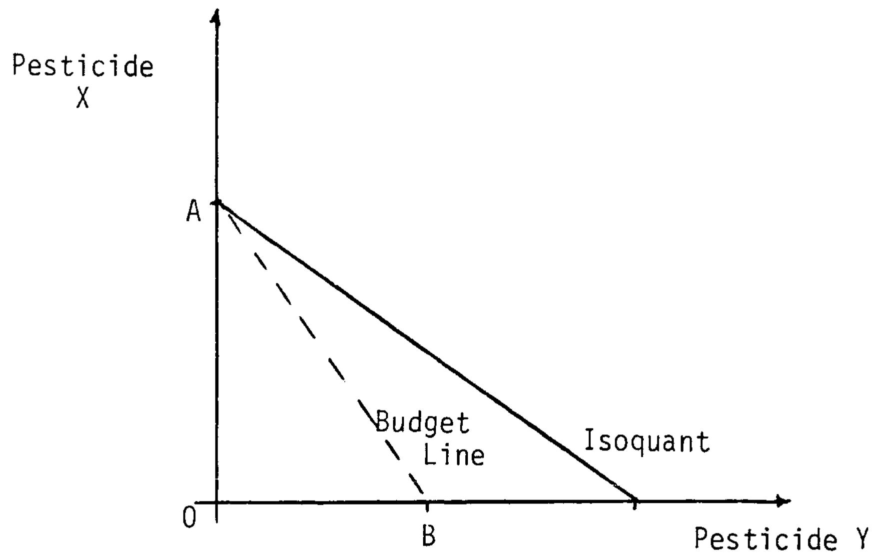
Results of Pest Management Surveys and Budget Analyses

The pest management survey was divided between the two counties. Therefore, the presentation of results of the survey and consequent analyses are presented in two sections: one for Pinal County and one involving Maricopa County. Although the data collection and analytical techniques are identical for the two study groups, the results are found to vary somewhat.

The scenarios derived through the use of this survey have been modeled using the computer-based farm budget models described in Chapter Four. The analysis has been performed to determine the change in short-run returns over operating costs for the individual scenarios. Sensitivity analyses have also been performed in each instance to determine the effects on results of changing prices, costs, crop rotations, and government cotton program specifications. This information is also presented by county and pesticide type.

This analysis has concentrated on the effects of substitutions between farm inputs. The concept can be explained using basic economic theory. Figure 8 shows the illustration of the isoquant for two specific pesticides which are assumed to be perfect substitutes.

FIGURE 8: THEORETICAL EXPLANATION OF INPUT SUBSTITUTION



An isoquant refers to a set of all combinations of two inputs which can be combined to produce a given level of output. As seen in the graph above, an isoquant for two inputs which are perfect substitutes is linear. The dotted line in the graph is the budget line. This represents all combinations of the two inputs which are obtainable given the producer's fixed budget. In order to optimize, the producer will normally operate at a point such that the budget line is tangent to the highest obtainable isoquant. Due to the linearity of the isoquant, tangency is not possible. Therefore, the producer will necessarily choose to operate at the "corner" of the budget line (A or B, in this instance) at which the highest isoquant obtainable is reached. In this case, the producer would choose to operate at point A, at which he uses all of pesticide X and none of pesticide Y.

The interpretation of this concept is that if two pesticides are believed to do exactly the same job, the farmer would normally choose to use all of the least expensive product in order to maximize profits. In this study, that situation has been found to occur in several instances. Therefore, in those cases in which the sample respondents feel that there would be no yield change resulting from the substitution, the estimated effect of a ban on one of the products on the farmer is based soleley on the relative prices of the two inputs.

Pinal County

As stated above, a sample of ten Pest Control Advisors was taken for Pinal County. The Pest Management Survey shown in Appendix 2 was utilized with this group. A brief look at the qualifications of the sample respondents clearly shows that they are an experienced and knowledgeable group. The ten individuals average over thirteen years of experience in pest control for the cotton industry with a range from three to thirty-five years. They make recommendations on an average of over five thousand acres per individual per year. Individual acreages range from 1,200 to over 12,000 acres. In addition, four of the group are also cotton producers with an average farm size of over 900 acres. These credentials make the group a suitable panel from which to gather the relevant data. A summary of individual responses is shown in Appendix 4. The following section outlines the aggregate results of this survey.

The pesticide budgets for Pinal County are shown in their entirety in Appendix 6. The results of modeling are discussed below. Results of the sensitivity analyses are displayed in Appendix 8. In general, the sensitivity analyses show that the results are only moderately responsive to changes in the values of most variables.

Insecticides. A major portion of the chemical pesticides used in the production of cotton in Pinal County is targeted at the control of insect pests. Therefore, an emphasis has been placed on insecticides in this study. The representative farm budgets utilized in this analysis assume that the average farmer in the county will rely chiefly on the following compounds for the control of insects: 1) methyl parathion, 2) Fundal/Galecron, and 3) Cymbush. These are commonly-used substances in the area.

Seventy percent of the survey respondents agreed that this was a realistic assumption for a representative insecticide program for the county. The remaining thirty percent had reservations regarding the use of one specific insectide included in the program. The compound which was objectionable was not consistent between repondents. In addition, sixty percent of the respondents agreed with the costs assumed in the study. Of those disagreeing with the cost assumptions, only one resondent felt that the overall level of prices was low. Others suggested minor adjustments in individual values.

A summary of the responses regarding program changes with the elimination of specific chemicals is shown in Table 5. Although there is some variance of opinion within the study group on most substitutions, there does exist a consensus on all decisions. Repondents prefer

Azodrin greater than 2:1 over all other compounds as a substitute for Methyl Parathion. Methyl Parathion has been widely used for some time in the area, not for its effectiveness as much as for its low cost. PCAs questioned commented that Azodrin would be at least as effective, but would also be more expensive.

A substantial controversy exists regarding the use of Fundal/Galecron. These two products are tradenames for various formulations of the compound Chlordimeform. Chlordimeform is used as an ovicide in the cotton industry. Respondents claim that by using this product with their regular sprays, they can destroy the insect pests at the egg stage and eliminate the use of other compounds which treat the same insects at later stages of their life cycles. This product was removed from the market in the late 1970's due to results of laboratory tests which concluded that the agent could act as a sterilant in some cases. A controversy ensued in which growers claimed that the ban of this chemical had drastically reduced their ability to control insect pests. The compound was reinstated for use after two years off the market.

The state of California has revoked the registration of Chlordimeform for use as an ovicide on cotton. Growers in Arizona suspect that a similar revocation is in store for Arizona in the near future. For this reason, most individuals questioned have strong opinions regarding the use of Chlordimeform. There is a great deal of direct disagreement on this issue. While the focus of this study is to determine the economic effects of banning such chemicals, conclusive

TABLE 5: RESULTS OF PESTICIDE SURVEY-INSECTICIDES, PINAL COUNTY

A. Alternative Product with the Elimination of Methyl Parathion:

PRODUCT	# RESPONSES	% OF SAMPLE
Azodrin	5	41.7
Penncap-M	2	16.6
Cygon	1	8.3
Pydrin	1	8.3
"Pyrethroids"	1	8.3
Dimethoate	1	8.3
Guthion	1	8.3

B. Alternative Product with the Elimination of Fundal/Galecron:

PRODUCT	# RESPONSES	% OF SAMPLE
Nothing Works	5	50.0
Lannate	3	30.0
Methyl Parathion	1	10.0
Cymbush	1	10.0

C. Alternative Product with the Elimination of Cymbush:

PRODUCT	# RESPONSES	% OF SAMPLE
Asana	3	27.3
Methyl Parathion	2	18.2
Pydrin	2	18.2
Pay-Off	2	18.2
Pyrethroids"	1	9.1
Scout	1	9.1

technical data on the yield and insect effects of such a ban is unavailable at this time.

Cymbush is one of a family of compounds known as pyrethroids. Due to the similarity of the various compounds, the marketing and sales of pyrethroid insectides is quite competitive. Respondents to this survey slightly prefer the compound Asana to the other available options. While the margin of preference in this case is quite small, the difference in the effects of changing to Asana or one of several other compounds should also be relatively small.

Given these results, specific pest management scenarios were chosen to be analyzed through use of the farm budget models. These scenarios are as follows:

1) The elimination of Methyl Parathion: It is assumed that Azodrin will be substituted. The preferred method is four applications at a rate of 1.5 pints per acre. Resondents feel that there will be no change in yield associated with this substitution.

2) The elimination of Fundal/Galecron: In this case, two scenarios are modeled. One scenario is that the grower switches to one application of Lannate at .25 pounds per acre. Results of the survey show that PCAs feel that this substitution will result in an average fifty pound per acre yield decrease and necessitate a 35 percent increase in the applications of other insecticides. The second scenario is that no compounds are realistic substitutes, including Lannate. In this case, respondents believe that producers will suffer an average 200-pound per acre yield drop with an increase of 100 percent in the applications of other insecticides.

3) The elimination of Cymbush: The assumed substitute is Asana, with three applications at a rate of 2.8 ounces per acre. There is no yield change associated with this substitution.

Results of the modeling for insecticides in Pinal County are shown in Table 6. The lower portion of the table shows the change in net returns which can be expected in view of the scenarios modeled. In each case, the losses in expected net returns are most drastic when the grower does not participate in the government upland cotton program. This is to be expected. The changes studied are projected to alter net returns per cotton acre. Participation in the government cotton program normally implies that the grower will produce less cotton than he otherwise would. For this reason, the effects of legislative actions which lower the profitability of cotton would have less effect on a farmer who is producing less cotton.

Results for the elimination of Methyl Parathion amount to 7.1 percent of expected net returns for a farmer in the government cotton program. While this might not be devastating to the operation, it will serve to increase the cost of production by this amount.

The most significant result is the loss in returns as a result of the elimination of Fundal/Galecron (Chlordimeform). As discussed earlier in this chapter, considerable controversy exists as to the viability of other compounds as a substitute. These results show that there is a good reason for this controversy. The effectiveness of Lannate as an ovicidal agent can greatly reduce the losses attributed to the elimination of Chlordimeform.

TABLE 6: RESULTS OF MODELING—INSECTICIDES, PINAL COUNTY
INITIAL ASSUMPTIONS

RETURNS OVER OPERATING COSTS

SCENARIO	FULL PARTICIPATION	NO PARTICIPATION	50–92 PARTICIPATION
Benchmark	$122,575	$96,031	$89,278
Without MP	113,892	84,454	84,937
Without FG–Lannate	94,824	59,030	75,403
Without FG–Nothing	53,574	4,029	54,777
Without Cymbush	122,992	96,586	89,486

CHANGE IN RETURNS FROM BENCHMARK

SCENARIO	FULL PART.	% OF BENCHMARK	NO PART.	% OF BENCHMARK	50–92 PART.	% OF BENCHMARK
Benchmark	-----	-----	-----	-----	-----	-----
Without MP	(8,683)	7.1	(11,577)	12.1	(4,341)	4.9
Without FG–Lannate	(27,751)	22.6	(37,001)	38.5	(13,875)	15.5
Without FG–Nothing	(69,001)	56.3	(92,002)	95.8	(34,501)	38.6
Without Cymbush	417	0.3	555	0.6	208	0.2

In the absence of a substitute, a farmer who is not in the cotton program can lose up to $92,000 per year on a 750-acre farm. This is equal to 95.8 percent of his expected net returns. It is important to remember that this analysis has not allowed for the payment of fixed costs, nor for a return on investment. It is logical to assume that a farmer whose net returns over operating costs are as low as $4,029 will be at a substantial loss position once fixed costs are paid. While participation in the government program can negate the losses somewhat, a loss of even 56.3 percent of your expected operating returns will definetly serve to put a financial stress on the operation.

If Lannate does substitute as well as modeled, however, the losses are curtailed somewhat. It is important to note that these projections do not assume that Lannate is a perfect substitute. There are substantial yield losses and increases in the applications of other chemicals involved with the scenarios modeled.

Even though the losses are partially mitigated by the substitute, a change in net returns of 22.6 percent is significant. The elimination of Chlordimeform as an ovicide, even in the presence of a partial substitute, will severely affect the farmer's profitability.

The change in net returns associated with the change from Cymbush to Asana is actually positive in this case. The change is, however, less than one percent of expected net returns. This result is due to the availability of other pyrethroids at near the same cost. The elimination of any one of these pyrethroids at the present time would appear to have only a minimal result. Although this study has not analyzed the effects of the elimination of the entire family of pyrethroids, it is expected that such a result would be much more significant.

Herbicides. Another portion of the chemicals applied during cotton production are intended for the control of weeds. A section of the Pest Management Surveys deals with the use of herbicides. The representative farm budgets assume a herbicide program using the compounds Treflan and Caparol.

Eighty percent of the individuals questioned noted that they currently use the program outlined in the farm budgets. In addition, sixty percent of those surveyed agreed with the cost assumptions. Of those not in agreement on cost data, there was not a consensus regarding the direction of error.

A summary of the individual responses is shown in Table 7. A greater amount of consensus exists concerning herbicides than was the case with insecticides. Eighty percent of the respondents favor the use of Prowl as a substitute for Treflan in its absence. Furthermore, one of those recommending a compound other than Prowl suggested the use of Triflauralin. Triflauralin is the generic formulation of Treflan. Therefore, it is doubtful that this generic substance would be available if Treflan was not.

A similar situation exists with the preference for a substitute for Caparol. Forty-five percent of the respondents prefer Dyrex/Diuron as an alternative chemical. The second most popular alternative (36%) is Prometryn. Prometryn is the generic formulation of Caparol. Therefore, it is also unlikely that it would be available in the absence of Caparol.

TABLE 7: RESULTS OF PESTICIDE SURVEY-HERBICIDES, PINAL COUNTY

A. Alternative Product with the Elimination of Treflan:

PRODUCT	# RESPONSES	% OF SAMPLE
Prowl	8	80.0
Dyrex/Diuron	1	10.0
Triflauralin	1	10.0

B. Alternative Product with the Elimination of Caparol:

PRODUCT	# RESPONSES	% OF SAMPLE
Dyrex/Diuron	5	45.5
Prometryn	4	36.4
Carmex	1	9.1
Bladex	1	9.1

The following pest management scenarios have been modeled for herbicide use:

1) The elimination of Treflan: It is assumed that the alternative compound is Prowl. This is preferred at 1.25 quarts per acre with one application. There is no change in cotton yield believed to be associated with this substitution.

2) The elimination of Caparol: The assumed substitute for Caparol is the combination of one application of Dyrex at 1.0 pints per acre and one application of Carmex at 1.5 pints per acre. Likewise, no change in yield is expected to result.

Results of the herbicides budget analysis are shown in Table 8. Each of the changes in net returns is shown to be positive. The results for the change from Treflan to Prowl are negligible. Under each program option, the results for such a change are less than one percent of estimated net returns.

The positive results for the change from Caparol to a combination of Dyrex and Carmex are more substantial. For a farmer in the cotton program, net returns are increased by over $4,000. This is equal to 3.3 percent of expected net returns. There are three possible reasons for these values being positive. One possibility is that farmers are actually losing returns by not already using the combination rather than Caparol.

This explanation is inconsistent with the assumption that individual operators act as profit maximizers. A second explanation is that there could actually be yield effects which occur as a result of the change, but were not reported in the survey. This could be the case

TABLE 8: RESULTS OF MODELING–HERBICIDES, PINAL COUNTY
INITIAL ASSUMPTIONS

RETURNS OVER OPERATING COSTS

SCENARIO	FULL PARTICIPATION	NO PARTICIPATION	50–92 PARTICIPATION
Benchmark	$126,209	$100,876	$91,095
Without Treflan	126,658	101,475	91,320
Without Caparol	130,322	106,359	93,151

CHANGE IN RETURNS FROM BENCHMARK

SCENARIO	FULL PART.	% OF BENCHMARK	NO PART.	% OF BENCHMARK	50–92 PART.	% OF BENCHMARK
Benchmark	-----	-----	-----	-----	-----	-----
Without Treflan	449	0.4	599	0.6	225	0.2
Without Caparol	4,113	3.3	5,483	5.4	2,056	2.0

if the yield effects are so small as to have been disregarded by the survey respondents in their answer. A third, more plausible, explanation is that there are factors other than cost or yield which affect the decision regarding chemical use. These factors could range from non-yield cultural changes to dealer/distributor incentives. Such incentives may include dealer rebates, gifts, and promotional materials. In some cases, the input marketing system in the area has a great deal to do with grower preference.

Defoliants. The final area investigated in the pesticide portion of this study involves the use of chemicals which act as defoliating and harvest preparation agents. These compounds are utilized to remove the foliar growth from the plant in order to facilitate harvest of the cotton lint. The representative farm budgets for Pinal County assume that farmers use a combination of applications of DEF and Sodium Chlorate in the defoliation process.

The survey results are more varied in this area. Although the level of its human toxicity is in question, DEF has a noxious and distinguishable odor. Therefore, many farmers, especially those near urban areas, hesitate to use it on their crop. Sample respondents in general feel that this hesitation is more due to the problems with neighbor complaints than to a concern over the possible toxicity. Forty percent of those individuals interviewed stated that they use no DEF in their programs. Each of those answering in this fashion conduct the majority of their business near urban or residential areas. Sixty percent of the respondents agreed with the cost assumptions in this section. The remaining forty percent felt that the costs were somewhat too low for their particular area.

The individual responses are summarized in Table 9. Fifty percent of the respondents stated that they would use the product Dropp if DEF were not available. Obviously, a portion of this fifty percent would utilize Dropp even if DEF were available. Thirty percent said that they would change from DEF to Folex. However, DEF and Folex are products which are of identical chemical formulation, but are marketed by different manufacturers under different names. It is doubtful that Folex would be available if DEF were not. The remaining twenty percent recommended the increase in application of Sodium Chlorate without the inclusion of an additional chemical to replace DEF.

Forty-two percent of the respondents stated that if Sodium Chlorate was not available, they would use only DEF/Folex and not include another product. The reason for this involves timing considerations. Products such as DEF and Folex work best with high temperatures (greater than 100 degrees). The only product believed to defoliate effectively during cooler nights is Sodium Chlorate. Therefore, the elimination of this product would force growers to terminate the crop at an earlier date. While there are many who believe that a shorter cotton season would actually increase profitability, this would eliminate the farmer's option of extending the season. Despite this shortening of growing season, respondents feel that the elimination of Sodium Chlorate would not affect the average yield achieved by farmers.

TABLE 9: RESULTS OF PESTICIDE SURVEY-DEFOLIANTS, PINAL COUNTY

A. Alternative Product with the Elimination of DEF:

PRODUCT	# RESPONSES	% OF SAMPLE
Dropp	5	50.0
Folex	3	30.0
Sodium Chlorate	2	20.0

B. Alternative Product with the Elimination of Sodium Chlorate:

PRODUCT	# RESPONSES	% OF SAMPLE
DEF/Folex	5	41.7
Paraquat	2	16.7
Dropp	2	16.7
L-10 Acid	1	8.3
Nothing Works	1	8.3
Prep	1	8.3

The management scenarios for defoliant use in Pinal County have, therefore, been modeled using the following assumptions:

1) The elimination of DEF: The preferred alternative is Dropp. This would be done in one application at a rate of .15 pounds per acre. No resulting yield change is expected.

2) The elimination of Sodium Chlorate : The modeled substitute is DEF/Folex with two applications at a rate of 1.5 pints per acre. No yield change is projected.

Farm budget analysis results for defoliants are shown in Table 10. All estimated changes in returns are negative. Although the negativity of these numbers signifies that the farmers will lose returns from the elimination of either chemical, these results are also minimal. For a farmer fully participating in the government cotton programs, estimates are of a loss of less than one percent of estimated net returns.

Maricopa County

Due to the larger population in Maricopa County, both in terms of number of Pest Control Advisors and acres of cotton, a larger sample has been taken. Fifteen individuals were interviewed for the survey. These fifteen individuals have an average of over fifteen years of experience in the pest control industry. Experience levels range from three to thirty-six years. They make recommendations on an average of over five thousand acres of cotton per year. Acres recommended vary from 2,000 to 10,500. Four of the group farm on their own. The average farm size for these four individuals is 468 acres. A summary of their individual responses is shown in Appendix 5. The compiled results are

TABLE 10: RESULTS OF MODELING–DEFOLIANTS, PINAL COUNTY
INITIAL ASSUMPTIONS

RETURNS OVER OPERATING COSTS

SCENARIO	FULL PARTICIPATION	NO PARTICIPATION	50–92 PARTICIPATION
Benchmark	$125,145	$99,457	$90,563
Without DEF	124,156	98,138	90,068
Without NaCl	124,075	98,030	90,028

CHANGE IN RETURNS FROM BENCHMARK

SCENARIO	FULL PART.	% OF BENCHMARK	NO PART.	% OF BENCHMARK	50–92 PART.	% OF BENCHMARK
Benchmark	-----	-----	-----	-----	-----	-----
Without DEF	(989)	0.8	(1,319)	1.3	(495)	0.5
Without NaCl	(1,070)	0.9	(1,427)	1.4	(535)	0.6

discussed below. Although the numerical results tend to be different than those for Pinal County, many of the concerns and issues are identical.

In general, the estimated losses in net returns for Maricopa County are smaller than those estimated for Pinal County. This is because Maricopa County in general has less of a production problem with insect pressure. In addition, the assumed prices of the chemicals ranges five to ten percent higher for Pinal County. The complete pesticide budget models for Maricopa County are shown in Appendix 7. Sensitivity analyses are also included in Appendix 9. As in the Pinal County analysis, sensitivity analyses show that the results are not heavily responsive to changes in the levels of the assumed variables.

Insecticides. The assumed insecticide program for the county consists of Methyl Parathion, Fundal/Galecron, and Cymbush. Ninety-three percent of the survey respondents agreed that this is a typical program for the area. Sixty percent of the individuals agreed with the cost assumptions utilized.

As shown in Table 11, an equal amount (23.8%) recommended Azodrin and Guthion as an alternative for Methyl Parathion. There was also a greater diversity on other substitutes recommended in this case than there was in Pinal County. This can be attributed to the fact that Maricopa County encompasses a much wider geographic area than does Pinal County. For this reason, individual local problems are more diverse in the Maricopa County area.

The attitudes on the Chlordimeform issue, however, were quite similar to those expressed by Pinal County PCAs. Forty-one percent of

TABLE 11: RESULTS OF PESTICIDE SURVEY-INSECTICIDES, MARICOPA COUNTY

A. Alternative Product with the Elimination of Methyl Parathion:

PRODUCT	# RESPONSES	% OF SAMPLE
Azodrin	5	23.8
Guthion	5	23.8
Penncap-M	3	14.3
Ammo	3	14.3
Asana	2	9.5
Pydrin,Pounce,Bydrin	1 each	4.8 each

B. Alternative Product with the Elimination of Fundal/Galecron:

PRODUCT	# RESPONSES	% OF SAMPLE
Nothing Works	7	41.2
Lannate	5	29.4
Don't Use	2	11.8
Capture,Pounce,Scout	1 each	5.9 each

C. Alternative Product with the Elimination of Cymbush:

PRODUCT	# RESPONSES	% OF SAMPLE
Asana	8	42.1
Scout	3	15.8
Pay-Off	2	10.5
Capture	2	10.5
Pydrin,Pounce,Nothing	1 each	5.3 each

those interviewed feel that there is no viable substitute for this product. Another twenty-nine percent feel that Lannate can be used as an alternative product, with varying degrees of success. Interestingly, two respondents in Maricopa County stated that they currently do not use Chlordimeform and would feel no effect at all of its loss.

Forty-two percent of those interviewed recommended Asana as an alternative to Cymbush. As in Pinal County, the effects of changing to this as opposed to other pyrethroids is minimal. In general, the choice of which pyrethroid to use varies by grower and distributor preference.

The following scenarios have been modeled for change in insecticide use in Maricopa County:

1) The elimination of Methyl Parathion: Due to the lack of consensus between Guthion and Azodrin as substitutes, both scenarios have been modeled. The first alternative assumes six applications of Guthion at 1.0 pint per acre. The second alternative assumes six applications of Azodrin at 1.0 pint per acre. There is no expected yield loss associated with either of these alternatives.

2) The elimination of Fundal/Galecron: As in Pinal County, controversy exists regarding the effectiveness of Lannate as an ovicide. Therefore, both cases have been modeled. The first scenario assumes that three applications of Lannate are used at a rate of .25 pounds per acre. An increase in the application of other chemicals of 20 percent is modeled. In addition, a 65-pound yield drop is expected. The second scenario assumes that no substitute products are used. This entails a sixty percent increase of other chemicals and a 200-pound yield decrease.

3) The elimination of Cymbush: The assumed substitute is Asana, with three applications at a rate of 3.0 ounces per acre. There is no yield change associated with this substitution.

Results of the budget modeling for insecticides for Maricopa County are shown in Table 12. As discussed previously, two different scenarios in response to the elimination of Methyl Parathion have been modeled. Although respondents were not in consensus as to whether to switch to Guthion or Azodrin, it appears from this analysis that Guthion leads to a more profitable situation. This could, of course, be altered by non-price factors which could be involved. The change to Guthion results in a loss due to the elimination of Methyl Parathion of less than .25 percent. Azodrin, conversely, is slightly more expensive and results in a loss in returns of 2.6 percent for a grower participating in the government program.

As in Pinal County, the most significant results are associated with the elimination of Chlordimeform. Depending on whether Lannate is effective as a partial substitute, losses can be as high as $74,398 for a 750-acre farm not in the government program.

The change in returns resulting from the elimination of Cymbush is zero in this case. This is because price and yield information from Pinal County indicated that Asana is a perfect substitute at an identical price.

Herbicides. The herbicide program assumed for the representative farm budget models for Maricopa County involves the application of Treflan and Caparol. These are also the same compounds assumed for Pinal County. Ninety-three percent of those interviewed agreed that this is a

TABLE 12: RESULTS OF MODELING–INSECTICIDES, MARICOPA COUNTY INITIAL ASSUMPTIONS

RETURNS OVER OPERATING COSTS

SCENARIO	FULL PARTICIPATION	NO PARTICIPATION	50–92 PARTICIPATION
Benchmark	$195,299	$165,410	$171,505
Without MP–Guthion	195,049	165,077	171,380
Without MP–Azodrin	190,149	158,543	168,930
Without FG–Lannate	177,557	141,754	162,634
Without FG–Nothing	139,500	91,012	143,605
Without Cymbush	195,299	165,410	171,505

CHANGE IN RETURNS FROM BENCHMARK

SCENARIO	FULL PART.	% OF BENCHMARK	NO PART.	% OF BENCHMARK	50–92 PART.	% OF BENCHMARK
Benchmark	-----	-----	-----	-----	-----	-----
Without MP–Guthion	(250)	0.1	(333)	0.2	(125)	0.1
Without MP–Azodrin	(5,150)	2.6	(6,867)	4.2	(2,575)	1.5
Without FG–Lannate	(17,742)	9.1	(23,656)	14.3	(8,871)	5.2
Without FG–Nothing	(55,799)	28.6	(74,398)	45.0	(27,900)	16.3
Without Cymbush	0	0.0	0	0.0	0	0

representative program for the area. One hundred percent also agree with the cost assumptions. Of those disagreeing with the cost assumptions, two respondents believed that the costs were low for their area and one individual cited special needs for his fields because they were located in close proximity to urban and residential areas. Such a location necessitates the use of application by helicopter rather than airplanes for safety factors.

Results for herbicide use in Maricopa County are shown in Table 13. Eighty-seven percent of the respondents preferred Prowl as an alternative to Treflan. This was also the resulting substitute for Pinal County. Fifty-six percent preferred Bladex as a substitute for Caparol. Dyrex/Diuron, which was preferred in Pinal County, was indicated by only nineteen percent of those questioned in Maricopa County.

The following scenarios have been modeled for herbicide use in Maricopa County:

1) The elimination of Treflan: The preferred substitute is Prowl at a rate of 1.5 pints per acre. One application should be required. There is no yield change projected for this substitution.

2) The elimination of Caparol: It is assumed that Bladex is substituted for Caparol, with one application at 2.0 pints per acre. No yield change is expected.

Table 14 indicates the results of herbicide modeling for Maricopa County. As in Pinal County, all results show positive changes in net returns resulting from a change from the assumed chemicals.

TABLE 13: RESULTS OF PESTICIDE SURVEY-HERBICIDES, MARICOPA COUNTY

A. Alternative Product with the Elimination of Treflan:

PRODUCT	# RESPONSES	% OF SAMPLE
Prowl	13	86.7
Post	1	6.7
Carmex	1	6.7

B. Alternative Product with the Elimination of Caparol:

PRODUCT	# RESPONSES	% OF SAMPLE
Bladex	9	56.3
Dyrex/Diuron	3	18.8
Carmex	1	6.3
Goal	1	6.3
Prometryn	1	6.3

TABLE 14: RESULTS OF MODELING-HERBICIDES, MARICOPA COUNTY
INITIAL ASSUMPTIONS

RETURNS OVER OPERATING COSTS

SCENARIO	FULL PARTICIPATION	NO PARTICIPATION	50-92 PARTICIPATION
Benchmark	$200,397	$172,207	$174,054
Without Treflan	200,591	172,466	174,151
Without Caparol	201,190	173,265	174,450

CHANGE IN RETURNS FROM BENCHMARK

SCENARIO	FULL PART.	% OF BENCHMARK	NO PART.	% OF BENCHMARK	50-92 PART.	% OF BENCHMARK
Benchmark	-----	-----	-----	-----	-----	-----
Without Treflan	194	0.1	259	0.2	97	0.1
Without Caparol	793	0.4	1,058	0.6	396	0.2

Conclusions similar to those for Pinal County can be drawn from these results.

Defoliants. Fifty-six percent of the individuals agreed with the representative defoliant program for Maricopa County. As with Pinal County, four individuals stated that they do not use DEF due to the problems associated with its odor. All of the respondents agreed with the cost assumptions.

As seen in Table 15, the alternative chemicals are the same compounds chosen by the Pinal group. Forty-four percent preferred Dropp as an alternative to DEF. Thirty-five percent indicated that they would use DEF/Folex as a substitute for Sodium Chlorate, but would be forced to defoliate earlier.

The modeled assumptions for defoliant use in Maricopa County are shown below:

1) The elimination of DEF : It is assumed that the alternative will be Dropp at a rate of 0.2 pounds per acre and one application. No yield change is expected.

2) The elimination of Sodium Chlorate: The preferred action is to increase the applications of DEF from one to two. There is no change in lint yield believed to be associated with this substitution.

Table 16 shows the results of farm budget modeling for defoliant use. Although results show a loss to farmers associated with the elimination of specific defoliating agents, all changes amount to less than one percent of the expected net returns for the farm.

TABLE 15: RESULTS OF PESTICIDE SURVEY-DEFOLIANTS, MARICOPA COUNTY

A. Alternative Product with the Elimination of DEF:

PRODUCT	# RESPONSES	% OF SAMPLE
Dropp	7	43.8
Folex	4	25.0
Sodium Chlorate	3	18.8
Cotton-Aid	1	6.3
Prep	1	6.3

B. Alternative Product with the Elimination of Sodium Chlorate:

PRODUCT	# RESPONSES	% OF SAMPLE
DEF/Folex	6	35.3
L-10 Acid	3	17.6
Paraquat	2	11.8
Dropp	2	11.8
H-10 Acid	1	5.9
Prep	1	5.9
Bolls-Eye	1	5.9
Don't Use	1	5.9

TABLE 16: RESULTS OF MODELING-DEFOLIANTS, MARICOPA COUNTY INITIAL ASSUMPTIONS

RETURNS OVER OPERATING COSTS

SCENARIO	FULL PARTICIPATION	NO PARTICIPATION	50-92 PARTICIPATION
Benchmark	$200,891	$172,867	$174,301
Without DEF	199,970	171,638	173,840
Without NaCl	199,835	171,458	173,773

CHANGE IN RETURNS FROM BENCHMARK

SCENARIO	FULL PART.	% OF BENCHMARK	NO PART.	% OF BENCHMARK	50-92 PART.	% OF BENCHMARK
Benchmark	-----	-----	-----	-----	-----	-----
Without DEF	(921)	0.5	(1,229)	0.7	(461)	0.3
Without NaCl	(1,056)	0.5	(1,409)	0.8	(528)	0.3

Nematocides. In some areas of the country, there has been a significant groundwater pollution problem with chemicals designed to control nematodes. Nematodes have been found to be most prevalent in areas of light,sandy soil (University of California, 1979). The nematode problem in Pinal County is extremely limited due to the predominant soil types. There is believed to be more of a problem in Maricopa County. Sixty percent of those interviewed in Maricopa County believed that nematodes were a problem on fields which they examined.

Due to the limited extent of the problem in the study area as a whole and the limited amount of technical data available on the subject, this study has not addressed specifically the issue of nematocide use. Further study on this problem is recommended.

Summary

A survey of a sample of licensed Pest Control Advisors residing within the study area has been performed. Results of this survey have been used to determine the manner in which individual growers are expected to react in response to the elimination of specific chemicals. These responses, along with projected changes in production, have been modeled using the representative farm budget models discussed in Chapter Four.

Results of the modeling provide an estimate of the changes in profitability for central Arizona cotton producers resulting from the elimination of specific agricultural pesticides. Chapter Six examines the profitability changes resulting from varying the levels of nitrogen fertilizer applied. The policy implications of profitability changes are discussed in Chapter Seven.

CHAPTER SIX

ANALYSIS OF NITROGEN FERTILIZER REGULATIONS

The second major portion of this study deals with the application of nitrogen fertilizers. Arizona's Environmental Quality Act establishes Advisory Committees for nitrogen use. These committees are charged with the responsibility of generating Best Management Practices for the use of nitrogen in crop production and concentrated animal feeding operations. This study focuses on the effects of those practices prescribed for cotton producers. This analysis is performed in a manner similar to that done for pesticides. Representative farm budget models similar to those used in the pesticides analysis are utilized. All preliminary assumptions and sensitivity analyses are also identical with respect to study area, farm size, irrigation systems, rotational crops, and cultural practices.

Nitrogen Fertilizer Research and Data Collection

The study of nitrogen fertilizer application utilizing the representative farm budgets requires the input of technical agronomic data. In addition, the specific management practices to be analyzed must be selected. The first portion of this chapter will describe the procedures for gathering technical data and selecting management practices to be studied.

Derivation of Cotton-Nitrogen Production Functions

In order to estimate the effects of changing nitrogen practices on net returns, it is first necessary to determine the change in yield which will result from a change in nitrogen fertilizer applications. This involves of the derivation of production functions relating cotton yield to applied nitrogen levels.

The preferred method to estimate expected yield for a given farm relies on historical yield and nitrogen data for that farm or the use of experimental data taken from nearby locations. A study similar to this was performed by Ayer and Hoyt (1981) for the production of cotton in Arizona. They performed regression analysis on data taken from research done at the Agricultural Experiment Stations located around the state.

Their main objective was to relate the production of cotton lint yield to the amount of irrigation water applied. However, some of the functions they estimated contain a variable which shows the effect of nitrogen applications on yield.

A detailed search of field test data regarding nitrogen application and cotton yield determined that those functions estimated by Ayer and Hoyt are the best available for use in central Arizona. Ayer and Hoyt estimated functions for coarse, medium, and fine texture soils. However, only the coarse and fine texture functions contain a nitrogen yield response term. Data for the coarse texture soils was taken from the Yuma Mesa Experimental Station; fine texture tests were performed at the Yuma Valley and Safford Stations. Consultation with local soil fertility specialists (Doerge, 1987a) indicated that the soils in the study area are more similar to those in the fine texture areas than to those in the coarse texture regions. For these reasons, the Ayer and Hoyt functions for fine texture soils are used in this study.

The function derived by Ayer and Hoyt for cotton on fine texture soils is shown below:

$$Yc=-380.377+35.032W-.499W^2+.307WEVAP+2.262N-.007N^2 \qquad \text{(Eq.1)}$$

where Yc= cotton lint yield (lbs/acre),

W = water applied per acre (acre-inches),

EVAP = pan evaporation (inches/season),

N = nitrogen applied (lbs/acre).

$\bar{R}^2 = .93 \qquad T = 147.52$

It is necessary to set all variables other than applied nitrogen (N) equal to constants in order to isolate the effects of changes in nitrogen applications. Water applied is set equal to the level assumed by Hathorn (1987) for each county. The pan evaporation rate (WEVAP) is set at the mean level for each county as outlined by Ayer and Hoyt.

While the reaction of the cotton plant to applied nitrogen (and, therefore, the shape of the production function) should be similar between regions, the exact magnitude of production is found to vary between areas. This is because the level of yield is dependent on several variables other than soil texture. Among these are climate, elevation, and growing conditions. For this reason, it is necessary to adjust the individual production functions to reflect changes in local conditions. This can be done by adjusting the y-intercept such that the functions are consistent with the yield levels and quantities of nitrogen applied assumed by Hathorn for each county. A detailed explanation of this procedure is found in Appendix 10. While this adjustment implies that Hathorn's assumptions define a point on the production function, it does not require that such point is a maximum. Adjustment to the functional form has involved a change in the intercept term only, not a change in the marginal reaction of cotton yield as a response to changes in the amount of nitrogen applied. The resulting functions relating yield to applied nitrogen for each county are shown below:

Maricopa: $Yc = 1{,}018.20 + 2.262N - .007N^2$ (Eq. 2a)

Pinal: $Yc = 1{,}073.39 + 2.262N - .007N^2$ (Eq. 2b)

where Yc = cotton lint yield (lbs/acre), and

N = nitrogen applied (lbs/acre).

In addition to the nitrogen applied during production, some amount of nitrogen is normally present as a residual in the soil. This nitrogen can be a result of applications in previous periods as well as some level which occurs through natural soil processes. It has been found that cotton lint yield is also a function of this form of nitrogen (Gardner and Tucker, 1967). It is therefore prudent to insert a variable in the cotton-nitrogen production function which accounts for this factor. However, research has not uncovered reliable estimates of the effect on yield of this type of nitrogen.

A study by Doerge (1985) has conducted extensive soil sampling in all Arizona counties. The result has been an estimate of the mean level of residual soil nitrogen in each county. In the absence of specific data on the levels of residual soil nitrogen at each field test examined by Ayer and Hoyt, it is logical to assume that the intercept term in the production function for each county is a direct result of the county average of the residual soil nitrogen.

With this result, it is estimated that the y-intercept yields in Equations 2a and 2b are a function of equivalent pounds per acre of residual soil nitrogen. It has been found that lint yield will react differently to residual nitrogen than it does to nitrogen applied (Doerge, 1987a). There are no reliable estimates of functions relating cotton lint yield to residual nitrogen levels in Arizona. Therefore, this study estimates the effects of a change in applied nitrogen fertilizer only. Technical data is not available in order to examine how the change in net returns is related to a variance in the level of residual soil nitrogen present.

Figure 9 is a graphical representation of the production function for each county, assuming the county average soil residual nitrogen levels. These are the cotton-nitrogen production functions which have been used in this analysis. While there are some limitations to their applicability due to the number of assumptions required in their derivation, each function is consistent with normal yield data for the individual counties.

Selection of Management Practices Studied

Implementation of the provisions of the Environmental Quality Act relating to nitrogen fertilizers in crop operations is not yet

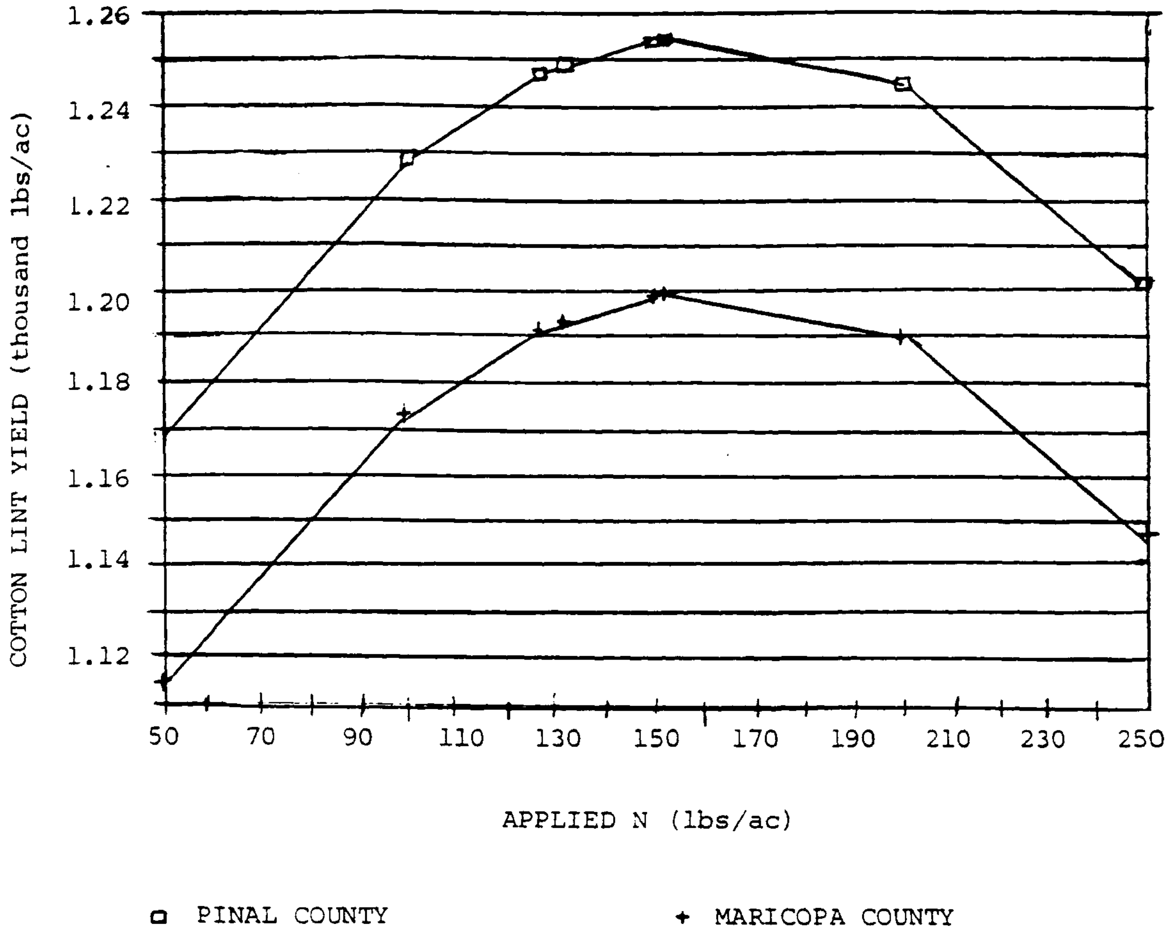


FIGURE 9 : COTTON-NITROGEN PRODUCTION FUNCTIONS

underway at the time of this analysis. Interviews with various personnel involved with the formulation of the guidelines has revealed little information on the nature of possible prescribed practices.

The only regulatory action which has been proposed by most experts has been the monitoring of levels of total applied nitrogen per acre. Due to the early stage of the implementation process and the lack of consensus on other possible regulatory actions, this study concentrates solely on regulations which would regulate the maximum allowable level of total applied nitrogen per acre of cotton.

Optimality of Assumed Practices

The study has analyzed the effect of varying applied nitrogen in each county by 50-pound increments. This is done by comparing the net returns at each level to those at the level assumed by Hathorn to be typical for the county. Incidentally, the levels assumed in the Hathorn budgets are near the levels at which the net returns per acre of cotton would be maximized given the model specifications outlined above. This can be calculated by designing a profit function per acre of cotton and solving this equation for the optimal level of nitrogen fertilizer applied. For example, using Equation 2a as a cotton-nitrogen production function for Maricopa County, maintaining price and cost assumptions outlined in Chapter Four, and ignoring the effects of the government price support program, a function relating profit per cotton acre to the amount of nitrogen applied can be derived as:

$$\text{Profit} = \text{Total Revenue} - \text{Total Cost}$$

$$= (\text{Price} * \text{Yield}) - (\text{Cost Per Acre})$$

$$= (\text{Price} * \text{Yield}) - (\text{N Cost/Acre} + \text{Non-N Cost/Acre})$$

$$= .59\ (1018.2 + 2.262N - .007N^2) - (.1087\ N + 472.93)$$

$$= 127.808 + 1.22588\ N - .00413\ N^2$$

Where Lint Price = $.59 per pound,

Cotton Yield = $1{,}018.2 + 2.262\ N - .007\ N^2$ (Eq.2a)

Nitrogen Cost = $.1087 per pound applied (material cost + cost of application, Hathorn, 1987),

Non-N Cost = $472.93 per acre.

Differentiating the profit per acre function with respect to applied nitrogen per acre will result in the level of applied nitrogen which maximizes profit. This procedure is shown below:

$$\text{Profit} = 127.808 + 1.22588\ N - .00413\ N^2$$

$$d\ \text{Profit}/d\ N = 1.22588 - .00826\ N$$

At the optimal level of nitrogen per acre, the derivative will be equal to zero. Such as:

$$d\ \text{Profit}/d\ N = 1.22588 - .00826\ N = 0$$

$$1.22588 = .00826\ N$$

$$N^* = 148.412$$

Therefore, the level of nitrogen applied which maximizes profit per acre of cotton for a farmer in Maricopa County facing the assumed production function is 148.412 pounds per acre. Due to the payment limitations imposed upon the government cotton program, it is difficult to determine the effects of this program on a per acre basis. The maximum program payments for a farmer is currently $50,000, regardless of the number of acres farmed. Therefore, this analysis the optimality calculation discussed above has been performed using only the market price, and not the government deficiency payments. The level of applied nitrogen which Hathorn assumes to be representative for the county is 149.96 pounds per acre. Therefore, if Hathorn's levels are indeed representative of farmers in the area, the average farmer does act as if he is a profit maximizer with respect to the application of nitrogen on cotton. This is significant from a policy standpoint, because it means that any regulations which force the typical farmer away from his current program is also moving away from optimal profitability. Therefore, a movement away from current levels of nitrogen application should result in a decrease in profits for the average farmer.

The situation also holds true for Pinal County. The optimal level of nitrogen applied given the assumed production function and prices is calculated to be 127.317 pounds per acre. Hathorn's assumption for a representative farmer is at a level of 132.04 pounds. This also indicates that Pinal County farmers act as if they seek to maximize the profit per acre with their nitrogen applications.

There are some limitations to this analysis. This procedure assumes that the functions generated by Ayer and Hoyt are applicable for the average farmer in the area. In addition, it assumes that Hathorn's assumptions are also typical of the amount of fertilizer applied by growers in the counties. Furthermore, the optimization done in this analysis concentrates solely on the level of fertilizer applied to cotton. It ignores the decision as to the quantity of cotton to produce relative to other enterprises.

This discussion is, however, significant because it finds the average farmer does maximize profit when determining the level of fertilizer to apply. The functions derived by Ayer and Hoyt and the levels assumed by Hathorn have been determined independently. There is no reason to believe that their agreement is the result of any systematic factor in their determination.

Results of Budget Analysis of Nitrogen Fertilizer Data

The profitability effects of varying the amount of nitrogen fertilizer applied have been estimated using the production functions discussed above and the farm budget models described in Chapter Four. This analysis has been performed to determine the change in short-run net returns over operating costs in relation to those at the level of nitrogen application assumed by Hathorn.

The Hathorn levels have been chosen instead of the calculated optimal levels because the purpose of this study is to estimate the effects on the average farmer, not necessarily the most profitable farmer. In addition, the optimality calculated in the preceeding section has centered only on the production of cotton, and not on the basis of an entire operation. As evident from the discussion above, the effects in relation to the assumed program should be similar to those in relation to an optimal level.

Because slightly different production functions have been modeled for each county, this analysis will be presented by county. Results for the two areas are of similar magnitude.

Maricopa County

The nitrogen fertilizer budget for Maricopa County is shown in Appendix 11. Inserting Equation 2a as the yield variable, the net returns for each level of applied nitrogen can be calculated. These results are shown in Table 17 and Figure 10. As seen in the results, a fifty-pound variance in either direction from the assumed program will result in a loss in returns.

Due to the shape of the assumed production function, a farmer who applies more than the optimal level of nitrogen actually loses more than those who apply less than optimal. This is because the function specifies that the marginal productivity of nitrogen falls sharply at levels greater than optimal. This is consistent with work done by soil scientists in the area (Doerge, 1987a).

The probable regulations concerning nitrogen are most likely to set maximum levels of applied nitrogen per acre. Therefore, legislation setting a maximum level at an amount greater than the farmer is currently using should have no effect on the grower. For example, if the average farmer in Maricopa County is currently applying approximatley 150 pounds of nitrogen per acre, a regulation setting the maximum applied at 200 pounds per acre would not prohibit the farmer from using his preferred level. Therefore, a legislated maximum can be detrimental to the individual only if it is set at a amount less than his preferred level. Table 18 shows the effects on farm returns of regulated maximum levels of applied nitrogen set at varying levels.

Table 18 shows that levels set at greater than 150 pounds per acre should have no effect on the average farmer in Maricopa County. In

TABLE 17: NET RETURNS OVER OPERATING COSTS FOR VARYING LEVELS OF NITROGEN-MARICOPA COUNTY

SHORT-RUN NET RETURNS OVER OPERATING COST

Applied N (lbs/ac)	50	100	150	200	250
Full Participation	$188,448	$198,940	$201,237	$195,378	$181,263
No Participation	$157,387	170,578	173,327	165,629	147,377
50-92 Participation	$168,420	173,421	174,474	171,579	164,696

CHANGE IN NET RETURNS FROM ASSUMED PROGRAM

Applied N (lbs/ac)	50	100	150	200	250
Full Participation	($12,789)	($2,297)	---	($5,589)	($19,974)
No Participation	(15,940)	(2,749)	---	(7,698)	(25,950)
50-92 Participation	(6,054)	(1,053)	---	(2,895)	(9,778)

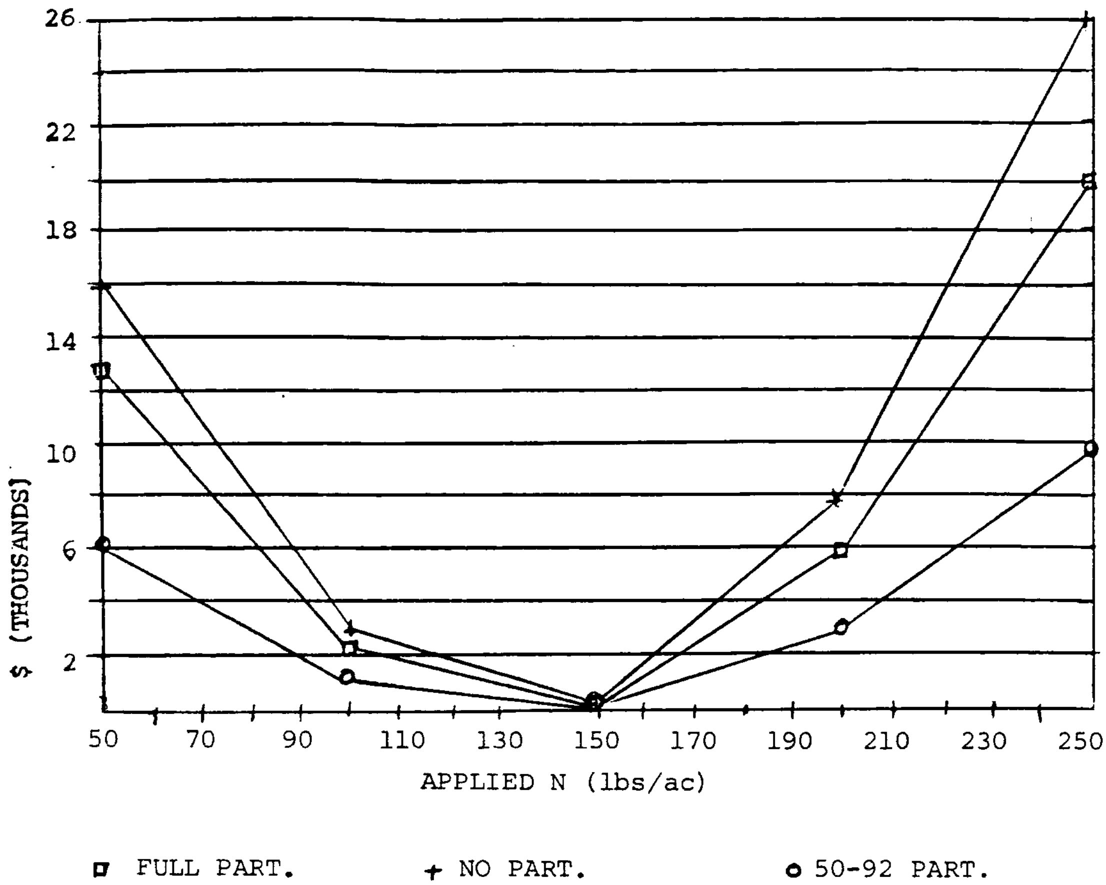


FIGURE 10 : LOSS IN SHORT-RUN NET RETURNS BY VARYING NITROGEN LEVEL, MARICOPA COUNTY

TABLE 18: EFFECT ON NET RETURNS OF REGULATIONS SETTING MAXIMUM ALLOWABLE APPLIED NITROGEN PER ACRE AT VARIOUS LEVELS -MARICOPA COUNTY

CHANGE IN SHORT-RUN NET RETURNS OVER OPERATING COST

Applied N (lbs/ac)	50	100	150	200	250
Full Participation	($12,789)	($2,297)	-0-	-0-	-0-
No Participation	(15,940)	(2,749)	-0-	-0-	-0-
50-92 Participation	(6,054)	(1,053)	-0-	-0-	-0-

addition, levels at less than 150 pounds should have a less drastic effect on profitability than might have been expected.

Sensitivity analyses have been performed on these results to determine the effects on results of varying the values of assumed prices, crop rotations, and business organization characteristics which affect participation in the government program. The results of these analyses are shown in Appendix 12.

The sensitivity analyses show that the change in net returns is most sensitive to the cotton lint price and the price of nitrogen fertilizer. This is to be expected as the change in cotton yield resulting from a change in fertilizer will result in a larger change in net returns if the value of the product is higher. Similarly, the effects of a change in nitrogen applied is related to the price of that nitrogen.

Pinal County

Assumptions for Pinal County are similar to those for Maricopa County. Equation 2b is assumed to be the appropriate cotton-nitrogen production function. Output price and input cost assumptions are consistent with those used by Hathorn. Table 19 and Figure 11 illustrate the effect on net returns of varying applied nitrogen per cotton acre for the county. The losses associated with levels of nitrogen greater than the assumed level are larger than those estimated for Maricopa County. Conversely, those associated with levels less than the assumed program are of a lesser magnitude. This is dependent on the assumed level of fertilizer applied.

TABLE 19: NET RETURNS OVER OPERATING COSTS FOR VARYING LEVELS OF NITROGEN-PINAL COUNTY

SHORT-RUN NET RETURNS OVER OPERATING COST

Applied N (lbs/ac)	50	100	132	150	200
Full Participation	$115,090	$123,991	$125,570	$125,080	$118,262
No Participation	$86,207	97,957	100,025	99,362	90,287
50-92 Participation	$85,528	89,984	90,776	90,531	87,121

CHANGE IN NET RETURNS FROM ASSUMED PROGRAM

Applied N (lbs/ac)	50	100	132	150	200
Full Participation	($10,480)	(1,579)	---	($490)	($7,308)
No Participation	(13,818)	(2,068)	---	(663)	(9,738)
50-92 Participation	(5,248)	(792)	---	(245)	(3,655)

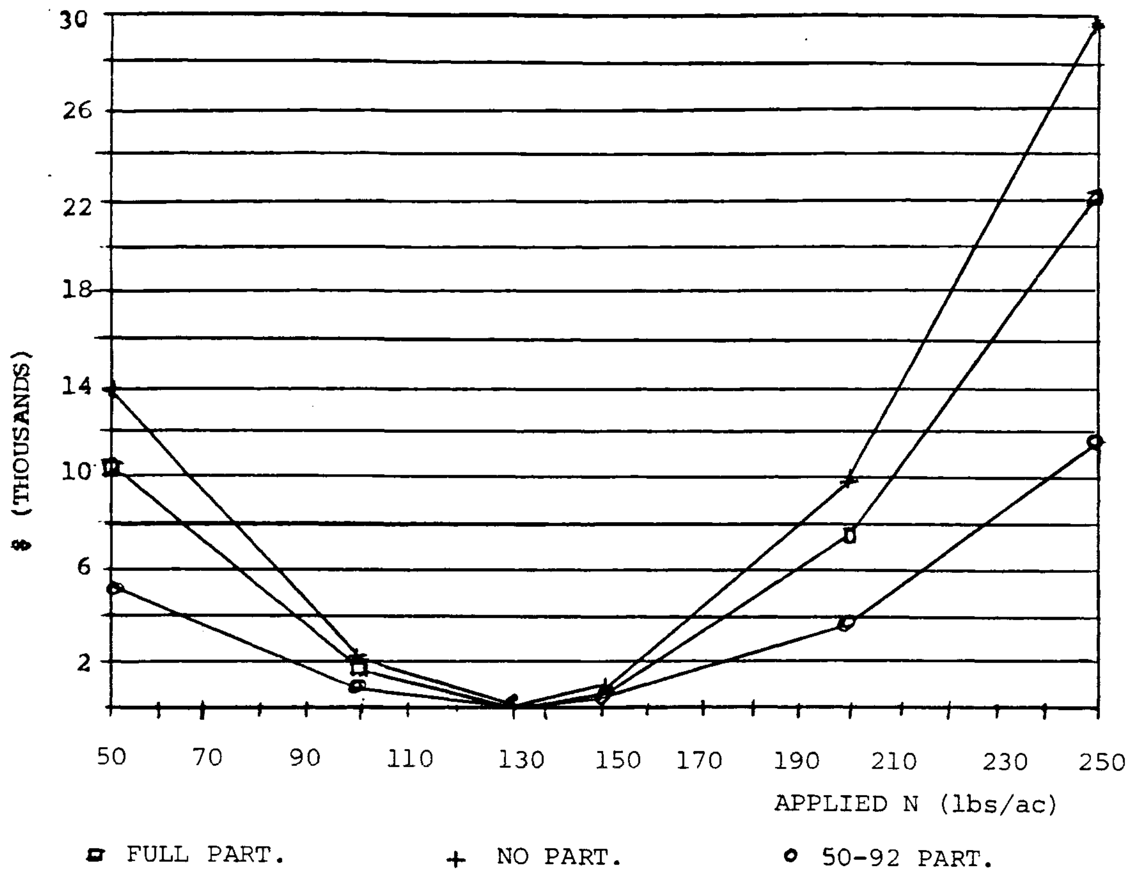


FIGURE 11 : LOSS IN SHORT-RUN NET RETURNS BY VARYING NITROGEN LEVEL, PINAL COUNTY

Table 20 shows the effects on net returns of government policies which regulate a maximum level of applied nitrogen at various levels. As shown in the table, a maximum level of greater than approximately 132 pounds of nitrogen per acre should have no effect on the average producer. Maximum levels which are less than this amount should adversely affect profitability.

Sensitivity analyses similar to those for Maricopa County have been performed using these results. The results for Pinal County are slightly more sensitive to changes in cotton lint price due to the higher yields assumed for the county. The results of the sensitivity analyses are shown in Appendix 13.

Summary

This analysis has estimated the profitability effects of regulations setting maximum allowable amounts of nitrogen fertilizer applied per acre of cotton. This has been performed using cotton-nitrogen production functions estimated from test data from field experiments in the state. These functions have been adjusted to reflect local production factors.

Results show that maximum levels set in excess of current application rates should have no effect on the average farmer. In addition, maxima set at lower levels of nitrogen should have relatively small adverse effects on profitability. Policy implications of these results are discussed in the following chapter.

TABLE 20: EFFECT ON NET RETURNS OF REGULATIONS SETTING MAXIMUM ALLOWABLE APPLIED NITROGEN PER ACRE AT VARIOUS LEVELS -PINAL COUNTY

CHANGE IN SHORT-RUN NET RETURNS OVER OPERATING COST

Applied N (lbs/ac)	50	100	150	200	250
Full Participation	($10,480)	($1,579)	-0-	-0-	-0-
No Participation	(13,818)	(2,068)	-0-	-0-	-0-
50-92 Participation	(5,248)	(792)	-0-	-0-	-0-

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

This study has estimated the farm-level effects of specific legislative policies on the average central Arizona cotton producer. This has been accomplished through the use of computer-based budget models of representative farm operations for the two principal cotton-producing counties in the area. Characteristics of representative operations have been determined through the use of crop budgets published by Cooperative Extension and through a series of personal interviews conducted with knowledgeable individuals in the industry.

The analysis has dealt solely with legislation regulating the use of agricultural pesticides and nitrogen fertilizers. The results of such analysis can provide valuable insight into the profitability effects on central Arizona farmers of legislation which might affect the use of these production inputs.

Summary of Results

The majority of the estimates of change in net returns are relatively small in magnitude. There are, however, a few significant exceptions. A brief summary of the estimates is given in the following section.

Pesticides

The change in net returns as a result of the elimination of specific chemicals has been estimated for each county. The most significant results are attributed to the elimination of the compound Chlordimeform (Fundal/Galecron). While considerable controversy exists over the availability of a substitute, the study finds that the loss in short-run returns can be substantial even if the substitute is somewhat effective. Consistent with the results of the survey of Pest Control Advisors, two scenarios have been modeled in which Chlordimeform is eliminated. One of these scenarios assumes that there is a partial substitute, the other assumes that no compound is available as a legitimate substitute. Although the estimated decrease in net returns varies on average from ten to sixty percent of expected returns, all estimates are substantial.

The only other result in which a large decrease in expected returns has been estimated pertains to the elimination of Methyl Parathion in the Pinal County model. This loss can be as high as twelve percent of expected returns for a farmer not participating in the government program. This result appears to be associated with the increase in the material cost of a substitute, and not with the efficacy of the alternate compounds.

Nitrogen Fertilizers

The analysis relating to nitrogen fertilizers has concentrated solely on regulations which would limit the total amount of nitrogen which could be applied to each acre of cotton. Results show that the farm losses attributed to such legislation are likely to be smaller than expected. Personal interviews with local soil fertility specialists and research have shown that the levels at which legislated maxima are most likely to be set are in excess of the amount of nitrogen currently used by the average farmer in the area. In addition, these maxima are also in excess of the level of nitrogen fertilizer use which maximizes profit per cotton acre for the average farmer.

Estimate of Aggregate Effects

The farm-level results of this study can be used to arrive at a rough estimate of what the effects might be on the two-county region of banning certain pesticides. This can be accomplished by utilizing the effects of banning certain products found in this study for a 750-acre farm in order to determine the effect per acre of cotton. Using the responses by the Pest Control Advisors regarding their use of the product as an estimate of the percent of cotton acres in each county which use a given product, one can determine the net effect on the region. The number of cotton acres per county used in this study are assumed to be those 1986 levels referred to in Table 4. The results of this estimation are shown in Table 21.

The relative magnitudes of the results of specific pesticides shown in Table 21 are similar to those at the farm level. The information presented in this table can best be viewed as a rough estimate of the combined economic effects on all growers in the two counties in the first growing season following such a ban. The magnitude of the Chlordimeform effects make this issue one which appears

TABLE 21: ESTIMATE OF AGGREGATE EFFECTS ON CENTRAL ARIZONA COTTON FARMERS OF BANNING SPECIFIC PESTICIDES

COUNTY	MARICOPA	PINAL	TOTAL
COTTON ACRES(1986)	120,100	111,500	131,600
Insecticides:			
Methyl Parathion	(52,324)	(2,008,227)	($2,060,551)
Fundal/Galecron			
>Lannate	(3,788,194)	(6,418,052)	($10,206,246)
>Nothing	(11,913,680)	(15,957,323)	($27,871,003)
Cymbush	0	96,782	$96,782
Herbicides:			
Treflan	63,665	118,636	$182,301
Caparol	148,552	1,087,348	$1,235,900
Defoliants:			
DEF	(196,017)	(183,609)	($379,626)
NaCl	(212,073)	(210,502)	($422,575)

worthy of continued investigation. A similar analysis for nitrogen fertilizers is inappropriate due to the lack of data regarding the percentage of cotton acres on which given levels of nitrogen are applied.

Conclusions

These empirical results can lead to certain implications for policy formulation in the area of agricultural chemcials. The policy implications outlined below are surely not the only conclusions which can be drawn from this study. They are, however, the most logical and defensible implications for agricultural policy, given the results discussed above.

Policy Implications for Pest Control Methods

The most obvious policy issue relating to the use of insecticides in the area is concern over a possible ban on the use of Chlordimeform as an ovicide in cotton production. Results of this modeling have shown that such a ban could have serious financial ramifications for producers in the area. While there are many who support other compounds as viable substitutes for Chlordimeform, the survey of Pest Control Advisors has found that, in general, local PCAs do not believe that there is a feasible substitute available at this time. Until a proven substitute for Chlordimeform is located, the controversy over the yield effects of a ban on its use will continue.

Until this controversy is resolved, any policy regarding the ban of Chlordimeform is sure to create a considerable uproar on the part of certain farmers. While the effects of the elimination of the chemical cannot be positively determined without a reliable estimate of the change in yield, it would appear at this point that they are quite substantial. Provisions of The Environmental Quality Act require regulators to consider the economic effects of prescribed policies on the individual grower. The average farmer in Pinal and Maricopa county appears to have a valid case for questioning a ban on the use of Chlordimeform on the grounds that the product is an integral component of profitable cotton production in the region. Without further test data which indicates that there is some economically-viable substitute for Fundal/Galecron as a cotton ovicide, the elimination of this product for use in the region should be made only under close scrutinty and with reasonably conclusive data on its effects on the health of the citizenry.

Estimated effects of the elimination of other specific compounds are relatively small in comparison to Chlordimeform. It is important to restate, however, that this study has analyzed the effects of removing only one specific chemical in each scenario. It would, therefore, be inappropriate to take the fact that the elimination of individual pyrethroid insecticides have a relatively small estimated effect on profitability and extrapolate this information to assume that the elimination of all pyrethroids in general would have a similar effect. It is obvious that there would definitely be negative synergistic effects of the elimination of an entire class of chemicals. Therefore, the effect of the elimination of all chemicals in a specific class should be larger than the sum of the effects of the individual chemcials if eliminated individually. The reason that the effects of the elimination of one specific pyrethroid are so small is that there are several other pyrethroid insecticides which can serve as substitutes. If these substitutes were also eliminated simultaneously, a more significant impact would result.

Similar conclusions can be drawn for the relatively small estimated individual effects of the elimination of specific herbicides and defoliants. While the effects of banning the use of one specific chemical might be small, the elimination of all compounds which perform a specific function should be relatively more significant.

Therefore, it is important for policymakers to consider individual situations closely in reference to a ban on certain agricultural pesticides. While the elimination of one chemcial in a specific situation may have a relativley small effect, the elimation of other chemicals in different situations could have substantial detrimental effects on farm profitability.

Policy Implications for Nitrogen Fertilizer Use

This study has shown that probable legislative policies in regard to the total amount of nitrogen applied per acre should have a relatively small effect on the average farmer. While regulations set at levels above the average will not affect the average farmer, it is almost certain that maximum levels set at virtually any level will have some effect on certain specific farmers. There are certain cases in which individual farmers will need to apply above average levels of nitrogen to particular fields. This would be the case if a farmer were facing a cotton-nitrogen production function different from the one modeled here. Therefore, while the average farmer will not be affected at most levels of regulation, the policymaker must be aware that certain individual growers could feel negative effects of maxima set at even higher levels if they face differing cotton-nitrogen yield response relationships.

One policy option which is available for nitrogen fertilizer use is the use of petiole analysis. Petiole analysis is a scientific technique in which a series of chemical tests are performed using a portion of the cotton plant at various times throughout the growing season. The object of a petiole analysis program is to determine the amount of nitrogen which the plant requires at specific points during the season and apply only that amount. This service is currently provided by several fertilizer distributors in most cotton-growing areas of the state at a reasonable cost. The benefits of a policy designed to encourage or mandate this practice would be that it has the possiblity to reduce the amount of fertilizer which is applied in excess of the crop needs. This would serve to reduce the amount of nitrogen available for contamination of groundwater sources, while not affecting the growth of the cotton plant and farmer profits.

Can Central Arizona Cotton Producers Survive under this Legislation?

In the final analysis, one question that legislators and administrators need to ask is, "Can the farmers of Arizona survive under the new regulations?" This is a pertinent question, the answers to which are not yet definitive. This study found that farmers experienced some positive net returns over operating costs in all scenarios modeled.

From this, one would assume that farmers could survive the first growing season under such regulation.

However, this study did not attempt to analyze what the farmer's net returns would be once fixed costs had been deducted. If these figures are negative, it is likely that some farmers would discontinue cotton production entirely in the long run. This is a question which was not specifically addressed in this study, but which is in need of continued analysis.

Limitations and Applicability

Despite the care with which this study has been undertaken, it has been necessary to make certain simplifying assumptions and generalizations. The presence of these assumptions brings forth the need for the reader to recognize the limitations to which the analysis is subject.

Specification of Study Area

One limitation to this analysis is that, in order to make a meaningful estimate of effects on farm profitability, it has been necessary to specify a particular area for study. Therefore, the results of this analysis are strictly applicable only in Maricopa and Pinal counties of central Arizona. While some conclusions can be drawn regarding the general effects of related legislation in similar areas, the strict numerical results of this study are determined solely for the particular study area.

Specification of Study Crop

Likewise, this study has analyzed only those effects which pertain to the production of cotton in the area. While alfalfa and wheat have been modeled as rotational crops, the variation in pesticide and nitrogen fertilizer application has been modeled on cotton only. It is possible that the Environmental Quality Act and related legislation will have a much different effect on other segments of agriculture than they have been estimated to have on cotton production. This study has focused on cotton because it is the largest cash crop in the area. In addition, cotton is known to be a pesticide- and fertilizer-intensive crop. There is no proven reason to believe that the greatest, or even most representative, impacts of environmental legislation will be felt by the cotton producers.

Identification of Production Function for Nitrogen Fertilizers

The derivation of cotton-nitrogen production functions in particular has involved a large number of simplifying assumptions. While specific technical data exists which supports these assumptions, the mere number of generalizations involved is a basis for concern. It is important to note that the effect of nitrogen regulations on an individual farmer will be dependent on the production function faced by that individual farmer. It is doubtful that all, or even most, of the farmers in each study area face exactly the same yield response curve as modeled here. While these estimates appear to be the best available for the average farmer, they are in no way purported to be the actual losses which would be incurred by every farmer in the study area.

Selection of Pesticides to Model

There are hundreds of pesticides which are currently applied in some area of Arizona agriculture. Furthermore, there are many chemicals which are applied to cotton in Maricopa or Pinal County which have not been mentioned in this study. This thesis has only analyzed the effects of eliminating each of just a few chemicals in each area. However, conscious efforts have been made to find those chemicals which are both most widely-used throughout the study area and which are the most vital to the production process. While there are surely various products which are considered a integral part of a certain farmer's program which have not been included here, the rate at which the Pest Control Advisors agree with the assumed programs is evidence that these products are quite representative of chemical use in the counties.

Designation of the Average Farmer

The most prevalent constraint in this and any use of the representative farm approach is the designation of exactly what is a representative farm. In each case, this analysis has attempted to determine the effect on the average farmer. In reality, there probably is no average farmer. Due to the effect of natural processes on the production cycle, each individual farmer is unique in terms of his specific geographic area, his experience, and his production constraints. It is important to note that, while this analysis has assumed that the average farmer is applying nitrogen fertilizer at a rate which is near the optimal level based upon his profitability, it is expected that there are several operators who are applying nitrogen far in excess of crop needs. Public policy for nitrogen fertilizers should be designed to especially regulate those farmers who are applying nitrogen at a rate which is not only causing a possible detriment to the quality of the state's groundwater, but who are doing so at a level which is not even economically optimal for their own operation.

Limitation to Short-Run Effects Only

While the effects estimated here are applicable within the course of one growing season, they are not purported to estimate the effects on producers over the long run. There is reason to believe that the long-run effects could be quite different. One reason that the long-run effects would be different is that some crop substitution could occur over a longer period. If the elimination of one product is so detrimental to the economics of cotton production as to make it less profitable than some other substitute crop, one would expect the farmer to transfer at least some acreage from cotton to that crop in a long-run situation. This substitution would serve to lessen the effects of agricultural chemical regulation on the average farmer.

In addition, a long-run decrease in the amount of cotton produced in Arizona could have a substantial effect of the overall domestic price level for cotton. Arizona does produce a significant portion of the cotton grown in the United States, particularly for the Pima variety. A large decline in the amount of cotton produced in Arizona could have a positive effect on the general cotton price level. This would serve to benefit the remaining growers, both in Arizona and in the other cotton-growing regions of the country.

Another reason that the long-run effects might be different is that the effects of limiting various production inputs appears to be cumulative. Assuming the farmer had a high level of residual soil nitrogen present in the first year, the effects of a lessened amount of applied nitrogen in that year might be relatively minimal. The amount of fertilizer applied in this year, however, will have a substantial effect on the residual nitrogen level available at the beginning of next year. The effects of a lower amount of allowable applied nitrogen in the second year might, therefore, be more significant due to the lower level of residual nitrogen available. A similar argument can be made for the cumulative long-run effects of pesticides on the insect population.

Specification of Public Policy Setting

It is also important to note that this study has analyzed the economic effects on farmers only in the current public policy setting as prescribed by Arizona's Environmental Quality Act. In a more general sense, one must consider the initial allocation of property rights. Why must farmers be forced to bear the cost of regulation? Is is possible that consumers, who desire the clean water, be required to pay for that privilege? Do the farmers have the "right to pollute" the water, or do the individuals have the right to clean water? In Arizona, it appears that these questions have been answered by the Environmental Quality Act. This research has taken the existing public policy structure as a given variable.

There do exist, however, several policy options available to lawmakers at an earlier stage. Strategies such as a pollution tax, subsidies for farmers who reduce pollution, and marketable pollution permits have been utilized in other situations with some success. Perhaps these strategies might have a more favorable ratio of benefits and costs. This study has looked at the costs of just one of several available policy options. These other options could, in fact, be more efficient than the one chosen.

In addition, it could be possible to grant the property rights to the users of groundwater (i.e. set maximum levels of pollution), while still allowing farmers the freedom to select their own mitigation practices. For instance, in other types of pollution cases policy has been designed to allow polluters to provide an alternate source of drinking water for the general public or to take measures to treat the contaminated water in order to bring it to potable standards. It appears that Arizona has determined its policy approach to the groundwater quality issue, readers need to be aware that a variety of policy approaches exist.

Implications for Further Research

In addition to the particular findings of the study, this research has brought forward several areas which are in need of further research. The most obvious need is for reliable technical data relating the use of nitrogen fertilizers and pesticides to cotton yield for central Arizona. Such data is necessary not only for determining the effects of changes imposed by legislative actions, but also for other farm management and planning uses.

The availability of reliable substitutes for Chlordimeform as an ovicide is an issue where there is much incentive for further study. Based upon the responses by the Pest Control Advisors, the presence of an effective ovicide should be a major issue in pest control for cotton production for some time to come.

The effect of residual soil nitrogen on the reaction of cotton lint yield to applied nitrogen is also an issue which deserves further research. Although significant research has been performed by various soil scientists, continued development in the area can possibly reduce the amount of nitrogen applied while also maintaining or increasing lint yield.

Summary

The results of this study show that certain types of regulation to protect groundwater quality could have significant effects on the profitability of cotton production in central Arizona. The results of these economic effects on Arizona farmers should be considered in the adoption of policies which regulate the use of agricultural inputs.

APPENDIX 1

PRE-SURVEY PHONE SCREENING

Good afternoon/evening, is this _______________? Hello, this is Mark McGinnis from the Department of Agricultural Economics at the University of Arizona. We are currently in the process of conducting research relating to the economics of pesticide use on cotton in Maricopa and Pinal counties. I understand your are a licensed Pest Control Advisor in Arizona.

Are you currently actively using your PCA license? Do you make chemical recommendations?

What county in Arizona would you say is the principal area in which you conduct your PCA activities?

Have you made any pesticide recommendations on cotton acreage in the last twelve months?

Would you be willing to take a few minutes in the next month or two in order to participate in our study? I will be in the ______ area at some point in the next few weeks, and would like to talk with you. The survey should take an hour or less.

Thank you for your cooperation. You should be hearing from me in the next few weeks.

APPENDIX 2

PEST MANAGEMENT SURVEY-PINAL COUNTY

The following is a survey designed as part of a study being performed at the Department of Agricultural Economics at the University of Arizona. The purpose of the study is to perform an economic analysis of alternative pest control strategies practiced in the cotton producing areas of central Arizona. Results of this analysis should provide area growers, pest control advisors, and extension personnel with further information regarding the economics of pesticide use.

There are two sections to this study. Each section will deal with the application of agricultural chemicals in Pinal County. The first section will deal with a typical central Arizona cotton farm utilizing furrow irrigation. The second will assume that the operation has a below ground drip irrigation system. Please answer all questions to the best of your ability. If necessary, answer only those questions about which you feel you have a given level of expertise. We realize your responses are simply your own estimates of what would happen given the situations described, but it is important that you be as accurate as possible.

Occupation: ______________________________

Is the majority of your business conducted in Pinal County?
___ Yes ___ No
If no, where is the majority of your activity conducted?
____
____

Are you involved with recommendations on any fields which utilize drip irrigation? __ Yes __ No

If Yes, answer both sections A and B.
If No, answer only section A.

Farms Using Furrow Irrigation

1. Insecticide Recommendations

In this instance, you are to assume that the farmer's current insecticide program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Methyl Parathion	1.0 pt	3.0	Air Spray	$3.00	July
Methyl Parathion	1.33 pt	1.0	Air Spray	3.00	July
Fundal/Galecron	0.5 pt	2.0	Air Spray	3.00	Aug,Sep
Cymbush	3.0 oz	3.0	Air Spray	3.00	M,Jl,A

COTTON LINT YIELD: 1250 lbs/ac

Is this the program you would recommend? ___ Yes ___No
If not, why? ____

____

Do you feel these yield and application cost assumptions are appropriate for Pinal County? ___ Yes ___ No
If not, why? ____

____

____

A) Given the assumptions about the current pesticide program, what change(s) would you recommend if Methyl parathion was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
___________	______	___	_____	_____
___________	______	___	_____	_____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Methyl Parathion? ______________ (new lint yield)

What other changes in production would you expect?

____

____

What additional non-chemical control measures might you recommend? ____

____

____

B) What would you recommend if all other compounds were available, but Fundal/Galecron was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
___________	______	___	_____	_____
___________	______	___	_____	_____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Ambush?
______________ (new lint yield)

What other changes in production would you expect? ________

____

____

What additional non-chemical control measures might you recommend? ____

____

____

C) What would you recommend if all other compounds were available, but Cymbush was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	________	____	______	______
________	________	____	______	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Cymbush?
________________ (new lint yield

What other changes in production would you expect? _______

____

____

What additional non-chemical control measures might you recommend? ____

____

____

2. Herbicide Recommendations

Now, assume that the farmer's current herbicide program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Treflan	1.2 pt	1.0	Ground Spray	$6.06	Mar, Apr
Caparol	2.5 pt	2.0	Ground Spray	7.10	July

COTTON LINT YIELD: 1250 lbs/ac

Is this the program you would recommend? ___ Yes ___ No
If not, why? ____

____

____

Do you feel these yield and application cost assumptions are appropriate for Pinal County? ___ Yes ___ No

If not, why? ______________________________

____

____

A) Given these assumptions, what changes would you recommend if Treflan was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
______	______	______	______	______
______	______	______	______	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Treflan? ______________ (new lint yield)

What other changes in production would you expect? ______

____

____

What additional non-chemical control measures might you recommend? ______________________________

____

____

B) What would you recommend if Treflan was available and Caparol was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
______	______	______	______	______
______	______	______	______	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Caparol? ______________ (new lint yield)

What other changes in production would you expect? ______

____

____

What additional non-chemical control meaures might you recommend? ______________________________

____

____

3. Defoliant Recommendations

Now, assume that the farmer's defoliant program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
DEF	1.5 pt	1.0	Air Spray	$ 3.60	Oct
Sodium Chlorate	2.0 gal	1.0	Air Spray	3.60	Oct

COTTON LINT YIELD: 1250 lbs/ac

Is this the program you would recommend? ___ Yes ___ No
If not, why? ____
____
____

Do you feel these yield and application cost assumptions are appropriate for Pinal County? ___ Yes ___ No
If not, why? ____
____
____

A) What would you recommend if Sodium Chlorate was available for use and DEF was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
____________	________	___	______	______
____________	________	___	______	______

What would you expect the change in lint yield (if any) to be as a result of using this chemical rather than DEF?
____________ (new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical defoliation measures might you recommend? ____
____
____

B) What would you recommend if DEF was available for use and Sodium Chlorate was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
____________	______	___	______	______
____________	______	___	______	______

What would you expect the change in lint yield (if any) to be as a result of using this chemical rather than Sodium Chlorate? ________________ (new lint yield)

What other changes in production would you expect?
____
____

What additional non-chemical defoliation measures might you recommend? ____________________
____
____

Farms Using Below Ground Drip Irrigation

1. Insecticide Recommendations

In this case, you are to assume that the farmer's current insecticide program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Guthion	2.0 pt	3.0	Spray	$1.29	Apr,J,J
Temik	5.0 lb	1.0	Spray	2.14	May
Cymbush	2.56 oz	3.0	Air Spray	3.00	Jl,A,S
Methyl Parathion	2.5 pt	2.0	Air Spray	3.00	August

COTTON LINT YIELD; 1705 lbs/ac

Is this the program you would recommend? ___ Yes ___ No
If not, why? ____________________
____
____

Do you feel these yield and application cost assumptions are appropriate for Pinal County? ___ Yes ___ No
If not, why? ____________________
____
____

A) Given these assumptions, what change(s) would you recommend (if any) if Guthion was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	________	___	________	________
________	________	___	________	________

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Guthion?
__________ (new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical control measures might you recommend? ____

____

____

B) What would you recommend if all other compounds were available, but Temik was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	___	______	______
________	______	___	______	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Temik?
______________ (new lint yield)
What other changes in production would you expect? ________

____

____

What additional non-chemical control measures might you recommend? ____

____

____

C) What would you recommend if all other chemicals were available, but Cymbush was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	___	______	______
________	______	___	______	______

What would you expect to be the change in lint yield to be (if any) as a result of using this chemical rather than Cymbush ________________ (new lint yield)
What other changes in production would you expect?

____

____

What additional non-chemical control measures might you recommend? ____

____

____

D) What would you recommend if all other compounds were available, but Methyl Parathion was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	___	______	______
________	______	___	______	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Methyl Parathion? ____________________(new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical control measures might you recommend? ____
____
____

2. Herbicide Recommendations

Now, assume that the farmer's current herbicide program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Caparol	0.5 pt	1.0	Ground Spray	$5.64	March
Caparol	1.5 pt	1.0	Ground Spray	2.43	July
Treflan	1.0 pt	1.0	With Caparol	0.00	March

COTTON LINT YIELD: 1705 lbs/ac

Is this the program you would recommend? ___ Yes ___ No
If not, why? ____
____
____

Do you feel these yield and application cost assumptions are appropriate for Pinal County? ___ Yes ___ No

If not, why? ____
____
____

A) What changes would you recommend if Caparol was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
____________	________	___	___________	______
____________	________	___	___________	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Caparol?
____________________ (new lint yield)
What other changes in production would you expect? ________
____

What additional non-chemical control measures might you recommend? ____________________________________
____
____

B) What would you recommend if Caparol was available for use and Treflan was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	__	________	_____
________	______	__	________	_____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Treflan?
______________ (new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical control measures might you recommend? ____________________________________
____
____

3. Defoliant Recommendations

Now, assume that the farmer's defoliant program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Sodium Chlorate	2.0 gal	1.0	Air Spray	$3.60	Oct

COTTON LINT YIELD: 1705 lbs/ac

Is this the program you would recommend? ___ Yes ___ No
If not, why? ____________________________________
____
____

Do you feel these yield and application cost assumptions are appropriate for Pinal County? ___ Yes ___ No
If not, why? ____________________________________
____
____

A) What would you recommend if Sodium Chlorate was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
____________	______	___	________	_____
____________	______	___	________	_____

What would you expect the change in lint yield (if any) to be as a result of using this chemical rather than Sodium Chlorate?
__________________ (new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical defoliation methods might you recommend? ____
____
____

PERSONAL CHARACTERISTICS

The following questions pertain to you and your background in the pest control field. This information will help us to show the characteristics of individuals from whom we have obtained our data.

1. How long have you been making recommendations on pest management cotton in Pinal County?
____

2. Approximately how many acres of cotton do you check each year? ______________________________

3. Do you also farm cotton on your own? ____________
If so, how many acres? ________________________

Your cooperation in this study has been greatly appreciated. Please note below any additional information which you feel might important to this research.

FURTHER INFORMATION:

COMMENTS PERTAINING TO THE STRUCTURE AND OBJECTIVES OF THIS STUDY ON THE ECONOMICS OF PESTICIDE USE:

APPENDIX 3

PEST MANAGEMENT SURVEY-MARICOPA COUNTY

The following is a survey designed as part of a study being performed at the Department of Agricultural Economics at the University of Arizona. The purpose of the study is to perform an economic analysis of alternative pest management strategies practiced in the cotton producing areas of central Arizona. Results of this analysis should provide area growers, pest control advisors, and extension personnel with further information regarding the economics of pesticide use.

The survey assumes a typical central Arizona cotton farm using furrow irrigation. Please answer all questions to the best of your ability. If necessary, answer only those questions about which you feel you have some level of expertise. We realize your responses are simply your own estimates of what would happen given these situations described, but it is important that you be as accurate as possible.

Occupation: ______________________________

Is the majority of your business conducted in Maricopa County? ___ Yes ___ No
If no, where is the majority of your activity conducted?
____
____

1. Insecticide Recommendations

In this instance, you are to assume that the farmer's current insecticide program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Methyl Parathion	1.0 pt	7.0	Air Spray	$3.00	M,Jl,A,S
Cymbush	3.0 oz	3.0	Air Spray	3.00	M,Jl,A
Fundal/Galecron	0.5 pt	2.0	Air Spray	3.00	Aug,Sep

COTTON LINT YIELD: 1200 lbs/ac

Is this the program you would recommend? ___ Yes ___ No
If not, why? ______________________________
____
____

Do you feel these yield and application cost assumptions are appropriate for Maricopa County? ___ Yes ___ No
If not, why? ______________________________

____

____

A) Given the assumptions about the current pesticide program, what change(s) would you recommend if <u>Methyl parathion</u> was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	____	_____	_____
________	______	____	_____	_____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Methyl Parathion? ______________ (new lint yield)
What other changes in production would you expect?

____

____

What additional non-chemical control measures might you recommend? ______________________________

____

____

B) What would you recommend if Methyl Parathion was available, but <u>Cymbush</u> was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	____	_____	_____
________	______	____	_____	_____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Cymbush?
______________ (new lint yield)

What other changes in production would you expect? ________

____

____

What additional non-chemical control measures might you recommend? ______________________________

____

____

C) What would you recommend if all other compounds were available, but <u>Fundal/Galecron</u> was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	____	__	____	____
________	____	__	____	____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Fundal/Galecron? ______________ (new lint yield)

What other changes in production would you expect? ________

____

____

What additional non-chemical control measures might you recommend? ________________________________

____

____

2. Herbicide Recommendations

Now, assume that the farmer's current herbicide program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
Treflan	1.2 pt	1.0	Ground Spray	$7.00	Jan,Feb
Caparol	2.5 pt	1.0	Air Spray	3.00	July

COTTON LINT YIELD: 1200 lbs/ac

Is this the program you would recommend? ___ Yes ___ No

If not, why? ________________________________

____

____

Do you feel these yield and application cost assumptions are appropriate for Maricopa County? ___ Yes ___ No

If not, why? ________________________________

____

____

A) Given these assumptions, what changes would you recommend if Treflan was unavailable for use?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	____	____	____	____
________	____	____	____	____
________	____	____	____	____

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Treflan? ______________ (new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical control measures might you recommend? ____
____
____

B) What would you recommend if Treflan was available and Caparol was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
____________	______	______	______	______
____________	______	______	______	______

What would you expect the change in lint yield to be (if any) as a result of using this chemical rather than Caparol? ____________ (new lint yield)

What other changes in production would you expect? _______
____

What additional non-chemical control meaures might you recommend? ____
____
____

3. Defoliant Recommendations

Now, assume that the farmer's defoliant program consists of the following:

PRODUCT	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
DEF	1.5 pt	1.0	Air Spray	$3.50	Sep,Oct
Sodium Chlorate	2.0 gal	1.0	Air Spray	3.50	Sep,Oct

COTTON LINT YIELD: 1200 lbs/ac

Is this the program you would recommend? ___Yes ___ No
If not, why? ____
____
____

Do you feel these yield and application cost assumptions are appropriate for Maricopa County? ___ Yes ___ No
If not, why? ____
____
____

A) What would you recommend if Sodium Chlorate was available for use and DEF was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	___	______	______
________	______	___	______	______

What would you expect the change in lint yield (if any) to be as a result of using this chemical rather than DEF?
______________ (new lint yield)

What other changes in production would you expect? ________
____
____

What additional non-chemical defoliation measures might you recommend? ____
____
____

B) What would you recommend if DEF was available for use and Sodium Chlorate was not?

NEW PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST
________	______	___	______	______
________	______	___	______	______

What would you expect the change in lint yield (if any) to be as a result of using this chemical rather than Sodium Chlorate? __________________ (new lint yield)

What other changes in production would you expect?
____
____

What additional non-chemical defoliation measures might you recommend? ____
____

4. Nematocide Recommendations

Do you feel that nematodes are a major problem in your area?
___ Yes ___ No

If so, what is your current program for nematode control?

PRODUCT(S)	RATE/ ACRE	NUMBER APPLICS	APPLIC METHOD	APPLIC COST	TIMING
________	______	___	______	______	______
________	______	___	______	______	______

What other products might you use if this were unavailable?

____

____

____

What changes in production, if any, would you expect as a result of using this new chemical? ____________________

____

____

PERSONAL CHARACTERISTICS

The following questions pertain to you and your background in the pest control field. This information will help us to show the characteristics of individuals from whom we have obtained our data.

1. How long have you been making recommendations on pest management for cotton in Maricopa County? __________

2. Approximately how many acres of cotton do you check each year? ______________________________

3. Do you also farm cotton on your own? ____________
   If so, how many acres? ________________________

Your cooperation in this study has been greatly appreciated. Please note below any additional information which you feel might important to this research.

FURTHER INFORMATION:

COMMENTS PERTAINING TO STRUCTURE AND OBJECTIVES OF THIS STUDY ON THE ECONOMICS OF PEST CONTROL:

APPENDIX 4

PEST MANAGEMENT SURVEY-PINAL COUNTY

SUMMARY OF RESULTS

RESPONDENT #	1	3	9	10
OCCUPATION	PCA	PCA	PCA	PCA
IN PINAL?	Yes	Yes	Yes	Yes
DRIP?	No	No	No	No
I.INSECTICIDES				
Use program?	No	Yes	Yes	Yes
Assumptions?	Yes	Yes	Costs low	Most
A)w/o MP	Cygon	Pyrethroids	Azodrin	Pydrin
B)w/o Fund/Gal	Lannate	Nothing	Nothing	Lannate/Nud
C)w/o Cymbush	Methyl parathion	Pyrethroids	M.parathion	Asana
II. HERBICIDES				
Use program?	Yes	Yes	Diff.rates	diff.rates
Assumptions?	Yes	Yes	Yes	some air
A)w/o Treflan	Prowl	Prowl	Prowl	Prowl
B)w/o Caparol	Dyrex	Carmex	Dyrex	Dyrex
III. DEFOLIANTS				
Use program?	No DEF	Yes	No	No
Assumptions?	Yes	Yes	Yes	Costs low
A)w/o DEF	Dropp	Dropp	Folex	Dropp
B)w/o NaCl	Dropp	Nothing	Folex	Paraquat
PERS. CHAR.				
Experience	30 years	35 years	13 years	5 years
Acres	2,500-3,000	6-8,000	3,500	3,000
Farm?	Yes	Yes	No	No
Acres	700-1,000	1,000-2,500	—	———

RESPONDENT #	13	15	21	22
OCCUPATION	PCA	PCA	PCA	PCA
IN PINAL?	Yes	Yes	Yes	Yes
DRIP?	No	No	No	No
I.INSECTICIDES				
Use program?	Mostly	No	Yes	Yes
Assumptions?	Yes	Yes	Yes	Costs low
A)w/o MP	Penncap,Azodrin	Azodrin,Dime	Azodrin	Penncap-M
B)w/o Fund/Gal	Nothing	Methyl parat	Cymbush	Lannate
C)w/o Cymbush	Scout	Asana	Pay-Off	Pydrin
II. HERBICIDES				
Use program?	No	Yes	Yes	Yes
Assumptions?	Costs high	Costs high	Yes	Yes
A)w/o Treflan	Prowl	Dyrex	Prowl	Triflauralin
B)w/o Caparol	Prometryn	Prometryn	Diuron	Prometryn
III. DEFOLIANTS				
Use program?		Yes	Yes	No DEF
Assumptions?	No DEF	Yes	Yes	Costs low
A)w/o DEF	Costs low	Dropp	Dropp	Folex
B)w/o NaCl	Chlorate Folex	Paraquat/Pre	Dropp	L-10
PERS. CHAR.				
Experience	10 years	3 years	6 years	5 years
Acres	5-6,000 acres	12,000	3,200	1,200
Farm?	No	Yes	No	No
Acres	---	113	—	—

RESPONDENT #	26	27
OCCUPATION	PCA,Cust.app	PCA
IN PINAL?	Yes	Yes
DRIP?	No	No
I.INSECTICIDES		
Use program?	Yes	Yes
Assumptions?	Costs low	Yes
A)w/o MP	Guthion	Azodrin
B)w/o Fund/Gal	Nothing	inc. others
C)w/o Cymbush	Pydrin	Asana, Payoff
II. HERBICIDES		
Use program?	Yes	No
Assumptions?	Cost $7/ac	Yes
A)w/o Treflan	Prowl	Prowl
B)w/o Caparol	Diuron,Bladex	Prometryn
III. DEFOLIANTS		
Use program?	#apps low	No DEF
Assumptions?	Costs low	Yes
A)w/o DEF	Folex	NaCl
B)w/o NaCl	DEF/Folex	DEF
PERS. CHAR.		
Experience	10 years	14 years
Acres	2-4,000	7,000
Farm?	No cotton	Yes
Acres	--	80

APPENDIX 5

PEST MANAGEMENT SURVEY- MARICOPA COUNTY

SUMMARY OF RESULTS

RESPONDENT #	2	8	10	11
OCCUPATION	PCA	PCA	PCA	Mfr's Rep
IN MARICOPA?	Yes	Yes	Yes	Yes
DRIP?	No	No	No	No
I.INSECTICIDES				
Use program?	Yes	Yes	Yes	Yes
Assumptions?	Yes	Yes	Yes	Costs low
A)w/o MP	Azodrin	Ammo	Bidrin	Penncap,Guth
B)w/o Fund/Gal	Nothing	Lannate	P-Off, Asana	Lannate
C)w/o Cymbush	Asana	Capture(exp)	Don't Use	Asana,P-off
II. HERBICIDES				
Use program?	Yes	Yes	Yes	Yes
Assumptions?	Yes	Yes	Yes	Costs low
A)w/o Treflan	Prowl	Carmex	Prowl	Prowl
B)w/o Caparol	Bladex	Bladex	Prometryn	Diuron,Bladex
III. DEFOLIANTS				
Use program?	Yes	No DEF	Yes	Yes
Assumptions?	Yes	Yes	Yes	Yes
A)w/o DEF	Folex,NaCl	NaCl	Folex	---
B)w/o NaCl	DEF	DEF	DEF,L-10	---
Nematodes?	Yes	No	No	Buckeye
PERS. CHAR.				
Experience	9 years	10 years	6 years	17 years
Acres	4,000	3,000	400	3-4,000
Farm?	No	Yes	Yes	No
Acres	---	100	175	---

RESPONDENT #	12	15	24	32
OCCUPATION	Mfr's Rep	PCA	PCA	PCA
IN MARICOPA?	Yes	Yes	Yes	Yes
DRIP?	No	No	No	No
I. INSECTICIDES				
Use program?	Yes	Yes	Yes	Yes
Assumptions?	Costs low	Yes	Yes	Yes
A)w/o MP	Asana, Ammo	Penncap, Guth	Guthion	Guth, Azodrin
B)w/o Fund/Gal	Nothing	Don't Use	Lannate	Lannate
C)w/o Cymbush	Scout, Asana	Capture	Asana	Scout, Pounce
II. HERBICIDES				
Use program?	Yes	Yes	Yes	No
Assumptions?	Yes	Yes	Yes	Yes
A)w/o Treflan	Prowl	Prowl	Prowl	Prowl
B)w/o Caparol	Bladex	Goal	Bladex	Bladex
III. DEFOLIANTS				
Use program?	Yes	Yes	No DEf/NaCl	2 apps DEF
Assumptions?	Yes	Yes	Yes	Yes
A)w/o DEF	Dropp	Folex	Dropp	Dropp
B)w/o NaCl	Paraquat	Dropp	L-10, H-10	Bolls-eye
'Nematodes?	No	Not sure	Yes	Yes
PERS. CHAR.				
Experience	9 years	36 years	20 years	10 years
Acres	5,000(pre-1981)	2,000	10,500	6-10,000
Farm?	No	No	No	No
Acres	---	---	---	---

RESPONDENT #	33	40	42	48
OCCUPATION	PCA,Grower	Mfr's Rep	PCA	PCA
IN MARICOPA?	Yes	Yes	Yes, & other	Yes
DRIP?	No	No	No	No
I.INSECTICIDES				
Use program?	No	Yes	Yes	Yes
Assumptions?	Costs low	Yes	Costs low	Mostly
A)w/o MP	Pounce,Ammo	Azodrin,Guth	Penncap	---
B)w/o Fund/Gal	Pounce,Scout	Nothing	Nothing	Lannate
C)w/o Cymbush	Nothing	Ammo	Scout	Asana
II. HERBICIDES				
Use program?	Yes	Yes	Yes	Yes
Assumptions?	Yes	Yes	Yes	Yes
A)w/o Treflan	Prowl	Prowl	Post	Prowl
B)w/o Caparol	Bladex	Bladex	Bladex	Cotton-Pro
III. DEFOLIANTS				
Use program?	No NaCl	Yes	Yes	Yes
Assumptions?	Yes	Yes	Yes	Yes
A)w/o DEF	Dropp,Prep	Dropp	Cotton-Aid	---
B)w/o NaCl	Don't Use	Paraquat	---	L-10
Nematodes?	Yes	Yes	No	Yes
PERS. CHAR.				
Experience	20 years	3 years	4 years	29 years
Acres	5,000	N/A	4,000	8,000
Farm?	Yes	No	No	No
Acres	600	---	---	---

RESPONDENT #	52	66	68
OCCUPATION	PCA	PCA	PCA,Grower
IN MARICOPA?	Yes	Also Pinal	Yes, some LaPaz
DRIP?	No	No	No
I.INSECTICIDES			
Use program?	Yes	Yes	Yes
Assumptions?	50% copter	Yes	Yes
A)w/o MP	Pydrin,Asana	Azodrin	Azodrin
B)w/o Fund/Gal	None,Capture	Nothing	---
C)w/o Cymbush	Pydrin,Asana	Asana	Ammo
II. HERBICIDES			
Use program?	Yes	Yes	Diff. rates
Assumptions?	Helicopter	Yes	Tank mix both
A)w/o Treflan	Prowl	Prowl	Prowl
B)w/o Caparol	Dyrex	Dyrex	Carmex
III. DEFOLIANTS			
Use program?	No DEF	No DEF	Yes
Assumptions?	Yes	Yes	Yes
A)w/o DEF	Dropp	Folex	Dropp,NaCl
B)w/o NaCl	Dropp	Folex,DEF	Prep,DEF
Nematodes?	5% affected	No	Yes
PERS. CHAR.			
Experience	35 years	17 years	3 years
Acres	8,000	7,000	5,000
Farm?	No	No	Yes
Acres	---	---	1,000

APPENDIX 6

PESTICIDE BUDGET MODELS-PINAL COUNTY

FARM BUDGETS VARYING INSECTICIDE USE (BENCHMARK) PINAL 1.00 Principal(s)
750.00 Acre Farm Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1250.00
Seed yield (tons/ac) =	1.08
Def. rate =	0.27
Base acres =	450.00
INSECTICIDE TYPE A =	Methyl parathion
Ins. A applied/app (pt/ac) =	1.00
Ins. A cost ($/pt app) =	1.86
Ins. A # applic/ac =	3.00
Ins. A material cost ($/ac) =	5.58
Ins. A application method =	Air
Ins. A applic. cost ($/app/ac)=	3.35
Ins. A applic. cost ($/ac) =	10.05
Total Ins. A cost ($/ac) =	15.63
INSECTICIDE TYPE B =	Methyl parathion
Ins. B applied/app (pt/ac) =	1.33
Ins. B cost ($/pt app) =	1.86
Ins. B # applic/ac =	1.00
Ins. B material cost ($/ac) =	2.47
Ins. B application method =	Air
Ins. B applic. cost ($/app/ac)=	3.35
Ins. B applic. cost ($/ac) =	3.35
Total Ins. B cost ($/ac) =	5.82
INSECTICIDE TYPE C =	Fundal/Gal
Ins. C applied/app (pt/ac) =	0.50
Ins. C cost ($/pt app) =	11.37
Ins. C # applic/ac =	2.00
Ins. C material cost ($/ac) =	11.37
Ins. C application method =	w/others
Ins. C applic. cost ($/app/ac)=	0.00
Ins. C applic. cost ($/ac) =	0.00
Total Ins. C cost ($/ac) =	11.37
INSECTICIDE TYPE D =	Cymbush
Ins. D applied/app (oz/ac) =	3.00
Ins. D cost ($/oz app) =	2.06
Ins. D # applic/ac =	3.00
Ins. D material cost ($/ac) =	18.54
Ins. D application method =	Air
Ins. D applic. cost ($/app/ac)=	3.35
Ins. D applic. cost ($/ac) =	10.05
Total Ins. D cost ($/ac) =	28.59
TOT INSECTICIDE COST ($/ac)=	61.41
Non-insect. oper. cost =	560.68
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	192.18	150.00	268.45
Alfalfa acres	96.09	75.00	134.23
Fallow acres	124.24	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	248906.25	331875.00	124453.13
Cotton seed	30839.06	41118.75	15419.53
Deficiency pmt.	50000.00	0.00	50000.00
Wheat	46554.54	36337.50	65032.12
Alfalfa	53809.17	42000.00	75166.12
TOTAL RECEIPTS	430109.02	451331.25	330070.89
OPERATING COSTS:			
Cotton:			
Insecticide cost	20727.16	27636.21	10363.58
Non-insect. cost	189229.50	252306.00	94614.75
Wheat	48099.63	37543.50	67190.46
Alfalfa	48447.47	37815.00	67676.35
Mntce adj ACR acs	1030.28	0.00	947.85
TOTAL OPERATING:	307534.03	355300.71	240792.99
RETURNS OVER OPER:	122574.99	96030.54	89277.90
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.26	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

ASCS Yield =	1250.00	WHEAT:	
Forecast Deficiency	114539.06	Price ($/ton) =	95.00
Free acres =	63.33	Yield (tons/ac) =	2.55
Target price =	0.79	Oper. cost ($/ac)	250.29
Max DP =	50000.00		
Relief factor =	0.44	ALFALFA :	
Adjusted ACR =	49.06	Price ($/ton) =	80.00
Maint. cost ACR acs	21.00	Yield (tons/ac) =	7.00
Free acres 50-92 =	58.26	Oper. cost ($/ac)	504.20
ACR FUL 50-92 =	103.40		
Adjusted ACR 50-92	45.14		
ACR Factor 50-92 =	0.30		
CU to protect base	119.59		

FARM BUDGETS VARYING HERBICIDE USE (BENCHMARK) PINAL 1.00 Principal(s)

750.00 Acre Farm Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1250.00
Seed yield (tons/ac) =	1.08
Def. rate =	0.27
Base acres =	450.00
HERBICIDE TYPE A =	Treflan
Herb. A applied/app (pt/ac) =	1.20
Herb. A cost ($/pt app) =	4.13
Herb. A # applic/ac =	1.00
Herb. A material cost ($/ac) =	4.96
Herb. A application method =	Grnd Spray
Herb. A applic. cost($/app/ac)=	6.06
Herb. A applic. cost ($/ac) =	6.06
Total Herb. A cost ($/ac) =	11.02
HERBICIDE TYPE B =	Caparol
Herb. B applied/app (pt/ac) =	2.50
Herb. B cost ($/pt app) =	3.34
Herb. B # applic/ac =	2.00
Herb. B material cost ($/ac) =	16.70
Herb. B application method =	Grnd Spray
Herb. B applic.cost($/app/ac)=	7.10
Herb. B applic. cost ($/ac) =	14.20
Total Herb. B cost ($/ac) =	30.90
TOTAL HERBICIDE COST ($/ac) =	41.92
Non-herb. oper. cost ($/ac) =	569.41
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1250.00
Forecast Def. FUL =	114539.06
Free acres =	63.33
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.44
Adjusted ACR =	49.06
Maint. cost ACR acres =	21.00
Free acres 50-92 =	58.26
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	45.14
ACR Factor 50-92 =	0.30
CU to protect base =	119.59

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	192.18	150.00	268.45
Alfalfa acres	96.09	75.00	134.23
Fallow acres	124.24	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	248906.25	331875.00	124453.13
Cotton seed	30839.06	41118.75	15419.53
Deficiency pmt.	50000.00	0.00	50000.00
Wheat	46554.54	36337.50	65032.12
Alfalfa	53809.17	42000.00	75166.12
TOTAL RECEIPTS	430109.02	451331.25	330070.89
OPERATING COSTS:			
Cotton:			
Herbicide cost	14146.65	18862.20	7073.33
Non-herb. cost	192175.88	256234.50	96087.94
Wheat	48099.63	37543.50	67190.46
Alfalfa	48447.47	37815.00	67676.35
Mntce cost adj ACR acs	1030.28	0.00	947.85
TOTAL OPERATING:	303899.90	350455.20	238975.93
RETURNS OVER OPER:	126209.12	100876.05	91094.97
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.26	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

WHEAT:		ALFALFA :	
Price ($/ton) =	95.00	Price ($/ton) =	80.00
Yield (tons/ac) =	2.55	Yield (tons/ac)	7.00
Oper. cost ($/ac) =	250.29	Oper.cost($/ac)	504.20

FARM BUDGETS VARYING DEFOLIANT USE (BENCHMARK) PINAL 1.00 Principal(s)
750.00 Acre Farm Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1250.00
Seed yield (tons/ac) =	1.08
Def. rate =	0.27
Base acres =	450.00
DEFOLIANT TYPE A =	DEF
Def. A applied/app (pt/ac) =	1.50
Def. A cost ($/pt app) =	3.38
Def. A # applic/ac =	1.00
Def. A material cost =	5.07
Def. A application method =	Air Spray
Def. A applic.cost($/app/ac)=	4.00
Def. A applic. cost ($/ac) =	4.00
Total Def. A cost ($/ac) =	9.07
DEFOLIANT TYPE B =	Sodium chlorate
Def. B applied/app (gal/ac) =	2.00
Def. B cost ($/gal app) =	0.95
Def. B # applic/ac =	1.00
Def. B material cost =	1.90
Def. B application method =	Air Spray
Def. B applic. cost($/app/ac)=	4.00
Def. B applic. cost ($/ac) =	4.00
Total Def. B cost ($/ac) =	5.90
TOTAL DEFOLIANT COST ($/ac) =	14.97
Non-def. oper. cost($/ac)=	599.51
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1250.00
Forecast Deficiency FUL =	114539.06
Free acres =	63.33
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.44
Adjusted ACR =	49.06
Maint. cost ACR acs=	21.00
Free acres 50-92 =	58.26
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	45.14
ACR Factor 50-92 =	0.30
CU to protect base =	119.59

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	192.18	150.00	268.45
Alfalfa acres	96.09	75.00	134.23
Fallow acres	124.24	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	248906.25	331875.00	124453.13
Cotton seed	30839.06	41118.75	15419.53
Deficiency pmt.	50000.00	0.00	50000.00
Wheat	46554.54	36337.50	65032.12
Alfalfa	53809.17	42000.00	75166.12
TOTAL RECEIPTS	430109.02	451331.25	330070.89
OPERATING COSTS:			
Cotton:			
Defoliant cost	5052.38	6736.50	2526.19
Non-def. cost	202334.63	269779.50	101167.31
Wheat	48099.63	37543.50	67190.46
Alfalfa	48447.47	37815.00	67676.35
Mntce cost adj ACR acs	1030.28	0.00	947.85
TOTAL OPERATING	304964.38	351874.50	239508.17
RETURNS OVER OPER	125144.64	99456.75	90562.72
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.26	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

WHEAT:		ALFALFA :	
Price ($/ton) =	95.00	Price ($/ton) =	80.00
Yield (tons/ac) =	2.55	Yield (tons/ac)	7.00
Oper. cost($/ac)=	250.29	Oper.cost($/ac)	504.20

APPENDIX 7

PESTICIDE BUDGET MODELS-MARICOPA COUNTY

FARM BUDGETS VARYING INSECTICIDE USE (BENCHMARK) MARICOPA 1.00 Principal(s)
750.00 Acre Farm Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1200.00
Seed yield (tons/ac) =	1.03
Def. rate =	0.27
Base acres =	450.00
INSECTICIDE TYPE A =	Methyl parathion
Ins. A applied/app(pt/ac)=	1.00
Ins. A cost ($/pt app) =	1.67
Ins. A # applic/ac =	7.00
Ins. A material cost($/ac)=	11.69
Ins. A application method =	Air Spray
Ins. A applic. cost($/app/ac)=	3.35
Ins. A applic. cost ($/ac) =	23.45
Total Ins. A cost ($/ac) =	35.14
INSECTICIDE TYPE B =	Cymbush
Ins. B applied/app (oz/ac) =	3.00
Ins. B cost ($/oz app) =	1.85
Ins. B # applic/ac =	3.00
Ins. B material cost ($/ac) =	16.65
Ins. B application method =	Air Spray
Ins. B applic. cost($/app/ac)=	3.35
Ins. B applic. cost ($/ac) =	10.05
Total Ins. B cost ($/ac) =	26.70
INSECTICIDE TYPE C =	Fundal/Gal
Ins. C applied/app (pt/ac) =	0.50
Ins. C cost ($/pt app) =	10.19
Ins. C # applic/ac =	2.00
Ins. C material cost ($/ac) =	10.19
Ins. C application method =	w/others
Ins. C applic. cost($/app/ac)=	0.00
Ins. C applic. cost ($/ac) =	0.00
Total Ins. C cost ($/ac) =	10.19
TOT INSECTICIDE COST ($/ac)=	72.03
Non-insect. oper. cost =	451.09
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1200.00
Forecast Deficiency FUL =	109957.50
Free acres =	61.28
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.45

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	190.81	150.00	268.45
Alfalfa acres	95.41	75.00	134.23
Fallow acres	126.28	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	238950.00	318600.00	119475.00
Cotton seed	29605.50	39474.00	14802.75
Deficiency payment	50000.00	0.00	50000.00
Wheat	64113.56	50400.00	90199.34
Alfalfa	55097.59	43312.50	77515.06
TOTAL RECEIPTS	437766.65	451786.50	351992.16
OPERATING COSTS:			
Cotton:			
Insecticide cost	24310.13	32413.50	12155.06
Non-insect. cost	152242.88	202990.50	76121.44
Wheat	34720.55	27294.00	48847.24
Alfalfa	30120.97	23678.25	42376.24
Mntce cost adj ACR acs	1073.20	0.00	987.35
TOTAL OPERATING COSTS	242467.72	286376.25	180487.33
RETURNS OVER OPERATING	195298.93	165410.25	171504.83
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.25	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

Adjusted ACR =	51.10
Maint. cost ACR acs=	21.00
Free acres 50-92 =	56.38
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	47.02
ACR Factor 50-92 =	0.30
CU to protect base =	121.47

WHEAT:	
Price ($/ton) =	120.00
Yield (tons/ac) =	2.80
Oper. cost($/ac)=	181.96
ALFALFA :	
Price ($/ton) =	75.00
Yield (tons/ac) =	7.70
Oper. cost($/ac)=	315.71

FARM BUDGETS VARYING HERBICIDE USE (BENCHMARK) MARICOPA 1.00 Principal(s)

750.00 Acre Farm Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1200.00
Seed yield (tons/ac) =	1.03
Def. rate =	0.27
Base acres =	450.00
HERBICIDE TYPE A =	Treflan
Herb. A applied/app(pt/ac)=	1.20
Herb. A cost ($/pt app) =	3.93
Herb. A # applic/ac =	1.00
Herb. A material cost($/ac)=	4.72
Herb. A application method =	Pre-plant
Herb. A applic. cost($/app/ac)=	7.00
Herb. A applic. cost ($/ac) =	7.00
Total Herb. A cost ($/ac) =	11.72
HERBICIDE TYPE B =	Caparol
Herb. B applied/app (pt/ac) =	2.50
Herb. B cost ($/pt app) =	3.18
Herb. B # applic/ac =	1.00
Herb. B material cost ($/ac) =	7.95
Herb. B application method =	Lay-by
Herb. B applic. cost($/app/ac)=	7.00
Herb. B applic. cost ($/ac) =	7.00
Total Herb. B cost ($/ac) =	14.95
TOTAL HERBICIDE COST ($/ac) =	26.67
Non-herb. operating cost($/ac)=	481.35
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1200.00
Forecast Deficiency FUL =	109957.50
Free acres =	61.28
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.45
Adjusted ACR =	51.10
Maint. cost ACR acs=	21.00
Free acres 50-92 =	56.38
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	47.02
ACR Factor 50-92 =	0.30
CU to protect base =	121.47

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	190.81	150.00	268.45
Alfalfa acres	95.41	75.00	134.23
Fallow acres	126.28	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	238950.00	318600.00	119475.00
Cotton seed	29605.50	39474.00	14802.75
Deficiency pmt.	50000.00	0.00	50000.00
Wheat	64113.56	50400.00	90199.34
Alfalfa	55097.59	43312.50	77515.06
TOTAL RECEIPTS	437766.65	451786.50	351992.16
OPERATING COSTS:			
Cotton:			
Herbicide cost	8999.78	11999.70	4499.89
Non-herb. cost	162455.63	216607.50	81227.81
Wheat	34720.55	27294.00	48847.24
Alfalfa	30120.97	23678.25	42376.24
Mntce cost adj ACR acs	1073.20	0.00	987.35
TOTAL OPERATING COSTS	237370.12	279579.45	177938.53
RETURNS OVER OPERATING	200396.53	172207.05	174053.63
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.25	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

WHEAT:		ALFALFA :	
Price ($/ton) =	120.00	Price ($/t	75.00
Yield (tons/ac) =	2.80	Yield (ton	7.70
Oper. cost($/ac)=	181.96	Oper. cost	315.71

FARM BUDGETS VARYING DEFOLIANT USE (BENCHMARK) MARICOPA 1.00 Principal
750.00 Acre Farm Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1200.00
Seed yield (tons/ac) =	1.03
Def. rate =	0.27
Base acres =	450.00
DEFOLIANT TYPE A =	DEF
Def. A applied/app(pt/ac)=	1.50
Def. A cost ($/pt app) =	3.22
Def. A # applic/ac =	1.00
Def. A material cost =	4.83
Def. A application method =	Air Spray
Def. A applic. cost($/app/ac)	4.00
Def. A applic. cost ($/ac) =	4.00
Total Def. A cost ($/ac) =	8.83
DEFOLIANT TYPE B =	Sodium chlorate
Def. B applied/app (gal/ac) =	2.00
Def. B cost ($/gal app) =	0.85
Def. B # applic/ac =	1.00
Def. B material cost =	1.70
Def. B application method =	Air Spray
Def. B applic. cost($/app/ac)	4.00
Def. B applic. cost ($/ac) =	4.00
Total Def. B cost ($/ac) =	5.70
TOTAL DEFOLIANT COST ($/ac) =	14.53
Non-defoliant oper. cost($/ac	492.02
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1200.00
Forecast Deficiency FUL =	109957.50
Free acres =	61.28
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.45
Adjusted ACR =	51.10
Maint. cost ACR acs=	21.00
Free acres 50-92 =	56.38
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	47.02
ACR Factor 50-92 =	0.30
CU to protect base =	121.47

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	190.81	150.00	268.45
Alfalfa acres	95.41	75.00	134.23
Fallow acres	126.28	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	238950.00	318600.00	119475.00
Cotton seed	29605.50	39474.00	14802.75
Deficiency payment	50000.00	0.00	50000.00
Wheat	64113.56	50400.00	90199.34
Alfalfa	55097.59	43312.50	77515.06
TOTAL RECEIPTS	437766.65	451786.50	351992.16
OPERATING COSTS:			
Cotton:			
Defoliant cost	4903.88	6538.50	2451.94
Non-def. cost	166056.75	221409.00	83028.38
Wheat	34720.55	27294.00	48847.24
Alfalfa	30120.97	23678.25	42376.24
Mntce cost adj ACR acs	1073.20	0.00	987.35
TOTAL OPERATING COSTS	236875.34	278919.75	177691.14
RETURNS OVER OPERATING	200891.30	172866.75	174301.01
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.25	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

WHEAT:		ALFALFA :	
Price ($/ton) =	120.00	Price ($/ton	75.00
Yield (tons/ac) =	2.80	Yield (tons/	7.70
Oper. cost($/ac)=	181.96	Oper.cost($/	315.71

APPENDIX 8

PESTICIDE SENSITIVITY ANALYSIS RESULTS-PINAL COUNTY

PINAL-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT METHYL PARATHION

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$8,683	$11,577	$4,341
Lint Price=.70	8,682	11,577	4,341
Lint Price=.80	8,683	11,577	4,342
Seed Price=75	8,683	11,577	4,341
Seed Price=95	8,682	11,577	4,341
Yc=(-100)	8,682	11,577	4,342
Yc=(+100)	8,683	11,577	4,341
Chem Price=(+10%)	9,551	12,734	4,775
Chem Price=(-10%)	7,814	10,419	3,908
Rot=40/10/40/10	8,683	7,717	4,341
Rot=30/10/50/10	8,683	5,789	4,341
Rot=80/20/0/0	8,683	15,436	4,341
Rot=30/30/30/10	8,683	5,789	4,341
# Princ.=2	8,583	11,577	4,341
# Princ.=3	8,683	11,577	4,341

PINAL-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT FUNDAL/GALECRON-LANNATE

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$27,751	$37,001	$13,875
Lint Price=.70	31,609	41,951	15,814
Lint Price=.80	34,984	46,451	17,502
Seed Price=75	27,606	36,614	13,813
Seed Price=95	28,187	37,388	14,103
Yc=(-100)	28,024	37,001	13,974
Yc=(+100)	27,875	37,001	13,946
Chem Price=(+10%)	28,095	37,264	14,056
Chem Price=(-10%)	27,698	36,737	13,859
Rot=40/10/40/10	27,897	24,667	13,958
Rot=30/10/50/10	27,897	18,501	13,958
Rot=80/20/0/0	27,897	49,335	13,958
Rot=30/30/30/10	27,897	18,501	13,958
# Princ.=2	28,043	37,001	14,040
# Princ.=3	36,914	37,001	23,038

PINAL-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT FUNDAL/GALECRON-NOTHING

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$69,001	$92,002	$34,501
Lint Price=.70	78,702	104,377	39,378
Lint Price=.80	87,140	115,627	43,597
Seed Price=75	68,696	91,034	34,375
Seed Price=95	70,147	92,969	35,101
Yc=(-100)	69,508	92,002	34,787
Yc=(+100)	69,355	92,002	34,700
Chem Price=(+10%)	69,935	92,687	34,994
Chem Price=(-10%)	68,907	91,317	34,481
Rot=40/10/40/10	69,421	61,334	34,738
Rot=30/10/50/10	69,421	46,001	34,738
Rot=80/20/0/0	69,421	122,670	34,738
Rot=30/30/30/10	69,421	46,001	34,738
# Princ.=2	77,859	92,002	43,145
# Princ.=3	91,910	92,002	60,408

PINAL-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT CYMBUSH

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	($417)	($555)	($208)
Lint Price=.70	(417)	(556)	(209)
Lint Price=.80	(417)	(556)	(208)
Seed Price=75	(417)	(556)	(208)
Seed Price=95	(417)	(556)	(209)
Yc=(-100)	(417)	(556)	(208)
Yc=(+100)	(417)	(556)	(209)
Chem Price=(+10%)	(459)	(612)	(230)
Chem Price=(-10%)	(376)	(500)	(187)
Rot=40/10/40/10	(417)	(371)	(208)
Rot=30/10/50/10	(417)	(278)	(208)
Rot=80/20/0/0	(417)	(741)	(208)
Rot=30/30/30/10	(417)	(278)	(208)
# Princ.=2	(417)	(556)	(209)
# Princ.=3	(417)	(556)	(209)

PINAL-HERBICIDES

CHANGE FROM BENCHMARK TO WITHOUT TREFLAN

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	($449)	($599)	($225)
Lint Price=.70	(450)	(599)	(225)
Lint Price=.80	(449)	(599)	(224)
Seed Price=75	(449)	(599)	(225)
Seed Price=95	(449)	(599)	(225)
Yc=(-100)	(450)	(599)	(224)
Yc=(+100)	(449)	(599)	(225)
Chem Price=(+10%)	(494)	(658)	(247)
Chem Price=(-10%)	(404)	(539)	(203)
Rot=40/10/40/10	(449)	(399)	(225)
Rot=30/10/50/10	(449)	(299)	(225)
Rot=80/20/0/0	(449)	(799)	(225)
Rot=30/30/30/10	(449)	(299)	(225)
# Princ.=2	(448)	(599)	(225)
# Princ.=3	(449)	(599)	(224)

PINAL-HERBICIDES

CHANGE FROM BENCHMARK TO WITHOUT CAPAROL

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	($4,113)	($5,483)	($2,056)
Lint Price=.70	(4,113)	(5,483)	(2,056)
Lint Price=.80	(4,112)	(5,483)	(2,056)
Seed Price=75	(4,112)	(5,483)	(2,056)
Seed Price=95	(4,113)	(5,483)	(2,056)
Yc=(-100)	(4,113)	(5,483)	(2,056)
Yc=(+100)	(4,113)	(5,483)	(2,056)
Chem Price=(+10%)	(4,524)	(6,031)	(2,261)
Chem Price=(-10%)	(3,701)	(4,935)	(1,871)
Rot=40/10/40/10	(4,113)	(3,655)	(2,056)
Rot=30/10/50/10	(4,113)	(2,741)	(2,056)
Rot=80/20/0/0	(4,113)	(7,311)	(2,056)
Rot=30/30/30/10	(4,113)	(2,741)	(2,056)
# Princ.=2	(4,112)	(5,483)	(2,056)
# Princ.=3	(4,112)	(5,483)	(2,056)

PINAL-DEFOLIANTS

CHANGE FROM BENCHMARK TO WITHOUT DEF

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$989	$1,319	$494
Lint Price=.70	989	1,319	495
Lint Price=.80	988	1,319	495
Seed Price=75	989	1,318	495
Seed Price=95	989	1,318	495
Yc=(-100)	989	1,318	494
Yc=(+100)	989	1,318	495
Chem Price=(+10%)	1,087	1,450	544
Chem Price=(-10%)	890	1,186	445
Rot=40/10/40/10	989	879	495
Rot=30/10/50/10	989	659	495
Rot=80/20/0/0	989	1,758	495
Rot=30/30/30/10	989	659	495
# Princ.=2	988	1,319	495
# Princ.=3	989	1,319	494

PINAL-DEFOLIANTS

CHANGE FROM BENCHMARK TO WITHOUT SODIUM CHLORATE

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$1,070	$1,427	$535
Lint Price=.70	1,070	1,427	535
Lint Price=.80	1,069	1,427	535
Seed Price=75	1,070	1,426	535
Seed Price=95	1,070	1,426	535
Yc=(-100)	1,070	1,426	534
Yc=(+100)	1,070	1,426	535
Chem Price=(+10%)	1,176	1,569	588
Chem Price=(-10%)	963	1,283	481
Rot=40/10/40/10	1,070	951	535
Rot=30/10/50/10	1,070	713	535
Rot=80/20/0/0	1,070	1,902	535
Rot=30/30/30/10	1,070	713	535
# Princ.=2	1,069	1,427	535
# Princ.=3	1,070	1,427	535

APPENDIX 9

PESTICIDE SENSITIVITY ANALYSIS RESULTS-MARICOPA COUNTY

MARICOPA-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT METHYL PARATHION-GUTHION

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$250	$333	$125
Lint Price=.70	250	333	125
Lint Price=.80	250	333	125
Seed Price=75	250	333	125
Seed Price=95	250	333	125
Yc=(-100)	250	333	125
Yc=(+100)	250	333	125
Chem Price=(+10%)	388	517	194
Chem Price=(-10%)	111	149	56
Rot=40/10/40/10	250	222	125
Rot=30/10/50/10	250	166	125
Rot=80/20/0/0	250	444	125
Rot=30/30/30/10	250	167	125
# Princ.=2	250	333	125
# Princ.=3	250	333	125

MARICOPA-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT METHYL PARATHION-AZODRIN

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$5,150	$6,867	$2,575
Lint Price=.70	5,150	6,867	2,575
Lint Price=.80	5,150	6,867	2,575
Seed Price=75	5,150	6,867	2,575
Seed Price=95	5,150	6,867	2,575
Yc=(-100)	5,150	6,867	2,575
Yc=(+100)	5,150	6,867	2,575
Chem Price=(+10%)	5,779	7,704	2,890
Chem Price=(-10%)	4,522	6,029	2,261
Rot=40/10/40/10	5,150	4,578	2,576
Rot=30/10/50/10	5,150	3,133	2,575
Rot=80/20/0/0	5,151	9,156	2,576
Rot=30/30/30/10	5,150	3,434	2,575
# Princ.=2	5,151	6,867	2,575
# Princ.=3	5,150	6,867	2,575

MARICOPA-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT FUNDAL/GALECRON-LANNATE

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$17,742	$23,656	$8,871
Lint Price=.70	20,772	26,873	10,134
Lint Price=.80	22,966	29,798	11,231
Seed Price=75	18,170	23,404	8,833
Seed Price=95	18,548	23,907	9,022
Yc=(-100)	18,480	23,656	8,938
Yc=(+100)	18,265	23,656	8,919
Chem Price=(+10%)	18,453	23,780	8,975
Chem Price=(-10%)	18,265	23,531	8,880
Rot=40/10/40/10	18,359	15,771	8,928
Rot=30/10/50/10	18,359	11,828	8,928
Rot=80/20/0/0	18,359	31,541	8,928
Rot=30/30/30/10	18,358	11,828	8,927
# Princ.=2	18,976	23,656	8,984
# Princ.=3	23,698	23,656	14,827

MARICOPA-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT FUNDAL/GALECRON-NOTHING

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$55,799	$74,398	$27,900
Lint Price=.70	65,378	84,298	31,810
Lint Price=.80	72,128	93,298	35,185
Seed Price=75	57,373	73,624	27,806
Seed Price=95	58,534	75,172	28,387
Yc=(-100)	58,410	74,399	28,139
Yc=(+100)	57,607	74,399	28,066
Chem Price=(+10%)	58,266	74,815	28,254
Chem Price=(-10%)	57,640	73,982	27,941
Rot=40/10/40/10	57,953	49,599	28,097
Rot=30/10/50/10	57,953	37,199	28,097
Rot=80/20/0/0	57,953	99,198	28,097
Rot=30/30/30/10	57,953	37,199	28,097
# Princ.=2	66,313	74,398	36,464
# Princ.=3	74,125	73,498	46,225

MARICOPA-INSECTICIDES

CHANGE FROM BENCHMARK TO WITHOUT CYMBUSH

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$0	$0	$0
Lint Price=.70	$0	$0	$0
Lint Price=.80	$0	$0	$0
Seed Price=75	$0	$0	$0
Seed Price=95	$0	$0	$0
Yc=(-100)	$0	$0	$0
Yc=(+100)	$0	$0	$0
Chem Price=(+10%)	$0	$0	$0
Chem Price=(-10%)	$0	$0	$0
Rot=40/10/40/10	$0	$0	$0
Rot=30/10/50/10	$0	$0	$0
Rot=80/20/0/0	$0	$0	$0
Rot=30/30/30/10	$0	$0	$0
# Princ.=2	$0	$0	$0
# Princ.=3	$0	$0	$0

MARICOPA-HERBICIDES

CHANGE FROM BENCHMARK TO WITHOUT TREFLAN

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	(\$194)	(\$259)	(\$97)
Lint Price=.70	(194)	(259)	(97)
Lint Price=.80	(194)	(259)	(97)
Seed Price=75	(194)	(259)	(97)
Seed Price=95	(194)	(259)	(97)
Yc=(-100)	(194)	(259)	(97)
Yc=(+100)	(194)	(259)	(98)
Chem Price=(+10%)	(214)	(285)	(107)
Chem Price=(-10%)	(175)	(233)	(88)
Rot=40/10/40/10	(195)	(173)	(98)
Rot=30/10/50/10	(194)	(129)	(97)
Rot=80/20/0/0	(195)	(346)	(98)
Rot=30/30/30/10	(194)	(130)	(97)
# Princ.=2	(195)	(259)	(97)
# Princ.=3	(194)	(259)	(97)

MARICOPA-HERBICIDES

CHANGE FROM BENCHMARK TO WITHOUT CAPAROL

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	($793)	($1,058)	($396)
Lint Price=.70	(793)	(1,058)	(396)
Lint Price=.80	(793)	(1,058)	(396)
Seed Price=75	(793)	(1,058)	(397)
Seed Price=95	(793)	(1,058)	(397)
Yc=(-100)	(793)	(1,057)	(397)
Yc=(+100)	(793)	(1,057)	(397)
Chem Price=(+10%)	(872)	(1,163)	(436)
Chem Price=(-10%)	(714)	(952)	(357)
Rot=40/10/40/10	(793)	(705)	(397)
Rot=30/10/50/10	(793)	(438)	(396)
Rot=80/20/0/0	(793)	(1,410)	(397)
Rot=30/30/30/10	(793)	(529)	(397)
# Princ.=2	(793)	(1,058)	(397)
# Princ.=3	(793)	(1,058)	(397)

MARICOPA-DEFOLIANTS

CHANGE FROM BENCHMARK TO WITHOUT DEF

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$921	$1,229	$461
Lint Price=.70	921	1,229	461
Lint Price=.80	921	1,229	461
Seed Price=75	921	1,229	461
Seed Price=95	921	1,229	461
Yc=(-100)	921	1,228	460
Yc=(+100)	921	1,228	461
Chem Price=(+10%)	1,014	1,351	507
Chem Price=(-10%)	830	1,106	414
Rot=40/10/40/10	921	819	461
Rot=30/10/50/10	921	615	461
Rot=80/20/0/0	921	1,638	461
Rot=30/30/30/10	922	614	461
# Princ.=2	921	1,229	461
# Princ.=3	921	1,229	461

MARICOPA-DEFOLIANTS

CHANGE FROM BENCHMARK TO WITHOUT SODIUM CHLORATE

LOSS IN RETURNS FROM BENCHMARK

ASSUMPTIONS	FULL PART.	NO PART.	50-92 PART.
INITIAL	$1,056	$1,409	$528
Lint Price=.70	1,056	1,409	528
Lint Price=.80	1,056	1,409	528
Seed Price=75	1,056	1,409	529
Seed Price=95	1,056	1,409	529
Yc=(-100)	1,056	1,408	528
Yc=(+100)	1,056	1,408	528
Chem Price=(+10%)	1,162	1,549	581
Chem Price=(-10%)	951	1,268	475
Rot=40/10/40/10	1,056	939	528
Rot=30/10/50/10	1,056	705	528
Rot=80/20/0/0	1,056	1,878	528
Rot=30/30/30/10	1,057	704	529
# Princ.=2	1,056	1,409	529
# Princ.=3	1,056	1,409	529

APPENDIX 10

ADJUSTMENT OF AYER-HOYT FUNCTIONS TO INDIVIDUAL COUNTIES

The cotton-nitrogen production functions used in this study have been derived from the production functions estimated by Ayer and Hoyt in their 1981 publication Crop-Water Production Functions: Economic Implications for Arizona. Having determined that the function for "fine texture" soils was appropriate for the Maricopa-Pinal study area, it was necessary to adapt the Ayer-Hoyt functions for the local growing conditions. This process involved inserting constant values into the equations for all variables except applied nitrogen. In addition, the y-intercept has been adjusted to modify for the general magnitude of local cotton yields. This adjustment has been performed to make the funcitons consistent with the assumptions made by Hathorn (1987).

The production function estimated by Ayer and Hoyt for fine texture soils is as follows:

$$Yc=-380.377+35.032W-.499W^2+.307WEVAP+2.262N-.007N^2 \qquad \text{(Eq.1)}$$

where Yc = cotton lint yield (lbs/acre),

W = water applied per acre (acre-inches),

EVAP = pan evaporation (inches/season),

N = nitrogen applied (lbs/acre).

By inserting mean values for each county for the non-nitrogen variables, one can derive a cotton-nitrogen production function for each county.

Maricopa County

The assumed mean values for Maricopa County are as follows:

W = 66 acre-inches/season (Hathorn, 1987),

EVAP = 81.4 inches/season (Ayer and Hoyt, 1981),

N = 150 lbs/acre (Hathorn, 1987),

Yc = 1200 lbs/acre (Hathorn, 1987).

Therefore, using the assumptions, the cotton-nitrogen production function for Maricopa County can be calculated as follows:

$$Yc= -380.377+35.032W-.499W^2 +.307WEVAP+2.262N-.007N^2 \qquad \text{(Eq.1)}$$

$$1,200=-a+35.032(66)-.499(66^2)+.307(66)(81.4)+2.262(150)-.007(150^2)$$

$$1,200+a= 2,312.11 - 2,173.64 + 1,649.33 +339.3 - 157.5$$

$$1,200 +a = 1,969.6$$

$$a = -1,200 + 1,969.6 = 769.6$$

This leads to :

$$Yc=-769.6+35.032(66)-.499(66^2)+.307(81.4)(66)+2.262(150)N-.007N^2$$

$$= -769.6 + 2,312.11 - 2,173.64 + 1,649.33 + 2.262 N -.007N^2$$

$$= 1,018.2 + 2.262N -.007N^2$$

Therefore,

$$Yc = 1,073.39 + 2.262 N - .007N^2 \qquad \text{(Eq.2a)}$$

Pinal County

The assumed mean values for Pinal County are as follows:

W = 60 acre-inches/season (Hathorn, 1987),

EVAP = 81.4 inches/season (Ayer and Hoyt, 1981),

N = 132 lbs/acre (Hathorn, 1987),

Yc = 1250 lbs/acre (Hathorn, 1987).

Therefore, using the assumptions, the cotton-nitrogen production function for Pinal County can be calculated as follows:

$$Yc= -380.377+35.032W-.499W^2 +.307WEVAP+2.262N-.007N^2 \qquad \text{(Eq.1)}$$

$$1,250=-a+35.032(60)-.499(60^2)+.307(60)(81.4)+2.262(132)-.007(132^2)$$

$$1,250 +a = 2,101.92 -1,796.40 +1,499.39 +298.584 -121.97$$

$$1,250 +a = 1,981.52$$

$$a = -1,250 + 1,981.52 = 731.52$$

This leads to :

$$Yc=-731.52+35.032(60)-.499(60^2)+.307(81.4)(60)+2.262N-.007N^2$$

$$= -731.52 + 2,101.92 - 1,796.4 + 1,499.39 + 2.262 N -.007N^2$$

$$= 1,073.39 + 2.262N -.007N^2$$

Therefore,

$$Yc = 1,073.39 + 2.262 N - .007N^2 \qquad \text{(Eq.2b)}$$

APPENDIX 11

NITROGEN FERTILIZER BUDGET MODELS-MARICOPA AND PINAL COUNTY

FARM BUDGETS VARYING NITROGEN USE (BENCHMARK) MARICOPA 1.00 Principal(s)
750.00 Acre Farm Fine Texture Soil Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1200.00
Seed yield (tons/ac) =	1.03
Def. rate =	0.27
Base acres =	450.00
Soil residual N (ppm) =	16.60
Equivalent N (lbs/ac) =	99.60
N-FERTILIZER =	Urea 46
N-fert. applied/applic.(lbs/ac)=	163.00
Nitrogen content (%) =	0.46
Actual N applied (lbs/ac) =	149.96
N-fert. cost ($/lb app) =	0.10
N-fert # applic/ac =	2.00
N-fert material cost ($/ac) =	32.60
N-fert application method =	Side-dress
N-fert applic. cost($/app/ac)=	5.68
N-fert. applic. cost ($/ac) =	11.36
Total N-fert. cost ($/ac) =	43.96
Non-N operating cost ($/ac) =	461.57
Permitted acres =	237.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1200.00
Forecast Deficiency FUL =	109957.50
Free acres =	61.28
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.45
Adjusted ACR =	51.10
Maint. cost ACR acres=	21.00
Free acres 50-92 =	56.38
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	47.02
ACR Factor 50-92 =	0.30
CU to protect base =	121.47
WHEAT:	
Price ($/ton) =	120.00
Yield (tons/ac) =	2.80
Operating cost ($/ac) =	181.96

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	190.81	150.00	268.45
Alfalfa acres	95.41	75.00	134.23
Fallow acres	126.28	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	238950.86	318601.14	119475.43
Cotton seed	29605.61	39474.14	14802.80
Deficiency pmt.	50000.00	0.00	50000.00
Wheat	64113.56	50400.00	90199.34
Alfalfa	55097.59	43312.50	77515.05
TOTAL RECEIPTS	437767.61	451787.79	351992.64
OPERATING COSTS:			
Cotton:			
N-fert. cost	14836.50	19782.00	7418.25
Non-N oper. cost	155779.88	207706.50	77889.94
Wheat	34720.55	27294.00	48847.24
Alfalfa	30120.97	23678.25	42376.24
Mntce cost adj ACR acs	1073.20	0.00	987.35
TOTAL OPERATING COSTS	236531.09	278460.75	177519.02
RETURNS OVER OPERATING	201236.52	173327.04	174473.62
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.25	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

ALFALFA :	
Price ($/ton) =	75.00
Yield (tons/ac) =	7.70
Operating cost ($/ac) =	315.71

FARM BUDGETS VARYING NITROGEN USE (BENCHMARK) PINAL 1.00 Principal(s)
750.00 Acre Farm Fine Texture Soil Furrow Irrigation

UPLAND COTTON:	
Lint price ($/lb) =	0.59
Seed price ($/ton) =	85.00
Lint yield (lbs/ac) =	1250.00
Seed yield (tons/ac) =	1.08
Def. rate =	0.27
Base acres =	450.00
Soil residual N (ppm) =	19.40
Equivalent N (lbs/ac) =	116.40
N-FERTILIZER TYPE A =	Anhydrous
N-fert.A applied/applic.(lbs/ac)	61.00
A Nitrogen content (%) =	0.82
Actual A N applied (lbs/ac) =	100.04
A N-fert. cost ($/lb app) =	0.13
A N-fert # applic/ac =	2.00
A N-fert material cost ($/ac) =	15.86
A N-fert application method =	Water-run
A N-fert applic. cost($/app/ac)=	0.00
A N-fert. applic. cost ($/ac) =	0.00
Total A N-fert. cost ($/ac) =	15.86
N-FERTILIZER TYPE B =	16-20-0
N-fert. B applied/applic.(lbs/ac	200.00
B Nitrogen content (%) =	0.16
Actual B N applied(lbs/ac) =	32.00
B N-fert. cost ($/lb app) =	0.11
B N fert. # applic/ac =	1.00
B N-fert. material cost ($/ac) =	21.50
B N-fert. application method =	Broadcast
B N-fert. applic. cost ($/app/ac	0.91
B N-fert. applic. cost ($/ac) =	0.91
Total B N-fert. cost ($/ac) =	22.41
Non-N operating cost ($/ac) =	574.95
Permitted acres =	337.50
ACR factor =	0.33
ACR FUL =	112.39
ASCS Yield =	1250.00
Forecast Deficiency FUL =	114539.06
Free acres =	63.22
Target price =	0.79
Max DP =	50000.00
Relief factor =	0.44
Adjusted ACR =	49.06
Maintenance cost on ACR acres =	21.00
Free acres 50-92 =	58.26
ACR FUL 50-92 =	103.40
Adjusted ACR 50-92 =	45.14
ACR Factor 50-92 =	0.30
CU to protect base =	119.59

	Part.	No Part.	50/92
ACRES:			
Cotton acres	337.50	450.00	168.75
Wheat acres	192.18	150.00	268.65
Alfalfa acres	96.09	75.00	134.23
Fallow acres	124.24	75.00	178.57
Total Acres	750.00	750.00	750.00
RECEIPTS:			
Cotton lint	248906.95	331875.93	124453.47
Cotton seed	30839.15	41118.87	15419.57
Deficiency pmt.	50000.00	0.00	50000.00
Wheat	46554.54	36337.50	65032.12
Alfalfa	53809.17	42000.00	75165.12
TOTAL RECEIPTS	430109.80	451332.30	330071.29
OPERATING COSTS:			
Cotton:			
N-fert. cost	12916.13	17221.50	6458.06
Non-N oper. cost	194045.63	258727.50	97022.81
Wheat	48099.63	37543.50	67190.46
Alfalfa	48447.47	37815.00	67675.35
Mntce cost adj ACR acs	1030.28	0.00	947.85
TOTAL OPERATING COSTS	304539.13	351307.50	239295.54
RETURNS OVER OPERATING	125570.68	100024.80	90775.75
CROP MIX:			
Cotton	0.45	0.60	0.23
Wheat	0.26	0.20	0.36
Alfalfa	0.13	0.10	0.18
Fallow	0.17	0.10	0.24

NITROGEN USE:	
Total Applied N (lbs/ac)	132.04
WHEAT:	
Price ($/ton) =	95.00
Yield (tons/ac) =	2.55
Operating cost ($/ac) =	250.29
ALFALFA :	
Price ($/ton) =	80.00
Yield (tons/ac) =	7.00
Operating cost ($/ac) =	504.20

APPENDIX 12

NITROGEN FERTILIZR SENSITIVITY ANALYSIS-MARICOPA COUNTY

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN-FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.70	X
Seed Price ($/ton) =	85	
Residual N (ppm) =	16.6	
N cost ($/lb) =	0.10	
# of principals =	1	
Wheat Price ($/ton) =	120	
Wheat yield (tons/ac)	2.8	
Alfalfa Price ($/ton)	75	
Alfalfa Yield (tons/ac	7.7	
Non-Program Crop Mix:		
Cotton (%)	60	
Wheat (%)	20	
Alfalfa (%)	10	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$223,807	$239,580	$245,787	$242,540	$229,798
None	204,099	224,564	232,727	228,712	$212,521
50-92	185,967	193,680	196,749	195,221	$189,095

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$21,980	$6,207	---	$3,247	$15,989
None	28,628	8,163	---	4,015	20,206
50-92	10,782	3,069	---	1,528	7,654

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.80	X
Seed Price ($/ton) =	85	
Residual N (ppm) =	16.6	
N cost ($/lb) =	0.10	
# of principals =	1	
Wheat Price ($/ton) =	120	
Wheat yield (tons/ac)	2.8	
Alfalfa Price ($/ton)	75	
Alfalfa Yield (tons/ac	7.7	
Non-Program Crop Mix:		
Cotton (%)	60	
Wheat (%)	20	
Alfalfa (%)	10	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$262,482	$279,763	$286,287	$282,177	$267,389
None	255,665	278,142	286,727	281,560	$262,642
50-92	205,304	213,771	216,999	215,040	$207,890

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$23,805	$6,524	---	$4,110	$18,898
None	31,062	8,585	---	5,167	24,085
50-92	11,695	3,228	---	1,959	9,109

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	16.6	
N cost ($/lb) =	0.08	X
# of principals =	1	
Wheat Price ($/ton) =	120	
Wheat yield (tons/ac)	2.8	
Alfalfa Price ($/ton)	75	
Alfalfa Yield (tons/ac	7.7	

Non-Program Crop Mix:

Cotton (%)	60
Wheat (%)	20
Alfalfa (%)	10
Fallow (%)	10

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$184,937	$198,313	$203,437	$204,408	$189,182
None	152,273	169,542	176,261	172,535	$158,365
50-92	166,532	173,047	175,574	174,155	$168,786

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$18,500	$5,124	---	($971)	$14,255
None	23,988	6,719	---	3,726	17,896
50-92	9,042	2,527	---	1,419	6,788

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	16.6	
N cost ($/lb) =	0.12	X
# of principals =	1	
Wheat Price ($/ton) =	120	
Wheat yield (tons/ac)	2.8	
Alfalfa Price ($/ton)	75	
Alfalfa Yield (tons/ac	7.7	
Non-Program Crop Mix:		
Cotton (%)	60	
Wheat (%)	20	
Alfalfa (%)	10	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$177,593	$192,443	$199,036	$197,473	$187,714
None	142,481	161,716	170,393	168,621	$156,408
50-92	162,860	170,112	173,373	172,688	$168,053

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$21,443	$6,593	---	$1,563	$11,322
None	27,912	8,677	---	1,772	13,985
50-92	10,513	3,261	---	685	5,320

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	16.6	
N cost ($/lb) =	0.10	
# of principals =	1	
Wheat Price ($/ton) =	120	
Wheat yield (tons/ac)	2.8	
Alfalfa Price ($/ton)	75	
Alfalfa Yield (tons/ac	7.7	
Non-Program Crop Mix:		
Cotton (%)	40	X
Wheat (%)	10	X
Alfalfa (%)	40	X
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$228,615	$242,728	$248,586	$246,290	$235,798
None	159,848	172,016	177,148	175,315	$166,521
50-92	212,045	218,929	221,823	220,771	$215,769

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$19,971	$5,858	---	$2,296	$12,788
None	17,300	5,132	---	1,833	10,627
50-92	9,778	2,894	---	1,052	6,054

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	16.6	
N cost ($/lb) =	0.10	
# of principals =	1	
Wheat Price ($/ton) =	120	
Wheat yield (tons/ac)	2.8	
Alfalfa Price ($/ton)	75	
Alfalfa Yield (tons/ac	7.7	
Non-Program Crop Mix:		
Cotton (%)	30	X
Wheat (%)	10	X
Alfalfa (%)	50	X
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$248,249	$262,362	$268,221	$265,924	$255,432
None	162,042	171,169	175,018	173,643	$167,048
50-92	231,680	238,563	241,458	240,405	$235,404

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$19,972	$5,859	---	$2,297	$12,789
None	12,976	3,849	---	1,375	7,970
50-92	9,778	2,895	---	1,053	6,054

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750
Lint Price ($/lb) =	0.59
Seed Price ($/ton) =	85
Residual N (ppm) =	16.6
N cost ($/lb) =	0.10
# of principals =	1
Wheat Price ($/ton) =	120
Wheat yield (tons/ac)	2.8
Alfalfa Price ($/ton)	75
Alfalfa Yield (tons/ac	7.7
Non-Program Crop Mix:	
Cotton (%)	80 X
Wheat (%)	20 X
Alfalfa (%)	0 X
Fallow (%)	0 X

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$161,631	$175,744	$181,602	$179,306	$168,814
None	162,621	186,958	197,222	193,556	$175,968
50-92	145,061	151,945	154,839	153,787	$148,785

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$19,971	$5,858	---	$2,296	$12,788
None	34,601	10,264	---	3,666	21,254
50-92	9,778	2,894	---	1,052	6,054

X = assumption varied from initial benchmark

MARICOPA-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =		750
Lint Price ($/lb) =		0.59
Seed Price ($/ton) =		85
Residual N (ppm) =		16.6
N cost ($/lb) =		0.10
# of principals =		1
Wheat Price ($/ton) =		120
Wheat yield (tons/ac)		2.8
Alfalfa Price ($/ton)		75
Alfalfa Yield (tons/ac		7.7
Non-Program Crop Mix:		
Cotton (%)	30 X	
Wheat (%)	30 X	
Alfalfa (%)	30 X	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	100	50
Full	$232,087	$246,200	$252,058	$249,762	$239,269
None	145,880	155,006	158,855	157,481	$150,885
50-92	215,517	222,401	225,295	224,243	$219,241

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	100	50
Full	$19,971	$5,858	---	$2,296	$12,789
None	12,975	3,849	---	1,374	7,970
50-92	9,778	2,894	---	1,052	6,054

X = assumption varied from initial benchmark

APPENDIX 13

NITROGEN FERTILIZER SENSITIVITY ANALYSIS-PINAL COUNTY

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.70 X	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.13	0.11
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	

Non-Program Crop Mix:

Cotton (%)	60
Wheat (%)	20
Alfalfa (%)	10
Fallow (%)	10

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$147,924	$164,517	$171,679	$171,977	$169,621	$158,472
None	129,919	151,960	161,493	161,900	158,797	$144,050
50-92	101,948	110,249	113,830	113,979	112,799	$107,219

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$24,053	$7,460	$298	---	$2,356	$13,505
None	31,981	9,940	407	---	3,103	17,850
50-92	12,031	3,730	149	---	1,180	6,760

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.80 X	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.13	0.11
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	
Non-Program Crop Mix:		
Cotton (%)	60	
Wheat (%)	20	
Alfalfa (%)	10	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$184,467	$206,567	$214,040	$214,165	$211,103	$197,910
None	183,978	208,027	217,975	218,150	214,106	$196,634
50-92	122,220	131,274	135,011	135,073	133,540	$126,938

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$29,698	$7,598	$125	---	$3,062	$16,255
None	34,172	10,123	175	---	4,044	21,516
50-92	12,853	3,799	62	---	1,533	8,135

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.15	0.13 X
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	
Non-Program Crop Mix:		
Cotton (%) 60		
Wheat (%) 20		
Alfalfa (%) 10		
Fallow (%) 10		

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$98,888	$114,735	$122,434	$123,228	$122,231	$114,210
None	64,539	85,584	95,833	96,902	95,610	$85,034
50-92	77,430	85,357	89,208	89,605	89,104	$85,088

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$24,340	$8,493	$794	---	$997	$9,018
None	32,363	11,318	1069	---	1,292	11,868
50-92	12,175	4,248	397	---	501	4,517

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.11	0.09 X
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	

Non-Program Crop Mix:

Cotton (%)	60
Wheat (%)	20
Alfalfa (%)	10
Fallow (%)	10

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$107,123	$121,282	$127,348	$127,575	$125,498	$115,844
None	75,519	94,314	102,385	102,698	99,966	$87,212
50-92	81,548	88,631	91,665	91,778	90,738	$85,905

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$20,452	$6,293	$227	---	$2,077	$11,731
None	27,179	8,384	313	---	2,732	15,486
50-92	10,230	3,147	113	---	1,040	5,873

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.13	0.11
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	
Non-Program Crop Mix:		
Cotton (%)	40 X	
Wheat (%)	10 X	
Alfalfa (%)	40 X	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$116,483	$131,420	$138,238	$138,729	$137,149	$128,248
None	61,121	74,342	80,392	80,834	79,456	$71,623
50-92	92,807	100,279	103,689	103,934	103,142	$98,686

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$22,246	$7,309	$491	---	$1,580	$10,481
None	19,713	6,492	442	---	1,378	9,211
50-92	11,127	3,655	245	---	792	5,248

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.13	0.11
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	
Non-Program Crop Mix:		
Cotton (%)	30 X	
Wheat (%)	10 X	
Alfalfa (%)	50 X	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$120,668	$135,605	$142,423	$142,914	$141,334	$132,433
None	54,060	63,976	68,513	68,845	67,811	$61,936
50-92	96,992	104,464	107,874	108,119	107,327	$102,871

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$22,246	$7,309	$491	---	$1,580	$10,481
None	14,785	4,869	332	---	1,034	6,909
50-92	11,127	3,655	245	---	792	5,248

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.13	0.11
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	
Non-Program Crop Mix:		
Cotton (%)	80 X	
Wheat (%)	20 X	
Alfalfa (%)	0 X	
Fallow (%)	0 X	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$99,140	$114,077	$120,895	$121,386	$119,806	$110,905
None	88,762	115,204	127,305	128,188	125,431	$109,765
50-92	75,464	82,936	86,346	86,591	85,799	$81,343

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$22,246	$7,309	$491	---	$1,580	$10,481
None	39,426	12,984	883	---	2,757	18,423
50-92	11,127	3,655	245	---	792	5,248

X = assumption varied from initial benchmark

PINAL-NITROGEN FERTILIZERS

LOSS IN RETURNS OVER OPERATING COSTS BY VARYING LEVELS
OF NITROGEN FERTILIZER

I. ASSUMPTIONS

Total Acres =	750	
Lint Price ($/lb) =	0.59	
Seed Price ($/ton) =	85	
Residual N (ppm) =	19.4	
N cost ($/lb) =	0.13	0.11
# of principals =	1	
Wheat Price ($/ton) =	95	
Wheat yield (tons/ac)	2.55	
Alfalfa Price ($/ton)	80	
Alfalfa Yield (tons/ac	7	
Non-Program Crop Mix:		
Cotton (%)	30 X	
Wheat (%)	30 X	
Alfalfa (%)	30 X	
Fallow (%)	10	

NET RETURNS OVER OPERATING COSTS

Applied N	250	200	150	132.04	100	50
Full	$111,092	$126,029	$132,847	$133,338	$131,758	$122,857
None	44,484	54,400	58,937	59,269	58,235	$52,360
50-92	87,416	94,888	98,298	98,543	97,751	$93,295

LOSS IN NET RETURNS FROM ASSUMED PROGRAM

Applied N	250	200	150	132.04	100	50
Full	$22,246	$7,309	$491	---	$1,580	$10,481
None	14,785	4,869	332	---	1,034	6,909
50-92	11,127	3,655	245	---	792	5,248

X = assumption varied from initial benchmark

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